



## **Solving the Parts Number Explosion Problem for Make-to-Order Manufacturers**

### **Introduction**

We have a client who makes large steel dumpsters in 16 basic models. But when we added up all the possible combinations of color and attachments we came up with over 100,000 different part numbers that would be needed to represent all their possible "standard" semi-custom finished products, not counting custom orders.

We have another client that makes custom piping systems. These systems may be fabricated from hundreds of thousands of different pipes and fittings as their raw materials. We have yet other clients who make curtain wall windows and kitchen cabinets that have an almost unlimited number of intermediate materials in different colors, lengths, widths, made from different materials, and are custom cut, drilled and machined from a large number of different raw materials.

The traditional "ERP" (Enterprise Resource Planning) or "MES" (Manufacturing Execution System) approach of assigning a separate part number to each possible combination of attributes for raw, intermediate, and finished products is not practically feasible in these, and similar cases.

It takes about 6 minutes to enter a part number into an ERP or MES system. As a result it would take 10,000 hours or over 5 person years to enter the Item Master part number setup data for 100,000 parts. This is obviously not cost effective.

In this white paper, we examine the alternate approach of using a small set of "generic" part numbers combined with tracking part attributes such as length, width, color and CAD system drawing number to track this large number of parts.

### **Using Generic Part Numbers**

The concept here is to use a small number of part numbers and then to assign attributes to them that can allow representation of a large number of parts.

As a simple example, consider golf shirts. These come in a variety of styles, colors, and sizes. By using the style of the shirt as the base part number and then using color and size as attributes that are separately tracked, we can significantly reduce the number of parts numbers we need to track.

In the case of the dumpster manufacturer, we were able to reduce the number of item master parts to 16 for their finished goods, which corresponded to the base models they make. In the case of the piping system manufacturer, we used generic parts such as pipe and elbow and T-fitting and then added attributes such as material type (copper, steel) and size to reduce the raw materials parts explosion. And in the case of the makers of windows and cabinets, we use the type of raw material, such as the extrusion or laminated board from which parts are made, as the generic part number and then track attributes such as length and width as well as the CAD system drawing for the part.

In the BellHawk materials tracking software, we enable the users to set up generic Item Master part numbers, just like any other part numbers and then specify attributes as user defined parameters that the system will prompt for when entering:

- Material into inventory
- Ship order lines
- Purchase order lines
- Pick order lines
- Bills of Materials for work order steps or operations.

The rules for setting up these attributes are imported into BellHawk by means of Excel spreadsheets and include information, such as data type and max and min values, which can be used for error checking during data entry. These rules also allow for attributes to be selected from user specified drop-down lists of choices or from check-boxes for Boolean values.

### **Tracking User Defined Attributes for Materials**

Unlike most ERP and MES systems, BellHawk tracks materials in containers, where each material is represented by a generic part number, with standard attributes such as lot number and expiration date, as well as user defined parameters such as length, width, and color. These containers can be tracked as nested containers (materials in boxes, on pallets) and as they move between different locations.

When materials are entered into inventory, the part number, quantity, standard and user defined attributes are stored in a container record in the containers table in the BellHawk database along with information, such as the location of the container, its parent container (if any), quality control status (waiting, passed, or failed inspection) and rolled up material plus labor plus machine cost per unit quantity.

In a system such as BellHawk, most containers have a unique "license-plate" tracking barcode attached to them, which can be scanned to identify the container, and thus access all the attributes of materials in the container. BellHawk does, however, have the ability to track "virtual containers" which do not have a tracking barcode attached. This enables, for example, materials to be tracked in a location or container which contains a mixed set of parts, with the same or different part numbers, with different user defined attributes.

BellHawk separately tracks each virtual container inside each physical container or location which has a tracking barcode label attached. This enables users to pick parts from a pallet or warehouse rack location containing mixed parts, with the same generic part number, by selecting the parts based on user defined as well as standard attributes.

BellHawk can also track the user defined attributes of individual items, such as electrical motors, or of assemblies such as windows or cabinets. These typically have their own "license-plate" tracking barcodes and serial numbers, which are tracked as standard attributes, along with user defined attributes.

## Using Inheritance

The process of making a custom or semi-custom product, typical starts with the entry of a ship order, which details all the finished materials to be shipped to a customer's site. Note that here we distinguish between the "sales order" from the customer and the ship order, which may be for a single release of products from a customer order.

In BellHawk, once the user has selected the generic part number to be shipped, along with the quantity, the system will request that the user enter the user defined attributes for the part being ordered. This may include attributes such as the size and color as well as the length, width, and thickness being ordered.

Once a make-to-order product has been entered into a ship order line, BellHawk can then automatically generate a work order from the ship order line. This work order can then automatically inherit the user defined attributes from the ship order line. Thus, in a simple example, the ship order line may be for five blue, large, T-Shirts with the U-Mass logo. This will then create a work order to make 5 generic T-shirts with attributes of blue, large, and with the U-Mass logo.

Also the attributes can be passed to purchase order lines generated directly from the ship order lines, or indirectly passed from the raw material demand generated by the work order.

The attributes are also directly passed from the ship orders to pick orders generated for recording the picking, packing and shipping and shipping of materials to customers or of being loaded onto a truck for delivery to site. This enables the system to check that the person doing the picking or packing is selecting the correct part, with the correct user defined attributes for the order.

The generation of work orders directly from ship order lines works for simpler, make to order operations, but more complex make-to-order products, such as for custom cabinets or curtain-wall windows, required each component to be designed using a CAD (computer aided design) system. In this case, the purchase orders and work orders are generated from data exported from the CAD system, complete with generic part numbers and user defined attributes.

## Mixing Standard and Generic Part Numbers

It is recognized that for some parts, such as some raw materials, it is better to use "standard" part numbers and to create an Item Master record for each of these standard parts. In BellHawk, we treat generic and standard part numbers the same, the only difference is that the standard part numbers do not have any user defined parameters.

This also enables those users that do not wish to setup generic part numbers with user defined attributes to use BellHawk as a standard materials tracking system.

## Inventory Reporting Issues

While the use of generic part numbers plus user defined attributes works very well for tracking containers of material, it does need some extensions for reporting.

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.

It is not enough to 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 grouping of like items by line. 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 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.

## **Barcode Label Generation Issues**

BellHawk supports the automated selection of the labels to be printed on-demand as part of data entry transactions that record individual items or containers of material into inventory. It also supports automatically filling in the correct data in the labels from the attributes of the item or container. These include standard attributes such as part number, description, and quantity as well as the lot number and expiration date, as well as user defined attributes such as "color" or "size".

In this way user defined attributes can be made to appear automatically on labels, as human readable information or as barcodes, if needed.

## **Work Order Simplification**

In BellHawk, work orders can be created to make a quantity of a standard part number. These work orders may have a sequence of operations as their route steps, with each route step having a Bill of Materials (BOM) of parts needed for each operation. These work orders are normally created from Item Master records which have their own route steps and BOMs associated with the work order step operations.

When parts are recorded out from an operation on a work order, as a BellHawk transaction, user defined attributes such as size, color and dimensions can be requested, which are carried as attributes to the part of container of materials being recorded out. This may be a finished product or the item or container may have a WIP flag set to indicate that it is still a work-in-process, even though it may have the same part number as the finished product.

Routes can be created for generic item numbers with generic BOMs for each operation, with each part having their own user defined attributes. This generic item data can then be used to create work orders to make parts with specific user defined attributes, which are requested at the time the work order is set up. This avoids creating separate Item Master records for each product to be made and uses generic part numbers to also avoid an explosion in the number of parts and routes to be setup.

Unfortunately, sometimes this is not the complete picture. For example, to make a set of custom kitchen cabinets may require several hundred different parts. In a conventional work-order tracking scheme, this would require creating several hundred work orders, one for each different length, width, and color part. Even though all these parts may be represented by a single generic item master part number, the large number of work orders becomes very cumbersome to track and manage.

To solve this problem, BellHawk supports the use of a single "generic" work order for a customer job, with a generic route of operations, into and out of which all the different boards needed to make a cabinet, for example, can be scanned as they go through different operations.

This can reduce the need to create several hundred work orders for a job, to just one for making the parts and one for the assembly of the finished products. Each work order can be used to track the progress of the parts from beginning to end, as well as being used to record the labor required and materials consumed on each work order.

### **ERP/Accounting Interface Issues**

Clients who use generic parts with user defined attributes generally prefer to enter their ship orders and purchase orders into BellHawk, which also captures the shipment and receipt of materials against these orders. The question then arises as to how to report these receipts and shipments to an accounting system.

Typically this is done by setting up the generic parts used in BellHawk as standard Items in the accounting system. Then, whenever a shipment is made in BellHawk, we export a corresponding sales order to the accounting system followed by the shipment itself.

The exported sales order may have repeated item numbers on different lines of the sales order, with descriptions that include the user defined attributes. Likewise the shipments against the sales order may have repeated part numbers with different descriptions.

A similar approach is used with purchase orders and receipts. In this way the number of items that need to be setup in the accounting system is kept to a relatively small number.

There is, of course, no concept of a standard cost or price for an item as different attributes result in different costs for the same item. As a result shipments are recorded in the accounting system at the unit price stated on the ship order line and receipts are recorded at the price stated on the purchase order.

As well as tracking the cost of raw materials, BellHawk is able to add-in the cost of labor and equipment time to compute the actual cost of making containers of intermediate materials as well as finished products.

Usually, on a nightly basis, the actual cost and quantity of all the containers of each generic part number are added up in BellHawk to get the quantity and value of the inventory. This is then transferred to the accounting system as a nightly adjustment in inventory quantity and value. This enables the accounting system to track the inventory value on a nightly basis and to include this in the accounting reports.

This approach is compatible with the use of specific part numbers for certain raw materials, as well as issuing purchase orders for items, such as snow-plowing, directly through the accounting system.

## **Commentary**

For make-to-order manufacturers of custom and semi-custom products, the use of generic part numbers with user defined attributes can result in a huge savings in setup time for their materials tracking system as well as for setting up the corresponding items in their accounting system. It can also provide the flexibility of easily adding new options to existing products without creating new part numbers for all the resultant new combinations of options in their ERP or accounting systems.

For those manufacturers that deal in dimensioned material, such as lengths of pipe or sheets of plywood, the use of a generic part number with width and length attributes enables the tracking of off-cuts without creating new part numbers. In BellHawk we can, for example, track the number of boards of plywood, with each board having its length and width tracked separately in BellHawk inventory. This can greatly facilitate the use of offcuts in making products and also ensure that the costs are properly allocated.

The use of generic parts, combined with container based tracking, also enables the tracking of inventory and work-in-process to a very fine granularity without cluttering up the accounting system with hundreds of thousands of part numbers, which would otherwise be needed to track that level of granularity.

As a result, if you have hundreds or thousands of custom or semi-custom parts being processed through your manufacturing plant at any one time then the use of generic parts will definitely have great benefit. But, if you make the same few products, month-in, month-out, in a long-run manufacturing operation, then the additional complexity will probably not be of benefit.

## **Author**

Dr Peter Green is an expert in using computer technologies such as barcodes, RFID, mobile computing, and real time Artificial Intelligence to track and trace materials. He currently serves as Technical Director of Milramco, where he was responsible for the development of the BellHawk software. Previously he was a member of the research staff at MIT and a Professor of Computer Engineering at WPI.

For more information, please contact [Peter.Green@BellHawk.com](mailto:Peter.Green@BellHawk.com). Also, please see [www.BellHawk.com](http://www.BellHawk.com) for more details on the BellHawk software technology.