

# THE IMPACT OF JUST IN TIME ON BILL OF MATERIAL STRUCTURING

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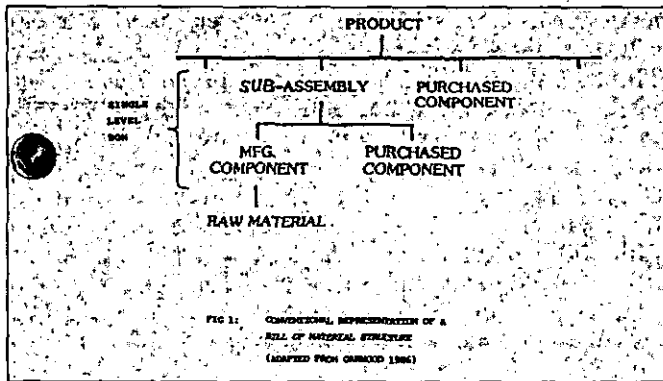
## Introduction

During the last two decades there has been a concerted effort in manufacturing companies to reduce manufacturing lead times. Nowadays, the popular jargon for such efforts is just in time (JIT), which simply means more effective management of the manufacturing activity. As a result, production plants have become more flexible and able to respond better to the dynamics of market demand, with the minimum of inventory.

This article describes the historical development of bill of material (BOM) structuring and considers whether the long held premise, that BOM should be structured the way the product is built, still holds true in a JIT environment.

## History of Bills of Material

The origins of the BOM lie in the simple parts list which merely itemised all the components required to manufacture a single product. Such lists were frequently unstructured or, in modern parlance each product was defined by one unique single level BOM. With the advent of material requirements planning (MRP), and the associated BOM processors, it was quickly found that these simple BOM structures were inadequate. There were two main reasons for this. Firstly, it became necessary to identify sub-assemblies with a part number so that they could be scheduled for manufacture. Secondly, the BOM based on simple parts lists were cumbersome and wasteful of file space when many of the same parts were repeatedly specified in several products. This was the launchpad for the development of the subject of BOM structuring (i.e. how the components required for manufacturing should be grouped or organised).



It is widely assumed that a product's sub-assemblies can be easily defined and that each sub-assembly can be represented by one single level BOM (as shown in figure 1). For some simple products this may be the case and, where it is, BOM structuring is not a problem. However, in practice, the definition of sub-assemblies is frequently not so straightforward. The crux of BOM structuring is the definition of what each single level BOM should contain. At the component level this is rarely a problem; purchased components by definition have no BOM (except when work is sub-contracted) and manufactured components are usually only made from one piece of raw material. Most of the confusion surrounds the definition of sub-assemblies.

Taken literally, a sub-assembly is a group of components which is pre-assembled in an operation which is both discrete and separate to the final assembly process. However, the product design engineers, who traditionally

are the people allotted the task of compiling BOM, often have little knowledge of the eventual assembly process whilst designing a product. Their attention is focussed on the function which the product is intended to perform and their thought processes lead them to mentally "assemble" the product in a different way from that which will be used on the assembly line. Typically the product specification is broken down into a series of design features and the engineer tends to construct specific solutions for each requirement. Frequently, they will describe these as "sub-assemblies", long before any serious consideration has been given to the method of assembly in the factory. These are not sub-assemblies in the physical sense, they are elements of the product design; convenient groups of components and systems which each provide a particular design feature. Only if the original design specification particularly requires that these be physically removable, are the engineers' "sub-assemblies" likely to resemble those used by manufacturing. Since the definition of the sub-assemblies, or single-level BOM, is the foundation upon which all BOM structures are based, this is the cause of the conflict between "engineering BOM" and "manufacturing BOM".

During the 1970's, this dilemma was resolved by companies who converted their "engineering BOM" into "manufacturing BOM" by identifying the physical sub-assemblies and coding design "sub-assemblies" as phantoms. Today, with the increasing application of the JIT philosophy, identification of the manufacturing sub-assemblies is becoming less important. For example, at Eaton's three European transmission plants, almost all sub-assembly is integrated with the final assembly process; sub-assemblies are only built as required and are therefore neither scheduled nor stocked. Therefore, there is no need to identify sub-assemblies with part numbers. This view is supported by the fact that employees of the company are rarely heard discussing sub-assembly numbers; all problems and decisions focus on either finished products or components. In the few cases where sub-assemblies are scheduled and stocked separately, identification by part number is of course essential; for example, control units which are manufactured at a UK plant, and stocked in the French plant. Only by identifying them with a part number is it possible for MRP to produce schedules and allow the appropriate lead times. However, this is an exception; the majority of components can be assembled into a complete transmission within a few hours which, for the purposes of MRP, is an insignificant lead time. Because of this, the BOM is no longer used as a complex critical path network, for netting off sub-assembly stocks and stacking their lead times. Eliminating many sub-assembly and phantom numbers would greatly simplify the BOM and make them much easier to use and interpret. JIT is therefore increasingly becoming associated with shallow or even single level product BOM.

Some authors have not quite come to terms with the full impact of this. For example, Prather (1984) suggests that:

"Just-in-time manufacturing, in its pure form, makes every manufacturing sub-assembly a transient sub-assembly or phantom BOM."

But why stop there? Do these manufacturing sub-assemblies really need to be identified by a part number at

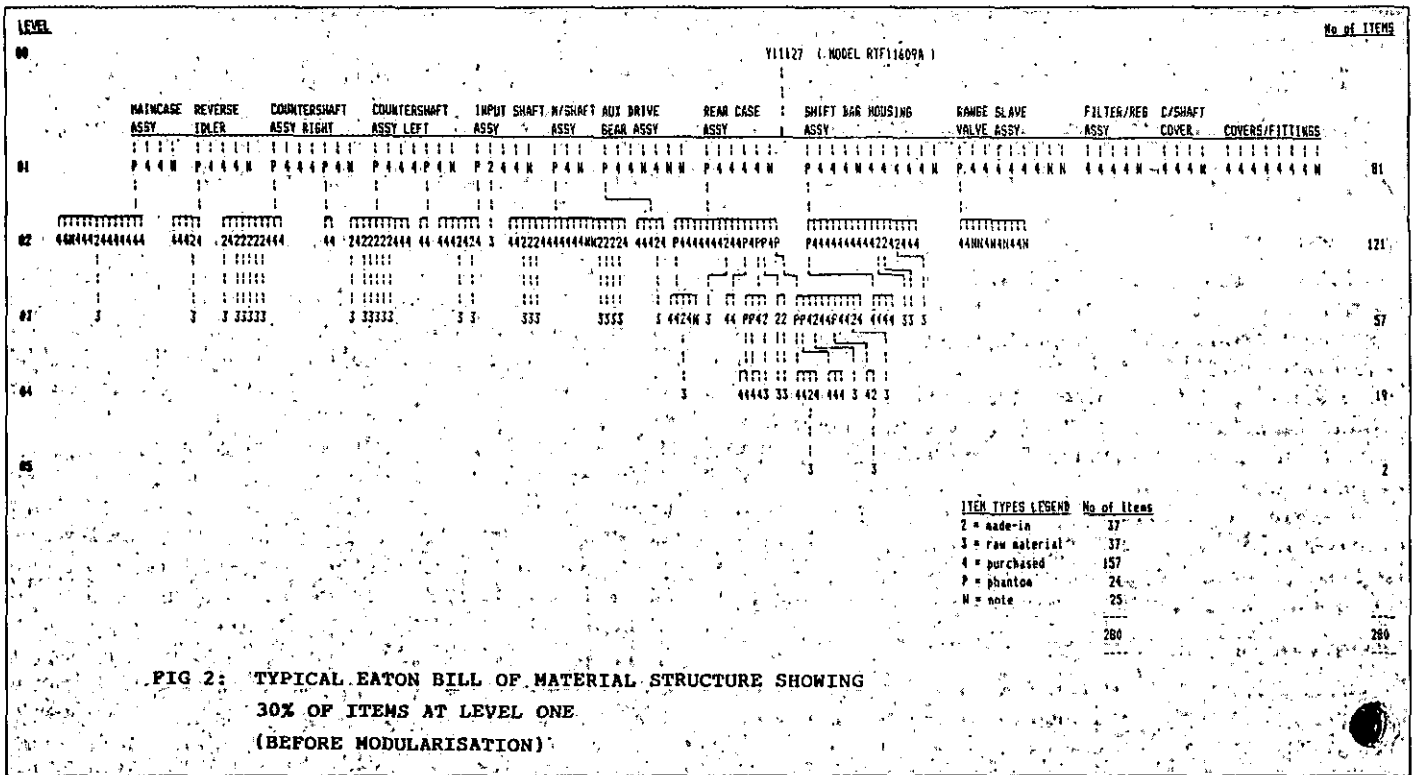


FIG 2: TYPICAL EATON BILL OF MATERIAL STRUCTURE SHOWING 30% OF ITEMS AT LEVEL ONE (BEFORE MODULARISATION)

all? Surely many of them can be completely eliminated from the BOM.

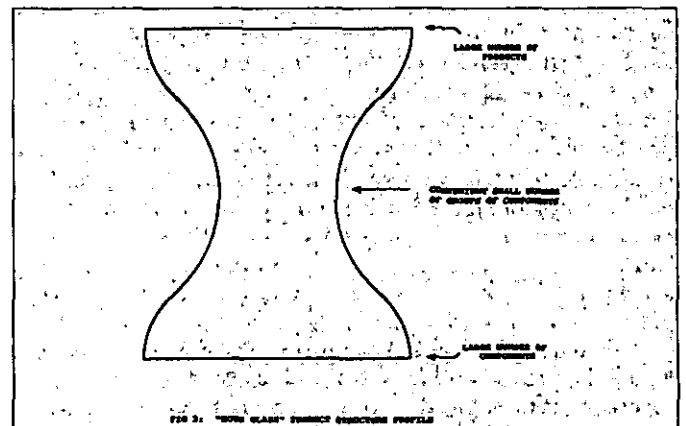
This brings us full circle. If all non-essential sub-assembly and phantom part numbers are deleted, what remains is a simple single level BOM for each product (i.e. an unstructured parts list). In this way JIT has largely resolved the tremendous engineering versus manufacturing BOM conflict which was rife during the 1970's. The manufacturing department no longer has any need to identify most sub-assemblies. The BOM structure can therefore be greatly simplified by reducing the number of part numbers and BOM levels.

#### Alternatives to Sub-Assemblies

However, there are also disadvantages arising from the elimination of all these sub-assembly numbers. For example, the current BOM structures for Eaton's transmission products happen to contain nearly 30% of all components at level one (see figure 2). The experience gained from using these product structures strongly indicates that all components should *not* be promoted to level one. This is because engineering changes (EC) involving commonly used components, which are at level one, are cumbersome to record on the BOM since the structural link between the component and every product in which it is used has to be individually changed. Although it is realised that many BOM packages now contain a "mass change" facility to cope with such circumstances, this merely tackles a symptom of poor BOM structuring rather than the root cause. The aim should be to permanently reduce the heavy work load of BOM maintenance. The "mass change" facility only shifts it onto the computer. Another problem with oversimplified BOM structures is that where-used reports (or implosions) tend to be very long and unhelpful. This is because the implosion of a component specified at level one of several product structures, will simply list all these product part numbers. Such a list says little about the component's function. So although JIT largely removes the manufacturing constraints on BOM structuring it is unwise to eliminate sub-assembly numbers without due regard to these negative impacts. The current interest in JIT manufacturing should be regarded as an opportunity to provide more

useful BOM structures.

If only the product/component relationship is defined, without any intervening grouping or structure, then forecasting and scheduling become complex to manage, because of the requirement to consider large quantities of numbers individually. Therefore one function of the BOM structure is to break down the products into more manageable chunks, each of which is represented by a single level BOM. Unless marketing and production personnel become actively involved in defining these structures, there may be a tendency for engineers to develop an organisation which is merely intuitively pleasing (e.g. by grouping pneumatic, electrical and mechanical items separately). However, such structures will have little relevance to the needs of the business. Through detailed analysis of the product/component relationships, many manufacturing companies may be able to identify component groups which are fewer in number than either the products which they constitute, or the components they represent. This concept is frequently represented as an "hour glass" (figure 3). Furthermore, with JIT manufacturing these new groups need not necessarily represent physical sub-assemblies. They may simply be groups of components which are convenient to schedule together as a matched set.



## Bill of Material Modularisation

In 1965 Starr defined the then new concept of modular production:

"The principle of modularity is to design, develop and produce the minimum number of parts that can be combined in the maximum number of ways to offer the greatest number of products."

Starr saw this as the only, indeed inevitable, response to the increasing demands of consumers for greater product variety. Throughout the 1960s and 1970s this philosophy became widely implemented and consumers became familiar with product ranges offering a wide variety of choice and options. This demand for product proliferation has given rise to everything from modular furniture to customised computer installations. However, initially the modular approach tended to only be implemented where demand for product variety was so great as to justify radical product re-design. For such products BOM structuring is not a problem since engineering design the modular sub-assemblies, which production schedule and make to stock. The final assembly often being carried out by the customer. The single level BOM are well defined because they relate directly to tangible discreet sub-assemblies.

However, customers are relentless in their demand for diversity and market competition ensures that consumer choice is not limited to simple bolt on attachments. In particular Original Equipment Manufacturers increasingly demand variants to parts which are integral to the basic product. An example from Eaton's transmissions is the choice of gear ratios. A particular set of gears cannot be pre-assembled as a module, they can only be fitted into the gearbox case during final assembly. In a JIT environment, where the final assembly lead time is much less than the competitive delivery time, it is quite feasible to offer this kind of product variety, without large inventories. A prerequisite however, is the availability of the necessary materials. What is needed is a BOM structure which most effectively records all the components required for each option and variant. Such a collection of parts may of course happen to be physically sub-assembled in the factory, but with JIT this is no longer a significant factor.

Having relaxed the need to identify physical sub-assemblies, the BOM can be re-organised (or re-structured) and its components allocated to new groupings which are useful for both scheduling and BOM maintenance. Modules represent groups of components which together provide a specific product feature. They are useful for scheduling because many customers require the same product features but in different combinations, and the modular structure enables the demand for any one feature to be aggregated. This structure is also useful for BOM maintenance, since whenever a product feature is subject to an EC then only one transaction is required on the module concerned; the EC is then automatically reflected wherever the module itself is used. Although modules are represented in the BOM by structural links, similar to those used for traditional sub-assemblies, the two should not be confused. The terms module and sub-assembly are only synonymous where a product feature is designed to be physically removable from the product as one unit; a transmission example is the control which can be removed and replaced by an alternative design. However, it is much more likely that design features do not equate with sub-assemblies. They must therefore have zero lead time because they cannot be built.

Defining all the options available in a particular product line is a complex task requiring input from a wide variety of company functions. In particular the process of BOM restructuring raises questions which only marketing and production control personnel can answer. It is now time for

BOM users to actually participate in BOM structuring instead of always expecting engineering to take responsibility for it. JIT manufacturing has already made manufacturing plants more responsive and flexible. This needs to be reflected in the BOM structures so that companies can use their business planning systems to take full advantage of this new found flexibility. This opportunity must be grasped and used. If it is not, organisations may find that customer demand increasingly fails to be satisfied; and they will not be able to blame the plant.

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