CHAPTER-7
FRAMEWORK FOR A DECISION SUPPORT SYSTEM
FOR SUPPLY CHAIN MANAGEMENT

As discussed before in this report, materials management problems, highly impact small scale industry, but are more critical for specialty industries including small scale electrical industries. The electrical industry needs to establish an effective materials management system to minimize problems that might arise if the activities related to materials management are not handled properly. Among these problems, the following are encountered: material shortages, misplacements, loss, and theft, which might result in increases in crew idle times, loss of productivity and delay of activities. Electrical industry should implement an efficient material management system due to the fact that in most of the cases they are asked to squeeze their bids in order to keep the costs of project under budget. In such a case, failure to effectively manage materials could result in decrease in profit or even a monetary loss. This chapter describes the supply chain management related decisions considered in the study, a graphical description of the processes related to such decisions, which includes the parameters and alternatives for each decision.
7.1 DESCRIPTION OF FRAMEWORK FOR DECISION MODEL AND DESCRIPTION OF THE DECISION MAKING PROCESS FOR SUPPLY CHAIN MANAGEMENT

Chapter 1 introduced the problem statement and the objective of this research work; to use decision-modeling techniques to develop an integrated system of decision support for material procurement for the electrical contractor. Chapter 6 described the decision modeling approach, the factors (or parameters) and alternatives that define the inputs of the decision model. Performance measures are the output of the descriptive decision model. Alternatives represent the different options available for a particular decision. Parameters are uncontrollable factors that influence a decision. The distinguishing characteristics of parameters are that they are not under the control of the decision makers and that they influence the performance measures along with the decision variables. Performance measures are used to measure the effectiveness of the choice of alternatives and parameters used as inputs. This section expands on the description presented in Section 6.2 and presents a description of the framework designed to assist decision makers with decisions related to material management, for the decision considered. In addition, this section will describe the decision making process on the decision nodes, as described in Chapter 5. In the decision making nodes or wherever a decision model is needed, a prescriptive model is used. These decision nodes are illustrated in Figures 7.1 to 7.6 with circles that contain the Decision Model (D.M.) inscription inside. The prescriptive model follows the structure illustrated in Figure 6.2.

7.1.1 "What Material to Buy" Decision Node

Figure 7.1 shows the decision process for "what material to buy". This decision node deals with what type of material to buy as well as whom to
buy the material from. This will consider requirements of the construction job, progress, schedule, productivity, among other factors. As was presented in Chapter 4, materials used by electrical contractors fall into two main categories: miscellaneous material and major material. The scope of this decision goes beyond deciding whether an item is miscellaneous or major, but, in addition, the alternatives consist of name, (or other identification) of the supplier that is chosen, brand, and the name (or stock-keeping-unit # or sku #) of the item that is purchased. The parameters for this decision node depend on the type of material being considered. Examples of parameters for major material include the brand, size, capacity and cost. One of the most important parameters for major material is the brand (1). Often, the brand of the material to be used in a certain project is specified in the contract documents, therefore the contractor has to buy the material from the specified source. If the brand is not specified in the contract documents, the contractor has two options to obtain material (2). The firm can use a negotiated process with a manufacturer or a bidding process. As gathered from the interviews, some contractors are in favor of a bidding process because they can get competitive prices by getting manufacturers to bid against each other.

For miscellaneous material the process is similar with the difference that there could be blanket orders or yearly contracts for the type of material being considered (3). If the brand is specified in the contract documents, the contractor verifies whether or not there is a blanket order for that material (4). If there is a blanket order in place, the contractor buys the material from that particular supplier. If there are no blanket orders, the contractor requests bids from different suppliers (5).
7.1
Once the supplying source is identified, the contractor needs to verify that the supplier/manufacturer complies with a series of requirements before signing the contract (6). The first requirement is that the supplier/manufacturer can provide the type of material specified. If the supplier/manufacturer is specified in the contract documents, but the material specified cannot be supplied by this manufacturer, the contractor should talk to the owner about the situation. If the supplier/manufacturer is not specified and the management is selecting the supplier/manufacturer, the management needs to verify that the selected supplier/manufacturer can supply the material as specified, if not, the firm needs to negotiate with another supplier/manufacturer.

If the first requirement is met, then the industry needs to verify the delivery times with the supplying source. Compliance with delivery times is critical to ensure that material is available on site when needed and that there won't be any activity delays or disruptions because of unavailability of materials. Other aspects to consider are the ability of the supplier to provide the quantities needed and that the material will be available on site when it is needed. Availability of material when needed is critical to ensure the progress of the work, to minimize delays in the activities and to minimize idle time of the crews. Absence of materials not only affects the activities that need the material, but also affect other activities. Material needs to be moved and set up to perform work in other activities; crews need to be moved around to perform other activities. Indirect cost will increase with absence of materials. Crews will pretend to be busy even when material is not available, increasing labor costs, which is a big component of a construction project.
7.1.2 "How Much to Buy" Decision Node

The decision of "how much to buy" is very important to assure that material quantities needed are available and that there are no material shortages. In addition, this decision is very important because excess inventory increases storage cost and decreases the available space to store other material. Inventory money is tied into material that is not being currently used. Figure 7.2 illustrates the decision process for “how much material to buy". As gathered from interviews there are three possible alternatives for this decision node: order as estimated in the pre-construction phase, order more than estimated and order less than estimated.
An alternative not considered by the contractors was included, the quantity calculated (Q*) from the economic order quantity (EOQ) model (1). The quantity calculated with this model is the optimum ordering quantity for a given ordering cost and a given demand. When ordering this quantity, the total costs are minimized. The first step in the analysis of this decision is the calculation of the EOQ. This quantity is then compared to the actual batch size being ordered (2). In order to do this comparison, the descriptive model is used. If the EOQ is less than the actual batch size, then the actual batch size is used to perform the analysis. If the EOQ is greater than the actual batch size, the decision model verifies if the available storage space is sufficient to store the EOQ.

This decision is affected by many parameters, as can be seen in the figure; therefore the contractor has to consider all the parameters that could have an effect in this decision (3). For example, the contractor could verify if the supplier would offer any discounts based on quantities bought. If the supplier offers any discounts, the contractor might consider buying a quantity greater than the actual quantity needed and store the rest of the material for future use. However, this decision is affected by the available storage space available. Similar to this example, there are other situations that require a close analysis before making the decision. The different parameters and the effect that they could have, are presented in Figure 7.2. In addition, this figure illustrates the times in which the descriptive model is used in the analysis.

7.1.3 "When to Buy Material" Decision Node

The decision of "when to buy" is important to ensure that material is available when needed. Usually the material requisition process is started by
field personnel. The foreman, being in charge of the construction operations, places an order based on the schedule and actual productivity rates. The schedules of the project and installation rates are two critical parameters when considering the time when an order should be placed. In addition, the supplier's lead time plays a key role in the timing when an order is placed. If material is ordered late and the supplier cannot deliver the material prior to the specified lead time, possible delays and work stoppage could be expected.

Figure 7.3 illustrates the decision process for "when to buy material" including the parameters that need to be considered and where the descriptive model is used to assist the decision maker. The decision process is different depending on the type of material needed (1). However, the performance of the supplying source is one of the most important parameters to consider regardless of the material type. The performance of the supplier and relationship between the supplier and the contractor could decide between a successful project and a project full of delays.

This performance is given by the lead time required for a particular material to be delivered and by the reliability of the supplier with respect to the ability to supply ordered quantities when needed. If the supplier has a history of being out of stock regularly for certain material and consequently material is often backordered, the contractor needs to consider this aspect when timing the order placements. Major material (2) require a big lead time because this type of material is fabricated specifically for the particular job. This material should be ordered early to avoid delays and possible penalties due to certain owner requirements. An example of an owner's requirement could be that the owner wants the building to be self powered by the end of the first year of construction. In this case, the transformer
needed becomes a critical item because absence of the transformer in the 
jobsite could increase the possibility of missing the deadline required by the 
owner, thus possibly incurring fines. Lead times are very small for 
miscellaneous material. The only problems that could rise from ordering late 
are the possibility that the supplier is not able to supply the required 
quantities or that the shipment could arrive a late.

However, miscellaneous materials (3) are common; therefore if a particular 
supplier cannot supply the total amount required, the rest of the material can 
be obtained from another supplier. Moreover, as gathered from interviews, 
the absence of miscellaneous material is not as critical as the absence of 
major material. If the material will be used for pre-fabrication, the material 
should be ordered as required by the personnel of the pre-fabrication shop 
(4). However, the firm needs to consider if the material will be bought for 
installation or bought for warehousing (5).
Figure 7.3: When to buy Material Decision Process
7.1.4 "When to Deliver Material" Decision Node

Ensuring that material deliveries occur on a timely basis is a very difficult task. Revisions and changes in a project are inevitable. Consequently, the original projected quantities could be different than the actual quantities needed. Changes in design could result in changes in requirements, additions or subtractions for certain material, which could affect the delivery schedule. The contractor has to consider that when changes occur, material could arrive late, the construction sequence could be altered or the fabrication process could be delayed. It is important to consider possible differences between the date that the material was requested to be delivered and the time at which the material will be delivered. Figure 7.4 depicts the decision process for “when to deliver”. As mentioned earlier, the reliability on the supplier is very important for setting delivery schedules.

If the supplier is not a reliable source (1), the firms would have to buy materials early, which will increase the storage costs. On the contrary, if the supplier is a reliable source (2), the firm could order materials as they are needed, considering the lead time specified by the supplier. In addition, the contractor needs to consider if the material will be delivered in a single batch or multiple batches. If the material would be delivered in a single batch, the contractor needs to free space and store the material when delivered. If the material will be delivered in multiple batches, the contractor should consider the promised delivery dates for the batches and schedule the material delivery sequence as needed on site. For example, the material to be used in the earlier activities should be delivered first. A very important aspect to consider is the reason for having multiple batches. If the reason for delivering in multiple batches is that the supplier doesn't have the quantities needed, the contractor needs to be aware about possible backorders which could delay the work.
On the other hand, if the multiple batches are due to the supplier's inability to deliver the entire material order in a single shipment, the contractor should ask the supplier to deliver the material as soon as more transportation equipment becomes available. Figure 7.4 illustrates how these factors (3) are considered in the decision and where the descriptive model is used in the analysis.
7.1.5 "Where to Deliver Material" Decision Node

The decision of "where to deliver material" requires space planning and consideration of site limitations, pre-fabrication strategies, and subcontractors to be used. Figure 7.5 shows the "where to deliver" decision process. The possible alternatives for delivery are jobsite, warehouse/pre-fabrication shop and subcontractor. Material is generally requested for delivery to the job site. In some instances delivering material directly to the jobsite may not be feasible due to storage or access limitations. In this case, the material is delivered to other locations such as the contractor's warehouse or another subcontractor storage area. The parameters that need to be considered are the criticality of the item, whether the material will be used for pre-fabrication (1) or not, whether the material was ordered to install or ordered to store, the available space for storage in all possible locations.

Material is delivered to the warehouse if it is a critical item that needed to ordered early and will not be installed immediately or when the item will be used for pre-fabrication. Materials are delivered to a subcontractor's yard when a subcontractor is needed for installation (2). Most of the contractors interviewed prefer to deliver the materials to the jobsite directly and store in sea cans. The descriptive model is used to analyze all these factors (3) and how they influence the decision to be made.
FIG 7.5
7.1.6 "Where to Store on Site" Decision Node

The decision for "where to store material on site" is important to minimize theft, loss or damage. Ideally, the contractor would like to store the material to be used the next day on the work area (1). The ability to store material on the floor of the building depends on any restrictions (2) imposed by the general contractor with respect to on-floor storage, number of trades working at the same time and possibility of damage. If there are multiple trades working at the same time, the contractor might have to move the material around to free space for the other trades, a factor that can increase the indirect costs due to re-handling.

Another alternative (3) for the contractor is to store material in the laydown areas next to the building. There is a concern related to the possibility of material being damaged by equipment, people or the weather. In addition, many contractors stated that in many projects the laydown areas around the buildings are limited, thus storing material in such areas is limited and often not allowed.

The alternative that is commonly used by most contractors is to store the material in sea cans and move it to the building as needed for installation. Figure 7.6 illustrates the decision process for "where to store on site". The process illustrated in the figure considers all the possible alternatives for onsite material storage and the factors (4) that affect this decision.
7.2 SUMMARY

This chapter presented a description of the decision making process for the small scale electrical industry. Figures 7.1-7.6 presented graphical descriptions of the decision making process for material management. The next chapter will describe a proposed new system to classify parameters needed in the decision making process. In addition, the chapter will describe a framework designed for a decision support tool for material supply chain for the electrical contracting and manufacturing industry.