Use of Decision Support Systems to Assist with Materials Management in Construction and Engineering Projects

Introduction

This paper is based on the author's experience with providing software to track and manage the materials for projects such as:

- Making and installing curtain-wall windows for tall office buildings
- Engineering and installing custom machines and production lines in manufacturing plants
- Making and installing custom kitchen cabinets and counter-tops
- Deploying and decommissioning green energy projects
- The quarrying, cutting, and shipping of granite cladding for buildings
- Engineering and making custom antennas for the US Department of Defense

These projects involve the design, purchasing, fabrication, assembly, shipment, and installation of many hundreds or thousands of different parts, assemblies, and sub-assemblies, many of which are unique to the specific project. Often these materials have to be delivered to site in releases, so that they can be incrementally installed, as the construction or engineering project progresses.

These projects often require custom jigs and fixtures for installation that need to designed and fabricated, as well as expensive tools, measuring equipment, and other assets that needs to be returned after the project is completed.

Keeping track of all these materials and assets can consume an incredible amount of manpower and the cost of mistakes is high.

One of the biggest cost-and-time wasters is to ship a release of materials to site only to have someone call up and say a part was missing. Without good materials tracking, it is hard to say whether the supposedly missing materials were not shipped to the site or simply lost or misappropriated by a tradesman for another purpose, once on site. Having to pay for replacement parts and the resultant delays can quickly erode the project profits.

Another big time and cost waster is due to the failure of someone to order, make or ship parts when needed. This can often happen when relying on paper documents for the management of project materials, especially if the responsibility for these actions is spread amongst different people at different locations. This communications problem is especially prevalent when sub-contractors are involved.

The intent of this white paper is to give guidance as to how to use materials tracking and decision support systems, such as those provided by KnarrTek, to assist with the complex task of managing materials and assets in engineering and construction projects.

Materials Tracking and Decision Support Systems

A Materials Tracking and Decision Support System, such as those provided by KnarrTek, have four main layers. These are:

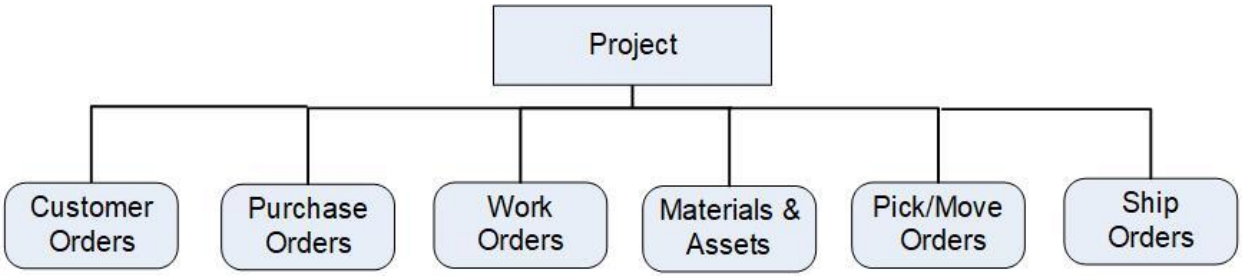
1. The materials tracking layer. This tracking is typically done using barcode tracking and mobile computers but RFID may be deployed where appropriate. In this layer warnings are given to materials handlers when they are about to make operational mistakes, typically on their mobile computers.

2. The data exchange layer where data is exchanged with other systems such as those used for Computer Aided Design (CAD) and ERP or accounting systems, used for entering customer orders and purchase orders, as well as for billing purposes.

3. A materials management layer, where purchase orders, work orders, material move orders, and ship orders are created in response to the engineering designs created in the CAD system.

4. A real-time alerting layer which automatically send Email or text message alerts to people when they need to take action, such as ordering, making, or shipping materials. This layer is also used to alert people when something has gone wrong, such as materials not arriving when needed, or when urgently needed materials have arrived on the receiving dock.

Project Organization



In most cases, organizations have many projects (sometimes called Jobs) going on at the same time. Associated with each project are:

- Customer Orders, which may be "blanket" orders requiring multiple shipments.
- Purchase Orders to purchase materials for the project
- Work Orders to make component materials, fabricate sub-assemblies or assemblies, as well as perform testing and installation.
- Materials and assets purchased or assigned to the project. This includes work-in-process materials or assemblies that are currently being worked on.
- Pick or materials move orders to pack or move materials to a different location
- Ship orders - to ship materials to a customer site (sometimes called releases).

Projects enable project managers and other support people to get a real-time view of all the orders and materials associated with each project.

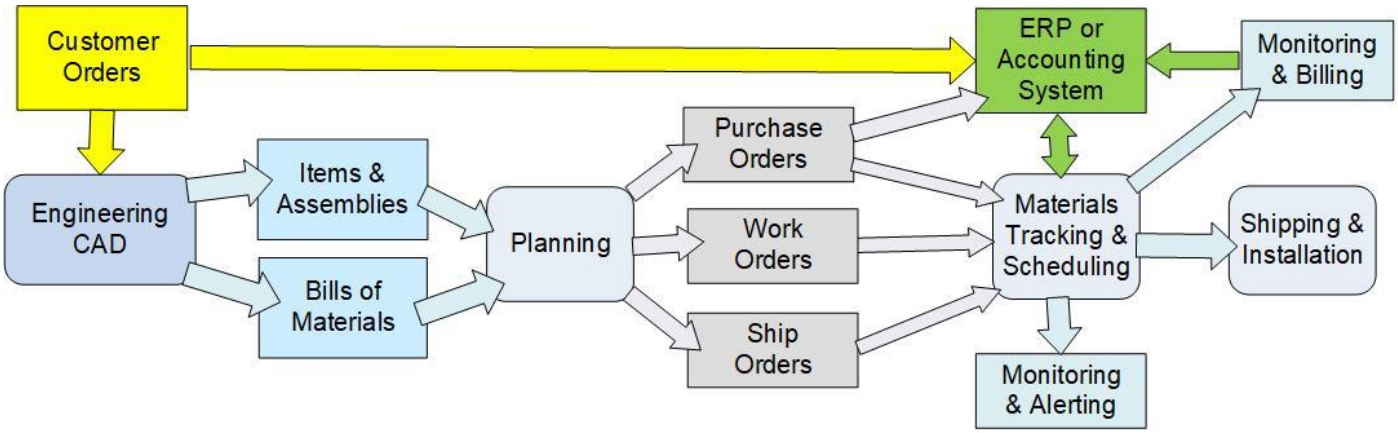
Projects also provide a convenient way of ensuring that materials assigned to one project are not inadvertently used on another project. Projects are also used to prevent the mixing of materials purchased or made for different projects.

This is not to preclude the transfer of materials and assets from one project to another, with the acquiescence of both project managers or the use of "Common Stock" inventory, which can be used by any project.

This is most common when there are multiple projects going on at the same time for the same customer. But sometimes materials are transferred from one customer to another, which may require the decision support system to notify the accounting system of the change, if it impacts customer billing.

The decision support system may also play a role in automating the reordering of replacement parts for the project from which the parts were "stolen".

Materials Flow within a Project



The process starts with a customer order, which is typically entered into an ERP or accounting system. This is then sent to Engineering to design the system or construction project. This is typically not new to Engineering, as they have often participated in quoting the project.

Engineering then uses computer aided design software to design all the assemblies and sub-assemblies that will be in the deliverable system plus they design all the custom component items and selects standard components to be purchased. The results of this are Bills of Materials (BOMs) for the assemblies, at various levels, BOMs for custom parts to be made, as well as the specification of standard parts to be used. As part of this process, engineering also produces design documents for each assembly and custom part to be made.

These Item and Assembly BOMs are then used in the Decision Support System (DSS) planning process to produce the needed purchase orders, work orders, and ship orders for the project.

Purchase orders are typically transferred to the ERP or accounting system, where they are handled as part of the organizations normal purchasing function. At the same time appropriate people are alerted on the need to take action to order materials. Subsequently they can be alerted when they need to make custom parts and assemblies or to ship finished assemblies.

The resultant tracking of materials receipts, scheduling of work orders to make custom parts, and tracking the shipping and installation of finished assemblies are then performed by the materials tracking system. Detailed scheduling is also performed dynamically be the materials tracking system based on the dates established during the planning process. The materials tracking activity is then monitored by the DSS to make sure that the project stays on schedule and alerts are issued if not.

The consumption of parts on a project, as well as the shipping and installation of finished systems components can also be monitored by the DSS and billing information sent to the ERP system to ensure that bills are sent out as soon as possible.

Materials Planning

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

When BOMs are imported from the CAD system, ship orders are identified along with the assemblies and parts that are to be included in each ship order. In addition, the materials that are needed for each assembly, including sub-assemblies, as well as the materials needed to make custom parts, are identified and detailed.

In a Decision Support System (DSS), like KnarrTek, materials planning starts with the ship orders line items. Upon selecting a line item, the person doing the planning is presented with a list of the parts that it is needed to make that line item, which is typically a top-level assembly. Some of these parts have been previously identified as purchased items, while others have been identified as only being made in-house, while others are identified as needing a make or buy decision.

As shown above, for each item, the user is shown what inventory is in stock, what is already allocated to other projects, how much is already on order, and the net available to meet that needed for the project. The user can then decide to create a purchase order to buy the materials or a work order to make the materials, as appropriate.

When deciding to create a work order to make an item, such as a sub-assembly, then the user is presented with a list of parts needed for the sub-assembly and can again make appropriate make or buy decisions. This is then repeated recursively until the user has created all the purchase orders and work orders necessary to ship the order. As they do this, the user can make decisions as to quantities to be purchased or made, which may be above the minimum quantities needed.

It is important to recognize:

1. That this is a process in which the system advises the user as to what materials to make or buy, and when, but where the user has complete control over this process. This enables users to make decisions based on their general knowledge and experience, as well as the specific knowledge embedded in the DSS.

2. The planning of materials purchases and manufacture for the project is incremental, in addition to other existing purchase and work orders that already exist. This is in contrast to a Materials Requirements Planning (MRP) system, such as those embedded in ERP Systems, which totally automate the planning and scheduling process. These MRP systems replan and reschedule all the needed purchase and work orders, even those

already in progress for other projects, to ensure an “optimum” plan, which can be very disruptive for make-to-order engineering and construction organizations.

3. The incremental approach works well in those situations where design and manufacture of early releases is done before subsequent releases have been designed.

4. This process is very idiosyncratic to each organization and the type of projects they do. As a result, this planning process almost always gets modified to meet the specific needs of each organization.

In these DSS systems, detailed scheduling of manufacturing operations is typically delegated to the materials tracking system which makes recommendations as to what activities to prioritize based on the expected delivery date of each ship order, as well as the times to make or purchase all the needed parts. As with planning, the scheduling is advisory enabling people to use their best judgement, when needed.

Commentary

I recognize that, in writing this white paper, I have omitted many details. For the KnarrTek software, many of these details can be found on www.KnarrTek.com. What I have tried to convey here is a sense of the overall process and how it functions.

My intent has been to provide some guidance for organizations looking to transition from tracking their project inventory using paper forms and Excel spreadsheets to using computer technology to track and manage their project inventory and assets.

I hope that, from this, it is apparent that there are many opportunities for process improvements, including eliminating the labor time needed to manually track project materials and to eliminate many possible sources of mistake. But, of even greater importance, is the ability to complete projects on-time and to make a profit in doing so through the use of an Artificial Intelligence (AI) based Materials Tracking and Decision Support (MTDS) systems.

As these MTDS systems have to be tailored to the specific needs of each organization, they are not inexpensive to implement, with expected non-recurring up-front expenditures of between $50,000 to $100,000 not being uncommon for a complete implementation. Clients can, however, expect to save the equivalent of one full-time equivalent manager at $150,000 per year in loaded labor costs. Also, preventing late delivery of a project can be priceless when avoiding loss of reputation as well as avoiding the cost of late delivery penalties.

Author

This white paper 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 implementing real-time Decision Support Systems for operations management and materials tracking within manufacturing and industrial distribution

organizations. He is a systems architect and led the team which developed the BellHawk materials tracking software and MilramX decision support software. Over the past decade Dr Green has also led the implementation of over 100 systems, based on BellHawk and MilramX, which use Decision Support Systems to assist manufacturers and other industrial organizations to improve the efficiency of their operations and to increase sales through improved customer satisfaction.

For further discussion, or to send comments, please contact the Author at peter.green@Milramco.com.

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