BellHawk Software Handbook

An Overview of the BellHawk Integrated Real-Time Work-in-Process and Materials Tracking Software for Industrial Organizations

Peter E Green

"Watching Your Operations like a Hawk and Ringing the Bell when Problems are about to Occur"

BellHawk®

Real-Time Work-in-Process and MaterialsTracking Software

www.BellHawk.com

Preface

The BellHawk software is used for real-time work-in-process and materials tracking by manufacturers, distributors, and other industrial organizations. It is primarily used by mid-sized manufacturers that specialize in making semi-custom products. BellHawk is also used by food and pharmaceutical processors, construction, engineering, defense, and repair organizations, as well as by other industrial organizations.

This handbook provides a detailed overview of the BellHawk software. The purpose of this handbook is to enable prospective and current users of the BellHawk software to understand the scope of the software, what it does, and how it does it.

Author

This handbook was written by Dr. Peter Green, who serves as the Technical Director of KnarrTek Inc. and Milramco LLC. Dr Green obtained his BSC (Hons) in Electrical Engineering and his Ph.D. Degrees in Electronics and Computer Science from Leeds University in England. Subsequently Dr. Green was a senior member of technical staff at Massachusetts Institute of Technology and a Professor of Computer Engineering at Worcester Polytechnic Institute. He has also been a member of the senior management team of eight high-technology start-ups or early-stage companies.

Dr Green is an expert in real-time materials tracking and operations management within industrial organizations. He is a systems architect and led the team which developed both the BellHawk and MilramX software. Over the past decade Dr Green has also led the implementation of over 100 systems, based on BellHawk, to assist manufacturers and other industrial organizations to improve the efficiency of their operations and to increase sales through improved customer satisfaction

Edition

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Handbook Organization

This handbook is organized into five sections:

A. BellHawk software overview

B. How the BellHawk software works

C. The BellHawk software product line

D. Implementing a BellHawk barcode tracking system

E. BellHawk software compliance

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Section A BellHawk Software Overview

1. Introduction to the BellHawk Software

The BellHawk software provides an integrated real-time work-in-process and materials tracking solution for manufacturers and other industrial organizations, such as distributors and repair organizations. It is based on the use of Microsoft database and web-server technologies.

The web-server version of the BellHawk software was originally developed in 2008 and 2009 by Dr. Peter Green, the Technical Director of Milramco LLC, to provide a simple-to-use work-in-process and materials tracking solution for use by small to mid-sized industrial organizations.

This development was in response to the limitations of prior client-server-based systems, which required a substantial IT staff presence on-site for their support. This IT support was expensive and precluded the use of these systems by many smaller organizations. This development was also in response to the movement to Cloud computing, with all its attendant cost saving benefits.

The initial goal of BellHawk was to replace the use of paper forms and manual keyboard data entry to track materials and work-in-process, in real-time, with the use of technologies such as barcode scanning and mobile computers.

This initial development was focused on the needs of the several hundred thousand small and medium size short-run, quick-turn, make-to-order manufacturing plants in the USA, of which 80% were (and many still are) using paper forms and manual keyboard data entry (primarily into Excel spreadsheets) to track their inventory and operations.

Since then, the capabilities of BellHawk have been expanded in over a decade of application, in collaboration with a number of partners, to become a comprehensive real-time materials and work-in-process tracking solution for a wide range of industrial organizations.

Users of BellHawk have included a wide range of manufacturers and industrial distributors, food and pharmaceutical processors, engineering, repair, defense, and construction organizations.

BellHawk is currently available on a software-as-a-service basis, in the Cloud, at affordable prices. This is ideal for smaller organizations, as it requires minimal IT support. BellHawk is also available for rental or purchase by the IT departments of larger organizations for installation in their own data centers.

Early on, in the development of BellHawk, a decision was made not to integrate Accounting or CRM (Customer Relations Management) capabilities into BellHawk but instead to provide interfaces to enable BellHawk to exchange data with a wide range of Accounting, ERP (Enterprise Resource Planning), and CRM systems. This has enabled BellHawk to be tailored to meet the specific needs of materials and production managers, and their staff, without turning BellHawk into "Bloatware" with so many features that it became very difficult to use.

BellHawk is based on the use of rules that integrate the best manufacturing and materials tracking and traceability practices. BellHawk, at its core, is a real-time expert system that uses Artificial Intelligence (AI) rules to make it easy to use. Users can configure these rules to meet their specific needs for a wide range of different applications, without needing to customize the software.

At the same time, the BellHawk DEX (Data Exchange) interface provides the capability for users to integrate their own custom reports into BellHawk, as well as to automate the exchange of data with a wide range of other systems, without needing to understand the internal architecture of BellHawk.

BellHawk uses a web-browser interface for all its user interaction. This enables BellHawk to be used on a wide-range of different computing devices such as PCs, Android based mobile computers, and smart phones, anywhere there is an Internet connection, without needing to load any special BellHawk software into each device.

As a result, BellHawk can be used to track materials and work-in-process at multiple different manufacturing plants, warehouses and other geographically distributed facilities. It can also be used to track materials in yards, at field-service sites, and at construction sites, as well as tracking materials in transit between facilities.

BellHawk integrates a rules-based capability for automatically printing custom labels on high-speed barcode label printers. These user defined rules enable situation specific labels to be automatically printed without manually entering data. Instead, the data to appear on the label is automatically retrieved from the BellHawk database and the label is formatted according to the needs of the situation.

BellHawk quickly pays for itself in labor savings, by eliminating the use of paper forms and manual keyboard data entry, and by preventing operational mistakes. It can also help prevent the expensive loss of unhappy customers by assisting managers to make sure that orders get shipped on-time, without product defects.

In addition, BellHawk now integrates capabilities for real-time scheduling and materials planning, as well as electronic integration with customer and supplier supply chains, through the use of the companion MilramX software. BellHawk also captures materials traceability data, where needed for FDA and other compliance requirements, as well as integrating job cost estimating and tracking capabilities.

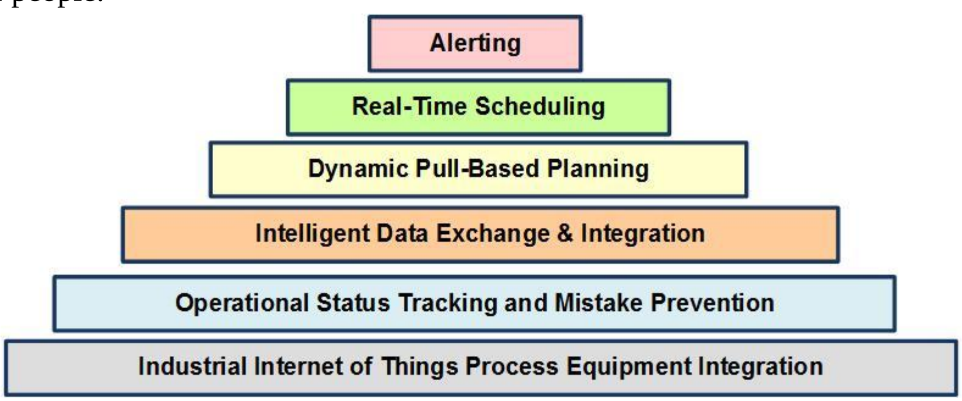
Features such as these have transitioned BellHawk from being a simple materials and work-in-process tracking system for make-to-order manufacturers to a fully integrated real-time operations management solution for a wide-range of industrial organizations.

The web-server version of BellHawk was the result of Dr. Peter Green's Tau-Adaptor project, back in 2008, which also resulted in what has become the MilramX software platform for enterprise and supply chain information exchange.

MilramX uses an intelligent-agent-approach to examine data in real-time as it is collected or generated by a variety of systems and to send alerts by Email or Text Message to people about events or issues that they need to be aware of. MilramX is also used to automatically exchange appropriate information between systems to make sure that everyone has the information they need to do their job, when they need it.

In simple applications, MilramX is used as the basis of the BellHawk DEX interface which enables users to create their own custom reports and to exchange data with a wide-variety of other systems.

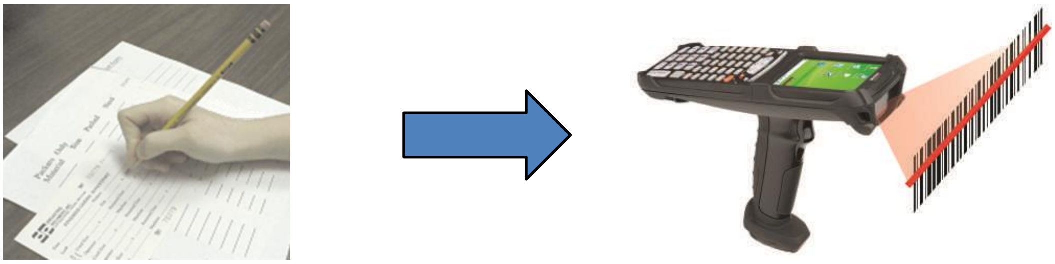
In more advanced applications, BellHawk can be used in conjunction with MilramX to provide an integrated real-time operations management solution, for mid-sized industrial organizations. Such applications typically have a significant level of embedded Artificial Intelligence to enable each plant and warehouse to be efficiently managed by a small team of people.



MilramX can also be used to integrate BellHawk with simple accounting systems, such as QuickBooks, and open-source CRM systems, such as Suite CRM, to provide an inexpensive alternative, with superior performance for many industrial organizations, to ERP systems costing hundreds of thousands or millions of dollars.

2. Capabilities, Features, and Benefits of BellHawk

2.1 What Does BellHawk Do?



At a fundamental level, BellHawk enables manufacturers, distributors, and other industrial organizations to transition from using paper forms and manual keyboard data entry to using technologies such as barcode scanning and mobile computing, to track their materials and work-in-process.

Within manufacturing organizations BellHawk track the receipt and put-away of raw materials, their picking and consumption in a sequence of manufacturing operation to produce intermediate and then finished products, including tracking work-in-process materials. BellHawk then tracks the picking, packing and shipping of the finished products to customers.

Within industrial distributors, BellHawk not only enables real-time tracking of their inventory and real-time warehouse management, at a very affordable cost, but also handles tracking of secondary operations such as kitting, assembly, repackaging, labeling, as well as supply-chain integration, through the use of MilramX.

Unlike traditional Warehouse Management Systems (WMS), which track the quantities of inventory at different locations, BellHawk tracks the quantity of materials in each container (such as in a box or bin or on a roll or reel), as well as individually tracking serialized items. BellHawk then uses a unique tracking barcode attached to each container or serialized item to track its location.

This is similar to the tracking method used by distributors such as Amazon and delivery services such as FedEx and UPS. This method now forms the basis for the GS1 standard for tracking materials in the global supply chain as well as forming the basis for materials traceability standards, such as promulgated by agencies such as the US Food and Drug Administration.

This use of container-based tracking, enables BellHawk to track the lot number and expiration date of the materials in each container as well as whether it has passed or failed quality control inspection. It enables BellHawk to perform inventory and operations tracking in real-time and to provide users, such as machine operators and material handlers, with point-of-action warnings when they are about to make a data collection or operational mistake.

This real-time capture of tracking information gives managers, supervisors, and their staff, a real-time view of the status of their materials and work-in-process. This, in turn enables efficient operation of the industrial enterprise and helps ensure that customer orders get processed and shipped on-time.

Purchase, picking, work, and shipment orders can be entered directly into BellHawk or imported from other systems, such as ERP systems, to assist in capturing data. BellHawk can use this order information, along with captured materials and work-in-process status data, to assist managers to plan and schedule production operations and materials purchases in real-time.

BellHawk can also use the tracking data it captures to determine the cost of each job as well as to capture materials traceability history data.

2.2 BellHawk Capabilities

Materials Tracking

- Accurately tracking raw, intermediate, and finished product materials in real-time.
- Tracking mixed pallets containing many different products.
- Tracking materials in, and moving between, multiple different geographic locations.
- Tracking materials in yards, at field-service and construction sites, and in-transit.
- Tracking lot and serial numbers and expiration dates of each container of materials.
- Warehouse operations management, including receiving, picking, packing, and shipping.
- Tracking assets, such as tools, jigs, and fixtures.

Tracking Work-in-Process

- Tracking when manufacturing operations start and end on each job/work order.
- Tracking work-in-process materials, as they flow from work-center to work-center.
- Capturing labor and materials expended on each operation for each job/work-order.
- Tracking equipment usage on each job.
- Capturing user defined data for materials produced.
- Estimating the cost of jobs, including materials, labor, and machine time.
- Comparing estimated versus actual job costs.
- Preventing mistakes, such as picking or using the wrong materials.

- Capturing materials traceability data for standards and regulatory compliance.
- Tracking quality control operations and preventing use of defective materials.
- Performing demand-based materials requirements planning.
- Real-time scheduling of production operations.

Systems Integration

- Availability of interfaces through which BellHawk can automatically exchange data with a wide range of ERP and accounting, CRM, E-Commerce, process control, CAD, shipping, and supply-chain systems.
- Automated generation of custom barcode labels on-demand.
- Integration with weighing scales as part of transactional data capture.
- Use of RFID sensors to automatically track movement of containers of material as well as serialized items and assets, such as computers and tools.

2.3 What Makes BellHawk Different?

BellHawk, at a high level, would appear to have many capabilities that overlap with those of existing Job Shop, Enterprise Resource Planning (ERP), and WMS (Warehouse Management Systems). And yet BellHawk is frequently used in conjunction with these same Job Shop and ERP systems and is used to replace existing WMS systems.

The factors that make BellHawk different are:

- BellHawk uses web-server rather than the client server-technology used by many ERP and Job Shop systems. BellHawk can be run in a secure data center and yet be securely accessed from anywhere there is an Internet connection. This also enables BellHawk to capture data using a wide-range of data collection equipment without needing to load any special software in the mobile computers, tablets, or PCs used for real-time data collection.

- BellHawk tracks containers of material using methods similar to those used by organizations such as UPS, FedEx, and Amazon. This makes the system easy-to-use and gives it the ability to track materials at many different geographically dispersed locations, as well as materials in-transit. This also enables the tracking of pallets or other nested containers holding many different products.

- BellHawk provides an integrated work-in-process, and materials tracking solution plus warehouse management and operations management capabilities. These enable managers to keep end-to-end track of their manufacturing and distribution operations in real-time at multiple geographic locations.

- BellHawk uses a separate database from the ERP, accounting and CRM systems, with which BellHawk works. This enables BellHawk to be focused on the needs of operations and materials managers, and yet, at the same time, BellHawk has a simple-to-use interface which enables it to easily exchange data with a wide variety of these systems. This avoids upgrading BellHawk system, every time the Tax rules change or new CRM features are introduced. Most significantly, it avoids BellHawk becoming "Bloatware" with so many features that it becomes very difficult to use like some ERP systems that try to integrate all these features into a one-size-fits all solution.

- BellHawk has integrated real-time scheduling of operations and incremental materials requirements planning for make-to-order manufacturers to help ensure customer orders get delivered on time. This is in contrast to traditional MRP (Materials Requirements Planning) and ERP systems where scheduling and planning is focused on long-run manufacturing which is scheduled months in advance and requires completely redoing operating schedules every time it is run.

- BellHawk has integrated materials traceability and quality control tracking capabilities, plus it is CFR 21 Part11 compliant, which enables the use of BellHawk in FDA regulated applications.

- BellHawk has integrated materials, job cost, and asset tracking capabilities which enable compliance with the cost accounting needs of Government agencies, such as the Department of Defense.

2.4 BellHawk Architecture

BellHawk is an open-architecture software platform which is based on the use of Microsoft Windows Server and Workstation operating systems, the Microsoft SQL Server database technology, and the Microsoft IIS Webserver technology. It was written using a variety of Microsoft .Net technologies.

BellHawk can be used in the Cloud as packaged software on a software-as-a-service basis or, for those organizations installing BellHawk in their own data center, it can be used as a powerful software development platform, which can be customized and integrated into their own IT infrastructure to support complex requirements.

The BellHawk software consists of a specialized website and a SQL Server database that run on a Windows Server computer. All user interaction is performed using a web-browser, thus avoiding the need to install special BellHawk software on each user's device. This also enables users to collect and view data using a wide range of Windows, Apple, Linux, and Android devices.

Data collection can be performed using devices such as PCs or Android tablets that have external corded or cordless barcode scanners. Data capture devices can also include ruggedized PDAs with integral barcode scanners as well gun-style units equipped with long-range barcode scanners, which are suitable for scanning from the seat of a fork-lift truck. Data viewing can be done by using these same devices as well as using smart mobile phones and tablets.

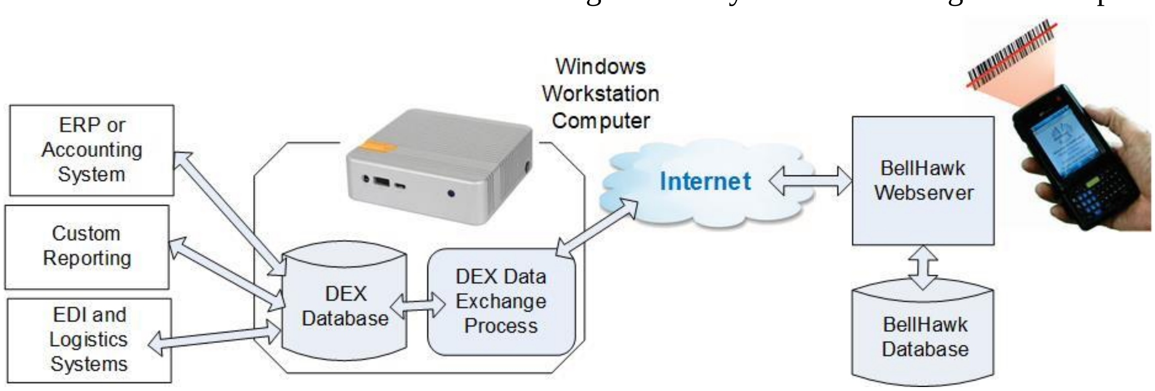
This data collection and viewing can take place over a local area network, over an Internet connection, or over a mobile phone data network, anywhere there is an Internet connection to the server computer. All communication is done using encrypted data links for security.

The BellHawk web-browser interface makes extensive use of embedded Expert Systems rules to make it easy for machine operators and material handlers to use BellHawk with minimum time spent on data entry. At the same time BellHawk provides immediate feedback, through their mobile devices, when these users are about to make an operational or data entry mistake.

This extensive use of rules, to direct data collection and provide warnings, enables organizations to tailor BellHawk to meet their specific data collection needs without customizing the software.

Installing BellHawk in a secure data center has many advantages, such as enabling users at many locations to capture and share tracking information over the Internet and ensuring a high-uptime by having the software under the control of an experienced IT staff at a data center with backup power and automated backup and restore capabilities.

But having BellHawk running remotely from the plants and warehouses in which it is used, also has disadvantages, in that the BellHawk database is in a remote location and is therefore not available for interfacing to other systems or creating custom reports.



To solve these problems BellHawk comes with the BellHawk store-and-forward DEX face software, which can be run on a Windows PC or Server in each local facility. This interface consists of a SQL Server database and a data exchange process which automatically exchanges data between DEX and the BellHawk database, at a remote data center, through the BellHawk web-services interface.

Users can send data, such as for Purchase Orders and Work Orders, to BellHawk by writing data into tables within this DEX database. Also, data captured by BellHawk, such as for Purchase Order receipts and resources (materials, labor and machine time) consumed by Work Order Operations, are relayed back from BellHawk into local tables in the DEX database, where they can be used for custom reporting and for data exchange with ERP and accounting systems.

With DEX, all setup data, as well as purchase, pick, work, and ship orders entered into BellHawk are relayed to the DEX database where they can be used, along with data captured by BellHawk, to enable custom reports to be produced. In addition, data such as advanced shipment notice data is exchanged with the DEX database, so that it can be used for supply chain integration, including interfacing with EDI, shipping and logistics systems.

The PC version of DEX provides a simple way for users to create their own custom reports by linking report generation software, such as Access, Crystal Reports, and Excel, to the DEX database. More advanced software, such as SSRS (SQL Server Reporting Service) can also be used to generate custom reports and then these reports can be integrated with, or replace, the standard reports, in BellHawk.

The DEX interface is based on the use of the MilramX automated information exchange platform. Where the DEX interface has to be run 24x7, such as in serving SSRS reports through the web or automatically exchanging data with an ERP system, or supply-chain systems then the DEX interface is typically run on a Windows Server, integrated with MilramX, to enable unattended operation for long periods of time.

There are also other situations, such as printing barcode labels on-demand in a local plant or warehouse, interfacing to weighing scales, and detecting the movement of materials using RFID sensors, where data needs to be exchanged between devices in the local facility and BellHawk running at a remote data center.

To meet these needs BellHawk has a set of interfaces, which can be run in Windows Workstations in each local plant. These available remote interfaces are:

1. The TAG barcode labeling software. This enables label printing requests to be made from mobile and other devices through the web-server interface and printed out on a selected barcode label printer in the local plant or warehouse.

2. A weighing-scale interface, which reads stable weights from RS232 or similar interfaces to weighing scales and relays these to BellHawk every time the weight changes. These weights can then be used within BellHawk data capture transactions to avoid data capture errors.

3. An RFID interface, which interfaces to RFID data-capture portals in a plant or warehouse to automatically record the movement of containers of material.

All of these interfaces, as well as DEX, communicate with BellHawk's web-services interface. They only need a standard outbound Internet connection (the same as the PCs, tablets, and mobile computers connected to BellHawk). This avoids the need to create special "holes" in the Internet firewall for each plant or warehouse, which could be a major security risk.

If BellHawk is installed on a Windows Server computer, accessible over the plant LAN, then this interface software can be installed on the same server as BellHawk. But normally these interfaces are installed on a Windows Workstation computer at each facility where local data exchange with BellHawk, running in a remote data center, is required.

In most cases, for running DEX and these interfaces, we recommend the use of industrial computers, such as those based on the use of the Windows IIOT software, which can automatically restart the transfers in the event of a power outage.

2.5 Some Features of BellHawk

- Uses technologies such as barcode and RFID scanning, as well as mobile computing, to automate the real-time tracking of inventory and the capture of operational data.
- Uses secure web-server technology so that it can be used from anywhere there is an Internet connection, such as in geographically separated manufacturing operations and warehouses, as well as in yards and at construction and field service sites.
- Can be used over a secure data link "in the Cloud", at a remote data center, or installed within an organization's own manufacturing plant or warehouse.
- Use of tracking methods similar to those used by FedEx, UPS, and Amazon to make it easy to track the movement of inventory, even when materials are stored in multiple different locations or even are in-transit.
- Easy-to-use by people who have limited computer or English-language skills, due to extensive use of embedded Artificial Intelligence to guide and simplify the capture of data. Also includes extensive, user configurable, rules to warn people when they are about to make an operational or data collection mistake.
- Can be run stand-alone or integrated with existing ERP (Enterprise Resource Planning) or accounting systems.
- Has a simple remote interface, which can be used to produce custom reports as well as to automatically exchange data with a wide-range of systems such as ERP and accounting systems, engineering and CAD systems, as well as process control systems.
- Can automatically exchange data with customer and supplier systems in the supply chain. This includes handling Automated Shipment Notice (ASN) data as well as supply-chain traceability data.

- Has an integrated rules-based barcode labeling capability to automatically print custom barcode labels on-demand without the need to manually enter setup data, which takes time and can lead to mistakes.
- Can be integrated with E-Commerce systems to provide real-time order taking and tracking capabilities for customers.

2.6 Some Benefits of BellHawk

1. Gives real-time visibility of the status of customer orders, and needed materials, to help ensure that orders get shipped, delivered, and/or installed on time.
2. Saves labor cost and prevents mistakes by replacing the use of paper forms and manual keyboard data entry, into Excel spreadsheets or ERP/accounting systems, with automated data collection.
3. Can pay for itself in a few weeks or months in labor savings as well as preventing much larger losses, such as from losing customers due to late or defective deliveries, or from massive recalls due to producing defective products.
4. Integrated real-time operations scheduling and materials planning enable make-to-order manufacturers to schedule products to be made and materials to be ordered on a just-in-time basis, as orders are received.
5. Can track materials in real-time at multiple geographic locations, including in manufacturing plants, warehouses, yards, field service and construction sites, as well as materials in-transit and kept on vehicles.
6. Does not require an on-site IT staff member to manage the system, which can result in large cost savings compared to older client-server systems.
7. Enables compliance with FDA and customer requirements for materials tracking and traceability.
8. Real-time job cost tracking enables real-time comparison with estimated costs to enable managers to quickly detect cost overruns and to take corrective action.
9. Provides an integrated work-in-process and materials tracking solution, which does not require separate inventory tracking, warehouse management, or job shop management software.
10. Just add a low-cost accounting and CRM (customer relations management) system and you have a complete integrated solution for managing your manufacturing operations that has more capabilities than most high-end ERP systems costing hundreds of thousands or millions of dollars.

3. Applications of BellHawk

3.1 Introduction

This chapter describes some of the more common applications in which the BellHawk software has been used.

3.2 Manufacturing Materials Management

A common application of BellHawk is to track raw and intermediate materials, as well as finished products, both in manufacturing plants and off-site warehouses. The most common driving factor for putting in a BellHawk materials tracking system is that the organization was losing track of their inventory.

Running a warehouse associated with a manufacturing company, especially one involved in make-to-order manufacturing, is much more complex than running a warehouse for consumer products. This is because the mix of products stored in the warehouse changes continually and materials have to be quickly delivered to production work-centers when needed. Often there is also a need to do quality control inspection of incoming materials and the need for maintaining materials traceability, for which BellHawk is ideally suited.

For make-to-order manufacturers, the ability of BellHawk to predict available inventory is especially valuable to many users. Here BellHawk not only tracks physical inventory but also predicts the availability of inventory at future times by taking account of physical inventory plus materials on order, or scheduled to be made, less materials due to be consumed on work orders or shipped to customers. This predicted available inventory can then be used as part of the Dynamic Resource Planning module to incrementally issue new purchase orders and work orders as new customer orders are received.

3.3 Manufacturing Operations Management

One of the more common applications of BellHawk is to track and manage manufacturing operations. This includes tracking work-in-process materials and work orders as they flow from one work-center to another.

As part of this process work-in-process (WIP) materials can be tracked into and out of each work-order operation, along with the labor and raw materials required for each operation. This combination provides accurate job costing, captures materials traceability data, and prevents mistakes, such as using the wrong or defective products to make products.

BellHawk is also used because it can automatically schedule jobs in real-time to make sure orders get shipped on time. In addition, BellHawk can be used to do job cost estimating and to compare actual versus estimated job costs, as well as to capture materials traceability history.

3.4 Industrial Distribution Warehouses

BellHawk is used in industrial distribution warehouses, where secondary operations such as repackaging, relabeling, kitting and light-assembly are performed. Here BellHawk is not only able to efficiently track the materials in the warehouse but is also able to track the transformation of materials which occurs with these secondary operations.

A major feature of BellHawk in these applications is in its ability to do system directed picking whereby pick orders can be assigned to a number of pickers, who are then directed by BellHawk to pick orders in an efficient sequence. At the same time these systems, which can be customized to the specific needs of each organization, result in a significant reduction in picking mistakes through the use of extensive real-time operational error checking.

One major use of BellHawk is in tracking a mix of products, picked and then packed onto a pallet and then shipped. This includes generating Advanced Shipment Notice (ASN) data for sending to customers by EDI about the contents of the mixed pallets. BellHawk is also useful where materials traceability data has to be tracked, such as for food and pharmaceutical products.

3.5 Rolled Materials Converting

A significant number of users of BellHawk are make-to-order, quick-turn rolled material converters. These clients include coaters, printers, and converters of paper, plastic, aluminum, woven and non-woven materials. as well as makers of packaging materials.

These clients use BellHawk because it is able to track rolls and sheets of materials in different units of measure and to convert between them. In these applications, the ability of BellHawk to track rolls and sheets by length and width and to convert to and from pounds, is essential. A major benefit of using BellHawk is its ability to track off-cuts of different size in inventory, so that these can be reused.

3.6 Architectural Materials Manufacturing

BellHawk has been used by manufacturers of architectural and building components such as curtain-wall windows, steel beams, duct-work, stone facias, millwork, granite countertops, and cabinets, to track the manufacture of these components, their shipping to site, and installation.

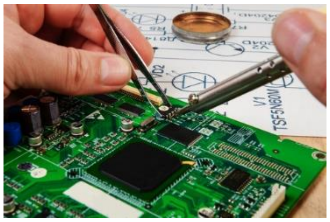
The project tracking and management capabilities of BellHawk enable the tracking and management of complex projects with many releases to site. Also, materials can be tracked at multiple locations, including in yards and at building sites to enable managers to get a complete real-time overview of the status of all the parts of complex projects.

3.7 Plastics Manufacturing and Recycling

BellHawk is used by plastic injection molders to track the molding and post-processing of an array of industrial products. It is also used to track the recycling of scrap plastics into regrind which can be used to manufacture new products from plastic.

In these applications, BellHawk is able to track the receipt of Gaylords of plastic pellets and then the automated feeding of pellets from the Gaylords into the molding machines, all the while keeping track of available inventory. BellHawk can also be used to track the setup, run, and cleanup times on the machines as well as to integrate automated inspection equipment into the tracking process.

3.8 Electronics Manufacturing and Electromechanical Assembly



BellHawk has been used to track the manufacture of printed circuit boards and their integration into electromechanical assemblies, primarily by contract manufacturing organizations and manufacturers of specialty industrial systems.

Here BellHawk is used to track and manage the ordering of a large number of different components for each project, the put-away of these components in stock rooms, and their kitting for production. It is also used to track which lot and serial number components went into each product, collect test data at the unit and system level, and track repairs and replacement parts.

3.9 Engineering and Government Contracting

BellHawk is used by engineering and defense contractors to track the progress on their projects, including the expenditure of labor to perform tasks such as engineering, purchasing, project management and quality control, the purchase and warehousing of materials for the project, the consumption of materials, labor and equipment time in making custom machines, components or assemblies, the production and testing of custom machines, components and assemblies, the packing and shipment of custom machines, components or assemblies to customer sites, the expenditure of labor and rental of assets for on-site installation, repair, and refurbishment, and the return of unused materials and assets from customer sites.

BellHawk is compliant with US Government requirements for tracking labor and materials expended on Department of Defense projects as well as for tracking Government owned assets and materials.

3.10 Specialty Chemicals Manufacturing

BellHawk has been used by specialty chemicals manufacturers because of its ability to track materials in multiple units of measure, such as gallons and pounds, and to translate between them. These manufacturers also use BellHawk to store the formulas for making products and its ability to make sure that the correct materials are used, in the correct quantities, to make products.

In these applications, BellHawk may be tied to weighing scales, to weigh ingredients as they are used to make a mix. BellHawk is also used to generate custom barcode labels for each container of product with hazardous materials information.

3.11 Precious Metals and Fine Jewelry Manufacturing

BellHawk is used by precious metals manufacturers, including fine jewelers, to track their inventory of precious metals, such as gold, and gemstones, such as diamonds. The primary reason for this is the ability of BellHawk to track their inventory with great precision in multiple units of measure. BellHawk can, for example, track the weight of parts made from gold as well as the quantity in eaches of components in a bag or other container, without assuming a universal standard weight for each part.

This enables valuation of the gold by weight based on spot market prices, rather than by the price at which it was purchased, while still tracking the count of available parts for production planning purposes. It also enables detection of theft by comparing the weight of gold issued for a production process with the weight of gold parts produced plus the weight of gold recovered by recycling sweepings.

3.12 Repair and Field Service

BellHawk has been used by organizations that repair and maintain complex systems, such as aero engines and landing gear, as well as by organizations that need to maintain systems in remote geographic locations. In these applications BellHawk is used to record when the units were serviced and by who and what parts were replaced.

In these applications, the ability of BellHawk to maintain material and repair traceability of records is critically important, including serial number and lot numbers of sub-assemblies or locations replaced. Also, the ability of BellHawk to record test data and parts replaced in the field, ensures accuracy and saves time.

3.13 Food and Natural Supplement Manufacturing

The BellHawk software enables food processors and natural supplement manufacturers to comply with food traceability requirements from the FDA and USDA without drowning in paperwork. It also enables compliance with FMSA, HACCP and SQFI food safety certification requirements.

BellHawk replaces the use of paper forms and manual keyboard data entry with barcode scanning and the use of mobile data collection devices. This not only saves significant labor but also eliminates mistakes in data collection. Most important BellHawk, as a result, is able to quickly and accurately recall materials traceability data to enable the rapid determination of sources of contamination and to minimize the scope of expensive recalls.

3.14 Medical Product Manufacturing and Distribution

Smaller manufacturers and distributors of over-the counter and prescription products, such as skin creams, as well as medical device manufacturers, use BellHawk because it is a low-cost CFR 21 Part 11 solution which can be validated to meet FDA requirements. Those manufacturers making prescription products also use BellHawk to produce serialized barcode labels to meet the requirements of the DSCSA (Drug Supply Chain Safety Act).

The BellHawk software also assists these organizations to capture materials traceability histories for the products they make, so as to enable rapid recalls in the event of contamination or other problems.

3.15 Laboratories

One unexpected use of BellHawk is in tracking the testing of samples, such as DNA samples, in laboratories as well as tracking the making of specialty reagents for testing. Here the ability of BellHawk to track the contents of individual vials, test-tubes, and even individual cells in multi-well plates proved invaluable as did the tracking of which equipment was used for testing and where samples were stored, such as in refrigerators.

In such applications, BellHawk is typically used in conjunction with a LIMS (Laboratory Information Management System) which is used to track the data obtained from samples. Here BellHawk makes sure that samples are processed in a timely manner. BellHawk can also track expiration dates of reagents used for testing to help make sure that bottles of reagent are not used past their expiration dates.

4. BellHawk versus Competitive Technologies

4.1 Introduction

While BellHawk has a unique combination of capabilities, which makes it very useful in tracking inventory and managing manufacturing operations, competitive technologies do exist. In this chapter, we compare BellHawk to some competing technologies, and discuss their relative merits.

4.2 Use of Paper Forms

There is nothing as apparently inexpensive as a Number 2 pencil and a paper form, for capturing production tracking or inventory data. This data can then subsequently be keyed into an Excel spreadsheet or into an accounting or ERP system for subsequent electronic recall.

This is why over 80% of all small and mid-sized manufacturing companies in the USA still track their inventory and production operations this way. But there are a number of issues with this approach:

- There can be substantial delays (hours or even days) between when data is recorded onto a paper form and when it is available in electronic format. As a result, managers and other staff have outdated information about the status of inventory and production operations, which can easily result in their losing track and in customer orders getting shipped late. It can also result in running out of critical inventory when materials are not reordered in time.

- There is no error detection. Material handlers and equipment operators can write anything down onto a paper form with no feedback as to whether they are making data collection or operational mistakes. Then mistakes can be made when keyboarding the contents of paper forms into Excel spreadsheets or other systems. This keyboarding is often done by supervisors or office staff who then have difficulty reading the handwriting on the paper forms filled out by operators, who often cannot remember what they wrote on the form on the previous day(s). This can result in inventory errors as well as errors in capturing cost and materials traceability data.

- Even worse, often the data on the paper forms is not converted into electronic format, where it can by quickly recalled and shared with other people. Often these forms are simply stored in a filing cabinet, to be retrieved when problems such as product defects occur or a major recall is ordered.

- Labor time taken filling out the paper forms and then subsequently manually keying this data into Excel spreadsheets or an ERP or accounting system can be substantial. This, along with wasted time finding and correcting mistakes, can often be the equivalent of one or more people, at a loaded labor cost of $50,000 per year each.

BellHawk solves these problems by using mobile computers, equipped with barcode scanners, to capture the tracking data in real-time. This enables BellHawk to provide real-time point-of-action feedback to users to prevent data collection and operational mistakes from occurring.

Through the use of barcode scanning, BellHawk is able to minimize the amount of manual keyboard data entry needed thus saving extensive labor costs in not filling in the paper forms, or manually keyboarding the data, and in not chasing-down mistakes in data entry.

As a result, inventory and operational status data is made available in real-time to everyone who needs this information, from managers and lead people, to machine operators and materials handlers, and customer support people, anywhere, anytime they have an internet connection, even on their smart phones. This enables efficient warehouse and manufacturing operation as well as enabling customer orders to be shipped on-time.

This electronic information can then be used to automatically update ERP and accounting systems as well as supplier and custom supply chain systems. It can also be used to generate alerts by Email or Text messages to managers and their staff, when there are situations that they need to pay attention to, such as needing to reorder inventory.

BellHawk also securely stores materials traceability data, so that it can be quickly retrieved to aid in finding the source of defects and minimize the scope of recalls.

When used to replace the use of paper forms and manual keyboard data entry, BellHawk quickly pays for itself in labor savings. It also provides a form of insurance against much bigger losses due to making operational mistakes, losing customers due to shipping their orders late, or having to implement a very expensive major recall due to being unable to rapidly identify the cause of product defects.

4.3 Accounting Systems

Many small-business accounting systems, such as QuickBooks, include the ability to track inventory. Typically, these systems track the quantity of each item in stock and its value, as well as receipts and shipments. They then use this data as part of their profit-and-loss and balance-sheet accounts reporting.

Organizations with small amounts of inventory can use this feature to also track the quantity of inventory in stock. This is usually done by recording the data on paper forms and then recording the changes to inventory in QuickBooks. Unfortunately, this has all the disadvantages described in the previous section.

The big advantage to this approach is that it is inexpensive and easy to use as all the data is contained in one system. The big disadvantages are that it is not good at preventing inventory errors and that the recording of inventory changes typically take a day or more to get entered.

In addition, there is typically no tracking of the location of inventory or of production operations, which still have to be done using Excel spreadsheets. Even where inventory locations are tracked, these systems do not track the same inventory in multiple locations, which can be a major disadvantage in those situations where the quantity of materials has grown to require a sizeable warehouse, for their storage.

The alternative is to use BellHawk to do all the production and inventory tracking, as well as warehouse management, and then to automatically update the accounting system as materials are received, consumed, produced, and shipped. This is more complex and more expensive than using an accounting system alone. But it avoids duplicate data entry into the accounting system and eliminates many sources of potential error. As a result, this approach quickly pays for itself in labor savings and mistake prevention.

4.4 Desktop Inventory Tracking Systems

Organizations that have outgrown the inventory tracking capabilities of their accounting systems will usually first consider using a desktop accounting system that enables the use of mobile computers to track the receipt, put-away, withdrawal, and shipping of product.

Typically, these desktop inventory tracking systems use a desktop PC with an attached barcode scanner to record the receipt, put-away, and withdrawal of inventory from stock. They can also use batch mode mobile computers, with integral barcode scanners, to record the locations where inventory is put away and to record the picking and shipping of that material.

These batch mode computers, have software installed on each data collection device, to capture the inventory data, which is then transferred to the desktop computer when the mobile computer is placed in a cradle attached to the PC. This has the advantage of not requiring wireless communication in the warehouse or stock room. But it does have the disadvantage of not providing point-of-action feedback when users are about to make an operational mistake, as the data connection device is disconnected from the inventory database.

These systems can track the quantity of each item at each location within a building and typically include simple recording of receiving and shipping of inventory. They often come with prebuilt data exchange interfaces with popular accounting systems, such as QuickBooks.

These systems can be a cost-effective solution for organizations that need to simply track the quantity of materials at locations within a single building. Their biggest drawback is that they cannot track lot numbers, serial numbers, and expiration dates of individual containers of material or serialized items. Also, they cannot track pallets of materials with multiple different containers of material or serialized items packed onto each pallet.

BellHawk solves these problems by tracking individual containers of material, rather than simply tracking the quantity of materials at a location. It also uses web-server technology to enable tracking materials at different geographic locations with point-of-action warnings when users are about to make a data collection or operational mistake, which is something that these desktop inventory management systems cannot do.

From an IT perspective, BellHawk can be run at a secure data center and does not require any special software to be loaded into each data collection device, which can result in a significant reduction in the need for IT support services.

The disadvantage is that a base BellHawk materials tracking system is typically slightly more expensive than a desktop inventory tracking system. Using BellHawk in the Cloud is easier than installing a desktop inventory tracking system. But container-based inventory tracking, by its very nature, can be more complex than simply tracking the quantity of materials at a location.

4.5 Warehouse Management Systems

These systems were an outgrowth from the desktop inventory tracking systems described in the previous section. These Warehouse Management Systems (WMS) typically run on a server computer rather than a desktop computer, enabling the use of a large number of data collection devices, which are connected to the server over a wireless communications network.

Instead of being integrated into small-business accounting systems, these WMS systems are typically integrated with ERP (Enterprise Resource Planning) systems.

These systems still use thick-client software installed on ruggedized mobile computers or tablets equipped with long-range barcode scanners mounted on fork-left trucks. These client devices then communicate with the central server via a wireless network installed in the warehouse rather than needing to be plugged into a cradle attached to a PC to transfer their data. This enables much better point-of-action warnings when material handlers are about to make a mistake.

These WMS systems typically support sophisticated receiving, put-away, picking and shipping processes, including the ability to pick kits for production processes and to record the return of finished products into the warehouse. These systems also typically integrate barcode labeling and interfaces to weighing scales in order to correctly label incoming and outgoing materials.

With its WMS option, BellHawk provides these same WMS capabilities except that they are focused on receiving, put-away, picking, packing, and shipping of containers of material. This enables BellHawk to do things that WMS systems cannot, such as to track the packing of multiple different materials onto each pallet. It also enables BellHawk to record the shipment of those pallets to customers, including preparing ASN (Advanced Shipment Notice) data about the contents of each pallet, for sending to those customers by EDI.

This ASN data enables great efficiency in receiving by simply scanning a single tracking barcode on the outside of each pallet to receive all the materials on the pallet. This is a capability supported by BellHawk as well as by high-end WMS systems.

BellHawk is much less expensive than most full-capability WMS systems and, as in previous cases, the big advantage of BellHawk is its ability to track inventory at multiple warehouses, yards, manufacturing plants, and construction sites at different geographic locations, whereas WMS systems cannot do this.

WMS systems are typically integrated with ERP systems from which they get the purchase orders, pick orders, and customer orders and to which they report inventory receipts, shipments, withdrawals and additions to inventory. BellHawk can also exchange data with a wide-range of ERP systems, including updating materials withdrawn and produced on work orders, which WMS systems typically cannot do.

One big difference between BellHawk and many WMS systems on the market is that most WMS systems are focused on the needs of business-to-consumer distribution centers whereas BellHawk is focused on the needs of industrial warehouses. Retail supply chain warehouses typically are focused on efficiently picking a high volume of customer orders from amongst a large number of different SKUs. BellHawk, by contrast, is focused on capturing much more detailed information, such as lot numbers and serial numbers, for industrial materials shipped to its customers in somewhat lower volumes.

In summary, for industrial use, BellHawk has greater capabilities than standard WMS systems at a much lower cost, with significantly reduced IT support requirements. But BellHawk is typically not an appropriate choice for warehouses in the retail supply chain, except for those with special traceability requirements, such as Food and Pharmaceutical distribution.

4.6 ERP Systems

ERP systems are an outgrowth of accounting systems. Early ERP systems added Materials Requirements Planning (MRP) capability to standard accounting functions to produce ERP systems, which were focused on planning and scheduling the purchase and manufacture of materials across multiple manufacturing plants. Subsequently many of these systems have added CRM (Customer Relationship Management) functionality so that they could keep an integrated customer history including products purchased by each customer.

ERP systems typically maintain a table of the quantity and value of inventory by Item and by Location. This is used as the basis of their materials planning which generates purchase orders to buy materials and work orders to make products. These ERP systems also serve as a repository for the routes of operational steps needed to make products and the associated BOMs (Bills of Materials), which are also used as part of their MRP algorithms.

The MRP algorithms used by most ERP systems are focused on the needs of manufacturers who make large quantities of products for stock based on sales forecasts, for several months in the future. These algorithms then determine what materials need to be purchased and when and what products need to be made and when, from which detailed operational schedules can be derived.

This unfortunately does not work for most small to mid-sized manufacturing plants which make products to order. With the advent of Amazon, clients now expect products to be made and orders delivered in a few days. These manufacturers therefore have limited visibility as to demand, except possibly for some commonly used intermediate materials, and, as a result, the production schedules produced by the MRP algorithms are of little or no use in scheduling production.

The outcome is that many make-to-order manufacturers use their ERP systems simply as accounting systems, with the ability to issue work orders to production. These work orders are then scheduled manually, typically by a full-time production planner as a result of daily planning meetings of all operations staff, which is a labor intensive, and thus an expensive task.

BellHawk, just like many ERP systems, maintains the BOMs (Bills of Material) and Routes which define how to make products. These are stored in BellHawk's database, except that, unlike most ERP systems, BellHawk maintains details of the materials to be used for each manufacturing operation, as well as the estimated labor and machine time for this operation, rather than just for making the overall product.

Like an ERP system, BellHawk can use this data to generate work orders for the manufacture of a specific quantity of products. BellHawk work orders, by contrast, typically have greater detail to facilitate a better detailed comparison of estimated versus actual costs.

Unlike ERP systems, which are required to totally replan materials purchases and reschedule operations on a weekly or monthly basis, BellHawk does its planning and scheduling incrementally as new orders arrive, which makes it ideal for make-to-order manufacturers who need to deliver customer orders with a short turnaround time. This real-time planning enables materials to be ordered on a just-in-time basis and the real-time scheduling enables production schedules to be dynamically adjusted to make sure that customer orders get delivered on time.

BellHawk can automatically exchange data with a wide-range of ERP systems to import BOMs and Routes, from which to generate work and purchase orders, in response to customer orders, or it can directly import purchase, picking, work and shipment orders from an ERP system. Even when the ERP system is used to do the materials planning, BellHawk can schedule the work order execution in real-time.

BellHawk can export the receipt and shipment of materials to its attached ERP system, as well as materials consumed and produced on work order operations. This enables the ERP system to maintain an updated inventory status for accounting and materials planning purposes while eliminating much of the need for manual keyboard data entry and preventing data collection or entry mistakes.

BellHawk can also export the labor and machine time consumed on each work order operation to the ERP system to enable it to maintain accurate cost histories for each job.

One question that many manufacturers ask is whether they need a new ERP system. For larger multi-plant organizations, and especially those with international operations, the answer is definitely yes. You need the best ERP system that is available, even if it costs several million dollars to implement.

But for the small to mid-sized make-to-order manufacturer with a single plant, a combination of BellHawk with a low-cost accounting system will give you better capabilities than most million-dollar ERP systems at a small fraction of the cost. In fact, if you are still using your legacy ERP system as a glorified accounting system, you can continue to use this, but integrate all the barcode tracking and make-to-order planning and scheduling capabilities of BellHawk at a very affordable cost.

4.7 Job Shop Tracking Systems

Job Shop Tracking Systems are used by job shops to issue work orders for making a batch of products through a route of operations. Each work order is then used to track the progress of the work order through a number of operations. In addition, these systems are used to capture the start and stop time of each operation as well as the labor required.

These systems are very similar to the Simple Production Tracking System (SPTS) version of BellHawk except that BellHawk is a web-server based system, whereas these Job Shop Tracking Systems use client-server technology, with data being captured using PCs on the shop floor, equipped with corded barcode scanners.

Many of these original job-shop tracking systems have now become ERP systems which include accounting and inventory tracking function. Their primary function, however, is still issuing work orders and the tracking of jobs on the factory floor and capturing job-cost data.

For those organizations running legacy Job Shop Tracking Systems and who wish to expand upon the capabilities of their existing system to include inventory and work-in-process materials tracking, transitioning to BellHawk SPTS is an easy first step, which can then be followed by incrementally adding some or all of the extensive set of features of BellHawk.

Section B How BellHawk Works

5. How BellHawk Tracks Materials

5.1 Introduction

What makes BellHawk unique is the way it tracks materials. BellHawk tracks containers of material rather than the quantity of inventory at each location.

Accounting systems, such as QuickBooks, simply track the total quantity of each item in stock and its average value. ERP (Enterprise Resource Planning) and WMS (Warehouse Management Systems) typically track the quantities of each materials at each location in a warehouse and their value.

BellHawk tracks the movement of materials in containers, as well as serialized items. It does this using License-Plate-Number (LPN) container tracking barcodes similar to how UPS, FedEx, and Amazon track the real-time flow of materials in their supply chains.

LPN tracking is performed by attaching a tracking barcode containing a unique alphanumeric tracking number to each container. This barcode is then scanned when materials are added to the container, the container is moved, or materials are withdrawn from the container.

This same methodology can be used to track the flow of materials within industrial plants and warehouses, as well as outdoors at building and other field sites. It can also be used to track the processing and distribution of food and pharmaceutical products.

The use of LPN container tracking by BellHawk is in contrast to systems such as Warehouse Management Systems (WMS) and Enterprise Resource Planning (ERP) systems which simply track the quantity of inventory at a location. These item-locator systems lack the ability to easily track which materials were used to make which products, which is essential for applications requiring materials traceability, such as the processing of food and pharmaceutical products.

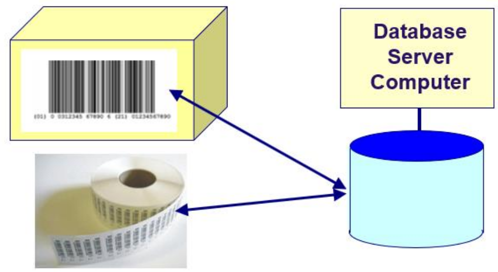
LPN container tracking systems are ideal for tracking materials at many different locations and the flow of materials between locations, including materials in-transit on vehicles. They also work well to track assets such as tools and computers that may be issued to people as well as to locations.

5.2 License-Plate-Number Container Tracking

The concept behind License-Plate-Number (LPN) container tracking is that a unique tracking barcode is applied to each container and then all the information about the container is stored in a database, where it can quickly be accessed. Also, data about that container, such as its location and the quantity in the container, can quickly be changed by scanning the tracking barcode on the container.

License-plate-number container tracking gets its name from what happens at the registry of motor vehicles when you go there to register a new car or truck. They hand you a license plate with a unique set of letters and numbers and the state of issue marked on the plate.

The license plate number is unique but otherwise is just a random set of letters and numbers. All the data about your car or truck is stored in a database so that, when you get pulled over for speeding, the police officer simply reaches over to his on-board computer and types in your license plate number and is able to see all the information about your car or truck.



We use a similar principal for license-plate tracking of materials except that we put a unique LPN tracking barcode or RFID tag on each container instead of an aluminum license plate.

Note this is very different from using barcodes with data such as item number, quantity, and lot number on each container. With license-plate tracking all the data is kept in a database and the tracking barcode is simply a reference to the database record.

For containers such as boxes and pallets, which are discarded when they are empty, we typically apply a pre-printed license-plate tracking barcode to the container of materials when it is first entered into inventory. For reusable containers, such as totes or bins, we can use permanent metal barcodes, as we do not have to change the license plate just because we changed the contents of a container (analogous to the license-plate on a car or truck). For shipping cartons and pallets, we typically print out a label, on demand, with an LPN barcode, as well as shipping and contents information

The benefit of this is that data such as part number, location, quality control status, and quantity of materials in the container can be changed as needed without replacing the tracking barcode on the container.

License-Plate-Number (LPN) tracking is the same method which is used by the GS1 (Global Supply Chain 1) standard for tracking containers. Here LPN tracking barcodes, to GS1 standards, are used for Serialized Shipping Container Code (SSCC) barcodes. These uniquely identify each container to which they are attached on a world-wide basis.

SSCC tracking barcodes enables a shipper to record details about all the different materials placed on a barcoded pallet in Asia. Shippers can then send the information about those materials, along with the pallet SSCC barcode, to a warehouse in the USA, in the form of an ASN (Advanced Shipment Notice). When the materials are received in the USA all that is necessary is to scan the SSCC license-plate barcode to lookup the ASN data and receive the materials into stock, without first breaking down the pallet.

The LPN tracking barcode may be as complex as a GS1 (Global Standards One) composite barcode, printed on-demand, with a GTIN, Lot Number, and Serial Number, for use in the Global supply chain, or as simple as a barcode taken from a pre-printed roll of serialized barcodes, such as that shown here, for internal use within the plant.

The license-plate tracking barcode may also contain an RFID chip with the same tracking number or a separate ruggedized RFID tag may be used depending on the application.

As well as being placed on containers, license plate tracking barcodes are placed on items, which are typically serial numbered, that are not in containers. Examples include large electric motors and other electro-mechanical assemblies which may need to be tracked independent of being in an external container. Serial number barcodes on these individually barcoded items may be used as their tracking barcodes or the serial numbers may be different and the items tracked using an LPN barcode.

Some types of container are obvious, such as boxes, pallets, and totes. Others are not so obvious, such as reels and rolls, which contain a quantity of an item. These can be treated as a container with so many feet, for example, of material, or as individually barcoded items where dimensions such as length, width, and thickness may be treated as attributes of the individually barcoded item.

5.3 Tracking the Location of Materials

Whenever a container of materials is moved, the materials handler scans the LPN tracking barcode on the container and a location barcode on a shelf, rack, floor post, or hung overhead.

These location barcodes uniquely identify each location, so that the location of each container can be tracked in real-time. These location barcodes can also be scanned to identify the location when performing cycle counting or inventory auditing.

BellHawk can also be used to track the location of untagged material (without a tracking barcode) by tracking the quantity placed in a location, by scanning the location barcode and recording the item and quantity added or removed.

The same applies if we have a set of barcoded bins on a shelf. In this situation, the bin barcode is scanned to record the quantity added or removed. Both the bins and the shelves have their own tracking barcode, with the bins being treated as a container and the shelves treated as a physical location. This enables the bins to be recorded as being in a new location, when they are moved, by scanning the bin barcode and then the location barcode.

In the model used by BellHawk, each location can hold a variety of different materials, some of which have tracking barcodes and some are untagged. Bins and other containers, on the other hand, can be designated as single use or multi-use. Single use bins and other containers can be restricted to hold a single item number, with a single lot number, for a single job or project. Multi-use containers, like locations, can hold many different materials.

Wherever possible, we recommend that single use bins or containers be used, as this avoids mixing up parts, which can lead to picking, manufacturing, and shipping errors. But there are circumstances where materials with different item, lot, serial number, and/or project and expiration date may be mixed together (such as on a shipping pallet or a picking tote) but still tracked separately for materials traceability purposes.

Often these materials are not loose (as in a pile of sand) but are in untagged containers, where it is not feasible or desirable to attach a tracking barcode to each box. In this case, rather than use the tracking barcode on the container, BellHawk assigns a tracking code based on the barcode of the location or bin in which they are placed.

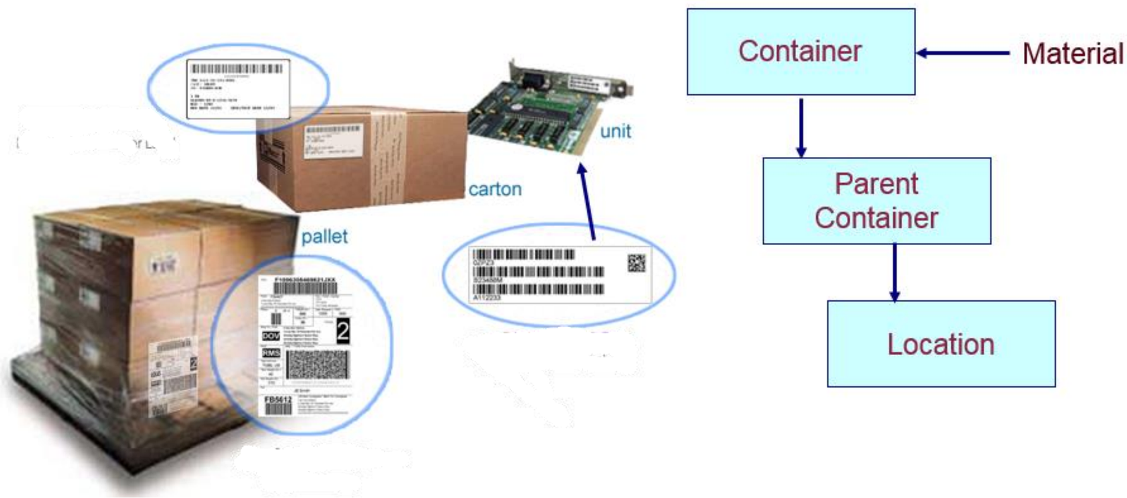
Normally reusable single use containers, such as totes, an be filled with a different part number when empty. Single use reusable containers, such as bins, can be designated as "Kanban" bins, which can hold only a single part number, even when empty. This enables tracking and replenishment of floor stock in these Kanban bins.

Also, BellHawk has the ability to receive items, such as pails of material on a pallet, and track them just using a pallet LPN barcode until each pail is withdrawn from the pallet, when it is assigned its own LPN barcode. This also applies to serialized items which are received in or on a shipping container.

It is noteworthy that, with BellHawk, it is only necessary to shut down a single location, such as a shelf or rack, when taking inventory rather than needing to shut down the whole of a warehouse in order to take inventory. This is because BellHawk has a fine-grained view of physical locations, such as aisle, shelf, and rack, rather than treating whole warehouses as "locations", as is done in many ERP systems.

5.4 Nested Container Tracking

One of the problems that is very hard for traditional inventory tracking systems to handle is how to track nested containers. In a nested container situation, such as the example below, we may have parts with different serial numbers in cartons, with cartons containing many different part numbers stacked on a pallet, with multiple such pallets at an inventory location.



In a traditional ERP or WMS inventory tracking scheme, when you move a pallet to a new location you have to record the withdrawal of all the parts from the old location and enter them into the new location.

BellHawk tracks materials, which may have their own license-plate tracking barcodes, in containers, which will have their own tracking barcodes, and may have a tree of parent containers, each with their own tracking barcodes, that are at a location.

Then, when you want to record the movement of the collection of materials, you simply scan the barcode on the outer parent container (in this case the pallet) and record its new location. All the data about all the materials on the pallet is automatically associated with the new location.

The same goes for shipping the parent container, when all the materials in the parent container can be recorded as having been shipped to the customer simply by scanning the tracking barcode on the outer container.

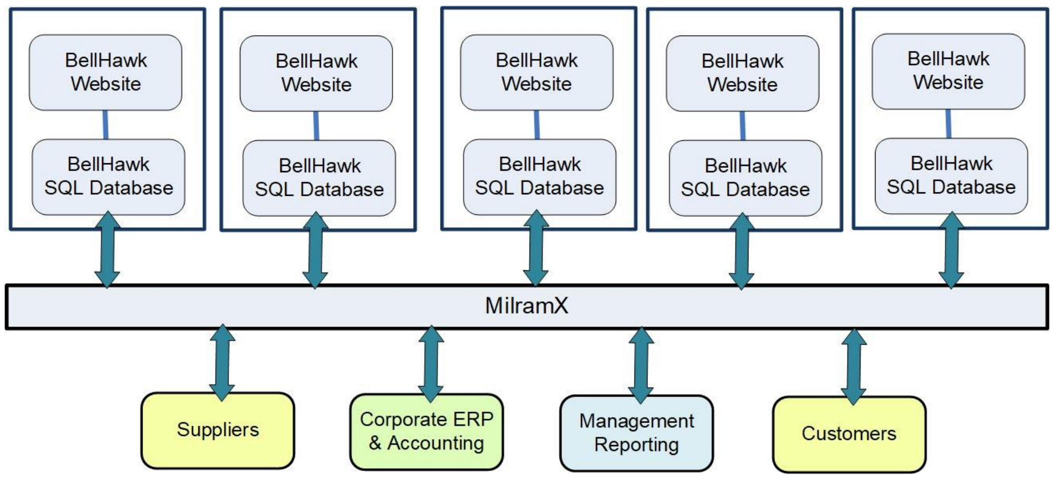
Even better, the nested container data, which a system like BellHawk tracks, forms the basis of Advanced Shipment Notice (ASN) data, that can be sent by EDI (Electronic Data Interchange) to customers so that all each customer has to do is to scan the tracking barcode on the shipping container, such as the pallet, and associate it with the ASN to receive all the materials into their inventory, with no additional data entry.

Similarly, systems like BellHawk can also use ASN data to minimize the work needed to record the receipt of materials from suppliers. Here the ASN data is used to create "pending" entries in BellHawk's container's table, with the full nested container description.

When each pallet (or other shipping container) is received, all that is necessary is to scan the tracking barcode on the outermost container to "activate" that container and all its child containers into the receiving organization's BellHawk container tracking table, complete with all their LPN barcodes and related part number, quantity, lot and serial number, as well as expiration date information.

At the same time, the purchase order data can be retrieved from the ASN and matched with the received materials to generate a set of receipts which can be exported to an ERP or accounting system through the DEX interface.

5.5 Facilities, Multiple Manufacturing Plants and Warehouses



While locations in BellHawk provide a fine-grained view of the location of inventory, and enable inventory to be easily found and used, a large number of locations can quickly become overwhelming from a viewing or reporting viewpoint.

For this reason, locations can be associated with Facilities, such as a stock room, warehouse, or production floor, permitting just the inventory in those facilities to be viewed or reported on together.

Users can, however, see or report on all the inventory in all facilities associated with, for example a manufacturing plant. This can be advantageous when the raw materials stock room, the production floor, and the finished goods warehouse are operating as a single organizational entity. But when there are multiple separate organizations, such as manufacturing plants that operate independently, then it can be confusing to material handlers to see the inventory in all the manufacturing plants in one system.

For this reason, BellHawk also supports plant-level separation, with multiple facilities, with their own locations. This is done by running multiple versions of BellHawk, each with their own tracking database, thus avoiding problems such as the use of the same location barcode in multiple plants in different geographic locations.

The people using each plant-level BellHawk system only see the inventory, as well as purchase, picking, work, and ship orders associated with facilities within their own plant. At the same time, BellHawk, through MilramX, supports tracking inter-plant shipments, with nested containers, such as pallets, being moved from one plant to another.

These multiple BellHawk systems are typically run at the corporation's data center along with a version of the MilramX information exchange software. This enables data exchange with a single corporate ERP system as well as providing a mechanism for cross-plant performance reporting for senior management. It can also provide a single data exchange interface for supplier and customer systems.

5.6 Difference from Traditional Inventory Tracking

BellHawk tracks its material in great detail at many different locations. It does this by tracking materials in containers with a tracking barcode. Whenever materials are moved, BellHawk simply records the new location of the container(s).

In an ERP or WMS system, which use an item-locator paradigm, whenever materials are moved, they have to be recorded as having been withdrawn from their old location and entered into their new location, even if the materials have just been moved across an aisle in a warehouse.

For this reason, most ERP systems often use large locations, such as whole warehouses, to avoid updating the ERP system every time material is moved within the warehouse. Organizations then use a WMS system to track the location of materials within the warehouse but again, these WMS systems are simply tracking the location of materials and have no concept of nested containers or the movement of containers of material.

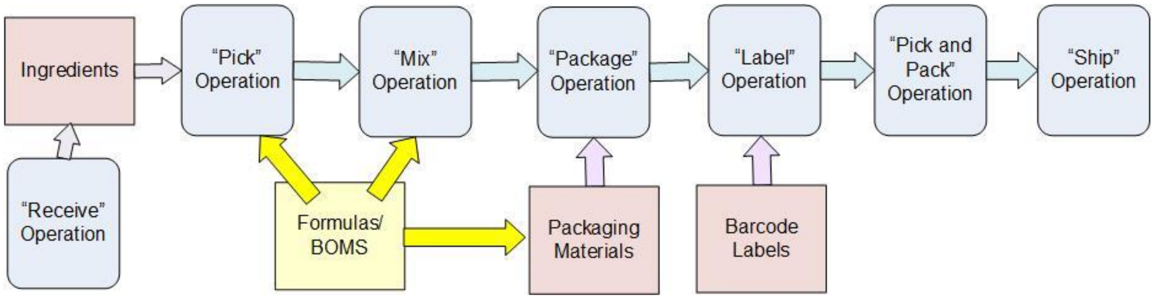
To update inventory in an ERP system, the BellHawk DEX interface can add up the contents of all containers in the ERP system's "locations" (which may be whole warehouses) and make this available for transfer to an ERP system as if this were the result of an inventory audit. This is typically done on a nightly basis by DEX.

Because recording a change in location is as easy as scanning the tracking barcode on the container and the location barcode on a shelf or rack, where we put it, organizations can use much finer grained locations for tracking. This enables them to know that our box of parts is on shelf A-10-6 rather than just somewhere in the warehouse.

It also makes "inventory taking" much easier in that organizations do not have to shut down operations to count the inventory in the whole of a warehouse but only have to validate that the containers of material on a shelf match those in BellHawk, one shelf at a time. As a result organizations can do inventory validation incrementally without shutting down or disrupting operations, in order to take inventory. This encourages checking inventory frequently rather than waiting for a once-a-year inventory taking to discover your inventory discrepancies.

The use of container-based tracking enables BellHawk to track which containers of material were used to make which products, as well as to accurately track the actual cost of making products.It also enables BellHawk to prevent mistakes such as picking or using the wrong materials when making products or shipping the wrong products to customers.

6. How BellHawk Tracks Manufacturing Operations



6.1 Introduction

BellHawk tracks the transformation of materials through a series of operations, including tracking the materials consumed and produced, work-in-process materials, and the labor and machine/equipment time required for each operation.

Material transformation occurs in a number of ways:

1. Traditional manufacturing where raw materials are converted to a finished product in a series of operations.
2. Food and drug processing, where raw materials are mixed, processed and then packaged to become finished products.
3. Repair operations, where broken items are repaired and retested.
4. When secondary operations, such as kitting, assembly, packing and labeling, are performed in a distribution warehouse.
5. In laboratories, test, and engineering organizations where the end products are documents.

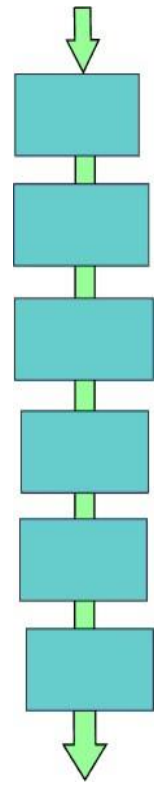
By tracking these operations, BellHawk is able to provide operations managers with the real-time status of their customer orders as they flow from operation to operation. This includes tracking of work-in-process for various parts of a customer order. It also enables BellHawk to provide material managers with an accurate status of the raw of intermediate materials that are needed to make product for customer orders.

Tracking these transformations enables BellHawk to trace-back from defective products to the materials and processes used in the manufacture, test, or repair of products, and the people involved, to find the probable source of the defects. It also enables us to trace-forward from defective materials or processes to find the location of all the effected products.

6.2 Operations and Routes

The transformation of materials typically involves multiple steps in transforming raw materials into work-in-process and then to intermediate products, which are typically used in making a variety of products. In production tracking, these steps are represented as "Operations" in which materials, labor, and equipment time are consumed, and one or more materials are produced.

Some types of operation are:



- Process operations in which materials are irreversibly transformed into new materials, such as by mixing, molding, welding, cutting, soldering, and gluing. The output material has a different part number from the input material(s).
- Assembly operations where parts are assembled together into an assembly or sub-assembly but the parts or sub-assemblies can be removed, if needed. The output assembly has the same part number as the input assembly.
- Kitting Operations where different parts are placed in a container, such as a box, with the resultant kit having its own part number.
- Test operations where there are no changes to the parts being tested but test parameters may be collected and the quality control status may be set to passed or failed or needing more inspection. Each output part or assembly has the same part number as the input part or assembly.
- Repair operation, in which parts are replaced in an assembly but the basic assembly does not change. Each output part or assembly has the same part number as the input part or assembly.
- Repackaging operations. Here the input materials are the same as the output materials but the packaging and its labeling change. The output material has a different part number from the input material(s).
- Service Operations. Here there is no product made or transformed but labor, materials, and equipment time is expended. These may include facilities maintenance, design and engineering tasks.

Operations to make a specific product may be organized into Routes, which consist of a sequence of operations. This enables the creation of Work Orders (also called Manufacturing Orders or Jobs in ERP systems) to make a batch of products with a specific route.

A barcoded Traveler, as shown below, can be printed out for each Work Order, with barcodes for the Work Order number and Operations, which can be scanned to facilitate data collection but this is not essential.


Work Order

WO00000101

Importance: Standard
Date Wanted: 12/22/2015
Sales Order #:
Customer: CDE Furniture Manufacturers
Instructions: Make Stainless Steel Knobs

Step # : 1
Operation: Production: Lathe
Step Instructions: Lathe

Step # : 2
Operation: Production: Drill and Tap
Step Instructions: Drill and Tap

Step # : 3
Operation: Production: Polish and Inspect
Step Instructions: Polish and Inspect

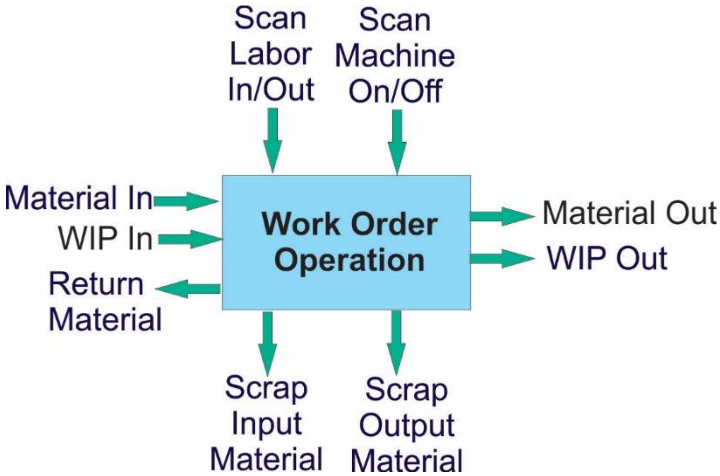
BellHawk does not require a pre-established route of operations. A work order can be created without a route and then work orders can be scanned into and out of operations as needed. This is often valuable for prototyping jobs where we want to record the steps taken to make the product but do not want to use a pre-assigned route.

BellHawk can also store template routes, which can be attached to a work-order when it is created, enabling easy creation of a work-order with a route, without needing to have previously setup an item master record with the route steps for making the part. Template routes are also useful for issuing service work orders, where a sequence of operations need to be carried out, without making a product.

Even for work orders with pre-established routes, operations which are not on the route, such as for rework, can be used for tracking purposes. This is useful for separating out resources consumed in rework, along with capturing the reasons for the rework.

It can be very useful. when comparing the actual versus estimated costs, to separate out the cost of expected operations versus the cost of unexpected operations, such as for rework. Actual expected costs can be then used to adjust future estimates, whereas rework costs typically indicate the need for process improvement and operator training.

6.3 Recording Resources Consumed and Produced



In BellHawk, operations can consume and produce "Resources". These resources include:

1. Raw or intermediate materials consumed
2. Finished or intermediate materials recorded out from the operation
3. Work-in-Process materials recorded out to the next operation
4. Work-in-Process materials recorded in from a prior operation
5. Scrap of input or output materials
6. Labor time of operators
7. Equipment or machine time consumed

Normally we record the part number and quantity of the materials, as they are consumed and produced by an operation. Sometimes it is not possible to determine, ahead of time, the quantity to be consumed, such as when a roll of material is loaded onto a machine from which multiple output items are produced. In this case, we normally record the whole roll as being consumed by the operation, when it is loaded onto the machine, and then weigh the unused part of the roll when it is returned, to enable the BellHawk system to determine the quantity used and the quantity returned to stock.

When recording the material-in to an operation, we have three choices:

1. Simply record the part number and quantity consumed. Useful for tracking materials but not very useful for materials traceability.
2. Record the part number, quantity, and lot number of the material consumed. This gives useful materials traceability information but can lead to difficulty pin-pointing the cause of problems and can lead to overly broad recalls.
3. Record the container from which the material was taken by scanning its LPN barcode and enter the quantity input. The part number, lot number, serial number,

and possibly other information, previously associated with the LPN tracking barcode are then automatically associated with the materials traceability history.

When recording labor and equipment time resources consumed, BellHawk can break these down into phases corresponding to setup, run, and cleanup, for the equipment. The same or different operators may be involved in the different phases, and these may all need to be recorded along with how long each phase took.

BellHawk can record when the machine or piece of equipment stops running and needs repair or maintenance and why. BellHawk can also record how long it is down, and who fixed the machine.

6.4 Comparison with ERP Systems

ERP (Enterprise Resource Planning) systems, at their core, consist of an accounting system plus a Materials Requirement Planning (MRP) system.

Work Orders are often imported into BellHawk from ERP systems as the starting point for performing materials tracking and traceability. As such, it is worthwhile making a few comments, by way of comparison.

Work Orders, generated by an ERP system, have a finished product part number and a quantity to be made, just like BellHawk. They also have a route of operations to be performed plus a bill-of-materials (BOM) of the "raw" materials to be consumed to make the desired quantity of the finished products.

The BOMs for making parts are used by the MRP sub-system to plan the creation of work orders to meet projected sales goals, as well as the raw materials that need to be purchased, and to schedule when the work orders need to executed. Sometimes this planning is performed across multiple linked manufacturing plants in the enterprise, hence the term Enterprise in ERP.

Most ERP systems do not have a concept of the materials to be consumed and produced by each Work Order operation. This can cause issues when their work orders are used as the input to BellHawk because, in this case, the only reasonable assumption is that all the materials are consumed in the first operation of the route, which may or may not be a reasonable approximation to the truth.

This works well for work orders with a single operation or a single process operation followed by a test operation. But if there are a sequence of processing or assembly operations, each consuming their own materials, spread out over an extended time period then this can cause operational problems relative to actual and planned materials consumed.

ERP systems will typically use the record of materials consumed and finished products produced, along with the labor and machine times, recorded by BellHawk as input to their cost accounting tracking functionality. They will not, however, use the record of materials consumed to adjust their inventory until the finished products are made or shipped, when the inventory is "back-flushed" based on the product BOMs.

This can result in major errors in the ERP system's inventory quantities. It does, however, avoid the problem of accounting for the value of inventory consumed in making the products a significant time ahead of realizing the gain from the sale of the products which the raw materials were used to make.

Some ERP systems will not only record the quantity of materials consumed on each work order but will also record the lot numbers consumed. This does give some measure of materials traceability but not with the precision of BellHawk.

6.5 Quality Control

An important aspect of BellHawk is recording when materials are inspected and the results recorded. This may be as a result of a simple go/no-go inspection of the materials or as a result of a separate test operation.

It is important to record when materials are inspected, to ensure that a planned quality assurance plan is being followed, and to make sure that materials, which have not passed inspection, are not used in a production operation or shipped to a customer by accident.

This is easy to do with BellHawk, as BellHawk can track the Quality Control (QC) status of each container or serialized item and record when they are inspected, and the outcome, including the reason codes for failing to pass QC inspection. BellHawk can also prevent the use of containers or serialized items, which failed inspection, as the container barcodes are scanned to record them as material-in to an operation.

This is much harder to do with lot tracking systems, as the only recourse to the failure of a member of the lot is to fail the whole lot until it is reinspected.

BellHawk also has the ability to capture test results and to add these to their materials tracking and traceability history. These results may be manually entered or captured directly from automated test stands.

6.6 Scrap and Wastage

Scrap takes a number of forms:

1. Defective raw material discovered when an attempt is made to use them on work order operation.
2. Defective WIP materials produced by a prior job step.
3. Defective finished product.

Wastage is part of the normal manufacturing process, such as scrap metal left over when parts are flame-cut from a sheet of steel. It is normally accounted for by adding a certain percentage to the planned input materials quantities needed for a desired production quantity.

For materials traceability, it is important to record scrap, as this is unexpected, and may be an important element in discovering the source of defects but wastage is a normal by-product of the manufacturing process. Also, when comparing actual versus estimated job cost, it is important to take account of unexpected scrap versus a certain amount of expected wastage.

The scrap or wastage material may simply be discarded or may be given a new part number, such as for scrap steel that is then tracked separately from the products being made.

Parts that did not pass tests to become a desired product may be recorded as output from an operation as another part number with a lower grade. Sometimes parts may be deliberately graded into different part numbers, depending on test results.

Tracking of scrap is straight forward with BellHawk, as it is easy to record quantities of scrap as added to scrap bins (such as by weight) when they occur. This is much more difficult with ERP systems that do not have a concept of intermediate materials or their being scrapped as part of a manufacturing process.

6.7 Work in Progress (WIP) Materials Tracking

In BellHawk, Work-in-Process (WIP) materials are not tracked as regular inventory, which is available for making products or shipment to a customer, unless they are true intermediate materials with their own part numbers.

Instead, BellHawk treats WIP materials as parts in the process of being made. These WIP materials have the same part number as the finished products, which they are in the process of becoming, but they have a WIP flag on their records in the BellHawk Containers Table, indicating that they cannot be used or shipped as regular inventory.

This avoids the need to create individual part numbers for the WIP materials output from each manufacturing operation, which could result in the need to create hundreds of thousands of part numbers, which could become a maintenance nightmare. Instead, in BellHawk, part numbers only need to be created (or imported from an ERP or accounting system) for raw, intermediate, and finished product inventory and not for WIP materials.

In BellHawk, containers of WIP materials can be tracked just like containers of regular inventory. Their records in the Containers Table in the BellHawk database include the rolled-up cost of raw materials, labor and machine time, which were accumulated from prior operations. They also have lot and serial numbers and expiration dates, just like regular inventory.

WIP materials are an important part of materials tracking and traceability, as the output of a container of WIP material from one operation becomes the input to another operation. If this container of material is defective, or becomes contaminated while waiting to be processed by the next operation, then we need to record this.

In its simplest form, we can simply record the quantity of WIP out of a job step as it occurs and assume that this is the WIP input to the next operation in the route. But this can cause problems if the WIP materials for one work order is used for another similar work order.

It can also cause problems if a batch is split and some of the output goes into containers destined for rework operations while other containers progress to the next operation in the route. Here, BellHawk tracks the contents of each container of WIP materials as it goes through its own sequence of operations.

BellHawk's use of a WIP flag, along with the part number being made, avoids the problem of inventing a large set of part numbers for each WIP step for all products.

BellHawk does track the work order and operation used to create the WIP. This enables BellHawk to warn operators when they are about to use WIP intended for another job. It also does enable BellHawk to maintain traceability, where excess WIP from one job is used on another job.

BellHawk can also track the case where the WIP is a product with its own item number. This typically happens with test, assembly and repair operations. Here the materials are not consumed when they are recorded into an operation nor are new materials produced when the WIP product is recorded out from the operation.

In this case, a tracking barcode is placed on the item at the beginning of the process and used to track the same item in and out of job steps.

6.8 Tracking Intermediate and Finished Goods

In materials tracking, all materials produced by manufacturing processes are typically placed in containers with LPN tracking barcodes. For intermediate materials, these tracking barcodes may be placed on totes or other carriers as well as on rolls, reels, and other such containers. For finished goods these are typically placed on “first-level” packaging such as cardboard boxes or wrappers.

License plate tracking barcodes on containers enable intermediate materials to be tracked into jobs to make finished goods. They also enable finished goods to be tracked into the warehouse and to be tracked as they are picked, packed, and shipped to customers.

In this way we form a traceability path from each work-order/batch to the containers of material or the serialized items produced as a result of that production batch. If a work-order/batch produces barcoded containers of intermediate material, then these materials are scanned into the job/batch to make the finished goods, thus maintaining traceability from raw materials, through intermediate materials, to finished goods.

BellHawk tracks the unit cost of materials purchased from outside sources, by the container. This enables BellHawk to compute the cost of materials used to make an intermediate or finished product, along with the cost of the labor and equipment time required. This rolled-up unit cost can then be saved for intermediate materials and used as part of the cost of the finished products made using the intermediate materials..

7. How BellHawk uses its Containers Table to Track Materials

7.1 Introduction

Unlike accounting systems, which track the quantity of material in stock, BellHawk tracks material in containers. At its core it is tracking the quantity of each item in or on each container, such as a box, barrel, or pallet. To compute the inventory of a specific item, BellHawk adds up the quantities of the item in all the containers.

This is also different from ERP (Enterprise Resource Planning) systems, which track the quantity of an item at a location. BellHawk tracks the quantity in a container, which has a location. Each container may move from location to location and, as a result, the inventory at a location will change.

BellHawk has a very fine grained, physical view of locations. To BellHawk, a location is a shelf, a rack, or a floor location. A location can also be a subcontractor or installation site. This is different from many ERP systems, for which locations are typically warehouses or production areas. In BellHawk, warehouses and production areas are referred to as Facilities, which are supersets of its physical locations.

In many cases, with ERP systems, "locations" are used to give properties to the inventory stored there, such as waiting for QC inspection, even though the materials in this "location" may be in many different physical locations.

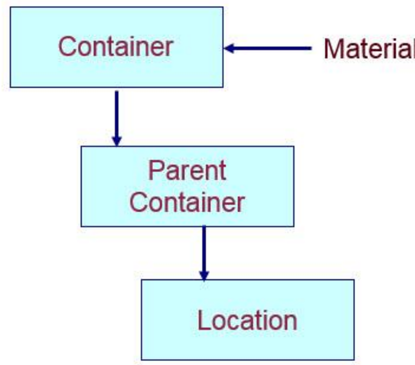
BellHawk tracks "physical" containers which have a license-plate-number (LPN) tracking barcode and "virtual" containers which do not. As a result, we can have a set of widgets in a barcoded box at a location or we can have these "loose" in a virtual container at a location.

These widgets could be in a physical box without a tracking barcode, which is still treated as a virtual container. Or we could have a mix of different parts, each in their own virtual container, in or on a physical container, such as a pallet, with its own LPN tracking barcode.

BellHawk also tracks individually barcoded parts, which have an LPN tracking barcode applied directly to each part. These parts are represented by a container with a quantity count of 1. These containers also typically have a serial number which is tracked by BellHawk.

BellHawk tracks the lot number and expiration date of the material in each real or virtual container. It can also track the serial number and quality control status of this material.

BellHawk can also track nested containers. As a result, we can have a parent container, such as a pallet with its own LPN tracking barcode, which has a set of cartons on it, each with their own LPN tracking barcodes, with each carton having individually barcoded parts within it. The benefit of this representation is that, when the parent container is recorded as being moved to a new location, then all the contents of the pallet are recorded as being moved to the new location.



This also enables BellHawk to keep track of what is left when a carton is removed from the pallet or a part is removed from a box. The removed cartons and parts can then be tracked individually.

BellHawk distinguishes between a Type 1 single use container that is restricted to containing a single part and lot number at the same time and a Type 2 multi-use container which can contain multiple Type 1 and virtual containers, as well as other Type 2 containers. In physical terms, Type 2 containers are things like pallets and shipping containers, whereas examples of Type 1 containers are boxes of bolts, cans of liquid, and reels of wire.

The use of Type 1 containers can prevent the accidental mixing of different products, or similar products having different lot numbers or expiration dates in a container that is supposed to contain identical products.

This fine-grained container and physical location view of the world enables materials managers to track their inventory in real-time and to be aware of its multiple physical locations at all times.

7.2 BellHawk Database Containers Table Records

BellHawk stores its inventory data in a containers table. Some of the important fields in this table include:

1. A unique LPN tracking barcode – this is how material handlers uniquely identify a physical container. This is required for all Real containers. A pseudo tracking barcode is generated for virtual containers in the form BBBBB>NN where BBBBB is the LPN barcode of the immediate parent container or location and NN is the sequence number of the virtual container within that parent container or location. This is used for selecting virtual containers for transactional purposes.

2. Container UOI - a universally unique identifier (UUID) which is a 128-bit random number used to uniquely identify a container record. This applies whether the

container record relates to an LPN barcode tagged container or not. Thus, the UUID (sometimes known as a GUID) enables container records to be generated by multiple different BellHawk (or external) systems without conflict or confusion.

3. Real or Virtual flag - a Real container has a tracking barcode and is physically tracked by its barcode. A Virtual container is how we track material without a tracking barcode that exists at a location or as one of a number of different materials in a Real container that has a tracking barcode.

4. Container type - (box, roll, reel etc.,) record which also relates to whether the container can be used to hold only a single part number or can hold multiple different part numbers.

5. Parent Container – this is the LPN of the parent Real-Container, if it exists.

6. Location – this is the physical location of the material.

7. Item Number – this is the part number for the material stored in the Real or Virtual container. This will be absent if the record simply represents a Parent container, such as a pallet that has a number of Real or Virtual containers of different material stacked on it. There will be an Item Number if this is a Kit or Assembly.

8. Quantity – this is the quantity of material in the Real or Virtual container.

9. Lot Number

10. Expiration Date

11. Serial Number

12. Quality Control Status

13. Unit Cost for materials in the container.

14. UDP - which contains user defined parameters for the container, such as length, width and color.

15. IsDeleted - this is normally set to 0. It is set to 1 to indicate that this record is not part of current physical inventory. Note that records in the containers table are never physically deleted, for referential integrity. When the materials in a virtual or real container are withdrawn from inventory then the IsDeleted flag is set to yes.

16. IsWIP - this is set to No for "normal" inventory and Yes for Work-in-Progress inventory, which is material in the process of being converted to the end product of a work order.

17. IsPending - this is normally set to zero unless this is for a container for which a pre-printed label has been printed or for which an Advanced Shipment Notice has been received but the container has not yet been received in the plant. This is set to 255 if a preprinted label has been destroyed.

BellHawk not only tracks active containers but also tracks containers of material that have been consumed or shipped. It marks these inactive containers with the IsDeleted flag so they do not appear in inventory. But it keeps them in its database so that the data is still available for shipping and similar reports that may refer to them, even if they are not in inventory. This also enables easier handling of returned material that has a tracking barcode.

7.3 Container Types

Each container record, which relates to a physical container, references the container type in the container type table Some of the useful fields in this table, which impact on the way BellHawk tracks its inventory, include:

1. ContainerType - an alphanumeric string, such as Box or Bag, that identifies the container type.
2. IsMultiUse - if this is No then this container type is a Type 1 (single use) container with its own tracking barcode, or an individually barcoded item (as set on the Item master record), or a virtual container. If this is set to Yes then this is a Type 2 parent container.
3. IsResusable - if this is No then the container is assumed to be discarded when empty. If this is set to Yes then the container record is retained when it becomes empty so that it can be reused. For example a box may be considered to be non-reusable whereas a tote would be reusable.
4. Tare weight - assumed weight of empty container of this type.
5. Tare weight UOM - unit of measure nomenclature (such as Kg) for this type of container.

7.4 Usage Examples

There are several special cases that we use all the time in tracking materials:

1. A Type 1 container. This is a real container with an LPN tracking barcode that contains a quantity of a single part number of a specific material that has a single lot number, quality control status and expiration date. This is most commonly used for tracking raw materials and work-in-process. Here the containers type is set to be single use.
2. A Type 2 container. This is a parent barcoded container that has one or more virtual or real containers with this container as its parent. This is typically used to represent shipping cartons and pallets that hold multiple different part numbers. Here the container type is set to multi-use.
3. An empty container. This is a barcoded container that does not yet have any materials picked or moved into it. It is typically recorded into the system using a Tag Container transaction, ready for picking materials into.

4. An individually barcoded item. This is a part, such as a circuit card or an electric motor that is tracked independent of a physical container. It has its own tracking barcode and always has a quantity of 1 each. This is different from a roll of material, which will also have its own tracking barcode, but will have a weight or length that will vary with the amount of material on the roll.

5. A serialized item is an individually barcoded item that also has a serial number that needs to be recorded when it is entered unto inventory.

6. Loose material at a location. This is where the material is stacked directly on shelves or racks or is stored in Silos. Here there is no container barcode. Instead these materials are tracked in Virtual containers at the location. There may be several materials in Virtual containers at a specific location.

7. Loose material of different types in a parent container. Here we have multiple virtual containers in a Type 2 container. When new materials are added to the Type 2 container a new virtual container is created unless the Item, Lot Number, Expiration Date, serial number and UDP parameters match an existing entry in the Type 2 container. In this latter case the quantities in the two virtual containers are added.

8. When new materials are added to a Type 1 container that already has material in it then the material can only be added if the Item, Lot Number, Expiration Date, Serial Number, and UDP Parameters match, when the quantities are added, otherwise the entry is rejected. The materials added must also be for the same project or customer as the other materials in the container or come from common or company owned stock.

As shown above, using an example of DoD (Department of Defense) compliant LPN tracking barcodes, the printed circuit cards are serialized items with their own individual tracking barcode. They are placed inside a Type 2 container. These Type 2 containers are stacked on a Type 2 pallet. If the items placed in the cartons were not individually barcoded, then they would be placed in Type 1 containers (same part and lot number) which would be placed on the Type 2 pallet.

It should be noted that BellHawk only tracks quality control status, lot numbers, serial numbers, and expiration dates for material in Type 1 containers, for individually barcoded items, and for virtual containers. It does not track these values for Type 2 parent containers.

BellHawk is setup to make it easy to track materials in Type 1 containers or to track individually barcoded items, as these are the most commonly tracked items in manufacturing and other similar industrial operations.

Type 2 containers are also easy to track or ship as an entity by simply scanning the barcode on the outermost parent container. But it requires more data entry to select which of multiple materials or lot numbers you wish to withdraw from a Type 2 parent container or directly from a physical location.

7.5 Supply Chain Integration

When a set of containers is recorded as being shipped in BellHawk, they are written into a Shipped Containers table in BellHawk, which is essentially a copy of the container records in BellHawk. This includes all the nested container information, such as which boxes, with serialized parts in them, were placed on which pallets shipped to the customer. These shipped container records include links to the shipment to which they belonged, which itself may contain data as to the truck on which it was shipped.

As the materials are picked and packed for the shipment, the BellHawk barcode labeling software (TAG) can be used to print out barcode labels with GS1 (Global Standards One) compatible SSCC (Serialized Shipment Container Code) barcodes for the boxes and pallets. This data is recorded in BellHawk, as the pallets are picked and packed, and then copied to the Shipped Containers table when the pallets are shipped.

This shipped containers data can then be exported for use by an EDI (Electronic Data Exchange) system to send Advanced Shipment Notice (ASN) data to the customer and/or distribution center which will receive the pallets or other containers.

When containers are shipped, they are marked as IsDeleted, in the main containers table, so they no longer appear in BellHawk's Inventory of containers. But the records are retained. This is so that, if containers or individually barcoded items are returned, then their license-plate tracking barcodes can be scanned and the container record "resurrected" back into the BellHawk container inventory.

When this happens, a full record is kept in the Inventory Transactions history table. This enables, for example, the repair of an instrument, to be tracked over multiple times that it is returned from a customer and shipped back to a customer after repair.

Checking in materials received from suppliers can be time consuming, with the need to attach a tracking barcode on each item, or container of parts and to enter all the data about the received parts, as well as recording the receipts into an ERP or accounting system so suppliers can get paid.

The time to receive materials can be minimized if the suppliers attach GS1 compliant tracking barcodes to their items and the containers in which they are packed, and then send an ASN for the shipment, as soon as it has left their plant. That ASN can be sent via EDI and then transferred to BellHawk, or sent directly to BellHawk using the DEX interface, or dropped as a comma delimited file by FTP into a web-accessible FTP site from which MilramX can retrieve the data and forward it to BellHawk.

BellHawk can then import this data as a set of pending containers in its containers table. These are not visible as part of the BellHawk containers inventory until the SSCC barcodes on the outside of the pallets are scanned, when the nested container records are activated, and made visible as part of BellHawk inventory.

This receipt data can also be automatically exported to an ERP or accounting system using the BellHawk DEX interface so as to avoid the need to manually enter the receipt data into one these systems.

As a result, the total data recording can be reduced to scanning the barcodes on the pallets as they are offloaded from the truck/trailer. This not only speeds receiving but significantly reduces the probability of data entry errors.

Because BellHawk is recording events such as receiving, transforming, labeling, packing, and shipping containers of material, it can also send these events to materials supply chain traceability repositories by means of the DEX interface.

7.6 Commentary

The containers table representation that BellHawk uses is a very powerful and concise way of storing data about materials. It allows for a wide variety of storage configurations from loose material on a shelf to complex nested container representations. It is designed to make it as simple as possible for material handlers to record the receipt, usage, transformation, picking, packing and shipping of materials. It also enables automated exchange of data with customer and supplier systems and the global supply chain.

BellHawk keeps historical track of every transaction on containers (real and virtual) in its Inventory Transaction database table. It does not, however, have the ability to easily recall the total inventory of a part on a specific date in the past. If this historical record keeping is required then nightly snapshots of the inventory should be taken using the BellHawk DEX interface and stored in the DEX database..

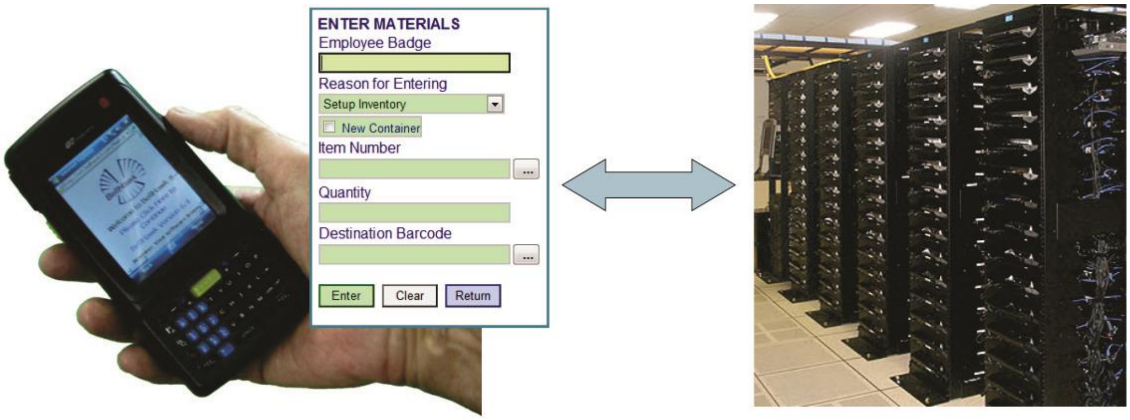
DEX retains these nightly inventory snapshots in its database for reporting on changes which have taken place to inventory over time. DEX also generates a current snapshot in a format suitable for exporting to an ERP or accounting system. In the former case, DEX records inventory quantities aggregated by BellHawk facility. In the latter case DEX reports inventory quantities aggregated by ERP locations (which could be whole warehouses).

DEX also maintains a "mirror" of the containers table in its database. This enables external systems to interrogate the containers table for reporting and data exchange purposes. But, please note that the containers table cannot be directly updated by external systems. Instead, this has to be done by entering commands such as Enter, Move, and

Withdraw through the DEX interface, so that BellHawk can maintain accurate materials traceability data.

By not allowing users to directly modify the containers table, and by keeping track of the history of the people and systems which made changes, BellHawk is able to maintain referential integrity and comply with the requirements of CFR 21 Part 11.

8. “Magic Forms” Data Entry



One of the big benefits of BellHawk using a web-based technology is that it can minimize user training through the use of web forms. Most employees are very familiar with filling in a form on a website from ordering products and services on-line. As a result, the BellHawk user interface was designed to mimic the use of this familiar interface.

The problem with using a forms-based interface for operations tracking is that, if we had a box for every possible option they could enter, we would require a large number of data entry boxes, which would be very confusing and mistake prone. Also, it is impossible to display all these entries on a mobile device screen, without extensive scrolling. So, instead, we use what we call “Magic Forms”.

When a user starts entering data, we only present a small number of data entry boxes. Every time the user enters data into one field of the form, this data is sent back to the server and checked against the contents of the database, so the user can be given an immediate warning if they are making a data entry or operational mistake.

If the entry checks OK then the form is reformatted, based on what was entered in the data field. Then the data entry focus is automatically moved to the next box into which data is to be entered. In this way, the familiar form-based data entry paradigm is retained but the form changes dynamically as the user enters data. Only a minimum set of data entry boxes is displayed and the user is led step-by-step through the data entry process.

Once all the boxes are filled in, the user can select a [Submit] button and have all the data in the form saved away in the BellHawk database. But, up to that time, they can change the data as much as they want, with the form adjusting to accommodate the changes made by the user.

When the submit button is pressed, all the data is checked once again before being stored away to ensure that bad data does not get into the tracking database. Then the user is presented with the data entry screen, just as they submitted it, so they know what they submitted and can then use the previously entered data as the basis for more data entry.

This is especially useful, for example, when entering a sequence of similar containers of a product into inventory where the use of Magic Forms minimizes the amount of manual data entry needed. Magic Forms are also set up so that the data entry into any field can be performed using a barcode scanner. They also encompass the ability to gather weights from weighing scales and to print out barcode labels, in user specified formats, on-demand on bench top or mobile barcode label printers.

The data to be collected and the error checking is based upon rules and parameters setup in the BellHawk knowledge base. This enables BellHawk to be configured to meet a wide range of user requirements without customization.

Also, clients can specify rules about when to collect additional data and how to check its validity. This further reduces the need for any customization of the software to collect specific data.

All of this makes it possible to configure BellHawk so that it is simple to use by people who have limited computer literacy and for whom English may be a second language. This also helps prevent mistakes and speeds data entry.

9. Item Master Records

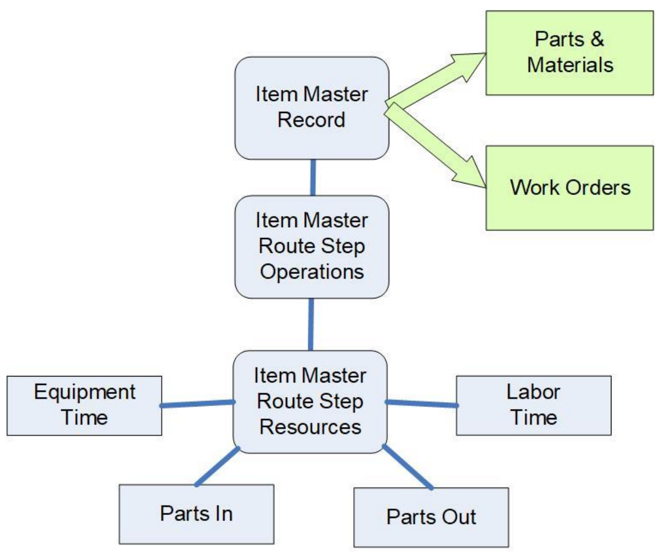
An important component of BellHawk is its Item Master Records. These contain the information necessary to enter parts and materials into BellHawk and to create Work Orders.

They can be as simple as a header record with a part number, description, and a category of parts to which the item belongs, such as raw, intermediate, or finished materials.

Item master records can also include sets of objects that define the route steps, plus the expected parts-in and parts-out for each route-step operation, as well as optionally the expected labor and equipment time for each operation, in order to make a specified quantity of parts or materials.

These item master records can be used to create work orders. In this case, the item master header record contains a standard route quantity for which all the part-in and part-out quantities, as well as the labor and machine times, are defined.

When a work order is created to make a specific quantity of a part, the route operations and their resources are copied to the work order from the item master record, except that they are scaled according to the quantity of parts or materials to be made.



Some of the other useful fields carried along in the item master header record are:

- Material Type – such as stainless steel or tomatoes – useful for searching for specific item master records.
- Made here? If Yes, allows, but does not require, item master record to have an associated route and resources.
- Is lot controlled? Sets whether a user is required to specify an external lot number when entering this part or materials into inventory.
- Is serialized? Sets whether a user is required to specific a serial number when entering this part or materials into inventory. Can also be used to have BellHawk automatically generate a serial number for each new part or container of materials.
- Expected product life – used to require a user to enter an expiration date for the material being entered into inventory.

- Is individually barcoded? Does each part have its own barcode or is it tracked by the LPN barcode on a box containing multiple such parts.
- Primary unit of measure (UOM) – the UOM used to record the quantity of this material in inventory.
- Secondary UOM and conversion factor to primary UOM. Typically, this is used to contain the per-unit weight and the conversion to one primary UOM. This is useful for determining primary UOM quantities by weighing containers of material.
- QC Every? Used to determine whether each part or container of materials needs to be inspected before it is used or shipped.

While BellHawk tracks the quantity of materials in a container using a primary UOM, with an optional secondary unit of measure, convertible to the primary UOM, BellHawk can also track materials in with independent primary and secondary units of measure. This enables, for example, the weight of gold earrings in a container to be tracked separately from the unit count.

While in many applications, such as counting washers by weight, a standard UOM conversion can be used, when dealing with gold and other precious substances, the variability in the piece weight can be significant. This variability can impact the valuation of the inventory, which may be based on the spot market price per unit of weight. But at the same time, for production purposes, it is essential to have an accurate count of the parts in the container.

Item Master records need to be created before any part or container of that material can be entered into BellHawk inventory. These records can be directly entered into BellHawk through the user interface, imported in the form of Excel spreadsheets, or can be imported from another system through the DEX interface.

New item master records can also be created by copying existing item mater records and editing them or through the use of template routes, complete with resources records, which can be added to item master headers.

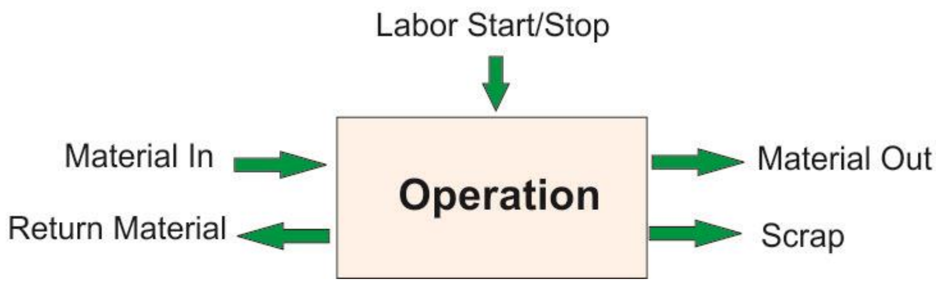
In addition to standard data entry items, users can define their own parameters for the item master part as well as for the part-in and part-out records. These are added as User Defined Parameters (UDP). Please see UDP data sheet for details.

The UDP parameters can include the ability to specify the length and width of materials, making it ideal for tracking dimensioned materials, including offcuts.

UDP parameters are rules based as to when they are requested and the data checks to be performed on them. UDP parameters and their rules can be defined by users, enabling flexible data collection without needing to customize the BellHawk code.

10. Work Orders

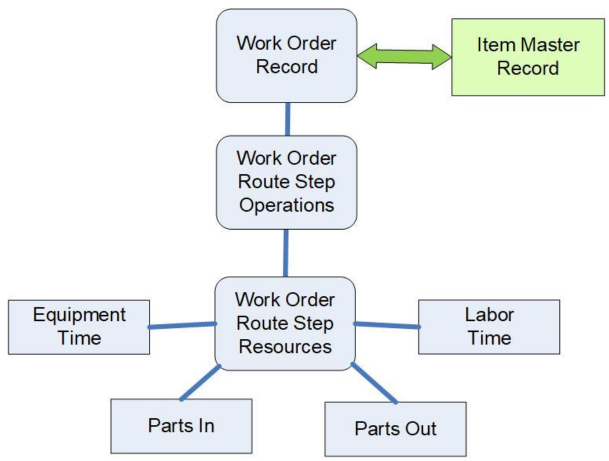
10.1 Data Representation



In BellHawk work orders are used as the basis of recording materials in and out of manufacturing or processing operations, as well as optionally recording the amount of labor and machine time taken for each operation.

BellHawk Work Orders come in two types:

- A service work order. This is what the BellHawk base Simple Production Tracking System (SPTS) tracks. It does not reference an Item Master record.
- A processing work order, which is what a base Real-Time Operations Tracking System (RTOPS) tracks. It references an Item Master record for the part or material being made.



Work Orders can consist only of a header record or they can have a set of route-step operations. Optionally these operations can have associated estimated labor resources and, with RTOPS, they can have part-in and part-out resource records, and with the Equipment Tracking Option (ETO) they can have equipment resources.

With RTOPS work orders can be created from the route and resources data stored in the Item Master record. This is done by BellHawk automatically copying the data from the Item Master records, so that the work order can be subsequently modified before being used. Also, part-in and part-out quantities are scaled in the ratio of the quantity of the item to be made to the standard route quantity specified in the item master.

Labor and equipment time estimates, if present, may be likewise scaled proportionately, when the work orders are created, to enable an accurate comparison of the actual versus estimated costs.

Work orders for make-to-order jobs can also be created from Ship Order lines, if this option is in use, based on the information stored in the corresponding Item Master record.

Work orders may be created simply as a work order header which is then used as the basis of scanning the start and end of operations, based on operation barcodes at each work station. In this case, template routes can also be defined and attached to these work orders as the work orders are created to enable rapid creation of work orders, which are only comprised of routes of operations.

Within BellHawk, work orders, and their operations, form the basis for recording materials traceability history by linking the materials recorded into each operation with the containers of material produced from each operation. Work orders are also used for recording the labor, materials, and equipment resources consumed on each operation and the comparison of actual versus estimated cost.

Work Orders can be imported into BellHawk from external systems, such as ERP systems, using Excel spreadsheets and direct transfers through the BellHawk DEX interface. Also all the materials, labor and equipment time transactions are available through the DEX interface for operational analysis, custom reporting, and use by an ERP system.

10.2 Importance Values

Importances are numbers, typically from 1 to 10, with 10 being the most important and 1 being the least important. They are values that can be given to work orders based on factors such as the closeness to wanted date. Thus, a work order may start out with an importance of 5, which is the standard importance value in BellHawk and increase in importance as the work order gets closer to its wanted date before it is completed.

Priority is an ordering amongst work orders. There can only be one work order that has a priority number 1. We can have work orders with Importances of 6, 7 and 8 and then create a new work order with an importance of 9. This immediately changes the priority of the previous work orders from 3, 2 and 1 to 4, 3, and 2 respectively.

In BellHawk, we do not attempt to ascribe a priority to work orders. If we have three work orders with an Importance of 10, the system would require an enormous amount of additional knowledge to prioritize between these. People are typically able to make this choice easily based on their general situational knowledge (such as if one of these work orders is for a customer with whom the company President plays golf) but even systems with deep artificial intelligence knowledge have difficulty making such decisions correctly.

In the BellHawk work center scheduling module, we present the work orders in importance order, with the most important work orders at the top of the list. There may be multiple work orders with the same importance but we rely on people’s general knowledge to prioritize between them rather than having the system try to pick the Priority order.

Importances are analogous for how neural networks in our brains add up sensory inputs. Importances are logarithmic in nature so I can have a customer with an importance of 3 and ascribe an importance of 6 to how close to the wanted date the work order is and then add them together to get an importance of 9 for the work order. This makes it very simple to incorporate a number of factors into computing the importance of a work order.

Importances are attributes of each individual work order and not of the relationship between them, which is needed to set priorities. This enables users to adjust the importance of work orders, or to have this done automatically, on a work order by work order basis without consideration for the importance of other work orders.

In BellHawk, we typically use a 1 to 10 scale for importance because human factors studies have shown that most people cannot distinguish between levels of importance such as “poor, fair, average, good, or outstanding” with more than a 5-point scale. In BellHawk, importance values can be given names such as “low, standard, and rush” to facilitate choices, when people are making the choice of importance for a work order.

Finally, it is important to recognize that, just because a work order is the most important, does not mean that it will always be worked on first. A required machine may be down or a person with the needed skills may be unavailable, making some lower importance work order the number 1 priority.

11. Exchanging Data with BellHawk

11.1 Introduction

While a BellHawk inventory tracking and operations management system can be run stand-alone, there is often the need to exchange data between BellHawk with other systems to avoid duplicate data entry. There is also the need to generate custom reports and the like from BellHawk.

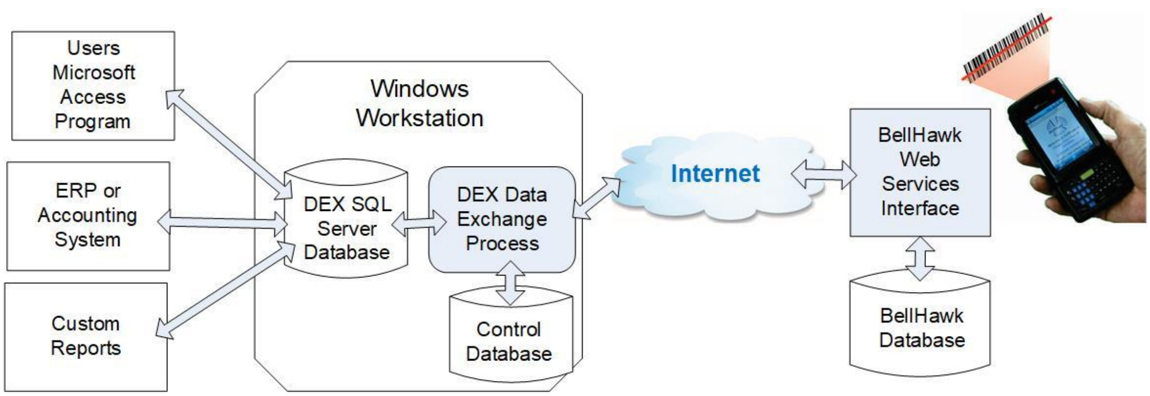
BellHawk, as standard, supports two interfaces for these purposes:

1. Excel Imports and Exports, which are performed manually using the standard web-browser interface to BellHawk. These transfers are performed using High Level Data Objects (HLDOs), as described in a following section.

2. The DEX store-and-forward data exchange interface uses a local SQL database running on a Windows Workstation computer in each manufacturing plant and warehouse. Data can be transferred to a BellHawk database (which may be running at a remote data center) by writing into the local DEX database. This data is then automatically transferred to the BellHawk database by the DEX data exchanges software running on the Windows Workstation.

   Any-time BellHawk captures transactional data, such as receiving, transforming, or shipping materials, this history data is transferred to the DEX database by the DEX software for use in data exchange or creating custom reports. Also, any purchase orders, pick orders, work orders, and ship orders entered into BellHawk are also automatically transferred to the DEX database for reporting and interface purposes.

11.2 DEX Interface Overview



The DEX interface provides a simple to use store-and-forward interface for exchanging data with BellHawk. This interface consists of an executable Windows program called DEX2.exe.and two SQL-Server databases, which can be installed using the free SQL Server Express database server from Microsoft. One database, called DEX, is used for the data exchange itself and one called DEXControl is used for controlling what data is transferred and how often.

Users wishing to send data, such as Work Orders or Purchase Orders, to BellHawk, simply write this data into a set of tables in the DEX database and then the DEX2 program automatically transfers new or updated entries to the BellHawk database. Similarly, transactional data captured in the BellHawk database is automatically transferred to a set of tables in the DEX database.

This enables users to easily implement automated data exchange interfaces with a wide variety of ERP and accounting systems, as well as to create custom reports from the data captured by BellHawk.

11.3 Benefits of DEX

Running software such as BellHawk "in the Cloud" has many advantages, whether it is being run on computers at a secure data center managed by a third party, or is being run at a client's data center, or on a private Cloud based server.

The disadvantage is that this makes the BellHawk database inaccessible for implementing automated data exchange interfaces with systems such as ERP and accounting systems or for clients creating custom reports.

The DEX interface automatically exchanges data between the BellHawk database and the local DEX SQL Server database, which is formatted such as to be user friendly for interface and custom report creators.

This approach also overcomes a major disadvantage of directly using the BellHawk database, which is structured for rapid response to many users doing barcode scanning at the same time. This structure, while good for rapid data capture, is not very user friendly for interface or report generation. The DEX approach also avoids the possibility of users inadvertently damaging the BellHawk database and ending up with a non-working BellHawk system, as a result.

Also, the DEX interface is well documented whereas the structure of the BellHawk database is only documented in a manner usable by knowledgeable software developers.

Some uses of the DEX interface include:

1. Automatically exchanging data with an ERP or accounting system.
2. Generating custom reports using software such as Access, Excel, Crystal Reports, or SSRS based on data from the BellHawk database.
3. Exchanging data with EDI and shipping systems.
4. Transferring data from CAD or other engineering design systems into BellHawk.
5. Interfacing BellHawk with process control equipment and machines.
6. Generating large screen shop-floor displays showing performance dashboards.

There can be multiple copies of the DEX interface communicating with BellHawk from different plants, warehouses, and data centers. This enables BellHawk to be interfaced to a variety of systems and used by people doing custom reporting from multiple geographically separated locations. Also a version of DEX is available for installation on a Windows Server computer, where 24x7 reliable communication with an external system is required.

In the future, it is planned to add the capability for external systems to send transactions to BellHawk, through the DEX interface, just as if they were directly recorded into BellHawk.

11.4 Data Exchange Overview

The data that can be exchanged consists of the following groups:

- Setup data for BellHawk - this is the same data as that which can be imported in HLDO (High Level Data Object) format through the Excel Setup data interface into BellHawk. The primary function of these transfers is to enable setup data to be transferred from ERP and accounting systems into BellHawk but this can also be a convenient way of manually transferring setup data into BellHawk.

- Orders for BellHawk. These are the same Purchase Orders, Pick Orders, Work Orders, and Ship Orders, which can be directly entered into BellHawk. They enable orders to be automatically sent to BellHawk directly from ERP and other systems.

- Transaction history data. This DEX data includes containers of material received and picked, material moved, material consumed and produced on work orders, containers of material shipped, labor and machine time consumed against work orders, and the change in quality control status of containers of material. New records are added whenever a transaction is recorded in BellHawk.

- Current status data. This includes the status of work orders and the contents of the containers table. These DEX tables are updated as changes occur in the BellHawk database.

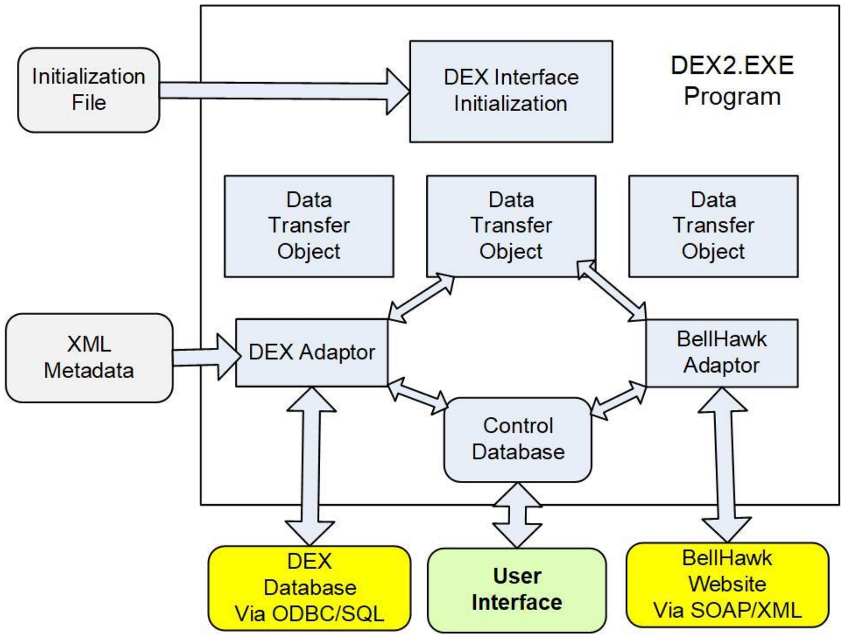
- Data for transfer to ERP and accounting systems. These include aggregated shipments and receipts, as well as nightly inventory snapshots. These are periodically transferred from BellHawk at intervals set by the DEX user.

- Setup Data from BellHawk. This includes the same set of data objects as can be transferred to BellHawk but they are transferred from BellHawk into a separate set of DEX tables, which are updated automatically as changes are made in BellHawk. These are useful for including in reports, especially when the setup data is imported directly into BellHawk or is automatically updated in BellHawk from another system.

- Orders from BellHawk. These are copies of the Purchase Orders, Pick Orders, Work Orders, and Ship Orders directly entered into BellHawk or imported into BellHawk from another system. These are written into a separate set of tables from the DEX tables used for sending orders to BellHawk and are automatically updated whenever changes are made in the BellHawk database. These are intended for reporting but are also useful for transferring order data to other systems, such as operational parameters for process control systems.

Please note that the data which can be exchanged depends on the BellHawk options in use.

11.5 DEX Architecture



The DEX2.exe program contains a set of Data Transfer Objects (DTOs) which are essentially subroutines that exchange specific data objects, such as Work Orders, between tables in the DEX database and BellHawk (through its remote Web-Services interface). These DTOs are scheduled according to data setup in the Control Database through the User Interface.

The User Interface also shows the status of each transfer and any errors that may have occurred.

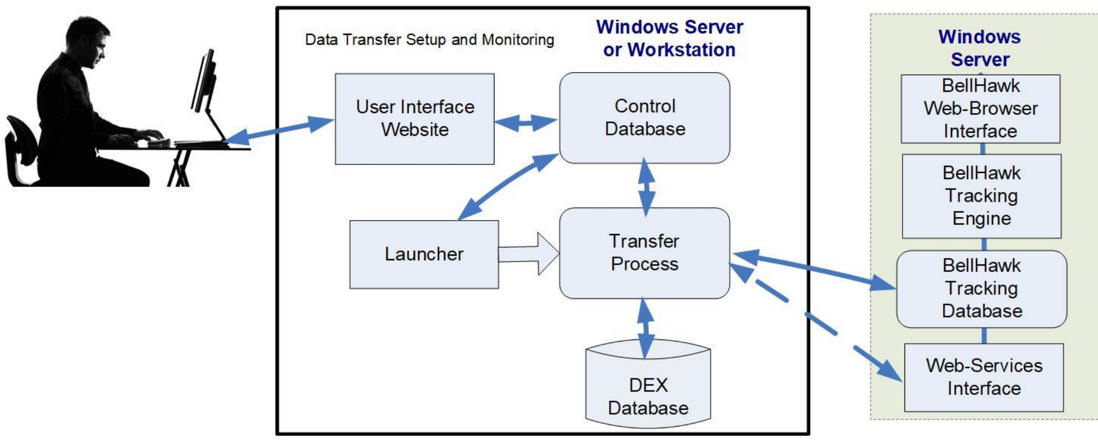
Connection information with BellHawk (through its URL) and login information for the DEX and Control SQL Server databases are setup in an initialization file, which is an editable text file, which is read by DEX2 when it is started running. The translation between the DEX database tables and HLDOs (High-Level-Data-Objects) used by BellHawk are read from XML metadata files, which are supplied with DEX2.

DEX2.exe runs as a regular user program and reads its initialization data from the local directory folder in which it was installed. It needs an outgoing Internet connection to the BellHawk server, with the same privileges as you would use to browse to the BellHawk website (using an HTTPS connection). It does not need any inbound "holes" in the organization's Internet connection, as all BellHawk data is fetched by DEX2 rather than pushed by the BellHawk Server.

DEX2 runs on a Windows PC or Workstation. The SQL Server databases can be installed on the same PC or made accessible over the facilities LAN (Local Area Network).

DEX2 works great for users who want to develop interfaces or only to transfer data intermittently for reporting or setup purposes. But manually running DEX2 whenever you want to transfer data may be inappropriate for automated data exchange interfaces that need to run 24x7 or SSRS (or other Web-based) custom reports which are integrated with BellHawk.

In this instance we take advantage of the fact that DEX2 is a subset of the MilramX software:



We use the same DEX and Control bases and the same set of DTOs but this time the DTOs are embedded in a Transfer Process, which is run by a Launcher process, which runs as a Windows Service. This enables the Transfer Process to restart automatically in the event of a power failure or a reboot of the Windows Server or Workstation on which the DEX interface is running.

In this case, the Launcher determines which DTO (and even which of multiple Transfer Processes) to run next, based on the contents of the Control database, and then launches and monitors the Transfer Process to run that DTO.

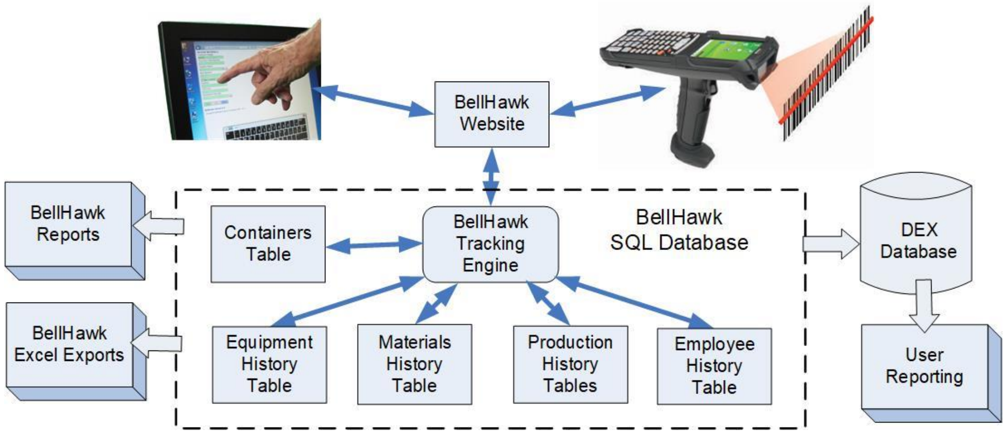
If the Transfer Process hangs for some reason, then the Launcher will kill-it and retry the transfer (up to a specified number of times) before moving on to another transfer, after notifying an IT person that a problem has occurred by Email or Text Message.

In this server-based version of DEX, we replace the local user interface, with a web-browser based interface which can be accessed anywhere there is an Interface to DEX. This requires installing the MilramX web-server software using Microsoft IIS web services but does give a remote IT person the ability to see what is going on and to remotely fix any transfer problems that may occur.

In this way, we enable the DEX interface to run reliably 24x7 for extended periods of time, without direct human intervention, except when servers or networks go down.

The server version of DEX can be installed on the same Windows Server (or LAN) as BellHawk, in a data center, in which cases, DEX can be configured through its initialization file to communicate directly with the BellHawk database though ODBC rather than using its web-services interface, for greater efficiency.

The DEX interface may be supplemented by a set of DTOs which provide direct data exchange with QuickBooks Enterprise Desktop via the QODBC read/write interface. A set of DTOs is also available for directly reading data from Sage 300 ERP databases.



11.6 Producing Custom Reports using DEX

BellHawk maintains the status of all active materials in its containers table. It also captures the transaction history in a set of tables relating to materials receipt, movement, usage, production and shipment as well as the equipment and labor times used in production operations.

From these tables BellHawk produces a set of standard reports that cover most standard operations and materials tracking requirements. Also "reports" such as barcoded receiving and picking sheets, as well as purchase, work, and ship orders can be customized in a limited way, such as by using the client's logo instead of the BellHawk logo, and by adding fields to the header and lines on these "reports".

These standard reports, along with related Excel exports, usually meet the requirements of most organizations for reporting real-time operational status. Users can then create their own reports using report generation software such as Access, Crystal Reports and Excel using the contents of the DEX database, which contains copies of the data in all of these BellHawk tables.

The PC based version of DEX makes it easy for users to run DEX2 to transfer the data they need from BellHawk into the DEX database. They can then run the reports they need by linking software such as Access, Excel and Crystal reports to the appropriate tables in the DEX database.

BellHawk has the capability to integrate external web-based reporting into its standard reports. To do this, users will need to create their custom reports using SSRS (SQL Server Reporting Services), or equivalent, and install these under IIS on a Windows Server so that they are accessible through a remote URL.

These custom reports can then be integrated into BellHawk through setup data imported into BellHawk, using Excel files, by the BellHawk Systems Administrator. This same feature can be used to replace existing BellHawk reports but not Excel exports.

11.7 DEX Technology Notes

Users of DEX can link Microsoft Access to the DEX database and simply treat it as an Access database or link Excel and use it for dumping the data as Excel spreadsheets. Users can also link report generation programs, such as Crystal reports, to this database in order to generate custom reports. More sophisticated users, can integrate this database into an SSRS reporting scheme.

The DEX data exchange process comes with a simple user interface through which users can control and monitor when each DTO is run and to set the priority of execution by setting the importance of each DTO. Users can also use this interface to setup sequences of DTOs to be run, to make sure that data is transferred in a specific order.

There is no need to setup any special "holes" in the network firewall of the plant or warehouse in which DEX is installed, as DEX uses a standard "outbound" Internet connection, just like any other PC on the network. This avoids a major security risk and a need to involve IT in the installation of DEX2.

There can be multiple copies of DEX, running at different geographic locations, interacting with BellHawk at the same time. This enables different departments, in different locations, to easily develop their own custom reports and Excel exports. It also enables integration with multiple external systems at different locations.

The overall processing load on the BellHawk database and server may, however, require a server with a dedicated processor for running BellHawk and a dedicated processor for running SQL Server, if the processing load becomes too high.

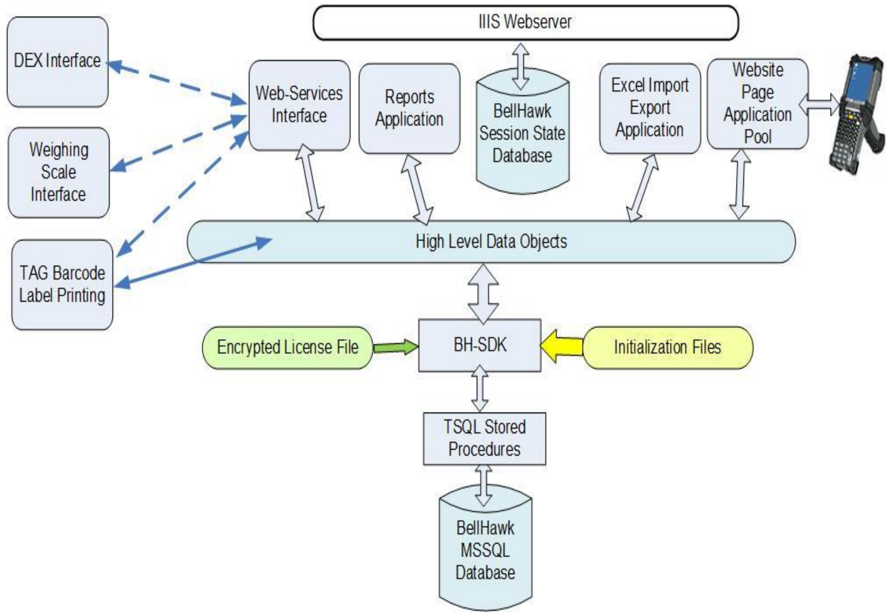
11.8 Commentary on DEX

The concept behind DEX is to make exchanging data with BellHawk and producing custom reports as simple as if BellHawk were running locally in each plant or warehouse or other facility. This method retains all the benefits of running BellHawk at a secure data center, on computers managed and maintained by IT professionals, where BellHawk can be accessed by many different users at many different locations over the Internet.

DEX is designed to run as a user program on a Windows PC. For those organizations that wish to have the DEX interface run as a system process, so as to enable 24x7 unattended operation, we recommend the use of the MilramX software platform (on which DEX is based). Please see the subsequent chapter on MilramX.

Please see the DEX Interface Manual for details of the tables through which data can be exchanged with BellHawk and details of how to use the DEX2 user interface.

11.9 High Level Data Objects



High Level Data Objects (HLDOs) are what BellHawk uses for its internal communications, whether it be for Excel import and Export of setup data for rules used to drive the system, or for data exchange with DEX, weighing scales, or the TAG label printing software. They are also what BellHawk uses to read and write its own database, though the BellHawk Software Developer Kit (BHSDK) interface.

HLDOs consist of a keyword, such as CUSTOMER, and a set of parameter name value pairs of strings such as `CustomerNumber:XYZCo`. Because they use Extended ASCII strings (one byte per character), HLDO's are intended to be processor and database format independent, enabling the import of Unicode data from a Windows platform or UTF8 data from a Unix based system, provided that they can be translated to an extended ASCII character set.

HLDOs are often represented as JSON strings in the format:

```
{"CustomerNumber":"XYZCo","CustomerName":"XYZ Company"},
```

which may be familiar to some readers.

When importing HLDO instances using Excel. We use the format shown below:

	A	B	C	D	E
1	CUSTOMER	CustomerNumber	CustomerName	IsPlant	UDP
2		CDEFurniture	CDE Furniture Manufacturers	N	
3		MYCOMPANY	Smith Industries	N	

In this, we have a header row with the keyword for the HLDO in column (A) followed by the parameter names of the value we are importing (2). In many cases it is only necessary to specify a limited subset of the parameters as many, such as IsPlant (Is this "customer" another manufacturing plant or warehouse within my organization?), can be allowed to default.

Below this (3) are one or more rows with the parameter values for the column header parameter names specified in the header row. Please note that MYCOMPANY (4) refers to the organization itself and exits to allow the organization to make or ship products (such as intermediate materials) for the organization itself.

Please note that this is different from the format used to import and export data using the DEX database, where data is simply entered or read from appropriate table columns in the DEX database. HLDOs, by contrast are in a format designed for message exchange over the Internet. Data stored or fetched from databases is then translated to and from HLDOs for communications purposes.

HLDO definitions are stored within BellHawk and DEX as XML metadata files, which are used for validating that the imported data is correct. These definitions can be printed out in BellHawk, using the System Administrator's DEXEL screen:

	A	B	C	D	E	F
1	**KEYHEADER**	**Keyword**	**Description**			
2		Customer	Customer Record			
3	**KEYPARAMS**	**ParName**	**Description**	**FieldType**	**DefaultValue**	**IsRequired**
4		CustomerNumber	Alpha-numeric identifier	TextID		1
5		CustomerName	Name of Customer	Text		1
6		IsPlant	Is a plant in a multi-plant system	YNBool	N	0
7		CreditHold	Customer is on credit hold	YNBool	N	0
8		CreditLimit	Credit Limit	Dollar		0
9		BalanceDue	Balance Due	Dollar		0
10		UDP	User Defined Parameters	JSON		0

In these definitions there is a header row (1), which defines the keyword and gives a description of the HLDO and a set of records defining the parameter values. The columns in this table are:

- ParName ((2) - Parameter Name)
- Description ((3) - Parameter Description)
- FieldType ((4) - Field Type) - these types, which are listed in the next section, are used to check that the data imported via Excel or DEX are in the correct format.
- DefaultValue ((5) - Default Value) - shows the assumed value if the field in the Excel import is left blank or the parameter value is not specified. It is also the value assumed on import if the entry in the DEX table is a NULL.
- IsRequired ((6) - Is Required) set to 1 - if a value must be supplied or 0 if this is an optional parameter.

Please note that there are more fields in the HLDO definition (such as maximum length of strings) than shown here. These are explained in detail in the "BellHawk High Level Data Object User Manual" which can be downloaded from www.BellHawk.com.

11.10 Field Data Types

Every field in each DEX table and HLDO has a specified field data type. These field types are used to check that a data value being set for a parameter is valid; for example, that a field type of DATE does indeed contain a string value that can be converted to a date without error. They are also used to check that the value of a parameter being retrieved from the database is valid and does not contain invalid characters for the data type.

Note that BellHawk only accepts extended ASCII characters (for reasons of real-time performance) and not Unicode or UTF8 characters. For user convenience DEX does contain a Character Translation table (tblChars) which can be used to translate from Unicode characters into a sequence of extended ASCII characters.

The valid field types are:

TEXTID – These are used to specify parameters that are lookup parameters and also text foreign key parameters whose value must match key values in other tables. These can contain any ASCII character except non-printing (control) characters and the percent (%), comma (,) and double quote (“) characters. Unlike TEXT fields they cannot contain an empty string.

TEXT – Contains any ASCII characters except for non-printing (control) characters. An empty string `""` is also a valid TEXT string.

INTEGER – Contains numeric digits. May be prefixed by + or – sign.

FLOAT – Can be prefixed with an optional + or – sign followed by one or more numeric digits. These may be followed by a decimal point and one or more numeric digits. This may be followed by an “e” or “E” for an exponent, followed by an optional + or – sign, followed by one or more numeric digits. An example is 34.79e-12

DECIMAL – May be prefixed by an optional + or – sign, followed by one or more numeric digits, followed optionally by a decimal point and one or more numeric digits. An example is +34.87.

DATE – must be in any valid date format for the system being used. Examples are 10/31/2009 and 2009-10-31.

DATETIME – must be in any valid time data format for the .Net system being used. An example is 10/29/2009 3:35 PM.

MLTEXT – Multi-Line Text. Same rules as for text except these can contain embedded carriage return or new line characters.

YNBOOL – Must be one of the characters “Y” or “N”, and used to specify the yes/no binary data types found throughout BellHawk.

JSON - a set of parameters in JSON format - such as {"Color":"Blue","Size":"Large"}. Please see next section on User Defined Parameters for details.

Please note that the maximum length for each of these fields is specified in the HLDO definition for each parameter for the object in question.

12. User Defined Parameters

12.1 Introduction

Using Excel HLDO imports (see previous sections), BellHawk has the ability to setup User Defined Parameters (UDP) which enable the capture of user defined data items as part of transactions recorded by BellHawk.

These can be values, such as the specified hardness of a metal rod received from a supplier, or the measured PH of a chemical mix in a test/QC operation. They can also be used to enter the color and size of custom products made with a common Item number or the length and width of off-cuts.

The parameter values captured can then be used on standard reports, exported through DEX for custom reports and exports to EDI system, and printed on custom barcode labels using the BellHawk TAG barcode labeling options.

UDP parameters can also be setup for capture when entering purchase, pick, work, and ship orders. These custom parameters then appear on the order screens and barcoded receiving and picking sheets to guide the material handlers and equipment operators. These UDP values are also available through the DEX interface for custom reporting purposes.

One of the big benefits of being able to setup user defined parameters for item configuration is the ability to use a single part number to represent items which have many different sizes, colors or other options. This is especially beneficial for make-to-order organizations, as well as distributors, who make or distribute common products in many different sizes and colors. It is also very useful for tracking the inventory of off-cuts returned from manufacturing processes.

User Defined Parameters are also useful in food processing where they can be used to capture data such as harvester, where harvested, and when harvested for each container of ingredients received.

12.2 Background

One of the challenges the development team faced with the web-server version of BellHawk was that almost all of the organizations using BellHawk wanted to capture additional inventory and work-in-process data that is unique to their specific business. At the same time, we wanted to make sure that BellHawk, as far as possible, worked without customization to meet the business needs of our clients. We also wanted to ensure that the database tables had only the needed column data, so as to maximize real-time performance.

To meet these customization requirements, with the old client-server version of BellHawk, the development team used to modify each client's database to add additional columns to multiple tables. This made maintenance and upgrades a very significant challenge as each client's BellHawk database was unique. It also often made the size of the database tables much larger than needed, with a resultant negative impact on real-time data collection performance.

Early in the development of the web-server version of BellHawk, we introduced the ability for BellHawk to collect up to eight different parameters, depending on material-type, in transactions recording materials into inventory. We also added the capability to capture user defined reason codes, where appropriate, for activities like scrapping materials and changing their QC state.

These, however, proved inadequate to meet the needs of many clients for custom data collection.

As a result, the web-server version:

1. Restricts the columns/fields of each table in a standard BellHawk system to just contain the data that is common to all applications, i.e. those which are needed to run BellHawk "working-out-of the-box".

2. Adds a UDP (User Defined Parameters) column to each table, as standard. This contains all the additional parameters that the system may collect as a JSON format string (see below).

In this way, BellHawk can use a standard format database and still collect additional parameters, which are unique to each client.

12.3 The Nature of UDP Data

UDP data is of the form of name:value pairs, such as `Width:30,Color:Blue`, etc.

UDP data is stored in a single Varchar(MAX) column added to each table and named UDP. The UDP data is stored in industry standard JSON format, which looks like:

```
{"Width":"30","Color":"Blue"}
```

In this way we are able to store a wide variety of user defined data within a standard BellHawk database.

UDP data is an extension to regular HLDO (High Level Data Object) data used throughout BellHawk and obeys the same data typing rules.

12.4 Setting Up and Using UDP Parameters

UDP parameters are setup using Excel HLDO imports into BellHawk through its web-browser interface. These are then stored as entries in the UDP fields of objects such as Items.

Once these UDP parameters are stored, they can be used as part of transactions that record the entry of containers of material into inventory to capture additional user defined parameter data. This data can then be used as part of reports, custom barcode labels, and exchanged with other systems, including those of upstream and downstream supply-chain partners.

13. Composite Part Numbers

13.1 Introduction

For those users of BellHawk who make semi-custom and custom products, the ability to track parts and containers of material using generic part numbers and attributes such as length, width, color, and size is very powerful. This is because this method can dramatically reduce the time to setup Item Master part records in BellHawk and in their accounting or ERP system.

One issue, however, that arises with the use of generic parts with user defined attributes to track materials, is how to report inventory.

While BellHawk may track the fact that there are many boxes of T-shirts, for example, in many different sizes and colors, it is not very helpful to simply list the fact that there are 57 T-Shirts in stock. What the user wants to know is how many of each size and color there are in stock.

BellHawk cannot simply list the inventory by part number and include the user defined attributes description of the inventory, as there may be many different attributes for different materials with the same part number. Instead we need to list the quantities of like parts, with the same user defined and standard attributes, on the same line but not list the contents of each container separately.

But not all user defined attributes may be important to the grouping of like items for inventory tracking purposes. For example, a user defined field containing the name of the quality inspector may be useful information to carry along for the material in each container but is not useful when used to group like inventory items together.

As a result, we use the concept of listing inventory by composite part number. These composite part numbers are created "on-the-fly" for reporting purposes. An example is "TShirt-B-L-UM" for a large, blue T-shirt with a U-Mass Logo.

Using Excel HLDO imports, users can define how to translate the part number and user defined attributes into composite part numbers for each type of material in their inventory. Inventory is then listed and grouped by composite part number, which makes it easy to see how many of each T-Shirt or other custom parts are in stock.

This same principle is used on "reports" such as picking sheets, work orders, packing lists, and Bills of Lading, where listing like-items with quantities on an 8.5" x 11" sheet of paper requires a concise description. It is also used when exporting Excel "reports" of inventory.

13.2 Specifying Composite Report Numbers for Reporting Purposes

The conversion between a generic part number, with user defined attributes, and the composite part number that appears in the Item Number column in the reports is specified in a Mask field that has been added to the Material HLDO. This allows differently structured part numbers to be used for different materials without needing to set up a Mask for each Item Master part record.

The Mask column in the Material HLDO setup contains entries such as "[Item]-[size]-[color,3]", where:

- [Item] is a predefined pseudonym for the item number - can be omitted
- [size] is a the parameter value for the part UDP parameter "size".
- [color,3] is a parameter value for the part UDP parameter "color" with a maximum number of characters of 3. If the UDP parameter value exceeds the designated number of characters, after eliminating any spaces, then the field will be truncated, by dropping trailing characters, to the designated number of characters.
- Everything else in the Mask is separator characters, which will appear in the composite part number. These must be valid TEXTID data type parameters. It is not necessary to use separators but these may help clarity.

When generating a report that lists items, such as "Items in Stock", BellHawk first generates an in-memory data set containing all the active containers records in inventory that meet the pre-selector criteria, such as Item Number, Category, or Material Type. As BellHawk is reading each record from the containers table, it replaces the Item Number column with the composite part number for each container based on the Item and the UDP parameters specified in the Mask for Item Material Type.

The data set will have columns for length and width. If the Item is dimensioned then we will add in the values for length and/or width, if specified.

BellHawk then sorts these by composite part number and adds up the quantities all entries with like composite part numbers and the same length and width and report the quantities of each composite part number having the same length and width values (within plus or minus .01).

Note that:

1. If there is no Mask for the Item's Material Type then the default mask of "[Item]" will be used for the composite part number. This ensures compatibility with systems not using UDP parameters and with items that are using specific and not generic part numbers.
2. In generating composite part-numbers all spaces are eliminated. Entries in the composite part number field can contain any valid UDP parameter.
3. For UDP parameters of type Choice, the choice values will be used in making up the composite part numbers. Thus color choices may be "Red", "Green", and "Blue" but the composite part number color field will contain the corresponding R, G, and B values.
4. Option type UDP parameters will appear as Y or N in the composite part number. If more meaningful values are required in the composite part number then these should be changed to Choice parameters.

5. Only parameters listed in the Mask will be shown in the composite part number. There may be other parameters such as the name of the inspector for the container that are not shown in the composite part number.

6. A composite part number, should:

    a. Not exceed 50 characters (same as a regular part number).

    b. Be a valid TEXTID type string.

7. If a specified parameter value in the Mask is not available then its value is replaced with a # symbol and a warning message is written into the log file.

13.3 Reports Affected

All of the BellHawk reports and their Excel export counterparts that use Item Numbers can have the Item Number column contain composite part numbers. These include:

- Inventory (in various formats)
- Material Transaction Report (in various formats)
- Receiving and Shipping Reports
- Expired Materials Report
- Receiving Sheet
- Ship Order Acknowledgement
- Picking Sheet
- Work Order Traveler
- Packing List
- Bill-of-Lading
- Load Report

13.4 Commentary

For those clients using BellHawk to track large numbers of different parts, the use of generic part numbers with user defined parameters can make the difference between being able to use an automated tracking system and being stuck with using paper forms. This addition of composite part numbers enables such users to be able to see their inventory presented in the way they want to see it while retaining the advantages of using generic part numbers.

Through the use of composite part numbers, we are also able to avoid the need to create custom reports to list inventory by user defined attributes.

Section C BellHawk Software Product Line Overview

14. The BellHawk Software Product Line

14.1 Introduction

The BellHawk software product line consists of three base systems as well as a number of optional modules, enabling BellHawk to be configured for each client's specific requirements.

Users can license one of the base systems, plus optional modules, on a subscription basis for use on a Software-as-a-Service in the Cloud, or on a rental or purchase basis for installation on the client's own Window Server computer. Clients also need to subscribe-to, rent, or purchase licenses for each data collection device (including DEX, weighing scales, and RFID data collection station) and for manager and staff user logins, in order to use BellHawk.

14.2 Base Systems

1. **BellHawk Material Tracking System (MTS)** contains all the features needed to do License-Plate-Number (LPN) tracking of raw, intermediate, WIP, and finished products in multiple geographically distributed warehouses, manufacturing plants, in-transit in vehicles, and at field sites. Captures materials traceability data as materials are moved from location to location.

2. **BellHawk Simple Production Tracking System (SPTS)** tracks work orders as they progress through multiple manufacturing, processing, or repair operations. SPTS can also capture labor expended on each operation. Only tracks the progress of work orders through operations, does not track materials except for piece-work quantities processed by each person on each operation for exporting to payroll systems through DEX.

3. **BellHawk Real-Time Operations Tracking System (RTOPS)** incorporates both MTS and SPTS plus adds the ability to track the transformation of materials through a sequence of work-order operations. Captures materials traceability data as raw material are transformed into finished good, including tracking work-in-process and its use on multiple jobs. Also captures cost data for making products by incrementally adding up the cost of labor and materials used in their manufacture.

Users can start with an SPTS or MTS systems and subsequently upgrade in-situ to an RTOPS system. Please see following chapters and sections of this book for details about each of these base systems, and the options listed below, for more details.

14.3 Warehouse Management Options

These optional modules can be individually added to the BellHawk MTS or to RTOPS systems. Usually, however, most clients use the WMS (Warehouse Management System) bundle, which includes all the modules listed on the next page.

Purchase Order Receiving Module (PO): Enables the entry or import of supplier purchase orders (POs) or advanced shipment notices (ASNs) for the receipt of customer owned materials. Produces POs that can be sent to suppliers by mail or Email and can also print out barcoded receiving documents. Tracks and records receipt of materials against PO/ASNs. Note that simple receiving of materials is included in the base BellHawk MTS system and does not require this option.

Ship Order Module (SO): Enables the entry or import of ship orders, which are typically based on customer sales orders. With RTOPS base system, this module includes generation of make-to-order manufacturing work orders based on the ship order lines. SO can generate a barcoded picking sheet to record picking and packing of materials for a customer order when used with the PICK module. Please note that simple shipping of materials is included in the base BellHawk MTS and RTOPS systems.

Picking Module (PICK): Enables generation of material picking and movement orders for ship orders, work-order operations, and material move tickets. Supports both self-directed and system-directed modes of picking. Produces and uses a barcoded picking sheet for recording self-directed picking. Also enables material handlers to easily find materials and pick oldest materials first.

System directed picking uses a tablet screen to direct material-handlers to move to different zones in the warehouse, and then directs them to pick all the needed materials in each zone. In both cases, BellHawk warns the material handler if they are trying to pick the wrong or potentially defective materials. It also automatically adjusts the picking instructions in real-time, for the actions of other material handlers, according to the amount of available inventory at each location.

Shipping Dock Option (SDO): Tracks loading of customer orders onto trucks/trailers at a shipping-dock. Warns material handlers if they attempt to load pallets or other shipping containers onto the wrong truck. Gives shipping supervisors visibility of what has been loaded. Sets up data to generate Bills of Lading and Advanced Shipment Notices. Ideal for make-to-order and engineer-to-order organizations that need proof of what was shipped to customer sites and when. Requires the use of the SO and PICK options.

Inventory Auditing Module (IAM): Enables blind and semi-blind inventory taking for financial audit purposes without shutting down operations. Tracks material that has moved. Produces discrepancy reports and spreadsheets. Tracks follow-up discrepancy resolution by materials manager. Please note that non-blind inventory checking and adjustment, such as would be used for cycle counting, is included in the base BellHawk MTS and RTOPS systems.

14.4 Quality Control and Materials Traceability Options

Quality Control Option (QC): Tracks the quality control status of materials from the time they are received to the time finished products are shipped. Prevents the use of materials that have not passed QC inspection to make products or their movement to non-QC inspection areas. Tracks reason-codes for quality failure and handles statistical inspection of lots. Also tracks material that needs to be reviewed into MRB locations.

When used with RTOPS adds the capability to integrate test operations, with data capture, which result in pass or fail of tested units.

Materials Traceability (TRACE): Enables users to interrogate materials history data captured by BellHawk RTOPS to trace what materials went into each product, enabling trace back from defective finished products to source components and their suppliers. Also gives the ability to trace forward to find all containers of products that may be defective, the customers to whom they were shipped, and the remaining materials in company warehouses. Enables rapid investigation of the source of contamination or defects and the minimization of resultant recalls.

14.5 Operations Management Options

While all of these modules work without customization, they are often customized to meet the specific operational and decision support requirements of each organization.

Project Management (PROJ): Tracks jobs/project activities from design, through manufacture and assembly, packing and shipping, as well as delivery and usage of materials at construction sites. Allows purchased and produced materials, as well as work orders, to be assigned to projects. Warns users if they attempt to use materials for wrong project or if they attempt to mix materials from different projects. This is very important for Department of Defense and other Engineer-to-Manufacture organizations. Provides project level reporting of PO, Work Order, and Ship Order status as well as inventory and work-in-process status.

Work Center Scheduling (WCS): Provides real-time scheduling of manufacturing operations. WCS is ideal for make-to-order or short-run, quick-turn manufacturers. Shows workers in each work center which work orders are waiting for them to work on, the date scheduled and the date wanted and the priority order for work orders. Employees or teams can then select the most important work order and the software assigns it to the employee or team. This helps ensure that employees are always working on the most important work order in their work center. This module also gives production supervisors the ability to view and to adjust the schedule by changing work order priorities and wanted dates.

Available Inventory Prediction (AIP): Tracks and predicts available inventory, taking into account materials in stock, on order and scheduled to be produced and consumed on work orders. Typically used with SO and PO modules. This performs the complex calculations needed for materials requirements planning (MRP) in real-time but leaves the decisions as to what parts to make or materials to order to the user. This makes AIP ideal for make-to-order manufacturers and other industrial organizations that must respond quickly to customer demands.

Demand Driven Materials Requirements Planning Module (DRP): This provides real-time incremental demand-driven materials requirement planning capabilities (MRP) for make-to-order and small batch manufacturers, as new orders arrive. It enables work orders to make parts, and purchase orders to buy parts, to be automatically generated, under manual control, from ship order lines based on the predicted availability inventory of needed parts. If parts are to be made, then DRP uses the bills of materials for these parts to be used, under manual control, to create more work orders or purchase orders for required parts. This can be continued recursively until all the required work orders or purchase orders have been created.

14.6 Equipment Related Options

Equipment Tracking Option (ETO): This module tracks the status of equipment, machines, and/or production lines in real time. Also tracks the setup, run, down, and cleanup time for equipment, product lines and machines. It also tracks reason codes that the equipment is down. This module includes allocating labor and equipment time, and materials consumed across the multiple work orders that are running at the same time on a piece of equipment or production line to get an accurate measure of production costs.

Rules Based Barcode Label Printing Option (TAG): While BellHawk will work with preprinted rolls of LPN barcodes, in certain applications users often needed to produce container labels that also contain human readable information, as well as other barcodes, in addition to the LPN tracking barcode. This module adds the ability to print custom barcode labels on demand using data stored within the BellHawk database, using user-defined rules. It can also preprint LPN tracking labels with human readable information for subsequent attachment to containers and parts. TAG software is normally installed in a Windows workstation in each facility so that it can print labels at high speed on barcode label printers in that facility while getting print requests from BellHawk located in a remote data center.

Weighing Scale Option (WSO): WSO runs as a background process in each Windows Workstation to which weighing scales are attached through an RS232 interface. WSO captures each stable weight of the weighing scale and relays it to BellHawk running in a remote data center. When weight inputs are required, in a transaction, BellHawk automatically inserts the weight into the appropriate data input box.

Please note that the code that runs in the workstation may need customization for specific weighing scales and the protocol they use.

Radio Frequency Tag Scanning Option (RFID): The BellHawk RFID option software runs in a Windows Workstation computer to which an RFID reader is attached and communicates the movement of containers with LPN RFID tags or composite RFID/barcode labels to BellHawk. The RFID software periodically gets reports of the LPN RFID codes that the antennas attached to the RFID reader are currently detecting. It then translates the RFID tag code of each new RFID tag it detects into a movement of the container, to which the RFID tag is attached, to the location of the antenna detecting the tag, and sends this as a Move transaction to BellHawk.

This enables the automatic recording of the movement of trolleys, carts, and totes around a factory and between buildings. It can also be used to record the loading of trailers and the receipts of pallets at a receiving dock. This is useful for accurately recording the movement of large items, such as pallets, but does not work well when there are many small items being moved together. This is due to limitations of industrial RFID technology where only 90% or less accuracy is achieved due to radio frequency interference when many RFID tags are broadcasting their presence at the same time.

15. BellHawk Materials Tracking System

15.1 Overview

The BellHawk Materials Tracking System (MTS) uses barcode scanning and mobile computing technology, combined with License-Plate-Number (LPN) container tracking methods, to track materials in warehouses, stock rooms, on production floors, in yards, at construction and other field sites.

MTS does not track inventory directly. Instead it tracks materials in containers, which may be nested inside other containers. It then tracks the movement of these containers as they move from location to location, which may be in different geographic locations.

MTS is designed for use in manufacturing, engineering, construction, laboratory, medical, and repair organizations as well as in warehouses and distribution centers.

MTS gives a real-time view of the status of inventory. Management users can also print out reports or obtain Excel exports giving the status of inventory and which items have fallen below planned minimum quantities. MTS can also be used to track work-in-progress of batches of parts or serialized parts as they travel from one manufacturing, test, or repair operation to another.

One major benefit of MTS is that materials can be tracked in real-time at multiple geographic locations including in warehouses, stock rooms, construction sites, manufacturing plants, and field maintenance sites.

15.2 What does MTS track?

The MTS system tracks the following:

- Entry into inventory and withdrawal of materials by part number, lot number, serial number, and expiration date.
- Real-time tracking of the location and movement of materials, including the movement of inventory between facilities and movement of materials to construction sites and return from site.
- Receipt and tracking of materials in barcoded bins or shelves, and in/on barcoded boxes, reels, rolls, barrels, and pallets.
- Receipt and tracking of serial numbered parts.
- Issuance of materials for production, assembly, or for installation and the return of unused materials to stock.
- Barcoded tracking of nested containers such as boxes on pallets.
- Shipping of materials to customers.
- Tracking the work-in-process status of serialized items as they travel through a sequence of manufacturing, repair, or test operations.

- Tracking of assets, such as tools, in stock rooms, on vehicles, as well as issued to departments or individual people.

15.3 Features of MTS

MTS tracks materials that have "License-Plate-Number" (LPN) tracking barcodes on individually tracked items and assets, as well as materials in barcoded containers such as boxes, barrels, and pallets. This tracking can be performed using pre-printed rolls of license-plate tracking barcodes, which are available at low cost from our partners. MTS can also track "loose" material, which does not have an LPN barcode, by location and by barcoded bin.

MTS can use "Dynamic Binning" methods to minimize the stockroom space needed to store materials. In this, it automatically records where every container of materials is stored. Then, when materials need to be retrieved, the operator is informed (on their mobile computer screen) where the materials are located in age-first order. In this way, materials can be placed wherever there is space without the problem of trying to find the materials.

MTS can inform material handlers as to the preferred location to put materials away but always gives the choice of putting materials away where there is space. This avoids having some bins and shelves overflowing when there is space elsewhere. It also enables stock rooms to dynamically cope with short and long term changes in requirements for storage.

MTS can be used for validating inventory quantities, either as part of periodic "cycle counting" operations or for spot checks.

MTS can be used for tracking maintenance inventory, including pre-positioned parts at various locations throughout a facility, and their use on maintenance jobs. It can also track the receipt, disbursement, and return of assets, including tracking those that need maintenance or inspection at regular intervals.

MTS can produce a report showing those items that have fallen below minimum required inventory as well as a report showing those items that are past their expiration date or need inspecting or maintaining. This latter feature makes MTS ideal for use in food processing and laboratory applications.

MTS can also be used to track when materials are loaded onto trucks and when delivered or used. This can make BellHawk ideal for "warehouse-on-wheels" applications as well as for construction activities where recording delivery to site can be a critical part of project management.

One of the biggest benefits of MTS is the ability to maintain materials traceability as materials are moved between multiple geographic locations including manufacturing plants, warehouses, yards, and field locations such as building sites. This includes tracking materials by lot and serial number, as well as by expiration date.

16. Simple Production Tracking Base System

16.1 Overview

BellHawk Simple Production Tracking System (SPTS) is a simple-to-use system that uses barcode scanning to track the progress of work orders through a sequence of operations. SPTS also captures the labor expended by individual people or teams on each operation.

SPTS is designed for use in manufacturing, fabrication, engineering, construction, assembly, repair and other industrial organizations.

SPTS gives a real-time view of the status of work-in-progress and captures the labor expended for subsequent analysis. Management users can print out reports or download Excel exports giving the status of work-in-progress and showing how long work orders are held up between operations.

16.2 How SPTS Works

Work Order

WO00000101

Importance: Standard
Date Wanted: 12/22/2015
Sales Order #:
Customer: CDE Furniture Manufacturers
Instructions: Make Stainless Steel Knobs

Step # : 1
Operation: Production: Lathe
Step Instructions: Lathe

Step # : 2
Operation: Production: Drill and Tap
Step Instructions: Drill and Tap

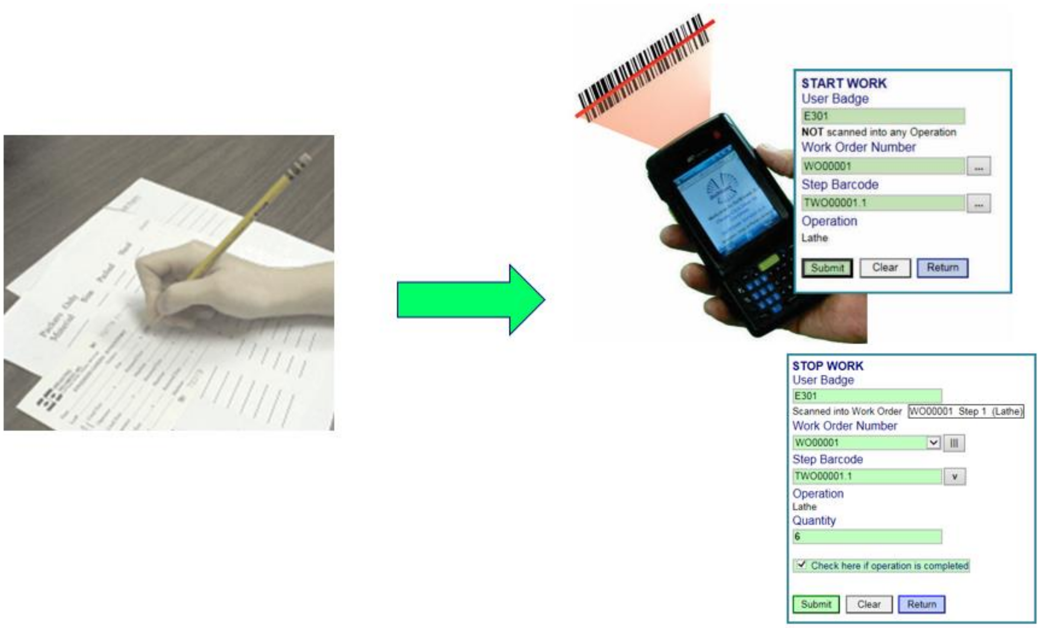
Step # : 3
Operation: Production: Polish and Inspect
Step Instructions: Polish and Inspect

With SPTS, users can set up production routes, and then use these to produce barcoded travelers, as shown here. These travelers can be scanned to track batches of material or individual items.

Alternately these work orders can be imported from another system using Excel spreadsheets the DEX interface for BellHawk.

Operators can then record the start and end of each operation by scanning the barcodes on these travelers. This includes recording their labor start and end times by scanning a barcode attached to their badge. They can also record the quantity produced or processed during this time.

SPTS enables organizations to easily transition from using paper forms and manual keyword data entry to having their employees directly capture work order tracking data on the shop floor. The biggest advantage of this transition is to enable managers to see the status of all their jobs in real-time so they can easily spot jobs that are in trouble or need extra attention. It also enables subsequent analysis of the labor performance of different workers.



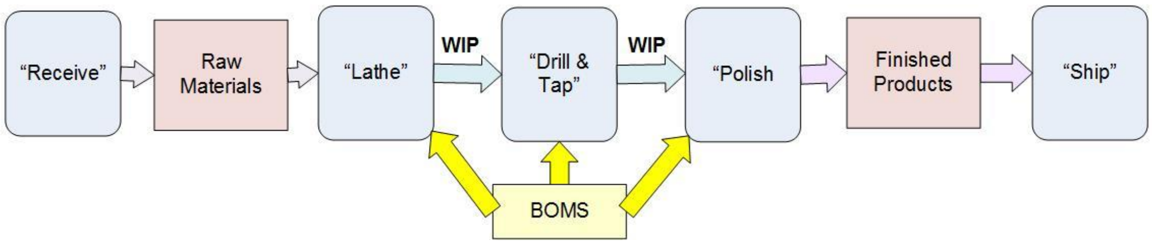
SPTS is designed for use by shop-floor workers who have limited computer literacy. By using barcode scanning manual data entry is minimized. Also, SPTS warns users if they make a data collection mistake and allows immediate data correction. SPTS only captures the minimum data needed for each tracking situation. This minimizes training time and eases the introduction of data collection technology to the shop floor.

SPTS enables the recording of time actually worked, as separate from the elapsed time to complete each operation, by enabling users to scan-out when they go on break or their shift ends. SPTS can also allocate labor time when someone is working on multiple work orders at the same time.

Managers, supervisors and customer support people, can then see the status of all the work orders in real-time, including how long each work order has taken or has been held-up, since completion of the last operation, waiting for the next operation to begin.

Managers are able to download Excel exports showing the progress of work orders, the elapsed time for each operation and how much labor was required. They are also able to get a labor report by work order or employee showing the amount of labor time, elapsed time, and quantity produced for each operation on the job.

17. Real-Time Operations Tracking Base System



The BellHawk Real-Time Operations Tracking System (RTOPS) is an integrated materials-tracking-and-traceability and operations-tracking system which is used by manufacturing, processing, testing, repair and distribution organizations in the industrial, medical, and construction supply chains to track the flow of materials.

RTOPS tracks the receipt and put-away of raw materials, their transformation through a sequence of production operations into intermediate and then finished products, and then their packing and shipping to customers, in real-time.

RTOPS integrates the license-plate-number (LPN) container tracking capabilities of BellHawk MTS and the production tracking capabilities of BellHawk SPTS and adds the ability to track the transformation of materials through a sequence of operations, including tracking the production and consumption of work-in-process materials.

This enables BellHawk to capture the cost of making each product as well as capturing a materials traceability history of which materials were used to make each product as well as who worked on which operation in making the products.

RTOPS also adds the capabilities to store the BOMs (Bills of Materials) required for each operation to make products as well as well as to store the expected labor and machine time for each operation.

This enables RTOPS to prevent mistakes, such as using the wrong materials on each operation for a work order, in making a batch of products. It also enables comparison of actual versus predicted costs for making each batch.

BellHawk RTOPS is designed to capture all aspects of transforming raw materials into finished products, including:

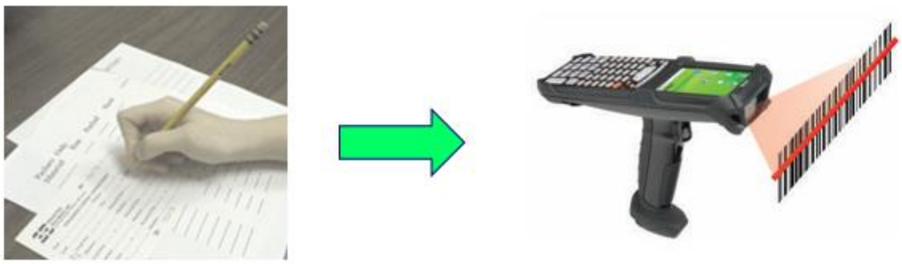
1. Providing managers, supervisors, and other staff members with a real-time view of work orders and materials, including the status of work-in-process (WIP) inventory and customer orders.

2. Collecting actual cost data in terms of labor and materials consumed to make products and compares this with projected costs.

3. Preventing mistakes, such as using the wrong materials for making a product, by comparing materials scanned-in with stored bills of materials for making products.

4. Tracking materials by lot-numbers, serial-numbers, and expiration dates and builds a traceability history of which materials were used to make which product.
5. Capturing performance data, such as how long each operation takes in making a product, how many parts were scrapped and the reasons, and how long materials were waiting at a location before being used or worked on.

One of the primary benefits of RTOPS is the labor cost savings and mistake prevention in transitioning an organization from using paper forms and manual keyboard data entry to doing real-time data capture using technologies such as barcode scanning and mobile computers. This not only gives managers a real-time view of the status of their operations but enables the system to warn material handlers and machine operators when they are about to make an operational or data collection mistake.



RTOPS is simple to use. All users need do is to use a PC, Mac, or Android based data collection device and point the web-browser on the device to the URL of the organization's private website. There is no special software to load. Data can be collected with any device with an external or internal barcode scanner that runs a modern web-browser.

Best of all, operational data can be viewed in real-time anywhere, and at any time, users have an Internet connection, including using smart phones and iPhones over the mobile phone data network. This enables organizations to track their materials and operations at multiple geographic locations including field and construction sites and on support and delivery vehicles.

RTOPS can be used stand-alone or can automatically exchange data with a wide-variety of legacy and Cloud-based ERP and accounting systems using the DEX interface. This enables BellHawk to be used as an extension to these systems to add the LPN materials tracking as well as work-in-process tracking and operations management capabilities of BellHawk.

18. Warehouse Management Options

18.1 Overview

The BellHawk Purchase Order (PO), Ship Order (SO), Pick Order (PICK), Shipping Dock Option (SDO) and Inventory Auditing (IAM) modules are available as separate options for BellHawk, which can be added to a base BellHawk Materials Tracking System as well as to the Real-Time Operations Tracking System. They are also available as the BellHawk Warehouse Management System (WMS) bundle.

The resultant BellHawk Warehouse Management System (WMS) is an affordable warehouse management solution that is suitable for use in manufacturing, industrial, food, pharmaceutical, construction, laboratory, medical, and distribution applications.

The BellHawk WMS uses barcode and wireless mobile computing technology to perform the following functions:

- Recording the receipt and put-away of materials.
- Tracking raw, intermediate and finished goods.
- Tracking materials by location or container or bin.
- Tracking withdrawal of materials from containers or locations for production or secondary operations.
- Recording return of unused materials from production operations.
- Recording the picking, packing and shipping of materials in nested containers.
- Tracks materials by lot and serial number as well as by expiration date.
- Tracks materials in nested containers such as cartons and pallets.
- Generates barcoded pick sheets and also performs directed zone picking.
- Performs “Cycle Counting” of inventory as well as inventory auditing.
- Records inventory adjustments and reason codes.
- Provides real-time reports and Excel exports for inventory status.
- Tracks who entered, moved or withdrew inventory and when.
- Can track materials in multiple stock rooms and warehouses, including off-site warehouses as well as floor stock in manufacturing plants.

BellHawk WMS uses a web-browser interface that is simple for material handlers to use with a wide range of mobile devices including Android tablets and ruggedized mobile computers with integral barcode scanners. It can also be used with fork-lift truck mounted barcode tracking systems which use touch screens as well as with fixed station PCs

18.2 PO Module for Purchase Order Receiving

The base BellHawk materials tracking system (MTS) and the Real-Time Operations Tracking System (RTOPS) allow users to record the receipt of materials from suppliers. Essentially this is a material entry with the selection of the supplier number and the entry of a tracking number, such as a PO number, as a text field.

The Purchase Order (PO) module expands upon these capabilities to enable:

1. The entry of purchase orders for inventoried items plus non-inventoried items, such as shipping charges, and the creation of purchase orders in PDF format for mailing or Emailing to suppliers.
2. The entry of multiple supplier bill-to and ship-to addresses.
3. Conversion between supplier part numbers and host-company part numbers, including conversions of quantities.
4. The entry or import of advanced shipment notice data for the receipt of customer owned materials as well as purchased materials.
5. Generation of barcoded receiving sheets to make it easier for receiving personnel to receive materials by scanning the PO number and PO Lines.
6. Using mobile devices to record the receipt of materials against purchase orders or advanced shipment notices. This simplifies the receipt of materials as it minimizes required data entry.
7. When used in conjunction with the weighing scale module, the PO module can be used to weigh incoming materials and to determine estimated quantities based on the net weight.
8. When used in conjunction with the TAG barcode scanning option, PO can be used to print tracking barcode labels with human readable information for attachment to incoming materials.
9. Can track the receipt of sequences of containers and generate sequenced labels for each container as they are received.
10. Editing and approval of each receipt before export to an ERP or accounting system. This includes the ability to edit the cost and quantity of non-inventoried items on the PO, such as shipping charges.

In addition, this module gives the ability to track the status of purchase orders, advanced shipment notices and receipts against those orders in real-time.

This module is required if purchase orders are to be imported into BellHawk from another system, such as an accounting, ERP, and MRP system. It can be used in conjunction with the User Defined Parameter (UDP) capabilities of MTS and RTOPS to enter and receive purchase orders for common part numbers with different sizes, dimensions, colors and markings.

18.3 Ship Order Module

The BellHawk Ship Order (SO) module expands upon the simple shipment recording capabilities of the base MTS or RTOPS BellHawk systems to enable:

1. The entry or import of ship orders for inventoried items plus non-inventoried items, such as shipping charges, and the sending of ship order acknowledgements.
2. Ability to include item length and width, as well as user defined parameters such as size and color, using a common part number, on ship order lines.
3. The recording of shipments against ship orders, including tracking back orders.
4. The use of multiple customer bill-to and ship-to addresses and the tracking of customer contacts.
5. Conversion between customer part numbers and company part numbers, including conversions of quantities.
6. Automatic generation of make-to-order work orders from ship order lines. This includes transferring user defined parameters, such as color and size, to the work order.
7. Recursive generation of make-to-order work orders and purchase orders from ship orders, when used with the Demand-Driven Materials-Resource-Planning (DRP) option.
8. With the Picking module:
    a. The generation of barcoded picking sheets for ship orders.
    b. The recording of materials picked and packed against these pick orders, including the generation of packing lists.
    c. The recording of materials shipped against each pick order.
9. With the Shipping Dock Option (SDO), SO gives the ability to record the loading of trucks, either from a staging area or by live-loading and generate Bills of Lading.
10. With the TAG barcode labeling software, SO gives the ability to generate shipping labels, including GS1 standard SSCC tracking barcodes, which can be used to record loading onto trucks and trailers, as well as for supply chain integration.
11. Editing and approval of each shipped order before export to an ERP or accounting system via a BellHawk interface or the MilramX software platform.

12. Generation of ASN nested container data for use by EDI software or integration with shipping system.

The SO module gives the ability for sales people to track the status of customer orders, ship orders, and related make-to-order jobs in real-time from anywhere they have an Internet connection.

Please note that Ship Orders are orders for physical shipments, which may be to customers, distribution centers, or third-party warehouses. They are different from customer orders, which may cover multiple shipments that take place at different times. Customer orders are typically managed in ERP, accounting, CRM or sales management systems, with required physical shipments being exported to BellHawk.

This module is required if ship orders are to be imported into BellHawk from another system, such as an accounting, ERP, or E-Commerce system. It is also required if BellHawk is to be integrated with a CRM or E-commerce system.

18.4 Pick Order Module

Pick Orders are orders to move materials from one location to another. BellHawk can generate pick orders from:

1. Ship Orders – to pick and pack materials for shipment to a customer.
2. Work Orders – to pick materials needed for a specific work order operation and to move them to the production location.
3. Material Move Tickets – to pick and move materials to a location where they are ready for use or to backup storage.

Pick orders are normally issued from within BellHawk but can also be imported by means of the DEX interface.

The BellHawk Pick module provides two alternate methods for picking:

1. Self-Directed mode
2. System-Directed mode

In Self-Directed, each Pick order is used to generate a barcoded picking sheet for a material handler, as shown here.


Pick Order P000033

Employee :

Ship Date : 12/11/2006

Ship Time : 10:30:00

Customer Name : XYZ Builders

Contract Number : C000030

Ship Order Number : S000043

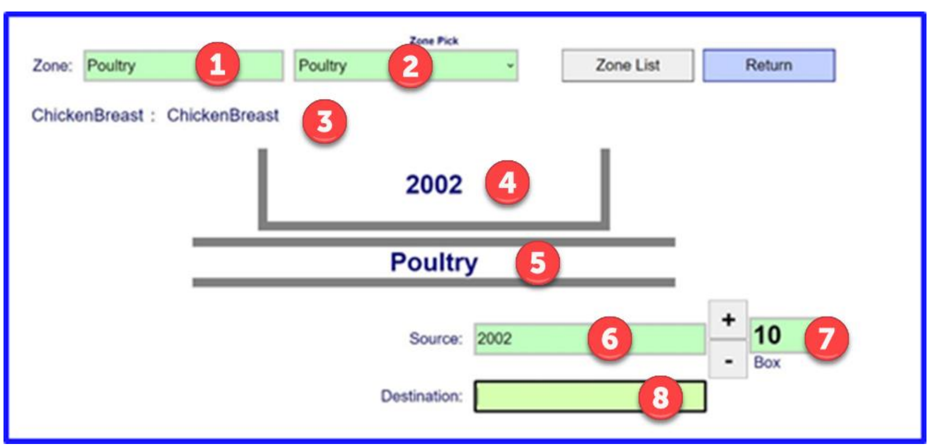
Pick Line Barcode	Part #	Qty To Pick	Qty Picked	Status
	T101 Red Roofing Tile	100	0	Released
	T102 Grey Roofing Tile	50	0	Released

The material handler can then pick materials in an order that makes the most sense to them based on their knowledge of the warehouse. If needed, the materials handler can use their mobile device to look up where the materials are located, in a FIFO or expiration date order, so they can pick the oldest materials first.

As they pick each line-item on the pick order, material handlers scan the line item barcode and the LPN tracking barcode on the container or part being picked or, if picking untagged material at a location, the location barcode. This will record the materials or parts as having been picked and will also warn the material handler if the wrong materials are being picked.

With System-Directed picking, by contrast, BellHawk determines what parts to pick from which locations based on the Pick Order and the location of the materials in stock. It then arranges the picking sequence by zones so that the person doing the picking will be able to pick all the parts in one zone before proceeding to the next zone, in an efficient picking sequence.

Shown below is a directed picking screen as an example of the directed picking screens used by BellHawk. Please note that these screens are typically customized for each specific picking application, as are the algorithms driving these screens.



On this screen, which is usually presented on a tablet screen, the user is presented with the warehouse zone (1) from which to pick the next product. Zones are simply a collection of shelves, which are designated as being co-located, so as to make it easy to pick this part of the order, without running up and down the aisle. This zone is automatically incremented as picking progresses, so that picking can proceed in an efficient order.

If needed, the zone can be changed manually (2) from a drop-down list when the system recommended zone is not accessible, at that time.

Within each zone, the system displays the next bin (4) from which to pick a product, along with the shelf on which the bin is located. Please note that these can be color coded on the screen to match bin and shelf colors, which again can help prevent mistakes.

The picker then scans the barcode on the bin (6) from which they are picking the product and the system warns the user if they are picking products from the wrong bin.

The quantity (7) to be picked from the bin is displayed, along with the ability to change the quantity picked. This can occur when an unexpected shortage in the quantity in the bin is observed by the picker.

If the picker changes the quantity downward then the system will automatically adjust the picking sequence to pick the missing product from another location, such as backup storage. Similarly, the picking algorithm can prompt the user to pick a quantity from multiple locations (based on zone) when there is not enough products in one bin.

Finally, the picker will scan the barcode (8) on the box into which the products are placed, which will record that line item as having been picked. As standard, the system will warn the user if they are attempting to mix parts for different pick orders in the same box.

Once the box barcode has been scanned, the system will then automatically move onto the next item to pick, until all items for that zone have been picked. Then it will move zones and the process will repeat until all orders have been picked.

At the same time, BellHawk enables pickers to become self-directed, when needed, choosing which zone to move to next (2). This solves the problem of multiple pickers waiting to enter the same picking zone at the same time.

The System-Directed Picking is optimal where many parts are to be picked from bins and shelves in close proximity. Self-Directed picking, is typically more efficient when a small number of parts is to be picked from widely separated locations as then the pickers can make use of their own knowledge of where parts are stored rather than rely on BellHawk's algorithm to direct them.

18.5 Shipping Dock Option

The BellHawk Shipping Dock Option (SDO) module is used in conjunction with the Ship Order (SO) module and the Picking (PICK) module to add the following capabilities to BellHawk:

1. Tracks loading of ship orders onto trucks, semi-trailers, rail-cars, and into ocean-freight shipping containers.
2. Warns operators if they attempt to load a pallet or other barcoded item onto the wrong Truck/Trailer.
3. Enables the shipping supervisor to see in real-time what has been loaded and what still needs to be loaded.
4. Supports the tracking of multiple orders being loaded at the same time onto a single Truck/Trailer.
5. Supports tracking the loading of mixed pallets and nested containers with a single scan.
6. Supports recording of each individual pallet or item as they are loaded. Also supports staging the materials to be picked and then recording the loading of everything in the staging area.
7. Produces a pre-load document for driver, to check items or pallets as they are loaded.
8. Produces a Bill-of-Lading for the materials actually loaded onto the Truck/Trailer once loading is finished.
9. Captures information about the Truck/Trailer and driver, if needed.
10. Captures Advanced Shipment Notice (ASN) data for feeding by means of third part EDI software to customers or warehouses expecting delivery of the shipment.

As a pallet is loaded onto the Truck/Trailer, a barcode located by the dock door is scanned followed by scanning the barcode on the item(s) or pallet being loaded. The individual items or the contents of the pallet are then checked against the orders being loaded and the material handler is warned on their mobile device if they are about to make a mistake.

The shipping dock option is fully integrated with the Ship Order module and enables editing of the shipment data, including shipping charges, before the shipment data is forwarded to an ERP or accounting system or used as the basis of EDI or ASN transactions with customers.

18.6 Inventory Auditing Module

The purpose of the BellHawk Inventory Audit Module (IAM) is to enable “blind” inventory auditing without requiring a warehouse to shut down while inventory auditing is taking place. Essentially a material handler:

1. Scans a barcode on a shelf or rack location to close that location to any further activity.
2. Records what is in that location.
3. Ends the auditing of the location, opening it up to further transactions.

While a shelf or rack location is closed for auditing no other transactions can take place against that location; but transactions can continue as normal in the rest of the warehouse.

At the conclusion of the auditing, the contents of the location recorded by the materials handler is compared with that which the system thinks that should be there.

If there is a discrepancy:

1. The discrepancy is logged in a discrepancy list for subsequent review by the materials manager.
2. If a container with a tracking barcode is missing then the discrepancy table is searched for it having been recorded in another location, and if so, it is automatically recorded as now being in the new location.
3. The discrepancies are displayed for the material handler so that the material handler can add an explanatory comment to the entry in the discrepancy table.

The materials manager can then view a list of discrepancies and resolve them in two ways:

1. By simply accepting the error. For example, if the audit shows that there are 498 nails in a bin rather than 500, then it may be best to simply accept this error and not make any correction.
2. By using an Adjust transaction to record the adjustment and then noting this adjustment in the discrepancy log table.

Please note that the Inventory Audit module does not replace the use of the Adjust transaction, which is used for cycle counting. In this mode, the location barcode on each rack or on each tracked container is scanned, using the Adjust transaction, and the system shows what should be at that location or in that container. An inventory qualified user can then enter an adjustment for the quantity of material at that location or in that container.

The Adjust transaction is part of a base BellHawk MTS system, whereas blind inventory auditing requires the IAM inventory auditing module in addition to MTS.

19. Quality Control and Materials Traceability Options

19.1 Quality Control QC Option

The primary purposes of the BellHawk Online Quality Control (QC) option are:

1. To prevent expensive mistakes being made due to operators using defective materials on jobs or material handlers picking defective materials for shipment to customers.
2. To collect history records of all inspections performed on materials so as to prove that specified quality control inspections took place and that the outcomes were appropriately controlled.

The base BellHawk system includes the ability to track materials by lot number, serial number, location, and expiration date. The BellHawk Quality Control module adds the capability to track the Quality Control (QC) status of:

1. Materials in tagged type 1 containers with an LPN tracking barcode, with a single part number, lot number, and expiration date.
2. Individually tracked items with LPN tracking barcodes, such as with serial numbers.
3. Materials in virtual containers in barcoded locations or type 2 barcoded containers.

As standard, the Quality Control module tracks the following states of material:

- Needs Inspecting
- Passed Inspection
- Failed Inspection with Reason Code.
- Needs Material Review by a Material Review Board (MRB)

In addition, developers can add their own QC states to the BellHawk Software.

BellHawk QC option gives the ability to designate quarantine and MRB locations. Material handlers will be warned if they attempt to move materials that have not passed inspection to non-quarantine areas. Also, material handlers will be warned if they attempt to pick materials that have not passed inspection for jobs or customer orders. In addition, operators will be warned if they attempt to use materials, which have not passed inspection, on jobs.

This module gives QC departments the ability to see, in real-time, all materials waiting for inspection at different locations. A QC qualified staff member can then go to the location and scan the tracking barcode on the container and enter whether it is passed or failed and, if failed, the reason why. Alternately, a QC qualified staff member can approve individual containers or whole lots or batches of material from a PC screen in their office.

The BellHawk Quality Control module enables items to be designated as not needing inspection, needing 100% inspection, or that they can be statistically inspected. If statistical inspection is used, whole lots can be approved at the same time. Alternately if the sample being tested has failed then the whole lot can be designated as failed or needing individual inspection.

The BellHawk (QC) module requires either the MTS or RTOPS base systems.

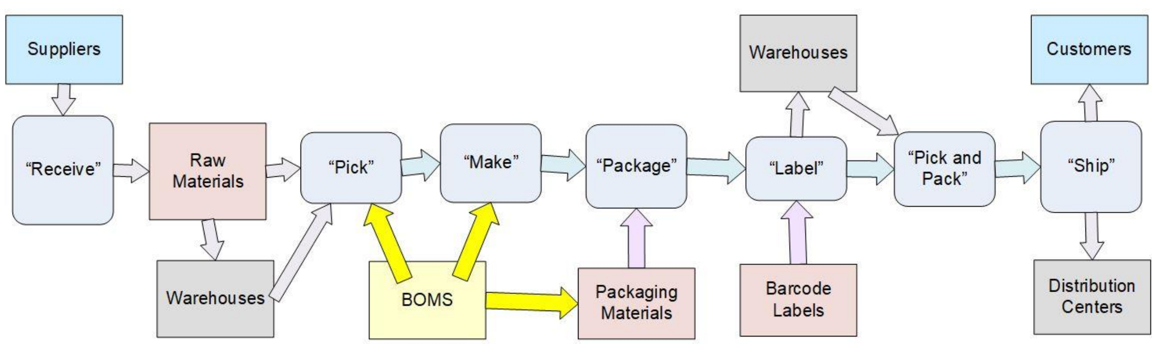
With RTOPS:

1. Parts, or containers of material, recorded out from work order operations may be designated as requiring inspection in the work order or Item Master record route step resources.
2. Operations can be designated as QC test operations, requiring that the QC status of the materials produced (passed, fail, etc.) be determined by a QC qualified person who is performing the test operation. This may be accompanied by the collection of test data results as part of the work order operation for each container of materials or individual item tested.

The QC module enables integration with external test stands and statistical analysis software packages that determine whether a part or sample taken from a container of material pass or fail the part or material.

The QC module also works with the BellHawk Materials Traceability module (TRACE) to enable marking all suspect containers of material to be marked as needing QC inspection before they are used or shipped to customers.

19.2 Materials Traceability Module



The BellHawk's Materials Traceability (TRACE) module is designed specifically for manufacturers, food processors and other industrial organizations that are required to maintain complete lot and/or serial number traceability throughout their operations. This option enables users to rapidly access all the materials tracking and traceability data captured by BellHawk.

BellHawk uses License-Plate-Number (LPN) container tracking methods to track the receipt and put-away of raw materials, their conversion into intermediate and finished products, including tracking containers of work-in-process materials. BellHawk then uses LPN methods to track the labeling, picking, packing and shipping of materials to customers or distribution centers. BellHawk can also track materials in multiple warehouses, at field sites, and on vehicles.

BellHawk stores all the data required for tracking and traceability compliance in a computer database so that it can quickly be accessed to provide the one-step-forward and one-step-backward recall data as required by ISO standards, the Food Safety Modernization Act of 2011, the Bioterrorism Act of 2002, HAACP, DSCSA and similar requirements. BellHawk enables organizations to minimize recalls when they have problems. This can not only save human lives but minimizes the cost and legal exposure from such incidents.

BellHawk provides a cost-effective solution that enables mid-sized manufacturers, food processors and other industrial organizations to track their inventory and production operations, including automatically collecting materials traceability data. BellHawk includes all the materials traceability capabilities required by the FDA, USDA, and HACCP. It also includes traceability capabilities required by aerospace, automotive and similar organizations.

BellHawk was designed to comply with the FDA's 21 CFR Part 11 regulations for software compliance and, as a result, can be used in Pharmaceutical and Biotechnology material tracking applications where validation is required.

BellHawk, as standard, captures all the needed tracking and traceability data in a series of history databases for materials, jobs, employees, and machines if BellHawk is used with the equipment tracking option (ETO). These can be accessed by clients who wish to generate their own materials traceability reports from BellHawk.

TRACE provides a set of screens which enable users to rapidly trace forward from defective raw materials to all the effected containers of products and the customers to whom they were shipped. This option also enables users to rapidly trace back to all the materials, people and equipment that were used to make a suspected product or defective intermediate materials.

A special feature of BellHawk's materials traceability capability is the automatic assignment of internal lot numbers to any material that BellHawk determines to be the same. This can be for a set of materials received at the same time, with the same item number, supplier lot number, parameters, expiration date, and serial number. It can also be for materials made at the same time from the same materials by the same people and equipment.

These internal lot numbers are generated and assigned to containers of material irrespective of whether an external lot number, such as a Julian date or a supplier lot number, is applied to the same materials. BellHawk can generate multiple internal lot numbers for each external lot number and tracks the relationship between them.

BellHawk internal lot numbers are invariant in space and time. Once issued these internal lot numbers do not change. They are permanently carried along by material, even though this material may have been split into multiple different containers in many different locations at multiple different times.

BellHawk also tracks which internal lot numbers of material are used to make which internal lot numbers of WIP, intermediate, or finished products. This enables BellHawk to maintain materials traceability records for products made at some time in the past using materials that are no longer in stock, including WIP materials in reusable containers such as Vats and Silos.

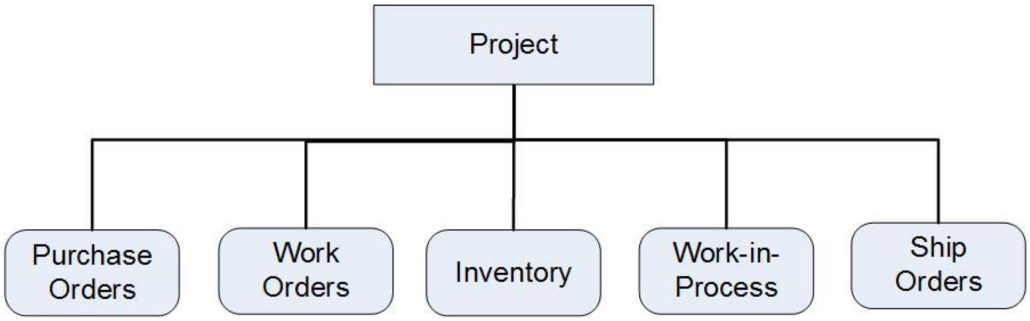
Also, when materials are received in bulk, such as a pallet load of materials received in separate containers such as bags or cans, the internal lot number assigned to the pallet at time of receipt is automatically assigned to each container as it is withdrawn from the pallet and receives its own LPN tracking barcode.

A key feature of TRACE is that users do not have to assign and record lot numbers for all materials they use in their manufacturing or distribution process. BellHawk automatically assigns these and then the TRACE module provides a convenient way of finding, tracking, and tracing all the internal lot numbers that belong to a specific shipment, were made on a work order operation, or were received from a specific supplier on a specified purchase order.

TRACE can also start with a supplier’s item and lot number for defective material and quickly generate an Excel export of all possibly effected containers of products, showing where they are located or who they were shipped to, thereby minimizing the risk of an expensive recall.

20. Operations Management Options

20.1 BellHawk Project Tracking Module



The BellHawk Project Tracking option adds a set of features to BellHawk that enable the real-time tracking and management of make-to-order, engineer-to-order, construction, refurbishment and similar projects or, as some organizations refer to them, jobs.

Within BellHawk, projects are at the top-level in a hierarchy of work orders, sales/shipment orders, purchase orders, and materials for a customer project. They enable users of the BellHawk Project option to see the real-time status of all materials and work orders, as well as open purchase orders and shipment orders for each project.

The project tracking option adds the following capabilities to BellHawk:

1. Screens on which to create and manage projects.
2. Ability to associate multiple customer sales/shipment orders with projects.
3. Ability to associate multiple work orders with a project. These can be work orders for manufacturing, engineering, assembly or repair or test jobs.
4. Ability to specify the purchase of parts or materials for specific customer projects.
5. Ability to record the receipt of customer owned materials for projects.
6. Tracking materials by project including warning material handlers if they attempt to mix materials purchased for different projects in the same bin or location.
7. Ability to specify project specific locations in a warehouse or stock room such as to cause BellHawk to warn material handlers if they attempt to put materials in locations not designated for the project to which they belong.
8. Ability to handle both project related materials and common stock. This includes the ability to substitute common stock for project specific materials on jobs.
9. Warning operators if they attempt to use materials purchased for one project on a job for another project.
10. Tracking materials, sub-assemblies and assemblies by project including materials shipped to customer sites.
11. Warning material handlers if they attempt to pick and ship materials belonging to another project to the wrong customer site.

12. Ability to see the real-time status of all materials on a project including all materials in stock, on-order, being made, and to be shipped to site.
13. Ability to track the labor used on projects by the work order and operation.
14. Ability to track equipment time used by the project.
15. Ability to report Inventory and Work-in-Process for specific projects
16. Ability to produce summary Excel export listing all project related Purchase Orders, Ship Orders and Work Orders and their current status.

Please note that some of the capabilities listed above may require optional modules in addition to the BellHawk RTOPS and the Project Tracking option.

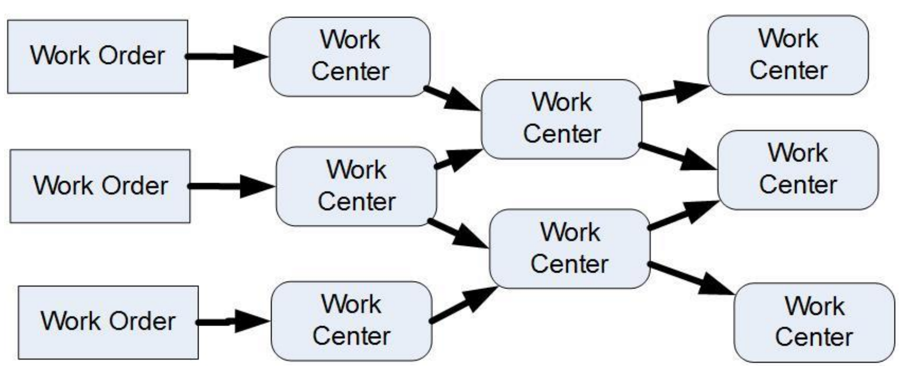
The BellHawk Project Tracking module enables all the information related to each customer project to be flagged as belonging to that project. This includes materials, labor and equipment time consumed on that project. This data can then be exported to ERP and project management software on a project-by-project basis.

BellHawk, with the Project Tracking, enables the real-time tracking and management of complex projects, which may take place at multiple geographic locations, including operations that may take place in the field and equipment assets that may be rented to customers for the duration of the project.

Please note that BellHawk uses the term “Project” rather than “Job”, which is often colloquially used to refer to what BellHawk calls a project. This is to avoid confusion with Work Orders, which in some organizations are also referred to as Jobs.

The Project option makes BellHawk especially useful for Defense and other Government contractors who are required to prove that materials purchased for a specific project are only used on that project and not comingled with common stock inventory.

20.2 Work Center Scheduling Module



The BellHawk Work Center Scheduling (WCS) module helps manufacturing and other industrial organizations ensure that customer orders get shipped on time by dynamically prioritizing work-orders through multiple work-centers. In performing this real-time scheduling, the BellHawk software takes into account the real-time status of each job, when each operation is supposed to be completed, when the order is planned to be delivered, and the importance of the customer order.

This rules-based scheduling takes place dynamically, in real-time, advising employees in each work center what is the highest priority task for them to work on, without needing invtervention from managers or supervisors. It automatically allocates more resources to jobs that are likely to be delivered late or are more important to the organization.

This form of scheduling allows dynamically for new orders to enter the system, machines that break down, people that get sick, and materials that are late arriving. It is ideal for short-run, quick-turn make-to-order manufacturers who do not have the benefit of long run planning or scheduling visibility.

The BellHawk work-center-scheduling comes with a standard set of rules that work for many organizations. More complex rules and algorithms can, however, be added, if needed. Such rules can take into account employee skills and equipment capabilities as well as materials availability.

The work center scheduling gives managers control over the rules, algorithms, and their parameters that are used but the scheduling runs quite automatically in real-time. This eliminates the need for employees to repeatedly contact their supervisors for guidance as to what to work on next. Also, managers and supervisors do not need to devote time to rescheduling operations whenever perturbing events occur.

When an employee in a work center finishes work on one task, they are given a prioritized list of other tasks they can work on. In this way the employee can, if needed, over-ride the system's recommendation based on their knowledge of a situation that would preclude them from doing the highest priority task. This over-ride is, however, recorded for subsequent review by the employee's supervisor to prevent "cherry-picking" of easy jobs by employees.

Planning and scheduling systems, typically found in ERP systems, that schedule work orders through work centers based on a sales and operations plan, and the predicted availability of people and equipment, require a substantial amount of work by one or more people to keep the database of available resources current. They also require a forecast of future demand from the sales department, which is often hard to get and is frequently inaccurate.

BellHawk, by contrast, simply uses the data captured as a standard part of real-time tracking of inventory and production processes, together with known ship orders. As a result, it does not need a person or team dedicated to planning and scheduling operations. This can make adding a BellHawk real-time scheduling system to a BellHawk data capture system, a simple decision that can significantly reduce overhead cost.

In a long-run manufacturing operation, BellHawk is not as optimal in its scheduling as running a resource-limited scheduler to plan operations. But, in a dynamic short-run, make-to-order, manufacturing operation, the BellHawk work-center scheduling algorithm makes much better use of whatever resources are available to process whatever orders come in and to get them out on time, if at all possible.

This mode of scheduling is based on prior research into systems that provided advice to fighter pilots. Here it was quickly learned that it was much better to give good advice quickly, to keep pilots out of harm's way, than to recommend an optimized plan, after they had been shot down.

The same applies to scheduling jobs through a quick-turn manufacturing plant. A sequence of good scheduling recommendations, made in real-time, as the operational status of the plant changes dynamically, is far better that a fixed schedule made with great precision days or weeks ahead of time.

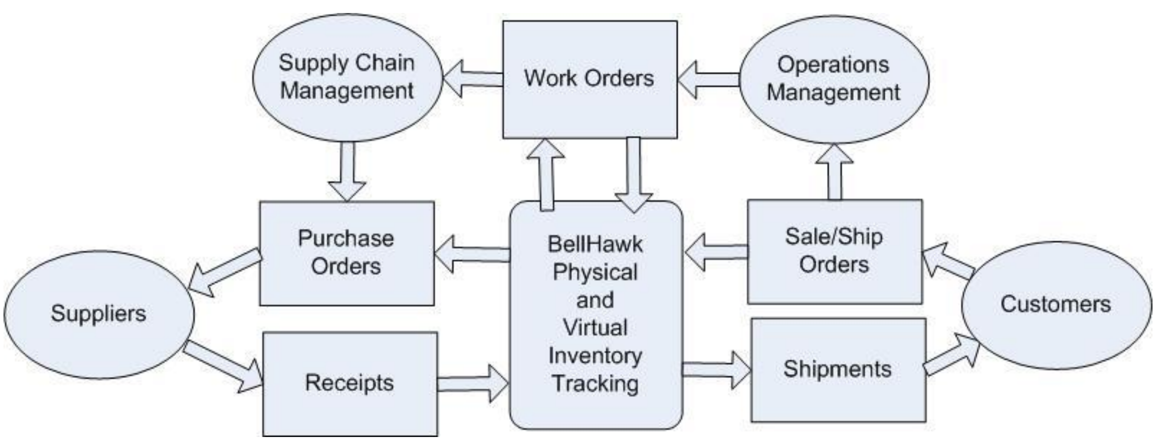
While BellHawk WCS can be used “out-of-the-box” it is typically customized, based on the use of the BellHawk platform, to meet the specific needs of each organization. In this role, WCS provides all the mechanisms needed for the implementation of a customized real-time scheduling system for single or multiple-plant operations.

20.3 Available Inventory Planning (AIP) Module

In quick-turn, make-to-order manufacturing, it is not sufficient to just track physical inventory. It is also important to track what you have on order, what you are going to make or consume on work orders, and what you are planning to ship.

You might, for example, have 10 widgets in stock and release a work order to consume 8 of them only to find that another work order, for another customer order, has been issued which will use 6 of these. As a result, although you might have 10 units in stock, you are out of inventory. Or, you might assume that you need to order another 4 widgets only to find out that you have already issued a Purchase Order (PO) for 6 more widgets, which are expected to arrive tomorrow.

The BellHawk Available Inventory Prediction (AIP) module solves this problem by tracking predicted inventory as well as physical inventory.



It does this in its virtual inventory table which contains the following fields:

- Item Number
- Quantity to be added or subtracted
- Expected date of add or subtract
- Reason for Add or Subtract (PO, Work Order, Ship Order)

This table is used as follows:

- Whenever a PO is entered then add entries are made for all PO lines with the expected date of receipt.
- Whenever a Receipt is made against a PO line then this increases physical inventory and reduces the corresponding add quantity in the virtual inventory table.
- Whenever a Ship Order is entered then a subtract entry is made for all the SO lines with the expected date of shipment.
- When a shipment is made against an SO line the physical inventory is reduced and the corresponding subtract quantity in the virtual inventory table is reduced.
- When a work order is entered then subtract entries are made in the virtual inventory table for the materials to be consumed on the work order, based on its expected bill of materials, with the expected start date. Also separate add entries are made for the materials to be produced by the work order at the wanted date.
- Whenever materials are recorded into a work-order route step/operation, the physical inventory is reduced and the corresponding subtract quantity in the virtual inventory table is reduced.
- Whenever materials are recorded out of a work order then this increases physical inventory and reduces the corresponding add quantity in the virtual inventory table.

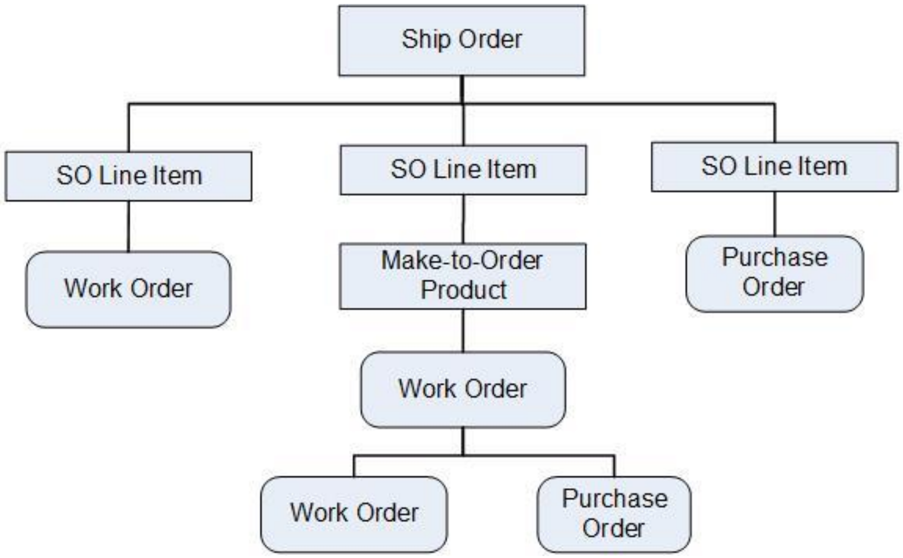
In this way, BellHawk keeps track of the expected materials to be added and subtracted from inventory and the dates when these changes are expected to happen. This data is used, along with the physical inventory to produce a screen which shows the available inventory, in real-time, with details of physical inventory, inventory to be received, inventory to be made and consumed on work orders, and inventory to be shipped on customer orders.

Details of the predicted inventory can also be exported as an Excel spreadsheet with details of when the available inventory will increase and decrease, with the reason for each change. This available inventory screen and Excel export then provide the real-time information needed by production and materials managers as to what materials will be available and when. This enables these managers to make informed make or buy decisions for needed materials.

20.4 Demand Driven Materials Resource Planning Module

While many BellHawk clients use the Available Inventory Prediction (AIP) module as the basis for issuing orders to buy or make materials for customer orders, this process can be made easier for make-to-order and quick-response manufacturers by the use of the Demand-Driven Materials Resource Planning (DRP) option. DRP facilitates the creation of purchase orders and work orders in response to lack of available inventory for new customer orders and work orders.

The BellHawk Demand Driven Materials Resource Planning (DRP) module, works in conjunction with the BellHawk Available Inventory Prediction module (AIP) to facilitate the creation of Purchase Orders (POs) and Work Orders in response to customer Ship Orders (SOs).



The BellHawk Available Inventory Prediction (AIP) module tracks materials which are on-order, to be consumed or made on work orders, or to be shipped to customers. BellHawk AIP tracks this so-called virtual inventory in addition to physical inventory, so as to give operations managers and supply-chain mangers a real-time view of what needs to be made or ordered in response to customer orders.

Based on the data provided by AIP, managers can manually issue work orders and purchase orders. This, however, can require a significant amount of duplicate data entry, copying data from customer orders to work orders or to purchase orders. This can become especially tedious when the SO line is for an assembly, which consists of multiple sub-assemblies, which consist of parts to be made and parts to be ordered.

DRP solves this problem by using the screen shown below to automate the creation of POs and Work Orders based on the ship order lines. At the ship order line level, the user is given the option to create a work order or issue a purchase order for the line item.

Item #	On-Hand	Alloc	On Order	Avail	Needed	Type	Create
P101	220	110	100	10	50	Purchased	Work Order PO
BP103	5	25	20	0	10	Made Here	Work Order PO
GR112	300	400	0	-100	50	Made Here	Work Order PO
CR39	19	0	100	119	50	Purchased	Work Order PO

If a work order is selected then the bill of materials (BOM) for the assembly or item is presented, with the option to purchase or make each part. This can be carried down recursively until only items to be purchased remain.

At each level, the user is presented with the physical inventory quantity on hand, the amount already allocated to customer orders or to other work orders, the quantity to be purchased or the quantity to be made, and the net quantity available, along with the quantity required according to the BOM for the item to be made. The user can then choose to create a work order, if the item can be made in-house, or to order the item from a supplier, depending on the manager's make/buy decision.

If a work order is to be created, all the necessary information is copied for the item to be made into the work order, with a default quantity of the difference between that needed for the job and the quantity available. This quantity can then be modified, if needed.

If a purchase order (PO) is to be created then the item can be added to an existing open but not released PO or a new PO can be created. Again, the PO and/or PO Line data is copied automatically, thereby avoiding duplicate data entry.

At each level in this recursive process, the system suggests wanted dates for purchase orders and work orders, as well as suggesting start dates for work orders, depending on the number of days for expected delivery or production. These dates can be modified by the manager using DRP as can the importance (low, standard, rush, etc.) assigned to the order.

At each level, DRP is creating unreleased work orders and purchase orders, which can be released immediately, or left to production managers and purchasing agents to finalize, schedule and release.

Note that this incremental real-time demand-driven planning process is very different from a conventional MRP (Materials Requirements Planning) system, which comes with most ERP (Enterprise Resource Planning) systems. These MRP systems start with a several months forecast of the products that need to be produced. They then recursively compute when work orders need to be released or products ordered based on pre-stored

BOMs for each item. This works very well for long-run manufacturing with predictable demand for product but does not work for short-run, quick-turn manufacturing where customer orders, and especially change orders, have lead times measured in days not months.

While most make-to-order manufacturers may have a projected aggregate demand level, the actual mix of customer orders with all their possible options and variations can vary dramatically from week to week. Often products need to be designed after the receipt of customer orders and so BOMs for products are not known ahead of time. This can make conventional MRP systems unusable in these applications.

The use of DRP differs from the use of a conventional MRP system in the following ways:

1. Each customer order is added incrementally to the materials purchasing and manufacturing plan as it occurs. There is no need for long range forecasting of demand, as if that were possible anyway in most make-to-order and quick-turn manufacturing shops.
2. BellHawk DRP is an advisory system that puts an experienced manager in the middle of the planning and decision making process, enabling them to make incremental decisions about what to make or buy. This is in contrast to a conventional MRP system which comes up with a plan according to some rules. These plans then typically need to be drastically modified, to correspond to reality, as time passes between when the MRP plan was produced and changes happen in customer demand and in events, such as machines going down, on the production floor.
3. DRP is an advisory system, which uses "artificial intelligence" rules to guide the user of the planning module and to automate many of their tasks. These rules can be setup in the BellHawk knowledge-base by each client by importing Excel spreadsheets that specify the rules for their business. This enables the user to take advantage of the computer to do specific knowledge-based tasks, such as recommending how much of each material to purchase. But, at the same time, it enables the user to take advantage of their general knowledge, such as about special quantity discounts being offered by vendors or about make-versus-buy tradeoffs in the decision-making process.
4. Like an MRP system, BellHawk DRP does rely on having a bill-of-materials (BOM) for each assembly or sub-assembly to be made. But, in the case of DRP, these BOMs can be generated by computer aided design software after the customer order is received. Then the POs and work orders can be created in response to the imported design data. This is in contrast to conventional MRP where the BOMs for all parts need to be established ahead of each several month MRP planning run.
5. Unlike conventional ERP systems BellHawk DRP allows the use of a generic part number that can encompass many options, sizes, colors, and finishes, that are specified at customer order or design time. This enables the use of generic BOMs to make assemblies with the options being inherited by the sub-assemblies, components, and purchased parts. This makes the use of DRP much easier for many make-to-order and semi-custom manufacturers.

6. BellHawk can also track off-cuts by length and/or width and include these in the available inventory calculations for use by DRP. This enables efficient use of off-cuts and avoids ordering or making more materials when sufficient off-cuts are in stock.

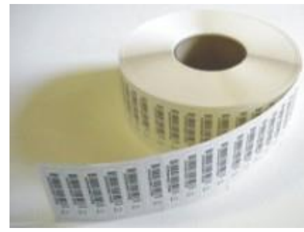
The AIP and DRP modules can be used to complement the MRP functionality of ERP systems. Here the ERP/MRP system is used to do long range materials planning and to order long-lead materials. AIP and DRP can be used to generate supplemental purchase orders for additional materials, when needed, which can be included in the next MRP long range materials plan.

For those organizations that do not need to do long-range materials planning, a major cost savings that can result from using DRP and AIP is that clients may not need the ERP system's manufacturing or MRP module. Also, clients may not need to incur the cost of licensing the needed "seats" to support detailed tracking of manufacturing data in the ERP system. Instead the ERP system simply becomes an accounting system, which only requires a few seats for tracking and reporting finances. In this case, the inventory and production tracking is done in BellHawk, along with using DRP and AIP to do all the materials planning at substantially lower cost.

While it will work without customization, DRP is typically customized as part of a BellHawk platform approach to integrate custom planning rules appropriate to each client organization. With the addition of such rules, the execution of DRP can be automated when new customer orders are received or inventory levels fall below specified levels. This is typically done in conjunction with the MilramX software package.

21. Barcode Label Printing (TAG) Module

21.1 Purpose



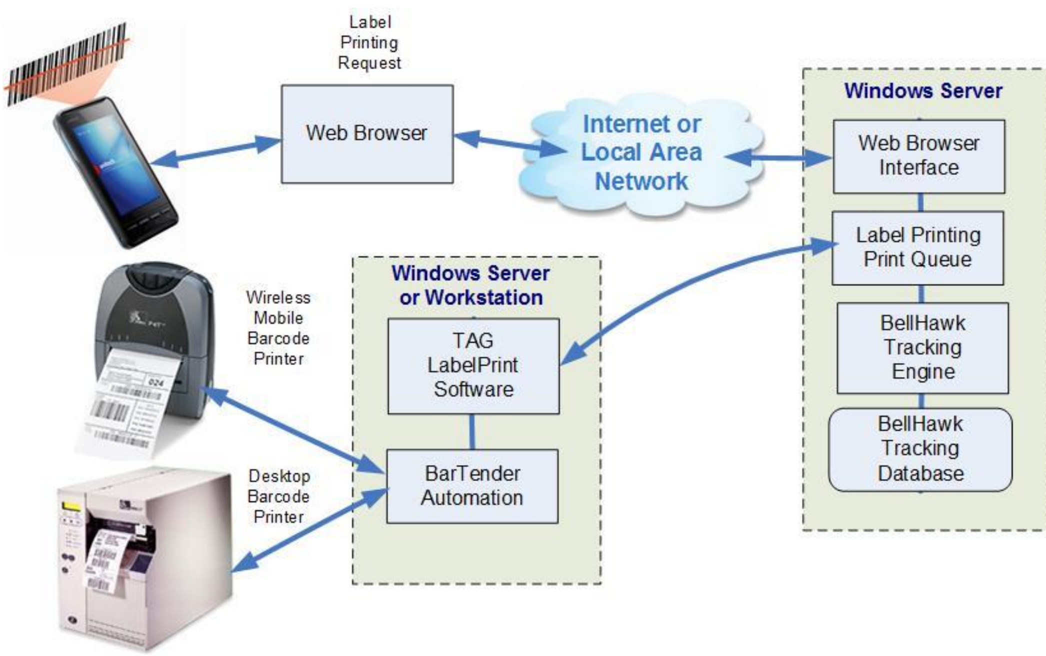
While BellHawk can track materials using pre-printed rolls of License-Plate-Number LPN tracking barcodes, such as that shown here, users are often required to apply barcode labels with human readable information, in addition to a unique LPN tracking barcode, and possibly other barcodes.

Such labels could be generated using a barcode label printing program by manually generating a unique tracking barcode and entering the other data before selecting a printer and manually printing out the required label. This is a time consuming and error prone process which can be automated using the optional BellHawk TAG module.

The purpose of the optional BellHawk TAG module is to reduce the time and eliminate mistakes in generating labels on barcode label printers for attachment to raw, intermediate and finished materials, as well as to assets and to shipping containers.

TAG does this by automatically selecting the correct label and printer for each specific situation, based on user defined rules. TAG then automatically fills in the data fields with the correct data from the BellHawk database. This eliminates errors resulting from selecting the wrong label format and manually filling in the wrong data.

21.2 How TAG Works



When an item or container of materials is being entered into inventory, a user can request that a tracking label be printed for the item or container. This is based on selecting a button on the screen of the device they are using, after entering the data about the item or container. This causes BellHawk to collect the appropriate data from the BellHawk database and place the resultant data in a label printing print queue in the BellHawk database.

If the TAG label printing software (LabelPrintS) is being run on the same server as BellHawk then LabelPrintS is launched as a background process by BellHawk. The LabelPrintS program then retrieves the printer name, the label format file name, and the data to fill into named fields on the label, from the print queue.

If label printing is being performed in a facility that is geographically remote from BellHawk then the TAG remote label printing software (LabelPrintR) is run on a Windows Workstation in the remote plant. LabelPrintR then monitors the Label Printing Queue remotely using the BellHawk web-services interface to get its print commands over the Internet.

The TAG LabelPrint software uses the BarTender Automation SDK (which must be running on the same computer) to populate the selected label format with the correct data and to cause the BarTender software to print it to the appropriate printer on the local area network. BarTender provides printer drivers for a wide range of barcode label printers as well as providing a tool for laying out the barcode label format, including specifying names for label fields.

An important advantage of TAG is that it can ensure that all the LPN tracking barcodes are unique, even across multiple geographically separated facilities, using a separate BLPA in each plant. Also, TAG can ensure that the labels all conform to GS1 standards.

21.3 BellHawk Label Printing Rules

In BellHawk, TAG rules can be imported using Excel spreadsheets. These rules can be used to specify which printer and label format should be used along with how the named fields on the label relate to standard and user-defined parameter values for the container or item to which the label will apply. These rules can be based on a number of factors, such as:

- Mobile device being used for data entry and the transaction being performed
- Part number, category, or material type or user defined characteristics such as a hazardous materials rating
- Type of container being used (box, bottle, pallet etc.)
- Customer to which the container or item will be shipped
- Quality Control status (passed or failed inspection)

These rules can also control how many duplicate labels and how many sequentially numbered labels (for different items or containers) are to be printed at a time.

For speed of barcode label printing, it is important that BarTender Automation be on the same local area network as the printers to which it is printing. These barcode label printers can be connected via the plant LAN or wireless network. They can also be plugged into PCs connected to the plant LAN or wireless network.

The TAG module can print out a wide range of information onto labels. This includes all the parameters associated with containers or individually barcoded items, such as part number, quantity, unit of measure, lot number, serial number, and expiration date. This information can also include customer and supplier names and address information. TAG can also be used to print out user defined parameters, such as sizes, colors, and hazardous equipment markings onto labels.

TAG can also drive combined barcode and RFID tag printers to create labels with embedded RFID tags (1), as well as LPN tracking barcodes (2) as shown here. The embedded RFID tags can be automatically interrogated to record the movement of containers from one location to another using the BellHawk RFID module.

21.4 Preprinting Labels

As well as printing barcode labels on-demand, as described above, TAG does support pre-printing of labels using a PC. This is so that barcode labels to be attached to containers or items can be printed ahead of time in an office environment.

While printing labels on-demand at time of application can help prevent errors due to placing labels on the wrong containers, there are situations where it is beneficial to print labels ahead of time. These include situations where:

1. The location where labels are to be applied would be hazardous to barcode labels printers due to dust, moisture, acidic, or explosive atmospheric conditions.
2. Large numbers of identical labels need to be applied to essentially identical containers by operators without needing to manage the reloading of media into barcode printers and fixing any jams that may occur. Here automated barcode label applicators are often used as part of automated production lines.

21.5 Transactions from which Barcode Labels can be printed

TAG supports print-on-demand and pre-printing of labels with the following material transactions:

1. Enter or receive material into inventory
2. Receive against purchase order
3. Record material out of work order step/operation
4. Return material from operation
5. Tagging pallets, totes, or other containers with a license-plate tracking barcode.
6. Packing materials into containers, such as boxes, and packing these boxes onto pallets

7. Picking and packing materials for customer orders
8. Shipping materials to customers

Print-on-demand labeling enables labels to be automatically generated as the operator is doing any of the listed transactions. The label format and the data on the label are automatically selected according to rules setup within the BellHawk knowledge-base by clients. TAG then uses the data entered during the transaction, along with other data in its database, to populate the fields on the label, via the print queue, including generating a unique "license-plate" tracking barcode. LabelPrint then automatically prints out the labels for the operator to apply to containers of material or individually barcoded items.

Each label contains a "license-plate" tracking barcode that uniquely identifies the container to which it is attached. This tracking barcode is then scanned to track the movement, usage, packing and shipping of the container.

With labels pre-printed through TAG, each label is printed with a pre-numbered "license plate" tracking barcode. Also the data about each container to which the label will be attached is stored in the BellHawk database. After the pre-printed label is attached to the container, the tracking barcode is scanned by the operator, and all the information stored with the label is transferred to the data entry transaction screen, thus saving duplicate data entry.

21.6 BellHawk Barcode Label Printing Structure

The TAG software consists of two components. The first is embedded within BellHawk. It uses user-defined rules to collect all the needed data for printing on the label, selects the printer and the label format to use, and then puts all the information in a label print queue in the BellHawk database. The second component, called LabelPrint, is run as a separate process. This reads the print queue entry and calls BarTender Automation to print the label on the designated printer.

Versions of LabelPrint are available for running on the same Windows Server as BellHawk and for running on a Windows workstation in a remote plant. The server version of LabelPrint is launched as a background process by BellHawk whenever a label print request is made from a data collection device. It gets the data from the print queue and then calls a version of BarTender running on the server computer to rapidly print out labels on printers attached to the local area network to which the server is attached.

When printing labels in a remote plant, LabelPrint is run as a process in a Windows Workstation in the remote plant. This version remotely monitors the label print queue and, when it sees a new print request, retrieves the data and calls a local copy of BarTender to print the label. As LabelPrint uses normal outgoing Internet access from the remote plant, no special firewall or security setups or VPN access are required for remote access. Also by being on the same LAN as the printers and BarTender, LabelPrint is able to rapidly print out labels on a wide variety of printers in the local plant.

TAG is designed so that multiple versions of LabelPrint can be accessing the print queue at the same time, printing out the labels on the designated printer in the appropriate facility from a common BellHawk tracking database.

21.7 Commentary

The LabelPrint processes are designed to be fully replaceable, as part of the BellHawk open-architecture concept. This enables clients to replace the use of BarTender Automation with different label printing software, if they already have a large investment in an alternate label printing software. This replacement can be done by the client's IT department or barcode equipment providers, if they have appropriate programming skills. Alternately, BellHawk partners can provide this replacement as part of a professional services task.

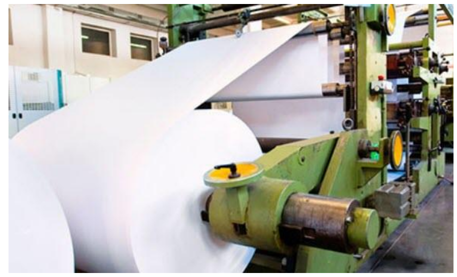
Please note that TAG and BarTender are not needed to print out forms, such as picking sheets with barcodes on them, from BellHawk as these are printed on office printers with software embedded in BellHawk. Also please note that TAG is not needed for materials tracking, which can be performed using pre-printed rolls of license-plate tracking barcodes.

BellHawk can work with barcode labels generated by other systems provided that the contents of the barcodes are appropriate and coordinated by data automated transmission to BellHawk from the system that generated the labels by means of the DEX interface.

However, for those situations where printing out labels in receiving, production, or packing is required, then it is generally much easier and less costly to generate the labels within BellHawk, as part of the normal transactional data entry, to save on data entry time and to prevent expensive label generation mistakes.

22. BellHawk Software Equipment Related Options

22.1 BellHawk Equipment Tracking Option



The equipment/line tracking option (ETO) module adds the following capabilities to the BellHawk Real-Time Operations Tracking System (RTOPS):

1. Ability to track the setup, run, and cleanup times and associated labor hours for equipment, production lines, and machines used on work order route steps or operations.
2. Ability to view the status of equipment in real-time including which work orders they are running.
3. Ability to track when equipment goes down and for what reason. Also, the ability to track when equipment is down for maintenance.
4. Capture of which equipment is used for which jobs along with the ability to capture operating parameters as part of the materials traceability history record.
5. Ability to include the cost of machines as part of work order and product cost.
6. Ability to allocate the time and cost of materials, machine, and labor costs across multiple work orders run at the same time on the same machine, production line, or piece of equipment.
7. Simplification of operator recording of a sequence of work orders run on the same machine.

Equipment operators or teams are able to scan into one or more pieces of equipment, machines, or production lines at the beginning of their shift and then scan a sequence of work orders onto and off of the equipment, machine or line. Their labor is then appropriately allocated across all the work orders they work on while running these machines as is the machine time and the materials consumed in the run-group.

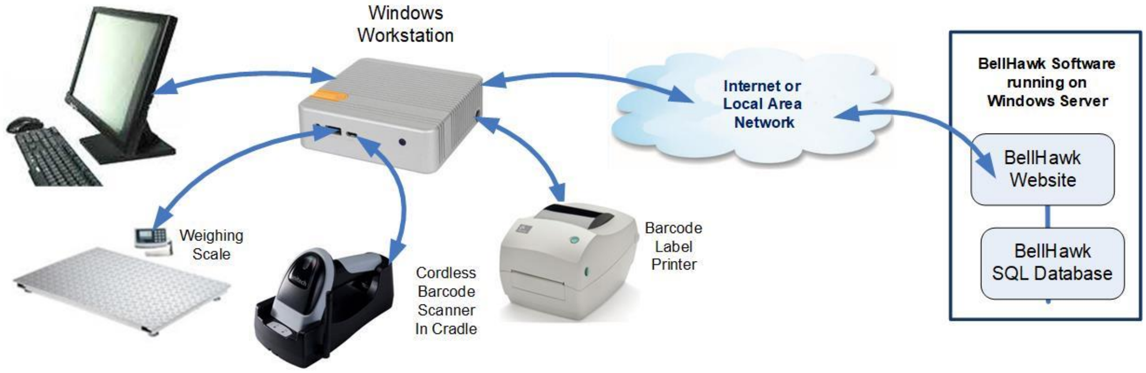
ETO is ideal for allocating costs and performing materials traceability when multiple jobs are run at the same time on a common machine, such as in converting rolls of material, or cutting parts for multiple jobs from sheets of steel or wood.

ETO is also an excellent starting point for integration with process control systems. With the user defined parameters capability of BellHawk, the operating parameters for machines and other equipment can be specified as part of the work-order step or operation setup data. This data can then be read by the process control equipment and used to control the operational process.

Operating conditions, along with statistical process control summary parameters can then be sent to BellHawk to be stored as part of the materials tracking and traceability data for individual products or batches of products. This data can also be integrated with the Quality Control tracking capabilities of BellHawk.

22.2 Weighing Scale Interface

The BellHawk Weighing Scale Interface (WSI) option enables the capture of weights from weighing scales. This avoids errors with the capture of weight data.



This WSI software runs on a Windows Workstation based computer in the local plant or warehouse and communicated with BellHawk running at a remote data center over the Internet.

Typically, one or more collocated weighing scales are connected to the Workstation computer which can then support, for example, a floor weighing scale and a bench scale, to enable the use of different scales according to the materials being weighed.

As standard, data is collected from each weighing scale via an RS232 interface to the electronic controller for that scale, but USB, Bluetooth and Ethernet connections require customization.

The WSI software periodically reads each weighing scale by sending an interrogation string to its controller. If the weight has changed significantly from the last reading, this program makes a number of readings until it detects a new stable weight. It then sends this new stable weight to the web-services interface of the BellHawk software, where this weight is stored in the BellHawk database.

Each weighing scale connected to BellHawk requires its own BellHawk data entry login license, which is used to keep data associated with each weighing scale separate.

With WSI, an additional feature is turned on, for appropriate BellHawk transactions, to enable material quantities to be recorded from a weighing scale, if either the primary or secondary units of measure (UOM) for the material being entered are of type weight and the weight UOM is selected for data entry.

The measured gross weight, along with the stored tare weight for the selected container type, is then displayed on the PC or mobile device web browser screen. The net weight is also computed from the measured gross weight less the stored tare weight of the container previously selected and shown on the screen.

When the transaction is completed, this net weight is then recorded as the net weight of the contents of the container in the BellHawk database, if weight is the primary UOM. If weight is the secondary UOM then the net weight may be converted into a count, length, or area quantity depending on the conversion factor stored in BellHawk for the material in question.

The computer on which the WSI is running can also be used as a data collection terminal, with a monitor, mouse, and keyboard, to run a BellHawk web browser session. In this case, the computer can also run the TAG barcode labeling option to drive a barcode label printer. This enables a label to be printed out for each container which includes the weight of the materials in the container. Also, if the setup data for the item includes a conversion factor, such as length per unit weight or count per unit weight, then the printed label can also include the length or count of the materials on or in the container.

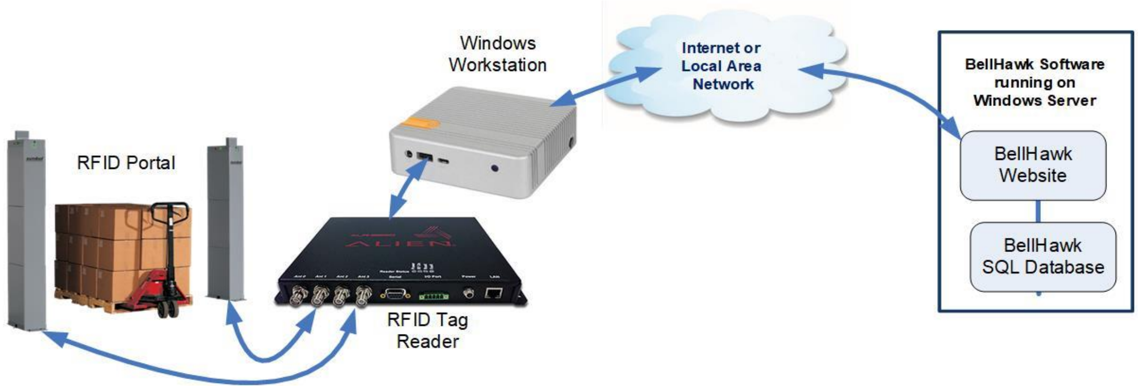
The weighing scale parameters (such as name, interrogation period and delta value for new stable weight) are setup through an Excel spread sheet that is imported into BellHawk using the standard BellHawk Excel setup import mechanism.

The connection to weighing scales can require customization, depending on the model of weighing scales and the interface in use. Some scales can respond to a simple interrogation string, returning a number, representing the weight in some pre-determined unit of measure. In this case, the interrogation string in the weighing scales software can be setup through the Excel import table. But, in other cases, the WSI software needs to be customized for more complex interaction protocols with the weighing scale.

Customization for specific weighing scales can be performed by BellHawk reseller partners or the VB.Net source code for the weighing scale interrogation code is available to clients so they can perform the customization themselves.

The WSI software communicates with BellHawk via its web-services interface, enabling weighing scales in multiple distributed locations to be used with a BellHawk server running in the Cloud at a data center thousands of miles away. All that is needed is for WSI to have an external connection to the Internet as there is no need for any special “holes” in the local Internet firewall for WSI to communicate with its server.

22.3 BellHawk RFID Interface Software



In BellHawk, individual items as well as containers of material can be tracked using "License-Plate-Number" (LPN) RFID tags as well as tracking barcodes. In practice, many such containers may have combination RFID tags (1) embedded in combination barcode labels (2) printed out using the BellHawk TAG software.

Alternately ruggedized RFID tags, such as those shown at left, with associated barcode labels, may be attached to pallets, totes, and vats.

When the combination barcode barcode/RFID tag is first attached to a container, its barcode is scanned and associated with the container, when the container is first entered into inventory.

The barcode may contain the same tracking "license-plate" number as the number embedded in the RFID tag, when no further work is required. Alternately the RFID tag may need to be separately read, using a combination RFID and barcode scanning device and recorded in the BellHawk containers tracking table.

Once the tracking barcode and RFID tag codes are stored in BellHawk the initial location of the container can be recorded using barcode scanning. The movement of the RFID tag through a portal or an area illuminated by an RFID antenna can then be detected by the BellHawk RFID software and translated into recording the new location of the container in the BellHawk database.

To do such automated movement recording, the RFID software reads from an RFID TAG reader, which is typically attached to a number of antennas.

When an RFID tag is detected by the RFID tag reader on a specific antenna, the tag number and antenna is reported from the RFID tag reader to the RFID software. The RFID software then translates from the RFID tag number to the specific container in BellHawk and translates from the antenna location stored in BellHawk to the new physical location of the container, which the RFID software then records into the BellHawk database through the BellHawk website's web services interface.

In this way, BellHawk is able to automatically track the movement of containers without needing to do barcode scanning.

It should be recognized, however, that RFID has many physics limitations. It is highly accurate when recording the movement of a pallet with a single RFID tag through a portal (such as on a dock door) and can read half a dozen or so tags on parts on a pallet moving at walking pace through a portal with a 98% or so accuracy. But, as the number of tags in the portal at the same time and their speed of motion through increases, then the probability of accurately reading the tags rapidly diminishes below 90%.

For many applications, such as recording the put-away locations of inventory, barcode scanning has a far superior accuracy. But for certain applications, such as recording the loading and off-loading of pallets at dock doors, or tracking the location of totes of WIP materials, then RFID has many advantages.

The BellHawk software then works through the BellHawk web-services interface to translate the RFID tag arrival event into a move transaction for the container to which it is attached.

The BellHawk RFID software will work with a number of RFID Tag readers, which will themselves work with a number of different antenna configurations. Please note, however, that each different reader typically requires some customization of the RFID reader interface code because of the different protocols each different RFID tag reader uses for communications.

The advantage of the BellHawk license-plate tracking approach is that clients can use both RFID and barcode scanning where they are appropriate without the need to use different systems for barcode and RFID scanning.

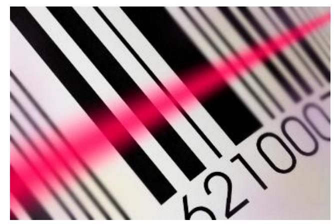
Section D. Implementing a BellHawk System

23 Selecting Barcode Scanning Equipment

23.1 Introduction

In this chapter we give a brief overview of some of the types of barcode equipment suitable for use with BellHawk for inventory, labor and order tracking in an industrial setting. There are many different models of barcode equipment available from many different vendors. The types of equipment that I have included here are typical of those that I have found to work successfully in a variety of industrial organizations.

23.2 Advantages of using Barcode Scanners for Data Collection



The advantages of using barcode scanners for data collection are:

1. High degree of accuracy. When a barcode is scanned correctly, the scanner beeps, otherwise it keeps trying to scan as long as the trigger is pressed. The rate of false reads is about 1 misread in 10 million.

2. Real-time data entry. When a data item is scanned, it is captured and verified in real-time, and then relayed to the operational database server as soon as the data entry is complete. There is no more delay waiting for someone to key in data that has been written down by hand. The data in BellHawk immediately reflects the real-time status of operations and can be used as a valuable management tool to efficiently run factory or warehouse operations.

3. Real-time data validation. The BellHawk software can validate that the data item being captured is correct. For example, that the barcode being scanned is a valid container tracking barcode and not the barcode from the employee's badge. This validation against the tracking system's database can take place in real-time with immediate warning to the operator if they made a mistake.

4. Real-Time operational mistake prevention. The BellHawk software can also validate that the operator is not making a mistake by checking the data just scanned against its database. It can, for example, detect that a material handler has just picked the wrong material for a job or for a customer order. The operator can then be warned in real-time that they are about to make a mistake and be prevented from proceeding with the scan sequence until they select the correct material.

5. Reduction in labor cost. It takes a lot of time to write down information, then to keyboard it, then to correct the errors. This can amount to many expensive hours each day. With BellHawk and barcode scanning, data collection takes place in less than 1 second per data item.

6. Multi-lingual. Barcode scanning does not require knowledge of any specific language. The employee simply points and scans. This is facilitated by the BellHawk

tracking software which makes extensive use of graphic icons to direct employees as to which barcode to scan. The BellHawk tracking software also makes extensive use of visual positional clues, such as on a barcoded traveler or picking form, so that employees intuitively scan the correct barcode.

7. Ease of training. It is much easier to train people to scan barcodes than it is to train them how to write data down on a paper form or to enter the data directly into an ERP system. This is especially true with the BellHawk tracking software that only takes in one item at a time and prompts the user with icons as to which barcode to scan.

23.3 Laser versus CCD based Scanners

Barcode scanners are of two types, a laser scanner, whereby the barcode is scanned with a laser beam, and a CCD imager, which essentially takes a picture of the barcode and then decodes the image.

Early barcode scanners, all used laser scanners, with a visible read beam, as CCD imagers did not have the needed resolution to successfully decode barcodes.

Laser scanners were typically used with one dimensional (1D) barcodes, which consist of bars and stripes, as it was easy to scan the barcode with an oscillating laser light and to decode the reflected signal. There were some laser scanners where the laser beam was mechanically moved in a two-dimensional raster pattern to enable them to scan a two-dimensional (2D) barcode. These have, however, been replaced with CCD imaging scanners.

Today CCD imagers are inexpensive and have high resolution, and are increasingly taking over from laser scanners. The one area of hold-out, for a long time, was in the area of long-range scanning, such as for scanning an overhead barcode used to mark a floor area. Here a range of 40' is required, which was beyond the effective range of CCD scanners because of their limited pixel resolution.

CCD scanners have now improved to the point where they are now being used for long range scanners. But this has brought with it the issue of which barcode to decode when multiple barcodes appear within the image captured by what is essentially a digital camera.

For 1D scanners this is usually solved by having an aiming spot, or a red-line (like a laser beam) projected onto the barcode, so the imager knows which barcode to select. This gets to be more of a problem with long-range scanners, which are much harder to aim correctly at a distance of 40 feet than a barcode scanned at a range of a few inches.

Some manufacturers have touted the ability to scan multiple barcodes at the same time as a useful feature. But, when it comes to scanning license-plate-number tracking barcodes or rack locations, for materials tracking and traceability purposes, this can be much more of a hindrance than a help.

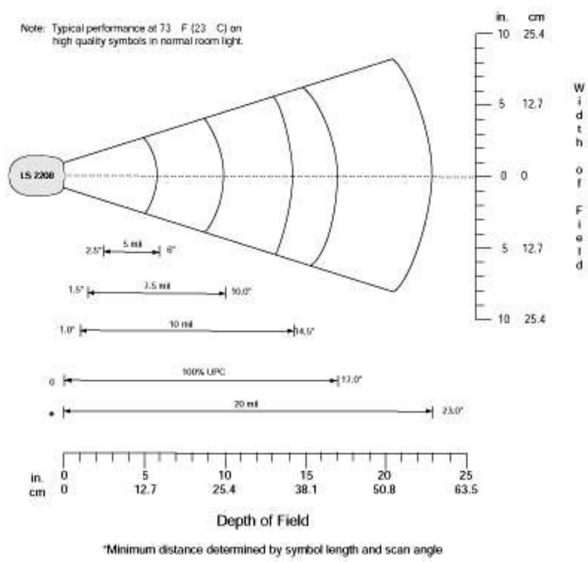
23.4 Scanner Resolution

Another factor to consider is the resolving power of the scanner, typically specified in terms of mils or thousandths of an inch. This is the width of the smallest bar or stripe for 1D barcodes or feature for 2D barcodes, that the scanner can resolve at its nominal scanning distance. The smaller the physical size of the barcode you are scanning, the higher the resolution of the scanner you will need.

Standard tracking barcodes used in industry have features that are 20 mils wide but the labels on sheets of scanning barcodes, such as picking sheets, are often 10 mils resolution in order to contain the needed information in a limited space.

The minimum feature that a scanner can resolve, is actually a function of the angle subtended by the feature at the imaging element. So the barcode resolution is related to the range at which the barcode is scanned as well as resolution in pixels of the imager. It is highly recommended that you check the manufacturers sepcifications for the specific scanner as to what resolution of barcode it can scan at what range.

These specifications are usually published in the form of a chart, such as that shown here:



If you are placing tracking barcodes in small spaces, such as on the top of an integrated circuit, then it may be necessary to use 5 mil resolution barcodes. All laser scanners and most contact imaging scanners will scan barcodes with 10 mil resolution. When you have to scan small 5 mil resolution barcodes then you need to make sure that the scanner you are selecting has that capability.

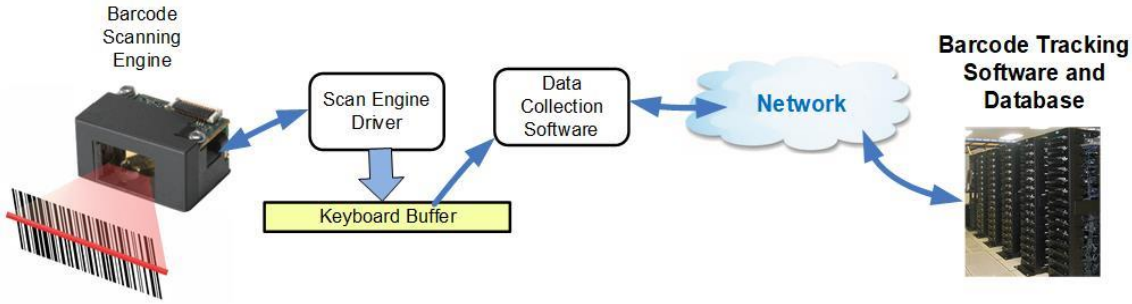
Medium range scanners, with ranges of several feet may well require barcodes with a minimum feature size of 20 mils and long-range scanners may require barcodes with a minimum feature size of 100 Mils.

Because they have simpler structure, 1D barcodes are easier to scan at longer range, which is why they are used on warehouse racks and on floor location markers. Because of their more complex structure, scanning of 2D barcodes is usually limited to short range.

Scanning barcodes at ranges beyond 10 feet require special long-range scanners. CCD based long-range scanners have special optics that enable them to focus on a target at these long distances. But this usually requires that the barcode be well lighted and of high contrast. This also precludes these scanners being used to scan high resolution barcodes at short ranges, without refocussing their optics (just like a camera).

This is why laser scanners are still often preferred for long-range scanning in warehouses as they provide their own illumination in the form of a laser beam and can be used with barcodes that have reflective "white space" to enhance distance. Some of these laser scanners are also able to scan high resolution barcodes at short distances, because their resolution is set by the low-dispersion width of their scanning laser beam rather than by the optics associated with the CCD imager.

23.5 Decoding Speed and Accuracy



Barcode scanning is done by a scan engine that scans the barcode using a laser scanner or uses a CCD (charge-coupled-device) to capture an image of the barcode as an array of pixels. The scan engine then decodes these into a set of alphanumeric characters, which are then typically placed into the keyboard buffer of the device to which the scan-engine is attached.

1D barcode scanners can automatically recognize the type of barcode by the “guard band” bars and stripes that are placed at the beginning and end of the barcode and unqiuely identify the barcode as a Code 128, Code 39. The 2D scanners recognize the type of barcode by the features in the 2D barcode that are unique to the 2D barcode being scanned. They can also scan 1D barcodes but without the benefit of the red aiming line.

One of the most critical human factors in using barcode scanners is their speed in recognizing and decoding a barcode. In an industrial setting, users get unhappy if there is more than a second or two between when they press a scan trigger on their device to when they see a response on the screen of the device to which the scanner is attached.

This means that the scan- engine and its driver have to be able to recognize and decode the barcode and place it into the keyboard buffer in about 100 milliseconds. This requires the use of special hardware and software inside the scan engine as the engine may have to attempt to decode the image or laser scan against dozens of different barcode formats to see which fits the best.

One of the key-features can be the ability to decode damaged or dirty barcodes. This is done by "fuzzy logic" to find the statistical best match, not only to the barcode label format, but also to a set of alphanumeric characters that match the capabilities of the barcode being scanned. This is sometimes accompanied by adaptive adjustment of the optics or laser scanning to get a meaningful decode by adjusting the optical focus or modulating the scan angle of the laser beam.

A useful feature is the ability to "program" the scan engine to emit a cariage return and/or a line feed character at the end of the barcode character string, when it is placed in the keyboard buffer of the PC. This can be beneficial when doing repeated scans that need to be entered into a computer program, such as a web-browser, which would otherwise expect the user to hit the Enter key on the keyboard after entering each data item.

This programming is typically performed by scanning special barcodes from the users manual provided by the manufacturer of the scanner. By programming the equivalent of pressing the Enter key as a postscript to the barcode contents, then the user does not have to go to the keyboard and press the Enter key after doing each scan.

This same programmability can be used to limit the scan engine to just recognize certain barcodes so as to improve decoding speed and accuracy.

Usually this is all taken for granted, as today's barcode scanners just work, for the most part. But it is important to select a scanner with the right scan engine for the job. Also speed and accuracy can be improved by programming the scanner to just look for types of barcodes that you are using.

It is important to make sure that the scanner, or the device to which it is attached, emits an audible beep or flashes a light, or both, when a barcode is successfully scanned. This is to provide feedback to the user which, if absent, makes the scanner hard to use as a user may be attempting to scan a barcode at a range (too near or far) and resolution that is beyond the capabilities of the scan engine to successfully decode and not know it.

Being able to retry scanning, at shorter or longer distances, until a beep is emitted is very useful feedback but sometimes, in high noise environments, this is not enough and needs to be supplemented by visual feedback.

Barcode scan engines are a miracle of modern engineering. They are lightweight, yet very rugged, and amazingly inexpensive considering what goes into them. They also have working lifetimes of many years without significant degradation.

Finally, one question I often get asked, is "Can I use the camera attached to my mobile phone as a barcode scanner"? The answer is yes, you can get third-party software that will use your camera to take a picture of a barcode, decode it, and place the resultant code into the keyboard buffer on your mobile phone. But a mobile-phone makes a very poor industrial barcode scanner for the following reasons:

1. Slow - It typically takes several seconds to manually aim the camera at the barcode and then to press the button to capture the image.
2. Accuracy -The decoding software running on your mobile phone's processor is no match for the specialized firmware in a scan engine for decode speed or accuracy.
3. Ruggedness - most industrial barcode scanners can take repeated several feet drops onto concrete but most mobile phones cannot.

There are specialized cases where mobile phone camera's may be useful, such as scanning QR codes to look up information on a website but, for industrial use, ruggedized mobile computers, with integral barcode scanners and mobile-phone capabilities, work much better and are not much more expensive than a mobile phone alone.

23.6 Tethered Scanners

Tethered or corded scanners work in conjunction with a PC. They are typically used to record operations at a bench or to record the start and stop of job steps at a shared PC. These scanners typically have a six foot long cord that is plugged into a USB port on the PC.

The simplest, and least expensive types, such as the unit shown here, have a scanning range of a few inches. They use a CCD camera element similar to the one in a cell phone. When a trigger on the scanner is pressed, a picture is taken of the barcode and the scanner decodes the barcode into a string of alphanumeric characters which are then automatically deposited into the keyboard of the PC, as if they were typed by the user.

These are available as 1D and 2D barcode scanners. The 1D units typically have a red aiming line similar to a laser scanner and the 2D units typically have an aiming spot. These scanners can recognize the type of barcode being scanned and automatically decode it.

The lowest cost tethered scanners are not dust and moisture sealed and are suitable for light industrial use with desktop PCs. More rugged, dust and moisture sealed tethered units are available at higher cost for use with industrial PCs. Also units with longer range scanning capabilities are available for applications such as plugging into industrial computers mounted on fork-lift trucks.

Tethered laser barcode scanners still have their uses, especially when hands-free scanning of 1D barcodes is required. An example of this is the unit shown at right, which acts as a tethered handheld 1D laser scanner, when removed from its cradle but will go into automated scan mode when placed in its cradle and a switch inside the scanner is triggered by a magnet on the cradle.

When a barcode is passed through the laser beam, the scanner decodes it and outputs the barcode contents, which is placed into the keyboard buffer of the PC, to which the scanner is attached. The scan engine can be programmed to emit an [Enter] sequence after scanning, causing automatic submittal of each barcode, as it is scanned, to the barcode scanning system software.

There are a number of different configurations for similar devices but all are able to switch between scanning manually and being used in a hands-free mode. This can enable their use as hands-free scanner to automatically scan the tracking barcodes on a sequence of boxes.

There are imaging scanners that have scan ranges of a few feet. We do not recommend these for industrial use, in general, as it is very difficult to select a scanning barcode from a sheet of barcodes or to select a specific barcode from those on a number of items close together.

The only place where this does not apply, is where it is necessary to scan 2D barcodes. In general, this application needs special care to ensure that the 2D barcodes need to be well separated from each other at time of scanning to avoid ambiguity.

I have had clients who have purchased scanners with 2D capability, just in case they needed it, only to find that these scanners were essentially unusable in the normal scanning of 1D barcodes because of their close proximity. In general, if you only need to scan 1D barcodes then purchase a 1D scanner and only purchase a 2D scanner, if really needed.

23.7 Cordless Scanners

Tethered scanners work very well for bench top applications or those applications, such as recording job labor or scanning the start and end of job. But they do not work well in those applications, such as in shipping and receiving, where there is typically a need to scan pallets and other containers that are stored on the floor.

You could extend the USB cable by about another 6 feet by using an extender cable but this is highly risky as it can cause people to trip and have accidents, which can result in the arrival of OSHA inspectors, which ……... , well let us just say that this is not a good idea.

You could use a wireless mobile computer, as described in the next section, but it is often much more convenient to lookup purchase orders, for example, on a large screen monitor attached to a PC rather than on the smaller screen of a mobile computer.

A solution to this problem is to use a cordless scanner. These scanners work just like a tethered barcode scanner except that, instead of a cable connected directly to the computer, the cordless scanner has a wireless data connection to a base station, which also serves as a charging station for the scanner. This base station then plugs into a USB port on the PC just like a tethered scanner.

The result is the same in that when you scan a barcode, the contents of the barcode are automatically transmitted to the PC's keyboard buffer just as if you had typed the numbers and letters on the keyboard. As with tethered scanners you can program the unit to emit an Enter code so that you can scan tracking barcodes on a succession of items without returning to the PC.

The big difference from tethered scanners is that the scanning device can operate up to about 30 feet from its base station, so there is no need to drag a cord across the receiving dock or other places where it might cause an accident.

One thing to bear in mind is that all user interaction takes place through the PC to which the base station is equipped. The only feedback from the scanner itself is a beep when it successfully completes a scan. As a result, these are not usable in stock rooms or warehouses or other situations where it would be inconvenient to walk back to the PC to complete the transactions.

Some of these scanner units connect to the base station using Bluetooth wireless communications (just like the method that connects a cell phone earpiece to a cell phone). Others use standard wireless communications, sharing the same bands as are used by wireless mobile communications, and using much of the same technology. Wireless communications have the potential advantage of quicker communications and better security but may also conflict with other devices using the same wireless frequencies.

Bluetooth is a short-range wireless communications technology that is designed for shared communications. Because of its short range, it can be inherently secure. Also, it does not suffer from the potential communications conflicts of standard wireless communications.

An alternate form of cordless scanner is shown at right. These small, lightweight, hand-held units are typically used in conjunction with Laptops, Tablets, and sometimes Mobile Phones. They are available with 1D and 2D CCD scan engines and communicate with a mobile device using Bluetooth protocols.

These units have limited battery life and are not suitable for applications requiring continuous barcode scanning because of the limited battery life. Lower cost units are not dust or moisture sealed but will typically survive a four-foot drop onto concrete (which the tablet, laptop or mobile phone to which they are attached will not).

These units are, however, ideal for field or mobile applications where a small portable barcode scanner is needed for occasional use. This includes adding "proper" barcode scanning to mobile phones.

23.8 Finger Mounted Scanners

Closely related to the cradle-mounted scanners are finger mounted scanners, like the one shown at right. These scanners typically communicate with Android tablets using Bluetooth communications.

The big benefit of these units is that they leave both hands free for materials handling without the need to pick up a scanner, every time the user needs to scan a tracking or location barcode.

These scanning units are available with 1D laser and imaging scan engines and 2D imaging scan engines. They are able to communicate with a tablet out to a range of 10 to 15 feet. But, please bear in mind that all user interaction takes place through the tablet.

Scanning is initiated by pressing a button on the side of the unit with a thumb. The resultant alphanumeric string is placed in the keyboard buffer of the tablet. As with other scan engines, the scan engine can be programmed to emit an [Enter] sequence following the scan, so as to automatically submit the scan to the barcode tracking software.

These scanners have a scan-range of a few inches, so the user needs to be close to the barcode being scanned. They are typically able to scan 10 mil and 20 mil barcodes.

The biggest limitation with these units is battery life. A unit, such as the one shown previously, will run for a few hours, depending on frequency of scanning, and then need to be recharged through a micros-USB port on the scanner. As a result, most organizations will need to have spare units, which can be recharged while other units are in use.

Units with longer battery life are available, such as the one shown at right, but these typically need to be worn across two fingers to comfortably support the additional battery weight.

Sometimes these units are also used with mobile phones, to add barcode scanning capabilities, without the limitations of the built-in camera in the mobile phone.

23.9 Wireless Mobile Data Collection Equipment

Material handlers who drive fork-lift trucks are typically equipped with wireless mobile data collection computers so as to enable them to perform scanning transactions wherever they are when they pick–up or drop–off materials in stock-rooms, warehouses or production or processing areas of a facility.

These units are essentially an Android tablet in a ruggedized portable format. They typically have a color touch-sensitive screen and a numeric or alpha-numeric keyboard. They have an integral barcode scanner and a built-in wireless LAN communications card. These units are normally dust and moisture sealed and will take repeated drops onto concrete and still keep functioning.

The use of wireless connected mobile data collection computers has largely replaced the use of the older batch-mode systems where the mobile computers have to be placed in a docking cradle (attached to a PC or directly to the LAN) in order to exchange data with the main server. The use of wireless communications enables the material handlers to perform their scan transactions without frequently returning to a fixed location to upload the data that they collected.

These wireless units communicate with the main database server, in which all the transactional data is stored, over a secure wireless LAN by means of an antenna built into the mobile computer and an antenna connected to a wireless access point, which is itself connected to the same LAN as the main server computer.

There are several categories of wireless mobile computer that are used in industrial applications. These are:

1. Very rugged units with embedded long-range barcode scanners, as shown on the prior page. These are suitable for use from fork-lift trucks. and typically have a “gun” configuration. They are the preferred units of choice for use in many industrial warehouses.

2. Lighter-weight units with embedded short-range barcode scanners and with an optional gun grip. These dust and moisture sealed units are typically used in stock room and WIP materials tracking applications

3. PDA (Personal Digital Assistant) configuration units, as shown at right, with embedded barcode scanners. These are suitable for use by QC inspectors, material managers, and other supervisory personnel that need to do scanning transactions.

4. Wearable computers with finger mounted barcode scanners that are suitable for hands-free picking operations.

For heavy duty use in industrial warehouses and yards, and for recording the movement of pallets of material on the factory floor, where fork-lift trucks are used, my current units of choice are typified by the Zebra 9000 series mobile computers, as shown at right.

These Android-based devices have an optional built-in “Lorax” self-adapting laser barcode scanning engine. This scanner is capable of scanning barcoded picking sheets at a range of a few inches and is also capable of scanning large retro-reflective barcode labels hung over floor locations from the ceiling of a warehouse at ranges exceeding 40 feet. It can also scan pallet labels at a range of 10 feet or so, making it ideal for use with fork lift trucks as material handlers do not have to leave their seat to do the scanning.

These units are very rugged and can take repeated 6-foot drops onto concrete and still keep working. They have a removable primary lithium-ion battery that is good for the duration of a shift in normal use. They also have a backup battery that will retain the state of the unit while the main battery is being charged.

The battery inside the unit can be recharged by placing the unit in a cradle, as shown at right, for several hours. Alternately the cradle has a charging slot for a spare battery that can simply be swapped out when needed.

Competitive units with CCD based scanners are available from companies such as Honeywell. These scan engines have the benefits and disadvantages described in a previous section of this chapter.

In industrial warehouses, the use of these ruggedized gun-style mobile computers has largely replaced the use of a tethered long-range barcode scanner attached to a mobile computer, which is permanently mounted on a fork-lift truck. This is because the gun-style mobile computers are very flexible. They can be used with fork-lift trucks but can also be used with pallet-jacks to move materials and can be taken with the materials handler wherever they go.

In large scale distribution warehouses, where there are dedicated fork-lift truck drivers, who do nothing else, then the fixed mount units have the benefit of larger screens. They are also powered directly by the fork-lift truck battery and so do not need charging.

For applications where extreme ruggedness and long-range scanning is not required (such as in a stock room), then there are a wide variety of units available at lower cost. These units typically have a short-range scanner so they can easily be used to scan barcodes from picking sheets as well as tracking barcodes on items and bins.

These units do not have a sophisticated battery backup system, so it is important that their internal battery be kept charged. But in a stock-room and similar applications, this is not an issue as these units live in their cradles when not in use.

As an alternative to the gun-style units, PDA (personal digital assistant) units are also very popular, because they are relatively inexpensive. These ruggedized units have a built-in short-range scan-engine, a wireless LAN card, and a processor that runs the Android operating system. These are available with laser or CCD scan engines, are typically dust and moisture sealed, and can take a several foot drop onto concrete. Some have physical keyboards and some rely on on-screen keyboards.

Many of these units are also available with mobile-phone data network communications capability, which enables these units to be used anywhere there is Internet connectivity available over the mobile phone data network.

All the above units work very well, but users do need to hold the scanner to do data entry. In some situations, such as picking, this can be a disadvantage. For these situations we recommend a wearable unit, such as the one shown here.

These units are typically mounted on a user’s wrist with a strap and then connected to a finger mount scanner by a Bluetooth connection. The finger mount scanner is triggered by pressing your thmb against the side of the scan unit. The scan unit contains a short range scanner, which can be aimed simply by pointing your finger at the barcode to be scanned.These units can be uncomfortable to wear for prolonged periods and so are not recommended for general warehouse use. But where hands-free picking is required, these are an excellent choice.

24. Barcode Labels and Printers

24.1 Using Preprinted Rolls of Barcode Labels

BellHawk can use pre-printed LPN tracking barcode labels, such are shown here for tracking containers. Each label has a unique tracking barcode number but have no human readable information, beyond the license-plate number itself.

These labels can simply be peeled off and attached to anything you want to track. Then the labels are scanned and the relevant information is entered into a tracking system. These are ideal for many internal tracking applications as they do not require users to print them out, when needed. Instead these can be purchased as pre-printed rolls or printed ahead of time using available barcode printers, such as in the shipping department.

24.2 Printing Picking and Receiving Sheets and Work Orders with Barcodes

While not essential, from an operational viewpoint, it is often convenient to print out sheets of paper with barcodes, such as for picking or work orders.

Pick Order P000033

Employee :

Ship Date : 12/11/2006

Ship Time : 10:30:00

Customer Name : XYZ Builders

Contract Number : C000030

Ship Order Number : S000043

Pick Line Barcode	Part #	Qty To Pick	Qty Picked	Status
	T101 Red Roofing Tile	100	0	Released
	T102 Grey Roofing Tile	50	0	Released

These are not printed on a barcode label printer but instead are printed on an office printer, using special software that automatically embeds the barcode images into the documents.

Such forms are typically printed on office laser printers or on ink-jet printers with waterproof inks. This is to avoid the barcodes becoming unreadable due to running and smudging.

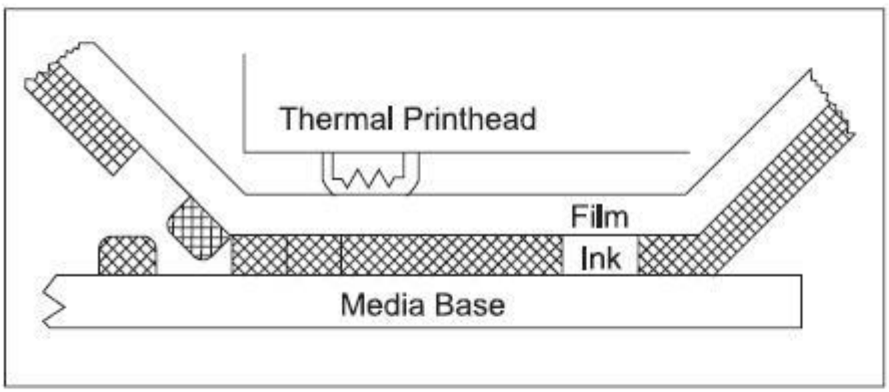
24.3 Printing Barcode Labels

While BellHawk will work with pre-printed LPN tracking labels, it is often desirable to print out barcode labels on demand. This is done using the BellHawk TAG option, as described in the previous section of this manual.

For printing barcode labels on a roll, such as those used for tracking barcodes or shipping labels, then an industrial barcode printer, such as those available from Zebra or Honeywell, should be used.

These units are rugged, reliable and designed to operate consistently for a long period of time, with only periodic maintenance.

These units use a thermal transfer process, in which the ink on a wax or resin film ribbon is melted by a thermal print head onto the barcode material stock:



For details of how barcode printers work and the different types of barcode media and ribbons available for different purposes, I highly recommend the white papers and other information on Zebra's website at www.Zebra.com.

These printers can be ordered either with USB connections for direct connection to a PC or a network card for direct communication to the IP address of the printer on the LAN. We recommend using Network printers as they do not require tying up a PC, unless the PC is needed for a supporting function, such as receiving or shipping.

Users of these printers do need training as to how to load the rolls of barcode media and ribbon and to adjust the printer to print high quality barcodes.

For lower volume applications, with simpler loading and setup requirements, many organizations will use a clam-shell printer such as that shown at right. These printers are lower cost and typically plugged into the USB port of a PC. They are not designed for high-volume printing but work-well for applications where intermittent printing of labels in low-volume are required.

Barcode label printers are also available as wearable units, as show at right. These units communicate through the wireless LAN and enable the user to print out labels on demand based on requests entered though their mobile device.

Many barcode label printers will also work with thermal media, in direct thermal mode. The thermal paper barcode labels used in this method change color from white to black where heated by the printhead to print the barcode and text on the label. The benefit of this is that wax or resin film ribbons are not required. The major disadvantage is that these barcode labels fade with time and are not rugged, unlike even the lowest-cost labels produced by melting the ink from the ribbon onto the label. As such direct thermal printing is not recommended to printing barcode labels for industrial use.

Barcode label printing units come in different resolutions, measured in dots per inch, of their thermal printheads. Depending on the resolution of the barcodes you plan to print, you will need to select a printer with a high-enough number of dots per inch to print a high-quality barcode. But you do not want to use too high a resolution as this can slow the printer down.

As standard, the BellHawk TAG option is used in conjunction with the Bartender software from Seagull Scientific. BarTender supports a wide range of printers and provide a visual layout tool for barcode labels. These tools then enable the BellHawk software to populate a user defined label format, using data from the BellHawk database, and then to automatically print the label on a selected barcode printer. This can avoid many mistakes caused by manually entering the data to be printed out on each label.

In receiving operations, labels are often printed out for each item to be received, at a PC, with each label having its own unique tracking barcode. These are printed out on a roll and then peeled off and attached to the received items. The tracking barcodes on each label are then scanned to complete the receiving process.

Elsewhere, such as at the end of a production line, the labels may be printed out one at a time on demand. In such a case, users may wish to consider ordering a barcode printer equipped with an automatic strip and peel fixture and a substrate rewinder so that each label can be simply pulled from the printer and attached to an item.

Labels printed on a barcode printer can each have their own unique tracking barcode plus human readable information, such as a part description, which is unique to the container to which it is being applied. This is the advantage of the use of a barcode printer over the use of pre-printed labels which simply have the tracking number.

25. Location Barcodes for Warehouses and Stock Rooms

25.1 Introduction

A location barcode specifies a location at which materials may be stored. A typical location barcode that might be attached to a shelf is shown at right.

It consists of a one-dimensional barcode, which contains the code for the location with the same code in human readable form. It may also contain arrows and other indicators to enable the selection of the correct barcode to scan for a shelf.

These barcodes are typically printed on a plastic substrate with the use of resin ribbons (for thermal transfer printing) or other durable inks (if colored) to make them as scuff and damage resistant as possible.

These barcode labels come with an adhesive backing that is suitable for attachment to metal shelves and have a peel-off paper backing. If these are to be attached to wood shelves, plastic surfaces, or used within refrigerated environments then labels with special adhesives may need to be ordered.

The horizontal width of the barcode depends on the number of characters to be encoded in the barcode plus start and stop bars and stripes plus white space that is required before and after the beginning and end of the barcode. It also depends on the width of the bars and stripes used to encode the characters in the barcode.

The width of the narrowest bar or stripe in the barcode sets the distance at which the barcode can be scanned because of the limitations of the angular resolution of the barcode scanning engine in the scanning device. This width is measured in thousandths of an inch or "mils". For shelf barcodes this width typically needs to be at least 20 mils for scanning at a range of about two to three feet. To scan at ranges of 8 feet of so, such as from the seat of a fork-lift truck, then the barcode should be typically 40 mil resolution.

These distances will be dependent on the angular resolution of the scanning device and its type (active laser or passive imager) and are provided here for general guidance. Please contact your equipment supplier for guidance as to the barcode widths and resolutions to use with specific barcode scanning devices in specific operational cases.

The reason that we use one dimensional barcode labels rather than two dimensional barcodes for locations is that they can be read at longer ranges, especially by active laser scanners. Laser scanners are traditionally preferred for materials handling applications because it is easier to select the correct barcode when one barcode has to be selected from among many other barcodes nearby using the red illuminating line of the scanning laser. Because they actively illuminate the target barcode laser scanners are also less susceptible to optical interference than passive imaging scanners, which are needed to scan two dimensional barcodes.

Of recent years, passive imaging scanners have improved dramatically in their resolution and are now starting to be used in materials handling applications as they are inherently more rugged and can be lower in cost. In the future, this may lead to a changeover to the use of two-dimensional barcodes for location barcodes as these can be read more reliably by imaging scanners. But for now, we recommend using one dimensional location barcodes, except in special applications.

25.2 Types of Location Barcode

A location barcode attached to a shelf can be used to record when containers of material with tracking barcodes or loose items are moved to a shelf.

They can also be used for bins, which hold large items, such as shown below:

However, when tracking small items, such as fasteners, medical supplies, or tools then tracking, and especially picking, is made easier by attaching a "license-plate" container tracking barcode to the bin, as shown at right.

The location of the bin can then be changed, if needed, by scanning the bin barcode and the new location barcode for the shelf on which it is placed. This provides flexible use of stock-room space as the product mix changes without replacing the barcodes that are permanently attached to the shelves.

These location and bin barcodes can then be scanned to record the movement of materials into and out of the bins or locations. They can also be scanned during "cycle counting" and inventory auditing to checking the amount of inventory present, in case someone has made a mistake in not recording the movement of inventory or has made an error in specifying the quantity moved or withdrawn.

Shelf barcodes work well when the shelves are at, or close to, eye level. But when warehouse racking is used, it becomes impossible to quickly and accurately scan barcodes placed on the high shelves. For this reason, we use a set of rack barcodes placed at eye level, on the rack verticals, as shown at right.

These rack barcodes:

- Are color coded as to the shelf level - to avoid mistakes. It helps if the shelf edges are colored (with tape or paint) to be the same color as the color used on the eye level barcodes.
- If fork-lift trucks are being used, have a barcode with large enough bars and stripes so they can be scanned by the driver without leaving his seat.
- Have an indicator arrow showing which set of shelves the barcodes belong to.

Many organizations also store materials on pallets in floor locations. Here there are three choices. Our preference is to use "traffic" cones with location barcodes attached to the top of these traffic cones, as shown at right. These are then placed inside a yellow lined floor area and the location barcode on the cone is scanned to record the location of any pallet placed within the floor area so marked.

The barcode on these location markers is located about 4 feet from the floor, and is large (typically 10"x6"), making it easy to scan by fork-lift truck drivers without leaving the seat of their truck. We recommend attaching the barcode (which is attached to a plastic board) to the cone by means of Velcro. In this way, when the fork-lift truck driver hits the cone with his truck, the cones can easily be stood up again and the barcode quickly reattached when it comes loose.

One alternative to these is to use overhead location barcodes hung over warehouse aisles, as shown here. The problem is that, in most industrial warehouses, these need to be hung at least 25' in the air, making them difficult to scan, even with expensive, long-range barcode scanners.

Another alternative is to use ceramic coated location barcodes epoxied to the warehouse floor. In our experience, these can easily become damaged in industrial use and are difficult to scan from the seat of a fork-lift truck.

The big advantage of the traffic cones is that they are inexpensive and that the warehouse floor locations can easily be changed, as needed, as different projects and products, need different amounts of floor space over time.

Note that the barcodes should always be placed so that the bars and stripes are vertical, in a "picket-fence" arrangement. This is because all the handheld barcode scanning devices are ergonomically designed to be used with barcodes in this configuration. Also, the height of the barcode should be chosen so as to allow for normal variability from horizontal in scanning.

Also note that barcodes should not be placed next to one another, horizontally, as this can lead to errors in selecting the correct barcode to scan. They can be placed together vertically, as in eye level rack barcodes, because it is easy to select the barcode to scan using a red aiming line from a one-dimensional barcode scanner. But this can still lead to problems when using two-dimensional imaging scanners, where a wider vertical separation is also required.

25.3 Choosing a Location Numbering Scheme

For location barcodes, we recommend using 6 to 8 characters. This gives enough characters for the barcode decoding algorithm inside the scanner to quickly and accurately decode the contents of the barcode. It also enables the use of wide-enough bars and stripes to make the barcode able to be scanned at a reasonable distance. If too few characters are used then the scan engine may not be able to accurately decode the contents of the barcode. If too many characters are used then the barcode becomes longer (approximately in proportion to the number of characters encoded) and the width of the bars and stripes in the barcode have to be made narrower to fit within the available space (such as the width of a warehouse rack) thereby reducing the range at which they can be scanned.

For warehouse racks, we recommend using a letter for each aisle or zone, followed by a number, for the rack bay, followed by a letter for the shelf height, such as is shown at right. These are much easier for material handlers to remember and use than something like "**`23.12.5`**".

Note that in the scheme shown above, at right we use the full width of the vertical rack for the barcode (plus needed white space on either side) to maximize the size of the barcode and thus the distance at which it can be scanned.

26. Project Management Issues in Systems Deployment

26.1 Introduction

In this chapter, we look at the project management issues in implementing a barcode inventory and production tracking system. Here we refer to:

- The "client" as shorthand for the senior management team and staff members of the plant or warehouse in which a BellHawk based system is being deployed.
- The "systems integrator" as shorthand for the staff of KnarrTek, which is the primary distribution and support organization for the BellHawk and MilramX software, and/or a KnarrTek BellHawk reseller and systems integration partner.

In some larger organizations, a corporate IT department may also act as the systems integrator, purchasing needed software licenses and services directly from KnarrTek.

26.2 Checklist for Project Implementation

This is a list of the things that clients need to do when implementing a barcode production and inventory tracking system. These steps, which are explained in subsequent sections of this chapter, are

1. Appoint a project leader. If there is an IT staff member or manufacturing engineer on-site then they are usually a likely candidate. If not, then someone like an operations manager who is in the plant or warehouse on a daily basis is best.
2. Select an initial area in which to start operational tracking. This may be in the receipt and put-away of raw materials, in work-in-progress tracking, or in tracking the picking, packing, and shipping of finished products.
3. Work with the selected systems integrator to do a preliminary system design on a remote basis. This will require that the client send a written description of their tracking problem to the integrator along with photos or videos of their operations. In return the systems integrator will recommend which BellHawk modules to use for the initial deployment, and which equipment and supplies will be needed, together with an estimate of the support services will be needed during the initial deployment.
4. Sign up with the systems integrator for a 3-month pilot subscription, using the free shared Cloud-based hosting service operated by KnarrTek, for the recommended BellHawk modules.
5. Setup a "training room pilot" installation in a training room at the plant or warehouse. This will typically consist of a PC with a corded barcode scanner and an office laser or waterproof inkjet printer. If inventory tracking is to be performed, then add a mobile computer and a preprinted roll of tracking barcodes

plus some sample location labels. This equipment and supplies can be ordered through your systems integrator.

6. Work with the systems integrator to setup a limited amount of test data in BellHawk, which will initially be running stand-alone. Then, after training in how to use BellHawk, start testing the use of BellHawk to capture data, using actual operational scenarios, to see whether it meets the organizations needs and where changes to configuration or customizations to the transactions may be needed.

7. After appropriate changes to the transactions, made by the KnarrTek software support team, then use the training room pilot to train the operators or material handlers in how to use the system. Pay careful attention to any issues they raise, as these may need more configuration changes or customizations to the data collection transactions.

8. Next have the senior management team examine the standard reports and Excel exports generated by BellHawk, as a result of the pilot testing. Do these meet their needs or do they need customizing? If so, the systems integrator can arrange for the KnarrTek software support team to modify these standard reports. If additional custom reports are required then these can be created by the KnarrTek team. Alternately the systems integrator or the client can generate custom reports using the BellHawk DEX interface.

9. If custom barcode label generation is required, then a barcode label printer needs to be added to the training-room pilot along with an industrial PC containing the on-site software needed to print labels on a local printer from data stored in BellHawk at its remote data center. This will, after the BellHawk software labeling rules and the barcode label formats have been setup, be used in its own testing cycle.

10. Once the pilot system is operating to the satisfaction of the client, then it is time to deploy the system in operation in the chosen initial deployment area. This may require:

    a. Ordering more equipment

    b. Ordering and installing rack and floor marker location barcodes

    c. Ordering more rolls of preprinted tracking barcodes

    d. Importing more setup data needed for full operation into BellHawk.

    e. Preparation of a standard operating procedure manual for process management

    f. Additional training for operators and materials handlers.

    g. Integration with an existing ERP or accounting system.

Fully automated data exchange integration with an ERP system is typically done using the MilramX software platform. This is done as a parallel project between the systems integrator, the technical staff of KnarrTek, and the IT group supporting the organization's ERP system. This typically only applies to plants or warehouses belonging to larger corporate groups with IT departments.

Smaller plants and warehouses typically use the BellHawk DEX interface to push data to BellHawk from their ERP or accounting system, or to pull data from BellHawk, under manual control, as this is much simpler.

It is to be expected that, once the BellHawk system is initially deployed, further adjustments and customizations may be needed as it is used for a wide-range of different operational scenarios. Also, management may need changes to reports or additional reports as they find other uses for the collected data. These may also require additions or changes to data exchanged with the plant's ERP or accounting system.

It is recommended that once the system is up and running that the training room pilot installation be kept in operation. This will require purchasing additional equipment. but is well worthwhile for:

- Training new employees
- Testing changes and additions to the system
- Testing integration with ERP and accounting systems
- Testing and training employees for subsequent deployment phases
- To act as a pool of spare equipment in case of failure

26.3 Applicability

In the USA, in 2019 there are over 540,000 separate manufacturing plants, making a wide variety of products. Of these approximately 3,000 are large "super-plants" such as automobile assembly plants, 60,000 are mid-size plants with sales/output of between $10Million and $100 Million per year and about 300,000 are small plants with annual sales of between $1 Million and $10 Million per year.

All the large super-plants employ large numbers of IT (Information Technology) staff, whose job it is to implement and maintain highly customized systems to enable these organizations to track and manage their operations in real-time. These super-plants typically use high-end ERP (Enterprise Resource Planning) systems such as SAP or Oracle, as the basis of their highly integrated systems.

About 80% of the mid-sized plants are still capturing their production tracking data on paper forms and then manually entering this data into mid-range ERP systems, such as those from Microsoft or Sage or one of the other 300 different ERP systems in common use.

About half of these plants are using some form of WMS (Warehouse Management System) to track their inventory, which may or may not be integrated with their ERP system. Today these plants may have zero or one IT staff member on site and rely heavily on outside organizations to update and maintain their IT infrastructure.

Just about all of the smaller plants are still using paper forms to track their inventory and production data. The inventory data is typically entered manually into an accounting system (such as QuickBooks) and the production data is tracked using Excel spreadsheets. These organizations have no on-site IT staff and increasingly reliant on Cloud-based systems to run their operations.

It is to those plants still making extensive use of paper forms and manual keyboard data entry that this chapter is addressed.

26.4 Paper Forms and Manual Keyboard Data Entry

The reason that many small and mid-sized manufacturing organizations still use paper forms, followed by manual keyboard data entry, is that their ERP or accounting systems, or even Excel spreadsheets, are designed for use by front-office staff. These systems are not designed for use by production workers and material handlers, for whom English is often a second language and who may have limited computer literacy, especially when it comes to using business computer systems.

Most attempts to get production workers to directly enter production and inventory tracking data by keyboard into these business systems have failed, typically due to the complexity of these systems, the multiple days of training needed to learn how to use these systems, often a very high data entry error rate, even for those who have completed the training, and a high level of ongoing supervisory intervention required to correct these mistakes.

As a result, most manufacturing organizations simply had the production workers and material handlers write the data down onto paper forms, with the data being keyed into the appropriate systems, typically on the following day, by supervisors or front-office staff.

While solving the problem of collecting the data, albeit still with some mistakes, this has caused other problems, such as:

1. Losing track of customer orders due to the available status data being at least a day old. This often results in the late shipment of customer orders, increased labor costs for expediting orders including unscheduled overtime, expedited shipping costs, late delivery penalties and, even worse, lost future orders from valued customers.

2. Losing track of raw materials inventory due to data entry being at least a day old combined with the ERP and accounting systems not recording withdrawal of raw materials until the resultant finished products are recorded into inventory (often many days after the raw materials are withdrawn from stock), or even worse delayed until the products are recorded as being shipped. This can result in stock-outs, which cause production delays, which result in late shipment of customer orders.

3. Maintaining excess inventory, at great expense, to compensate for the errors in the inventory tracking system. With today's make-to-order "Amazon" culture (see companion white paper on this subject) the demand for different products can change rapidly, resulting in this excess inventory becoming obsolete and having to be scrapped.

In addition, many of these organizations are now being pressured by their customers to:

1. Apply unique GS1 standard tracking barcodes to each pallet as it is shipped to a customer and send an electronic record of all the materials packed in nested boxes on the pallet, as part of an ASN (Advanced Shipment Notice). To be sent to the customer, as soon as the shipment leaves. This is so that the GS1 barcode on each pallet can be scanned and associated with the ASN data when the truck arrives at the customer destination, which may only be a 30-minute drive away. This obviously cannot be done with data captured on paper and entered the next day into some computer system.

2. Electronically capture materials traceability data recording which materials from which suppliers were used to make which products and who they were shipped to. This is so that the source of defects can be rapidly traced back and rapid recalls performed at minimum cost. Typically, the maximum time mandated for recalling traceability data is 4 hours, although it can be as little as 1 hour. The use of paper forms, especially if they are simply stored away in a filing cabinet without the data being keyboarded into a computer system capable of performing materials traceability (which ERP and accounting systems are not) do not fit this paradigm.

In addition, the use of paper forms, followed by manual keyboard data entry into an ERP or accounting system or an Excel spreadsheet is labor intensive and is mistake prone.

The labor costs for manual data capture, using paper forms, are often the equivalent of one or more full-time staff members at a loaded labor cost of $5,000/month or more. These costs can be saved by the use of Cloud-based barcode and mobile computer data capture technology, such as BellHawk, which typically costs less than $1,000/month for a small or mid-sized manufacturing plant to use.

26.5 Technology Evolution

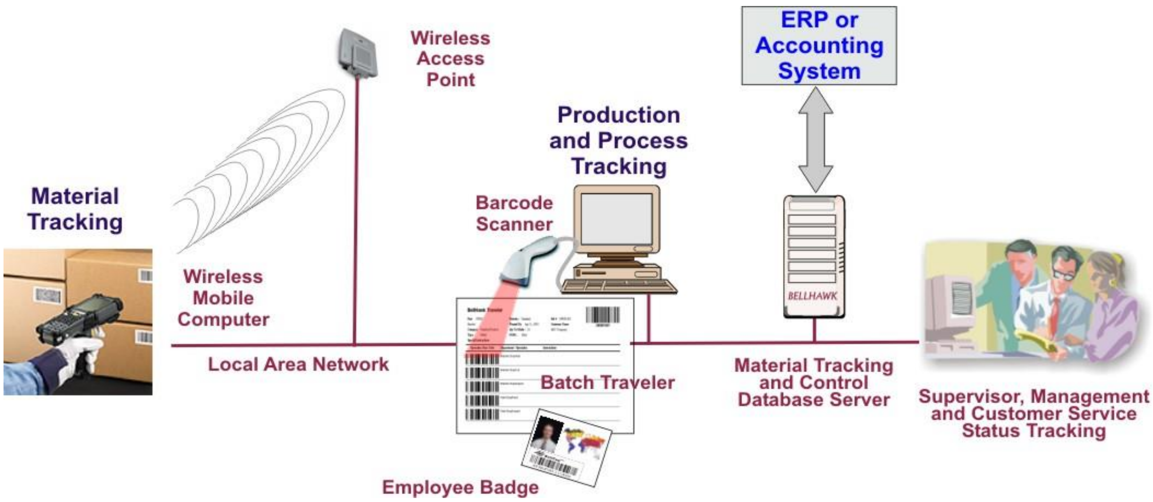
They say that if you don't understand the history of where we have come from then you are bound to make the same mistakes.

I started out in the AIDC (Automated Identification and Data Capture) field, by participating in the development of a simple single-user desktop application, to track operations in a PC board manufacturing plant. This application was written in Visual Basic, with an Access database, to replace an even-older "green screen" terminal application, which was tied to an old custom IBM mainframe application written in FORTRAN. This new application used a corded barcode scanner, which shared a "Y" connection with the PC's keyboard.

This single PC desktop system worked well, for about two days, until the production manager said "I love your new desktop production-tracking application but can you make it work so that all six of my work centers can each have their own PCs?"

So, we rewrote the application as a client-server application with an Access/VBA front end running in each Windows PC and a SQL Server backend. This client-server version of the software worked well and we installed it in a significant number of manufacturing plants, a couple of which are still using this client-server software today, nearly two decades later.

This client-server application, a diagram for which is shown below, worked well and was much-liked by many of our clients because it had a relatively simple database structure, from which it was easy to generate custom reports.



Also, the front-end, being written in VBA (Visual Basic for Applications), was easy to customize. But this system also had disadvantages, which were:

1. The software could only be run on PCs connected to the LAN (local area network) within the plant or warehouse. Data could not be captured or viewed from outside the warehouse or manufacturing plant.
2. A separate body of code, written entirely in Visual Basic, was required to be loaded into each wireless mobile computer if mobile data collection, over the warehouse or plant's wireless LAN, was to be integrated into the system.
3. This mobile code, also required a local store-and-forward database in each mobile computer, so as to be able to reliably exchange data with the main SQL Server database. This was also needed to provide local point-of-action warnings when an operator or materials handler was about to make a mistake. This setup required a significant level of IT support as any change to the front-end code had to be installed on all the PCs and Mobile Computers used for data collection or reporting.
4. Unfortunately, the store-and-forward databases in the mobile computers could get out of sync with the main database, especially if the mobile computers were left

where they could not communicate with the SQL Server database for several days. This could then require a substantial level of IT support to get the databases back in sync again.

Then along came the Cloud, with its promise of eliminating the need for any local IT support at a warehouse or manufacturing plant. Instead, all applications would run at a remote data center and users would interact with these applications over the Internet using a web-browser, with no need to load any applications software, into any end-point user device.

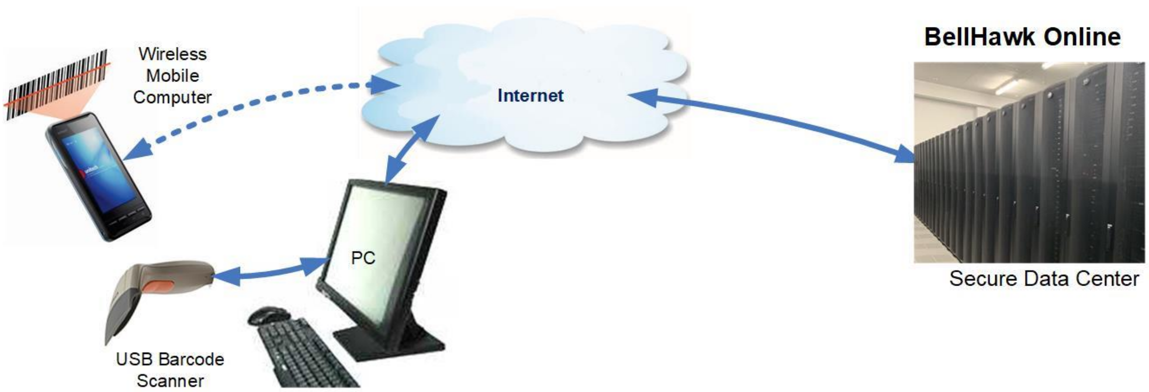
I would like to tell you that I saw this vision of Nirvana and immediately set to work developing a new Cloud-based version of what would become the new BellHawk software, to the sound of heraldic angels.

But no. What actually happened was that Microsoft, to force software developers like me to conform to their new marketing vision, took away most of the features in VBA that we used to support our client server applications.

As a result, all applications, such as BellHawk, had to move to the Cloud, as Microsoft steadily removed the compatibility features in Windows 7 and 8 which enabled old client-server VBA/Access applications still to be run. Then Microsoft drove a stake in the heart of these "vampire" applications with Windows 10, which no longer supported the needed compatibility features.

So, was this transition the path to the expected Nirvana? Well no. The use of the Cloud brought with it many of its expected advantages but also brought with it a whole new set of issues, which we have had to overcome.

26.6 Resolving the IT Issues with Cloud Operation



From a project management viewpoint, things have changed dramatically over the past decade or two. Twenty years ago, many of our mid-sized manufacturing plant clients had an IT Department with 5 or so staff members. Today our smaller clients have no IT staff and the mid-sized plants may have a single IT person (if they are lucky).

As a result, we have migrated from clients installing the tracking software on their own servers, in their own manufacturing plants, to using the software "in the Cloud" over the

Internet at a secure data center, where the software and the servers are managed by organizations such as KnarrTek, eliminating the need for on-site IT support.

This has brought with it the cost-saving ability of being able to share a single server between multiple smaller manufacturing and industrial distribution clients. While larger organizations still need a dedicated server in the Cloud to run tracking software, such as BellHawk, KnarrTek, for example, is able to offer free hosting to smaller organizations which are able to share the use of a single server.

This results in a tremendous cost savings for smaller organizations over an organization needing to purchase their own server and especially in the cost of an IT person needed to maintain the server and the tracking software installed on it.

We have also migrated, over the years, from using "thick-client" software, which had to be installed in each mobile device and, in reality, needed a local IT person, on-site, for the maintenance of these devices, to the use of a web-browser interface, which uses the pre-installed web-browser on these devices to communicate with the tracking software, running in the Cloud. This again, eliminates to need for an on-site IT person.

But there are always exceptions. BellHawk is also used by large multi-national organizations, who want to have the software installed at their own data center, which may be continents away from the manufacturing plants in which it is used. Here the organization's own corporate IT group takes over installation and management of the software but support for the operations people in the local plants is typically done by KnarrTek and its systems integrator partners.

The other exception is the military services and their defense contractors, which have high security requirements, for some applications. Here the BellHawk software needs to be installed on the organization's own servers and store-and-forward software installed in each mobile device to avoid the use of wireless communications. But these are very special (and expensive) implementations.

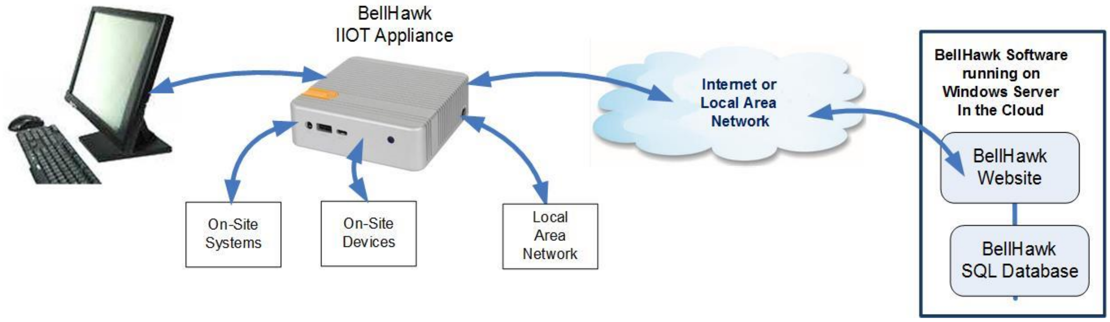
The use of Cloud computing also has issues, such as:

- Lack of access to the tracking system database in the Cloud for locally creating custom reports and/or for exchanging data with other locally installed systems.
- Inability to send the large volumes of data over the Internet to drive barcode label printers.
- Inability to directly communicate with devices in each plant such as RFID portals or weighing scales.

KnarrTek's solution to each of these issues has been to use software running in on or more Windows Workstations in the local manufacturing plant or warehouse. This software communicates over the Internet to the Cloud-based tracking system server to provide a local interface.

But, of course, we have now introduced software running on local computers which could need on-site IT support for installation and maintenance, which would defeat some of the benefits of running the software in the cloud.

Fortunately, KnarrTek and its systems integrator partners are able to supply this on-site software pre-loaded into IIOT (Industrial Internet of Things) computers which act as appliances that are self-starting and can be maintained remotely over the Internet, just like any other Cloud computer, thereby eliminating the need for on-site IT support.



26.7 End of the Waterfall

It used to be, that we would start out each system deployment with a design phase. In this, we would send a person to a client's site to view their operations and to gather information on all the problems they needed to solve. We would then design and document a system to meet all these requirements and prepare a detailed schedule and budget for its phased implementation, in what was called, back-then, the "Waterfall" method, as the implementation project progress was represented on a Waterfall chart showing how each task and phase flowed into the next.

These projects, which typically cost $50,000 to $200,000, were often funded on a 50% up-front and 50% payable on successful completion of the project to meet all the requirements in the design document, which was approved in writing by the customer.

The problem was that each phase took many months to deploy, with the overall project taking several years. During that time:

1. Requirements from the manufacturer or distributor's customers often evolved dramatically making the features, which were planned to be added in later phases, no longer needed and a whole new set of features and functions needing to be added.

2. As deployment progressed with the first phase, the client's staff became much more educated about the nuances of barcode and mobile computer tracking and their benefits and potential problems. As a result, they realized that the specifications they had signed off on were not what they now wanted.

3. The people involved in systems deployment changed from phase to phase as people moved on to new career opportunities. Often the new people would have a different vision as to what the system should do from the people who signed off on the original design.

4. Technology evolved, opening up opportunities for cost savings and better performance, over what was required by the original design.

These factors resulted in the failure of many of these projects. Many were cancelled after one or two phases, because they no longer met the organization's requirements. Others were completed to specification but never used as they no longer met the requirements of the company.

Unfortunately, in many cases, this resulted in unhappy customers, who often went back to using paper forms and Excel spreadsheets, and unhappy systems integrators, who ended up in lawsuits to try to get paid for the work they had done or from customers seeking redress for the failed systems.

Fortunately, there is a solution to these problems, which lies in the adoption of "agile" incremental deployment methods.

26.8 Agile Deployment

This method starts out by recognizing that the managers and staff within many organizations:

1. Have limited capacity to introduce new systems, including all the setup and training required, because people are busy doing their regular jobs.

2. Have limited visibility of future customer requirements. This is especially true of most small and mid-sized manufacturers who make products to order, with lead times of a few days or weeks at most.

3. Typically, have limited knowledge, when the project starts, of the potential operational benefits and the pitfalls in implementing a barcode tracking system.

4. Have very limited knowledge, when the project starts, as to all the steps involved in implementing a barcode inventory and production tracking system.

5. Have very limited time to manage a project such as this, in addition to their regular jobs.

One part of the solution to this, is to incrementally deploy the system, starting in one area such as the receiving and put-away of raw materials, or work-in-process tracking, or in the picking, packing, labeling, and shipping of customer orders. The choice will depend on where the client is currently having the most problems.

This will avoid overloading the people in the organization with too many simultaneous deployments. It will also get the collaboration of the people who need the system most. Once this initial deployment is successful, then the system can incrementally be rolled out to other departments, based on the lessons learned in the first phase of deployment.

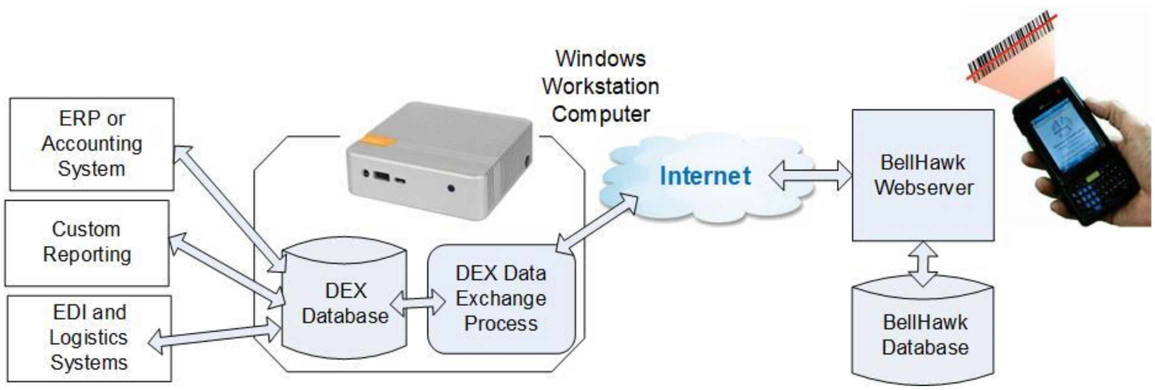
Another part of the solution is Agile deployment. In software development this consists of. developing a quick prototype, with little or no formal specifications, and then steadily refining the implementation, as it is tested by the users until the system works as required.

There is no detailed design phase and incremental changes may occur as requirements change.

When deploying a barcode tracking system, we use a standard version of BellHawk, running stand-alone in the Cloud as the "prototype". We pick a set of modules that come closest to our client's requirements and then assist them to set up and start using the system. This usually gets us 80% of the way to their immediate data collection requirements.

Then, without customization, we adjust the rules on which BellHawk is based to more closely meet the client's requirements based on their feedback. Sometime this is all that is needed but sometime we have to customize the data collection transactions to meet the client's specific requirements, especially in the area of error checks needed for the client's specific operational needs.

Once the data collection is working to the satisfaction of the client, we then start operational data collection. But first we need to complete entering all the operational setup data.



Sometimes, as part of entering their setup data into BellHawk, clients wish to transfer large amounts of data from an existing ERP or accounting system or Excel spreadsheet into BellHawk. This is best done using the BellHawk DEX interface, which runs in a Windows Workstation PC or Windows IIOT appliance computer, in the local plant. The DEX interface has a SQL Server database running on the PC. Data entered into tables in the DEX database is automatically transferred to the BellHawk database over the Internet.

This can be much easier than directly entering the setup data in BellHawk, using its setup screens. Also, importing setup data directly into BellHawk is limited to Excel spreadsheets with only a few thousand records, due to taking so long that the web-browser session times out.

Once, we have all the operational data, such as items and locations, setup in BellHawk, then operational data collection can commence.

Attention then typically turns to reports, which may be in the form of printed reports or Excel exports. Users typically find that they can use most of the standard reports and exports supplied with BellHawk but often some of these may need these modified for the client's specific requirements. This can be done most efficiently by the staff of KnarrTek as they maintain the BellHawk software which is running at a secure data center is running in the Cloud.

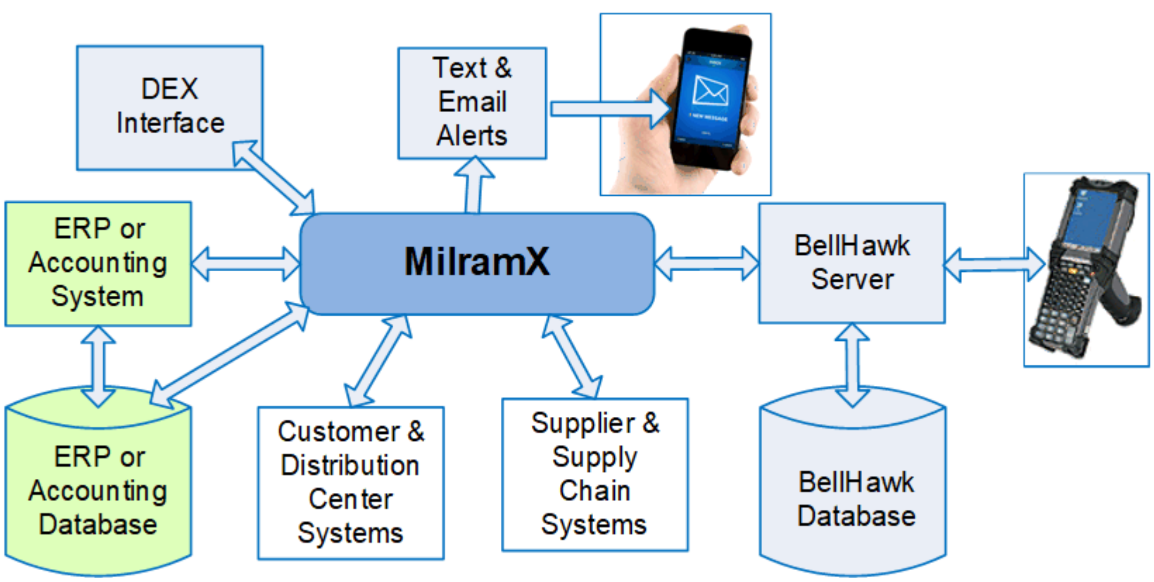
Note that the staff of KnarrTek is able to do different customization to transactions and standard reports for each client, because each client gets their own private website and database, as opposed to using a "shared tenancy" system in which all clients use the same code.

Sometimes clients want to create their own custom reports. In this case, we recommend that they use the BellHawk DEX interface. This automatically copies the data entered into BellHawk to the DEX SQL database in the PC. Clients can then link report generator programs, such as Crystal Reports, with which they are familiar, to the DEX database and produce their own custom reports.

This enables multiple users to generate their own custom reports, based on the data captured by BellHawk, without any danger of interfering with the operation of BellHawk, which used to be a real concern when users directly accessed the BellHawk database for report generation purposes.

Sometimes clients need to export Excel "reports" from BellHawk that contain more than a few thousand records. These often fail, especially when running on a shared server, due to web-browser timeouts before the data is retrieved from the database and prepared for download. As a result, these large Excel exports are better performed using the DEX interface.

Sometimes clients need to automatically exchange data with ERP or accounting systems. For simple data exchanges, such as transferring work orders to BellHawk when needed, the DEX interface can be used. But when many different types of data need to be exchanged on a periodic basis, with reliable 24x7 operation, then the MilramX software platform is used.



MilramX is a software platform for implementing automated information exchange systems. It is used for monitoring multiple sources of data for changes and then sending information updates to other systems. This includes sending Email and Text messages to user when events occur that they need to pay attention to. Please see next chapter for more details on MilramX.

MilramX is typically run on the same server as BellHawk or within the same data center. Data exchange is controlled by Data Transfer Objects (DTOs), which are essentially subroutines that are run to fetch updates from one or more specific data sources, and then to translate this data into information to be sent to other systems or people.

MilramX typically only comes into play when there is a corporate IT group which is responsible for maintaining and managing the corporate ERP system, either in their own data center, or in the Cloud. The staff at KnarrTek works closely with this IT staff, as a team, to implement the DTOs needed to meet the corporations needs for enterprise information integration as well as their supply-chain information integration requirements.

These projects typically also use agile implementation methods, with DTOs being developed, tested, and deployed incrementally to support the incremental deployment of the barcode tracking system. This development may be done by the client's IT staff, KnarrTek's staff, or more usually a combination of the two in a separate parallel project to the deployment of the barcode tracking system.

26.9 Remote Setup and Training Support

The Covid-19 pandemic changed everything.

For a typical barcode tracking system deployment, before Covid-19, systems integrators (which could be KnarrTek or one of its reseller partners) used to send people on-site to do an initial evaluation, in a system's design phase. Here, a member of the systems integration team typically spent a day flying and driving to the clint's plant, then spent one or two days on-site viewing the client's operations in action and meeting with the different staff people involved. Finally, that staff person spent a day to fly and drive back.

This was then followed by the staff person working with the rest of the systems integration team to write up a proposed system design and operational procedure for the proposed system plus prepare a schedule and budget. This was time consuming and expensive.

Now a systems integrator does a preliminary design phase before the project even starts. First, the integrator asks the client to send photos or videos of their operations, including pictures of their warehouse and production facilities. Then they hold on-line meetings with the appropriate people to gather the needed information to assist clients with selecting the right software, equipment and supplies for their first phase of deployment.

This approach, when combined with the incremental agile deployment methods described in the prior section, eliminates the need for the time and expense of a design phase. Instead, the integrator assists clients remotely, using on-line meeting technology, to quickly start testing the software and giving us feedback, so we can adjust the software to meet their specific requirements.

This is made possible by the use of Cloud technology, combined with the use of remotely managed on-site appliances to handle tasks such as barcode label printing, eliminating the need to send people on-site. Mobile devices and barcode scanners can also be ordered through the systems integrator or from a wide-variety of suppliers, with no need to load any special software, and are essentially plug and play with BellHawk.

The only possible issue is with barcode label printers, if used. The BellHawk barcode label printing appliance, which is shipped to clients loaded with software, can be used with a wide variety of barcode label printers. Setting up the printers themselves, however, can be a little tricky but typically most manufacturers and distributors are already using barcode label printers to print shipping labels and so know how to do this.

In this method, all training and support is done remotely using on-line meeting technology, which is proving just as good, in most cases, as sending someone on-site to perform these functions. It is certainly less time consuming and expensive than sending someone on-site.

All interaction with the client's corporate IT staff relative to interface development is done remotely, as it typically has been done for many years. We long-ago found that it is not necessary to get everyone together in one room and, in many cases, this was impossible, with members of the client's IT staff working in many different locations.

We now recommend that all clients start out by using KnarrTek's free hosting service on a shared server in the Cloud. This can then be migrated to a dedicated server either managed by KnarrTek or installed at the client's own data center if the performance of the shared server is not adequate or if MilramX is needed to be run on the same server, which requires the use of a dedicated server.

As part of these agile projects, we enable clients to incrementally pay for the support services they need in the form of prepaid support service bundles. These are like pre-paid telephone cards, which are used to add to each client's prepaid support account. Then, as preapproved support services are delivered, the time is charged, at standard labor rates, against the client's prepaid support account. This is very efficient, requires minimal paperwork, and gives clients complete control how they spend their support funds.

26.10 Pros and Cons of Agile Deployment Methods

The major benefits are

1. Quicker and less expensive deployments of these tracking systems.
2. Flexibility to enable the tracking system to change as customer and user requirements change and new technology becomes available.
3. Flexibility as to how much of the needed setup and training work will be done by the systems integrator's staff and how much will be done by the client's staff. This

can vary over time depending on how busy the client's staff members are with their own jobs.

4. Incremental expenditure of funds on software subscriptions and support services eliminates the need for capital expenditure budgeting, with its typical attendant delays.
5. Financial benefits are immediately visible as costs are charged to operating expenses and improved operational efficiency is reflected in increased revenues and decreased operating costs

The major issues are:

1. Total budget for overall project cannot be established as there is no overall system design. Some estimates can be made at the outset but these are usually wrong due to changing systems objectives.
2. These projects need close collaboration between client's personnel and KnarrTek's support team. This is made more difficult because of the lack of in-person meetings.
3. The assistance that the systems integrator's support team can give is limited by the information shared by the client's team about what is going on in the plant.
4. A significant level of commitment is required by the client team to ensure successful deployment as, in the end, they are the users and beneficiaries of the tracking system.

On balance, we have found that the incremental agile deployment method, combined with remote support, while it does have some issues, results in successful systems deployments whereas many deployments using traditional waterfall implementations have failed badly.

26.11 Critical Issues

It is critical that:

1. The client appoints one person to be the internal project manager (much better than a committee). This person needs to "own" the system and be the internal champion for the system as well as handling coordination between the system integrator and client teams.
2. Senior management is 100% behind this project and sets clear goals and a vision to guide the many decisions that will need to be made during deployment.

If needed, the systems integrator's people can do much of the work in implementing these systems, such as setting up needed data, generating custom reports, and implementing data exchange interfaces with other systems. This can get expensive but may be worthwhile to speed deployment.

It is still essential, however, for the client's team to take responsibility for the successful deployment and use of the system, including the on-site training and supervision of the material handlers and machine operators who will use barcode scanning to capture the operational data.

One issue not to be overlooked is the attitude of the material handlers and machine operators who will do the data collection. They will rightly suspect that management will now be able to monitor their performance much more closely and that underperformers may be weeded out. Many of them will experience a FUD (fear, uncertainty and doubt) factor with the deployment of the new system and will push-back against its deployment.

It is important not to tell these employees that the new system will make their lives easier because, at least initially, it will not. Instead tell them that barcode data capture will now become a standard part of their job and that they will be trained in how to do this properly.

In the course of time, they will become very proficient in using the system and will be the first to complain should the system go down for any reason (such as a switch over to a different ERP system) and they have to temporarily go back to the use of paper forms.

In our experience, it is critical to engage these employees early in the deployment of the new system by training them in the use of the system and then getting their feedback as to what works and what does not. In this way changes can be made early in the process and, more importantly, this makes for employee engagement in the success of the new system.

26.12 Commentary

The changes brought about by the switch to the use of Cloud technology, combined with incremental agile deployment of these barcode tracking systems, and the need to do everything remotely, as a result of Covid-19, have resulted in the development of much quicker and less expensive deployment methods.

These incremental deployments have, been more successful than prior deployments using waterfall project management methods due to the greater flexibility to respond to changes in customer requirements and the requirements imposed on them by their customers.

Will we ever go back to the old waterfall deployment methods? I don't think so, except for high security military deployments, which are a world unto themselves.

27. MilramX Software Platform Overview

27.1 Introduction

ERP vendors, such as SAP and Oracle claim to provide systems that will meet all the IT (Information Technology) needs of most industrial organizations.

This has only proved true for the largest of manufacturing and distribution companies and, even then, these systems have needed massive amounts of expensive customization to meet the specific needs of these large organizations.

Small and mid-sized industrial organizations, by contrast, rely on separate systems, which have been selected by their users to meet the different functional needs of each department, such as finance, sales, marketing, operations management, and materials management.

Problems arise when data in one of these departmental systems is needed by people who use a different system. Some of the traditional solutions to this include:

- Duplicate keyboard data entry, typically based on paper forms generated by one department and sent to another department.
- Transferring data from one system to another in the form of an Excel spreadsheet. This typically requires modifying the layout of the exported spreadsheet to meet the needs of the target system before manually importing this into the second system.

These approaches have the following issues:

1. They are typically labor intensive and mistake prone due to the large number of keystrokes required.
2. Data is delayed in getting from one system to another, typically by at least one day and often more.
3. People needing the data have to go look for it and often have to use multiple systems to get their needed data, which is very cumbersome.

The obvious solution, if you are tech-savvy, and the system databases are easily accessible, is to write some SQL statements to extract data from one database and insert these into another database. Then you can wrap these SQL statements into a computer program, written in a language such as Visual Basic, which is run manually when needed.

This approach works very well, if you are simply trying to create custom reports from the source data and not trying to exchange data with another system. But, while this approach can be a considerable improvement over manual keyboard data entry or Excel transfers, it still has many problems, including:

1. The program you manually create needs to be run whenever there is new data to be transferred. This requires frequent manual intervention by the developer. Alternately the data transfer computer program can be coded to run as a system process on a scheduled basis, but now this has taken this interface from a simple code development task to one needing knowledge of the operating system's internals.

2. Required data transfers are often not as simple as transferring just one data object from a source system to a destination system. The data exchange between a BellHawk materials tracking system and a QuickBooks accounting system typically requires the transfer of dozen or more data objects and this can quickly exceed 20 or more data objects to be exchanged with an ERP system. As a result, the number of lines of code that needs to be developed, to implement a meaningful interface, rapidly escalates.

3. Because of the large amounts of data typically involved, only the latest updates from the source system should be transferred to the target system. This requires tracking when the latest instance of each data object in the source system was transferred, which further adds to the complexity. Also, overwriting already transferred data in the target system may have undesired side effects.

4. Data objects need to be transferred in a specific order. For example, a new Purchase Order Line or Ship Order Line, may reference a newly entered Item object, which needs to be transferred first. If this ordering is built directly into the code, this quickly makes the addition of new data objects very complicated and error prone.

5. The fields in data objects to be transferred, often indirectly reference data in other tables, which requires the use of SQL statements with complex joins between tables. This can result in needing much more complex SQL code, which is often not the strength of people who are not professional programmers.

6. Data from the source system may have errors, especially if it has been in operating a long time. These need to be detected and corrected before the data is transferred to the target system. Code to detect and correct errors can often require an order of magnitude more lines of code than the code that actually transfers the data.

7. Data may need to be fetched from multiple sources in order to provide a meaningful data update to a target system. Also, instead of accessing a data base, data may need to be exchanged through a web-services interface. These can further dramatically increase code complexity.

8. Interfaces are not only needed between two systems. If you have 6 systems in common use then you could need 15 (5+4+3+2+1) different interfaces. These may need to be automatically scheduled at different times of the day.

9. Computers, databases, and networks involved in the data transfers all have limitations. It is therefore important to prioritize transfers to make sure that the most important data gets there first and does not negatively impact the performance of the systems involved.

10. Just transferring the data from one system to another is often not enough. It is essential that people get alerts by text message or Email when there are events happening which they need to pay attention to. Previously, action was often triggered by the arrival of a paper form. Now that we have done away with paper forms, we need to substitute electronic alerts.

As a result of all these complexities, developing a data exchange program between two systems can be a large and daunting programming task, let alone developing and maintaining multiple interfaces. Often these interfaces can run to tens or hundreds of thousands of lines of code, which is costly and can quickly become a maintenance nightmare, especially as the requirements for data exchange evolve over time.

MilramX is a software platform that is intended to provide 90% of the code, predeveloped or automatically generated, for implementing reliable automated data exchange interfaces between systems used by industrial organizations. The goal of MilramX is to substantially shorten the time and cost of developing these interfaces.

More importantly, MilramX provides a standard architecture to bring order out of the chaos that often results from these interfaces development efforts. MilramX enables interfaces to be implemented, modified, and maintained incrementally, under control, as requirements change over time, by different people.

MilramX solves the problem of having an interface developed and maintained by a single person, or even a small team, typically in the organization's IT department, who then move on to greater career opportunities rather than spend their lives maintaining the code "monster" they have created as the underlying databases, operating systems, and network architectures change over time.

27.2 The Myth of the Standard Interface

In the USA today, we are particularly prone to "Sound-Bite" myths, believing the latest advertising or sales message, rather than analyzing the facts and deciding what is best for our organization and all its stake holders.

One of the most common questions that I get, relative to the BellHawk materials tracking software is of the form: "Do you have a standard interface to my 1996 Podunk 5 ERP system?"

As there are at least 300 ERP systems in common use in the USA, the answer is inevitably "No". Which usually results in the reply that, as a result, the organization cannot possibly use the BellHawk software to automate their data collection and replace their use of paper forms and manual keyboard data entry as BellHawk does not have a standard interface to their ERP system.

At which point, the organization can do one of a number of things:

1. Purchase a new ERP system, typically at a cost of a few hundred thousand dollars for implementation, which the ERP sales person told them would handle all their real-time work-in-process and materials tracking needs. They then find that the ERP system does not meet these needs (because it was not designed to do so) and so they continue to use paper forms and manual keyboard data entry into their new, expensive, ERP system.

2. Continue to use paper forms and manual keyboard data entry for tracking their materials and work-in-process, as well as transferring needed data between systems, sometimes supplemented by the use of Excel spreadsheets. This typically results in unnecessary labor costs of between $50,000 and $150,000 per year as well as the inestimable costs of lost customers and expedited delivery costs due to late shipment of customer orders.

3. Attempt to customize their existing ERP or accounting system to meet their materials and work-in-process tracking needs. Even where successful, this then "freezes" the ERP or accounting system at its current version and so it cannot be upgraded when Tax or other financial requirements change, without paying to have the customizations moved to the latest update. As this results in organizations no longer buying software updates, most suppliers of ERP and accounting systems no longer make their source code available.

4. Attempt to develop a custom materials-tracking system that will work with their current ERP or accounting system or to develop their own custom interface to a system like BellHawk. Both these are expensive and time consuming and typically result in maintenance headaches and system abandonment when the developer leaves the organization for greener pastures.

5. Carefully analyze the situation and realize that in many cases, the investment in developing an interface, using a software platform like MilramX, can result in substantial cost savings and improved efficiency for the organization.

One of the facts that we have come to recognize is that, even if we had developed an interface to their Podunk 5 ERP system for another customer, then it would be unlikely to meet the requirements of the new prospective user of BellHawk, working out of the box.

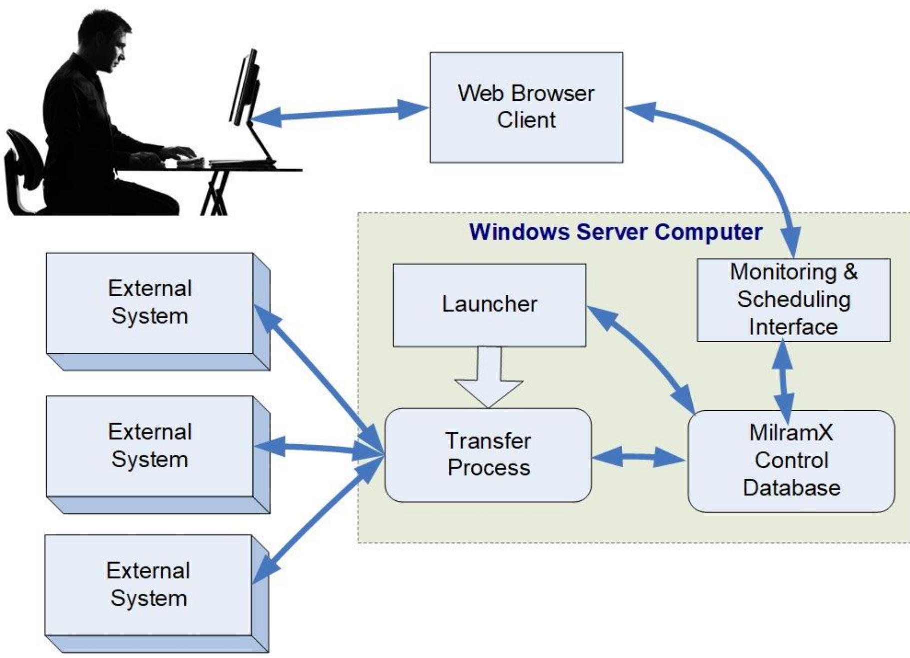
The reason for this is that, while the underlying database interfaces typically do not change from implementation to implementation, the way each organization uses its ERP system does.

One organization may want the inventory updated in its ERP system as soon as transactions are recorded in a material tracking system, like BellHawk. Another may want to update its raw materials inventory by "back-flushing" the inventory, based on expected Bills of Materials (BOMs) for products, after the products are made. This is done to avoid the "black-hole" problem of costs being incurred when raw materials are consumed, which may be days or weeks before the value of finished products are added back to the value of inventory.

Also, some organizations value WIP inventory, whereas others do not. Some organizations value certain materials at market or spot price whereas others value their inventory based on the purchase cost. Some organizations want to use customer sales orders from the ERP system and other want this data to come from an E-Commerce site. Some organizations need to send ASN data to their customers via EDI as soon as a shipment has left and others do not.

As you get into the needs of each individual organization, you quickly realize that there is no such thing as a standard interface, not even to a simple accounting system.

27.3 How MilramX Solves these Problems



MilramX runs on a Windows Server Computer and consists of four main components:

1. A Transfer Process, which transfers data between different systems. It contains multiple subroutines called Data Transfer Objects (DTOs) that serve to transfer data, typically for one data object, such as a PO line record, from one system to another.

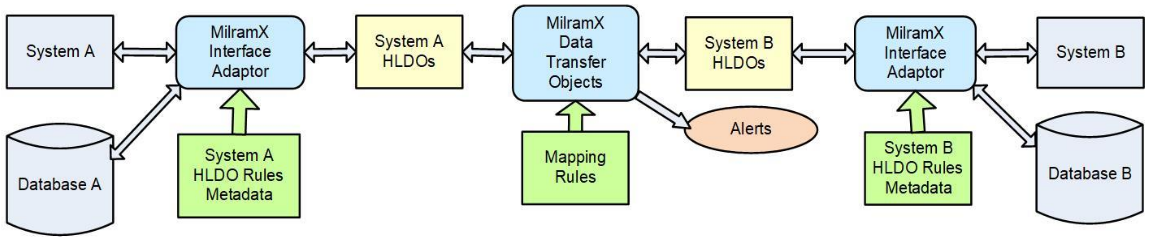
2. A Launcher, which runs as a system process and periodically runs the transfer process to transfer data objects using a specified DTO from a source system to a target system.

3. A SQL Server based Control database which stores all the scheduling and support information needed by the Launcher and Transfer processes. This also stores error reports and, if specified, a queue of the data objects which failed to transfer and can be retried, if needed, after editing.

4. A Monitoring and Scheduling Interface which can be remotely accessed through a web-browser to schedule the running of DTOs and to view and manage any errors which occurred during transfers.

There are also other components such as a daily log file of errors and a mechanism to notify an IT person that an error occurred in a data transfer. These enable IT staff members to remotely manage the transfers and to track down the source of errors and correct them, if needed.

Inside the transfer function there are:



- Adaptors which translate the fetching of data objects from complex database or web-services interfaces into simple High Level Data Objects (HLDOs). These Adaptors manage fetching just those data objects which have been added or changed since the last updates were fetched. They also manage the translation of HLDOs to be stored in the target system(s) into ODBC calls to store data into databases or web-services calls to store new data in external Cloud-based systems.
- Data Transfer Objects (DTOs) which:
    1. Fetch HLDO data from one or more source systems using the appropriate adaptors
    2. Translate this data into HLDOs to be sent to one or more target systems or into text or Email alerts, which are sent by the transfer function.
    3. Store one or more HLDOs in target systems using appropriate Adaptors.
- Metadata rules which control the actions of the interface adaptors.
- Mapping rules for 1:1 mapping between HLDO parameters.
- A mechanism to execute a Sequence of DTOs to make sure that different data objects are transferred in the correct sequence from source to target system.
- Error detection rules and code, which detect unacceptable characters fetched from a source system and has the ability to translate these characters into acceptable character strings for the destination system.
- An Alert mechanism which sends messages by Email or Text Messages to a list of recipients when an alert event is detected by a DTO.
- An FTP mechanism which will send files created by DTOs to destination FTP sites.

An HLDO consists of a keyword, such as “ITEM” and a set of parameter-name:parameter-value pairs of strings, such as “ItemNumber”:”ABC123”. Because parameter values are expressed as strings, they are independent of the data representation used in the underlying databases or interfaces. By convention we use “CamelBack” notation for parameter names, with no spaces (to avoid mistakes). This is similar to how JSON strings represent data

Each HLDO has an XML metadata description, and corresponding Excel representation (for setup purposes) that describe how the high level data object parameters relate to the schema used by the underlying database or web services interface. This metadata enables:

1. MilramX to automatically generate SQL code to translate between underlying databases and HLDOs exchanged between systems.
2. Verifying that the data being imported or exporting is in an acceptable format and does not contain any characters (such as control characters) that would be unacceptable to a target system or to code that is processing the HLDO data.
3. Setting of defaults for unknown values when data is stored into a target system.
4. Providing documentation of how HLDOs relate to underlying database, SDK, or web-services interfaces.

This use of HLDOs hides much of the complexity of the underlying data structures or web-services interface from the developer of the DTOs, which are typically developed using VB.Net but equally could be developed using C##.Net. This enables DTOs to have a very simple canonical form, which is as follows:

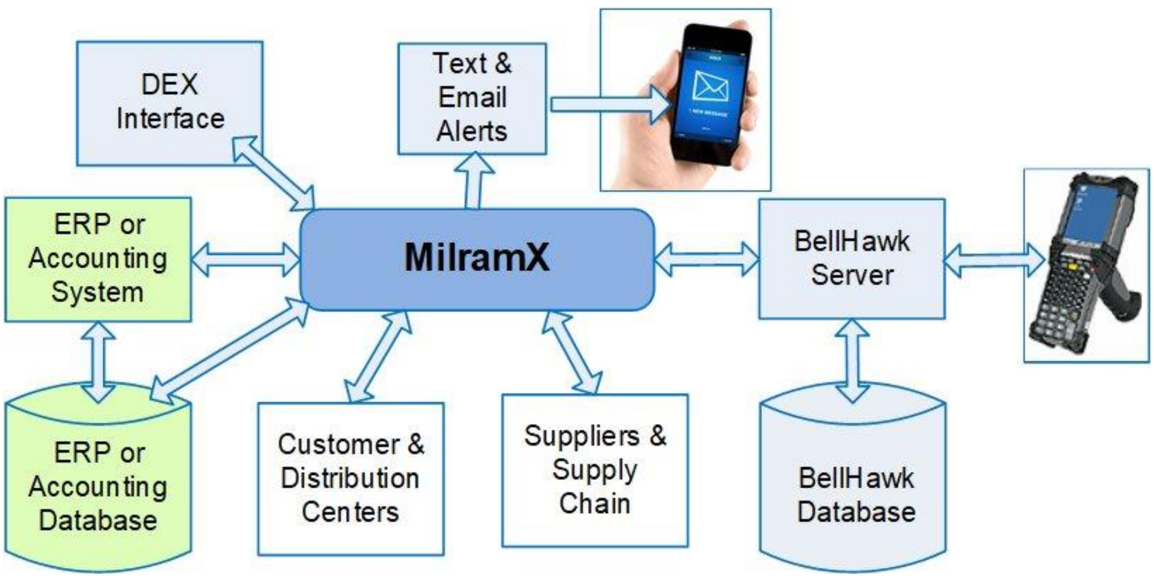
1. Use Fetch function to get latest updates to a specified data object from source system by simply providing the adaptor and HLDO name.
2. Use GetNextRecord function to get HLDOs resulting from Fetch one at a time.
3. Create Output HLDO from input HLDO
4. Use Store function to output created HLDO into the target system.
5. Repeat until there are no more Fetched records to process.

The only code that typically has to be created is that for translating the parameters of the source HLDO into those of the target HLDO, a sample for which is shown below.

```
DX_Receipts("SupplierNumber") = BH_Receipts("SupplierNumber")
DX_Receipts("PO") = BH_Receipts("PONumber")
DX_Receipts("LineNumber") = BH_Receipts("LineNumber")
DX_Receipts("ItemNumber") = BH_Receipts("ItemNumber")
DX_Receipts("UOM") = BH_Receipts("UOM")
DX_Receipts("Quantity") = BH_Receipts("Qty")
DX_Receipts("UnitCost") = BH_Receipts("UnitCost")
DX_Receipts("ExportDate") = BH_Receipts("ExportDate")
DX_Receipts("RefNumber") = strRefNumber
DX_Receipts("IsTransferred") = "N"
DX_Receipts("DateLastMod") = DateTime.Now.ToString("yyyy-MM-dd HH:mm:ss")
blnSuccess = DX_Receipts.Store("C")
```

Once the HLDO's are defined, using Excel spreadsheets, and imported into MilramX through its web-browser interface then the DTO coding becomes very simple and yet retains all the flexibility of using a programming language like VB.Net for more complex algorithms.

27.4 MilramX and BellHawk Integration



One of the principal-uses for MilramX is in implementing data exchange interfaces between BellHawk and a wide variety of ERP and accounting systems as well as providing mechanisms for supply chain integration. It is also used to generate text and Email alerts to notify people when events occur in BellHawk that they need to pay attention to.

To facilitate this MilramX comes with pre-defined HLDOs for BellHawk and interface adaptors enabling data exchange directly with the BellHawk database as well as to exchange data with BellHawk through its web-services interfaces. From a MilramX DTO view point, these interfaces are identical and can be used interchangeably.

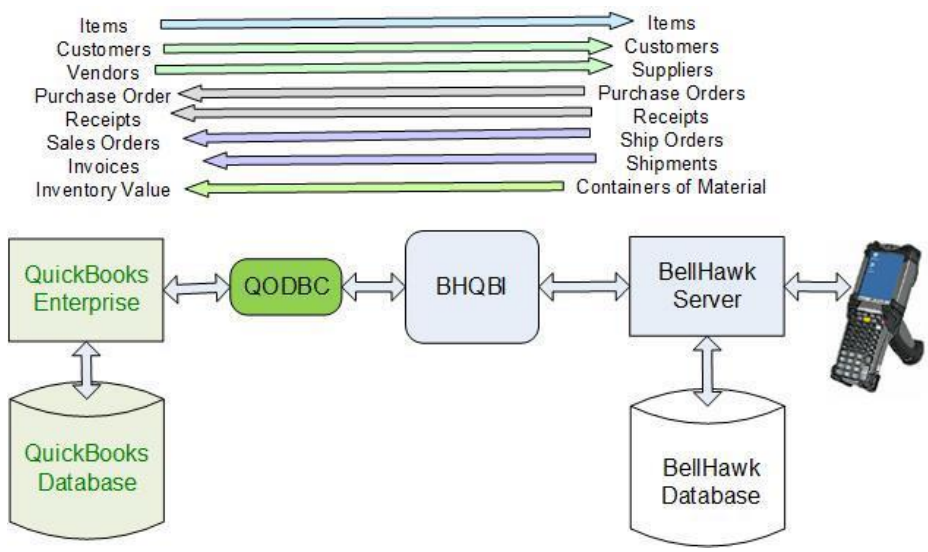
This enables MilramX to be installed on the same Windows Server as BellHawk and take advantage of the higher speed disk access to the BellHawk database. Or it can be installed on a Windows Server at a remote location and communicate with BellHawk using BellHawk's web services interface over the Internet. In either case, the DTOs are identical.

A set of DTOs is available with MilramX which enable communications between a local copy of the BellHawk DEX (data exchange) SQL database and a remote version of BellHawk. This enables MilramX and the DEX database to be used as the basis of producing custom SSRS (SQL Server Reporting Services) reports, based on data captured in BellHawk, on a 24x7 basis.

Many of the mechanisms from MilramX are incorporated into the BellHawk DEX interface which automatically exchanges data between a SQL Server Express database installed on a local PC in a plant or warehouse and a remote copy of BellHawk through its web-services interface. The difference here is that the DEX interface program is run when needed to transfer data rather than transfers being made on a predetermined schedule, as is the case with the full MilramX implementation.

27.5 Interface to QuickBooks

To every rule, there is an exception (sort of) in that there exists a set of DTOs and associated HLOs for interfacing with QuickBooks Enterprise. These DTOs, referred collectively as the BellHawk-QuickBooks Interface (BHQBI) perform the data transfers shown below:



The QuickBooks adaptor for MilramX use the QODBC read/write Desktop interface for exchanging data with the desktop version of QuickBooks Enterprise or the On-Line version of QODBC for exchanging data with the Cloud-based version of QuickBooks Enterprise.

While these BHQBI DTOs have been proven to perform the data exchange tasks needed by a significant number of organizations, please be aware that, in almost every case, the DTO code needed changing to meet the specific needs of each organization.

27.6 Supply Chain Integration

One of the uses of MilramX is supply chain integration. When used with BellHawk, a MilramX DTO can use the BellHawk database records of shipped containers, together with related ship order and customer order data, to create Advanced Shipment Notice (ASN) data. MilramX then transfers this ASN data to third party EDI (Electronic Data Interchange) or FTP (File Transfer Protocol) systems for delivery to the warehouse receiving the shipment.

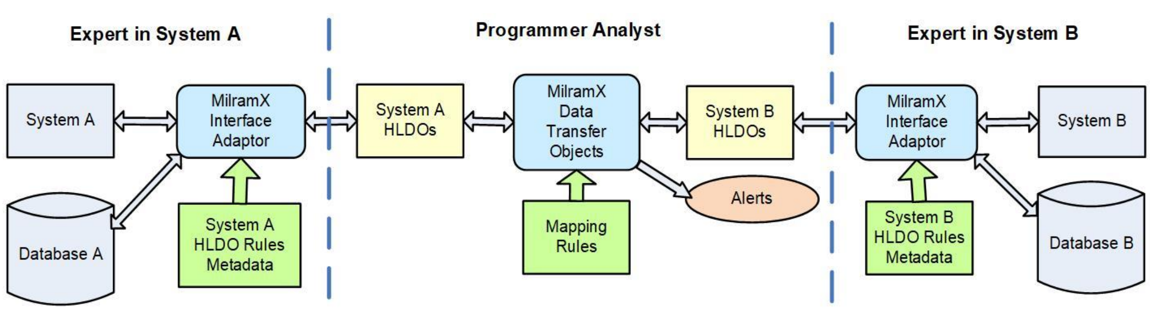
This ASN data can then be used by the receiving organization to quickly receive pallets of material by scanning the tracking barcode on the outside of the pallet and using the ASN data to receive its contents into inventory. Equally, MilramX can be used to receive ASN data from suppliers and to insert it into the BellHawk database, ready for the receipt of the pallets by scanning their tracking barcodes.

For products such as Pharmaceuticals, MilramX can also be used to send the traceability data captured by BellHawk to on-line repositories which can be rapidly interrogated by other systems to make sure that specific products are safe to use.

27.7 Interface Development

MilramX is a powerful tool which can be used to substantially reduce the time and cost of implementing automated data exchange interfaces within an industrial enterprise. But implementing these interfaces does need close collaboration between people who understand how each of the systems work and the details of their interfaces and the systems analysts who understand what information needs to be exchanged as well as what text message or Email alerts need to be generated.

This is facilitated by the structure of MilramX, where different people, who are experts in specific systems, can work on the HLDO rules for the different adaptors. Then these can then be integrated into DTOs by a programmer analyst who understands the information transfer requirements of the organization.



This solves the problem of finding one person who is an expert in the inner working of the two systems, which need to exchange data, as well as being an expert in developing the data exchange code.

When interfacing to BellHawk, all the HLDO's and adaptor rules for BellHawk have already been defined but there is still a significant consulting role that the organization supporting the BellHawk system need to play in implementing the interface. This is typically required to explain the nuance of the meanings of the predefined HLDO parameters.

It is best to use agile incremental methods to develop these interfaces, with one DTO being developed and tested at a time. This includes developing the HLDOs and the adaptor rules, needed to support the DTO. With BellHawk, this can often be done in parallel with its incremental deployment.

27.8 Commentary

While MilramX can significantly reduce the time to develop the interface code, these interfaces, and especially their pre-deployment testing, can take a substantial amount of labor time, if done internally by an organization's own IT staff or expense, if an external interface development and testing team is used.

These interfaces can quickly pay for themselves by saving the labor time of one or more full-time equivalent staff people, who typically cost at least $50,000/year for each person. Even more important these interfaces can enable an organization to prevent expensive mistakes and ensure that the organization is operating efficiently. This is achieved by making sure that each person has the information needed to do their job efficiently, when they need it, without waiting for the needed information to arrive on a paper form.

Section E Software Compliance

28. BellHawk Software Development Practices

The web server version of BellHawk was developed by Milramco LLC and its partners and is maintained according to good software development practices, as described below.

28.1 Version Control

Milramco maintains a complete on-line database of all past versions of the BellHawk software, by using the Subversion software. This includes the standard version of BellHawk as well as special modifications made for each client. Subversion enables the BellHawk development team to track all changes made and to recover prior or alternate versions upon demand.

Each release of BellHawk is clearly shown with its version and subversion number on each user screen to aid in tracking down any issues that may arise.

28.2 Upgrades

1. All proposed changes to the software are documented in writing by a qualified system's architect (M.Sc. or Ph.D. in Computer Science plus at least 10 years' experience). This document is then reviewed and approved by the originator of the request and the software development team and any needed changes made before a final specification document is issued.

2. The needed changes are then broken down into a series of tasks that can be accomplished by a single software developer. Each task is assigned to a senior software developer (with typically a Master's degree education in Computer Science and 10 years plus development experience) who may make the changes themselves or supervise more junior people in making the changes.

3. The tasks are logged as "tickets" in an on-line status tracking system, so their status can be tracked.

4. The resultant code changes for each task are then functionally tested by the assigned senior software developer to ensure compliance with algorithmic and database access requirements.

5. The resultant code changes are then reviewed or tested to requirements set by a systems architect to ensure compliance with the written specifications.

6. The resultant code changes are then tested by the requestor.

7. If any discrepancies are found, they are logged in Milramco's on-line ticket tracking system and assigned to appropriate people to be fixed, then retesting takes place, as appropriate.

28.3 Bugs and Errors

1. Bugs or other errors are logged in Milramco's on-line ticketing system along with their priority.
2. Problems are typically investigated by a senior software developer, who will test the software or evaluate the contents of a backup database, taken as soon as possible after the incident, to determine the cause of the problem.
3. If the cause is a data entry error on behalf of the client using the software then they will be so notified and charged for the time taken to investigate the problem.
4. If the cause is a system design problem then the issue will be investigated by a systems architect who may issue an upgrade request and the above upgrade process will be followed.
5. If the cause is a bug in the code, then a fix will be coded and tested by the programmer and tested by a senior programmer.
6. The bug fix will then be tested by the client or systems architect reporting the bug.
7. The status of the problem report is tracked through the on-line ticket tracking system until it is satisfactorily resolved.

29. BellHawk CFR 21 Part 11 Compliance

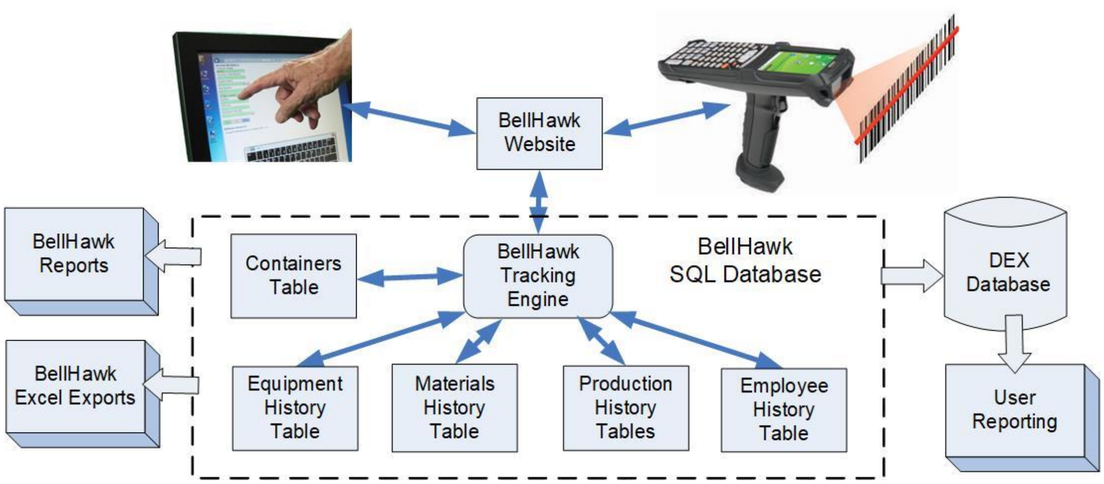
29.1 Introduction

This document details the compliance of the BellHawk® software with "CFR 21 Part 11" (Part 11) dated March 20, 1997 and the guidance document "General Principles of Software Validation; Final Guidance for Industry and FDA Staff," issued January 11, 2002 by the FDA.

The intellectual property rights for BellHawk are owned by Milramco LLC. The BellHawk software was developed by and is maintained by Milramco with the assistance of its partners.

29.2 Capture of Electronics Traceability History

The BellHawk software records the receipt and put-away of raw materials, their transformation into intermediate and finished products, as well as tracking work-in-process. In addition, BellHawk tracks the picking, packing, labeling, and shipping of finished products to customers and distribution centers.



As well as maintaining the current status of all containers of materials that it tracks, BellHawk also tracks the history of all transactions performed on materials, including the transformation of materials in production, as well as the people involved and the equipment used.

This data can then be interrogated through a series of standard reports and Excel exports, as well as used for materials traceability (one step forward, one step back) purposes using the BellHawk TRACE module. Capabilities exist for custom reporting on this data, such as through the DEX interface.

This data is retained perpetually in the BellHawk database. If this data is modified by a supervisor or manager to correct mistakes, such as wrong quantity or lot number, then a complete audit trail of such changes is maintained with the supervisor's name and reason for making the changes.

29.3 Electronic Signatures

BellHawk supports the use of an encrypted data link between the device on which the web-browser, used to access BellHawk, is running and the Windows Server computer on which the BellHawk code is executed and through which the SQL Server database, used to record the electronic record data, is accessed.

Each data collection device and external system that accesses the BellHawk software has its own encrypted login, thereby securing device access. Each employee using such a device is required to identify themselves by a means of scanning a barcode on their employee badge whenever they record transactional data, to identify who is recording the data. Optionally each employee can be required to have their own personal password, in addition to scanning their badge into a data entry device, thus meeting the requirement for two separate forms of identification, where needed.

Optionally BellHawk can print out documents, such as batch processing records, with places for physical signatures by employees recording materials into and out of a batch processing operation, as an extra visual layer of compliance.

All transactional data recorded in the BellHawk database is time tagged to the nearest second and identified as to who the person making the entry was.

BellHawk requires the use of a user name and password for all staff members accessing the BellHawk system. Staff members have review and electronic sign-off requirements on all data entered into the system, as appropriate to their management and supervisory role. All changes to the database records made by a staff member are recorded, with the retention of the original record and a recording of who made the changes.

All passwords are stored in the BellHawk database in non-reversible encrypted format. They can only be changed by the system's administrator, who is a trusted employee, with his or her own encrypted password. It is the responsibility of the system's administrator to ensure that appropriate password aging and control procedures are followed.

29.4 Permanence of Data Records

Data within the BellHawk database cannot be deleted through the BellHawk user interface or the DEX interface. Data can only be modified by direct access to database by the client's Information Technology (IT) staff who have such trusted privileges. It is incumbent on our clients to ensure that their IT practices related to the protection of the data in the database follow good IT practices for security and limitations on data access.

Any data record "deleted" by a user through the BellHawk user interface or the DEX interface are not physically deleted but are simply marked as deleted so as to be not visible to the user. These records can be recalled at any time for audit purposes.

All changes made to data records are logged as to who made the change and the time and date that the change is made. These data records are kept in permanent history tables as well as logged to a daily audit trail log as described in the next section.

If BellHawk is being hosted at a client's own data center, it is critical that the client's IT staff take a full backup of the database and daily audit log files at least daily and store this backup data in an off-site location from which it can be quickly retrieved in the event of the need for disaster recovery. This is done by the service provider, when BellHawk is used over the Internet on a Managed Services basis.

29.5 Audit Trail

BellHawk can produce a daily log file of all new entries and updates made to the BellHawk database. This log file is in standard extended ASCII human readable format. Log files can be downloaded through the manager's switchboard.

The data recorded in each record in the file includes:

1. The time and date in UTC (universal time code) format.
2. The person making the entry with first name, last name and employee number.
3. The keyword for the data object, such as ITEM for a change to an item master record.
4. The new parameters in JSON (JavaScript Standard Object Notation) standard format, such as {"ItemNumber": "ABC123", etc }.

A new log file is produced each day, with a file name that includes the date of the day on which the file was produced.

If errors occur during the operation of the system, they are included in the same log file.

29.6 Level of Compliance

The BellHawk software is a decision support system which is designed to assist trained and knowledgeable personnel in collecting and maintaining one-step forward, one-step backward traceability records and rapidly recalling that data when needed. It is not intended for use as a fully automated data collection system nor is it suitable for use in any application where any action of the software could directly cause harm to, or negatively impact the safety of, any person or animal.

BellHawk is purely a data collection and reporting system. Its results should only be used by trained and knowledgeable personnel to assist them in their decision-making processes. Such personnel must use their training and judgment in the interpretation of all reports and Excel exports produced by the BellHawk software.

BellHawk follows the implementation guidance documents published by the FDA to the extent that they are appropriate to a low-risk deployment in capturing materials tracking and traceability data for subsequent analysis by skilled personnel who are appropriately trained.

Summary

BellHawk is an integrated Real-Time Inventory Tracking and Operations Management software platform which is used by manufacturers, food and pharmaceutical processors, engineering, construction, defense, and repair organizations, as well as many other industrial organizations.

The current web-server version of BellHawk has been developed based on over a decade of practical application to solve a wide-range of materials tracking and operations management problems. While its core features are very stable, features continue to be added, especially to support supply chain and enterprise IT integration.

The BellHawk software can be used as a software product that works "out-of-the-box" and is designed to be configured by users to work in a wide range of applications. BellHawk can also be used as a software platform that can be customized by IT staff for specific applications.

BellHawk can be used at a remote data center or hosted on a Windows Server within a manufacturing plant or distribution center. It can be used with a wide-range of computing and data collection devices through a web-browser interface, without needing to load any special software on the devices. Through the use of software installed on local Windows Workstation computers, it can also support interaction with a wide range of local devices such as barcode label printers, weighing scales, and RFID portals.

BellHawk can be run stand-alone or can automatically exchange data, through its DEX interface, with a wide range of other systems including ERP and accounting systems, computer aided design and E-Commerce systems, as well as with process control equipment.

For more details about the BellHawk software and its capabilities, as well as demonstration videos and user manuals for BellHawk, please see www.BellHawk.com.

Sponsor

Publication of this edition was sponsored by KnarrTek Inc. KnarrTek distributes and supports the BellHawk and MilramX software in the USA, Canada, and the UK.

KnarrTek provides a full range of supporting services to assist its clients, systems integrators, and its partners to implement systems based on this software.

For more information, please see www.KnarrTek.com.

