CHAPTER ONE

INTRODUCTION AND RESEARCH FRAMEWORK

1.1. INTRODUCTION
This thesis deals with the study of use of simulation as a problem-solving tool to solve a few logistic system related problems. Transport systems involve multiple entities and getting good performance from such complex system is found to be a difficult exercise. Decision making in such systems are done with analytical, mathematical and heuristics based models. Simulation is also becoming a favorite tool in this area especially due to the common use of computers in problem solving and the availability of good simulation packages and trained personnel.

1.1.1. Logistics
Logistics management activities typically include inbound and outbound transportation management, fleet management, warehousing, materials handling, order fulfillment, logistics network design, inventory management, supply/demand planning, and management of third-party logistics services providers. To varying degrees, the logistics function also includes sourcing, procurement, production planning, scheduling, packaging, assembly and customer service. It is involved in all levels of planning and execution—strategic, operational and tactical. Logistics management is an integrating function, which coordinates and optimizes all logistics activities, as well as integrates logistics activities with other functions including marketing, sales manufacturing, finance, and information technology¹.

Logistics management takes into consideration every facility that has an impact on cost. It plays an important role in making the product conform to customer

requirements. Also it involves efficient integration of suppliers, manufacturers, warehouses and stores and encompasses the firms' activities at many levels, from the strategic level through the tactical to the operational level.

Logistics is a challenging and important activity because it serves as an integrating or boundary spanning function. It links suppliers with customers and it integrates functional entities across a company. With the ever-growing competition in today's market place it becomes necessary for a firm to use its resources to focus on strategic opportunities. This is where the concept of logistics plays a major role, i.e. it helps to leverage certain advantages the firm has in the marketplace.

The logistics network, consists of suppliers, manufacturing centers, warehouses, distribution centers and retail outlets, as well as raw materials, work-in-process inventory and finished products that flow between the facilities as illustrated in Figure 1.1.

**Figure 1.1: Elements of Industrial Logistics**

(Figure Source: Blanchard, B. S., *Logistics Engineering and Management*)
McGinnis (1998) categorize logistics activities into the following distinct groups,

**Transportation**: transporting a package or unit load from a specific origin to a specific destination.

**Distribution**: use of a warehouse as a staging point for satisfying customer orders together with transportation to the customer.

**Manufacturing**: all the material handling and control within a factory.

### 1.1.2. Supply chains

Researchers and practitioners have several definitions for the supply chain. Each definition contains common key words such as logistics network, supplier, end-customer, raw material, information, goods/products, services, and facilities. From a management view, Tan (1998) defines a supply chain as encompassing material/supply management from the supply of basic raw materials to final product; it also focuses on how firms utilize their suppliers, processes, technology and capability to enhance competitive advantage. From a logistics view, Saunders (1997) defines a supply chain as an external chain that is the total chain of exchange from original source of raw material, through the various firms involved in extracting and processing raw materials, manufacturing, assembling, distributing and retailing to ultimate end customers. Ellram (1991) defines a supply chain as a network of firms interacting to deliver product or service to end customer, linking flows from raw material supply to final delivery. Business concerns recognize the need to invest in and focus on supply chains. The growth in telecommunication and transportation technologies has led to further growth of the supply chain.

One of the great strengths of simulation modelling is the ability to model and analyze the dynamical behavior of a system. This makes simulation an ideal tool for analyzing supply chains because supply chains can exhibit very complex dynamical behavior.
1.1.3. Transport Terminals

A terminal is a node in a transport network between the supplier and the customer, it binds together transport modes with different characteristics into a transport chain in order to meet the supplier’s and the customer’s demand for frequency and capacity in the flow. The activities in a terminal will consequently be connected to problems created from differences, since varying structure between customers and suppliers as well as between different means of transportation must be overcome. This, among other things, leads to the fact that the problems are of a very varying sort depending on if they regard the operative activities or new constructions and/or expansion (Lumsden, 2002).

1.1.4. Managerial decision making.

The level or hierarchy of management involved in the decision making is dependent on the type of problem. Three types of problem categorization are common.

*Strategic level:* Strategic level problems consider long-term decisions that involve large capital expenditures.

*Tactical level:* Tactical level decisions affect operations over the course of year or so, and are often made by middle managers.

*Operational level:* Operational level problems deal with day-to-day decision issues. Operational decisions follow guidelines set during tactical planning.

1.2. THE PROBLEM AND OBJECTIVES OF STUDY

Transport terminals are key elements in the supply chains of industrial systems. Ideally, a terminal must be planned so as to ensure an acceptable level of service in terms of waiting time for transport means and goods/passengers. Insufficiency of capacity of infrastructure, and unpredictable problems (such as delay in ship arrival, variability in container numbers, breakdowns, etc.), reduce the level of service in terminal systems. There are basically two ways to face this situation: either to improve operational methods, and/or to invest in new facilities. The second solution is usually much more expensive, so the analysis should
begin by exhausting the first option. If the desired performance is not achieved, then the investment in new facilities should be considered. Simulation models and analytical models are used to solve a large number of such problems. The types of problems that can be studied by a model differ according to the flexibility of the model.

Air, sea, road and rail are the transport modes used to carry bulk cargo. It is to be noted that large terminal facilities exist mostly in the case of air, sea and rail and it is at these terminals that most delays and inefficiencies are present. Terminal operations are therefore key to improving these transport systems.

In this thesis we have studied the following three systems:

1. A Container terminal for a port
2. A railway marshalling yard for passenger trains
3. An Airport terminal

The basic purpose of any simulation model is to address the problem/problems of real world systems. Model(s) may be developed to solve a single problem or multiple problems. Usually a single model will not be able to solve many other problems. When many problems are to be solved many different models (these models need not be very different) are usually developed. Figure 1.2 illustrates this concept. Problems at hand may be similar or dissimilar. For example when a system runs on time schedules (e.g. an airport), problems like shift timing, fixing additional schedules, are similar. But a problem like design of system capacity is not similar to schedule related problems. There is a need for creating separate models for each of above problems. Single or multiple models of a system could be developed to tackle problems in four different ways as depicted in Figure 1.2.

It is not economical to build a new simulation model of a system each time a new problem is to be solved. A flexible modelling framework which addresses different categories of problem should be envisaged at the time of conceptual modelling. If we could develop techniques of categorizing problems and systems modelled, so that problems in the same category, can be solved using the same
or very similar model, it would be a great contribution to development and use of simulation. This issue has been focused on in this work with respect to terminal system characteristics.

The motivation for this research is the apparent lack of modelling studies related to terminal systems together even though there exist several models of each of individual types of terminal systems. Commonalities or differences in characteristics related to modelling, facility design, operational planning and problem solving remain relatively less researched. Another motivation was the fact that even though, Kerala State has some large terminal systems in and around Kochi, hardly any simulation modeling based studies have been reported.

Figure 1.2: Single or multiple models of a system
The objectives of this study were

1. To develop and use simulation models to help solve some problems of a container terminal of a seaport.
2. To develop and use simulation models to help solve some problems of a passenger rail yard.
3. To develop and use simulation models to help solve some problems of an airport.
4. Based on the above experience to develop a flexible modelling framework, which addresses different categories of problem so that problems in the same category can be solved using the same or very similar model.

1.3. METHODOLOGY
When using simulation issues such as conceptual model building, model validation, and experiments on model, interpretation of results, and adopting corrective measures become important. Research is being done in all these areas. There are two approaches that are seen to be used in literature. The first approach tries to tackle only one of the problems stated above e.g.: research to find out best ways of model building. The second approach combines more than one issue discusses above and try to present tools and methodology for all of the issues taken for specific cases. Later approach was adopted in this work.

Simulation modelling approach was used in this study. The steps involved simulation modelling studies described in all common books on simulation (see Law and Kelton, 1991; Banks et al, 1995). Figure 1.3 shows a schematic of a simulation study (Maria, 1997). The iterative nature of the process is indicated by the system under study becoming the altered system which then becomes the system under study and the cycle repeats.
Conceptual modelling involves abstraction of a model from a real or proposed system. Robinson (2004) defined the conceptual model as a "non-software specific description of the simulation model that is to be developed, describing the objectives, inputs, outputs, content, assumptions and simplifications of the model".

There are four basic steps (Pace, 2000) in the development of a simulation conceptual model. The first step is collection of authoritative information about the intended application domain that will comprise the simulation context. Development of the simulation concept and collection of authoritative information for the simulation context are likely to occur iteratively as the entities and processes to be represented in the simulation are more clearly defined. As depicted in Figure 1.4, next step is development of simulation elements. The
fourth step addresses relationships among simulation elements to ensure that constraints and boundary conditions imposed by the simulation context are accommodated.

Figure 1.4: Conceptual Model Development

Before developing simulation models, the ways of clustering problems and systems modelled were considered. In this case after considering different ways of categorising problems we found that clubbing problems on the basis of whether they were operational, tactical or strategic was found to be a good method. This was done because in the case of transport terminals we found that models, could be classified into tightly pre-scheduled, moderately pre-scheduled and unscheduled systems. This gave us a match between tightly prescheduled models and their use for solving operational type problems. Moderately prescheduled models found their match with Tactical type problems, and there was a match between unscheduled models and strategic problems. This pairing of model type and problem type makes it easier to develop models that can be used to solve similar type problems (See Figure1.5). This approach has been used by us to solve problems related to transport terminals such as Railway yard, Airport and Container terminal of a port.
The methodological framework of our research is summarized in Figure 1.6. The approach starts with study of each of terminal system, selection of a simulation tool, conceptual modelling and development of the model into simulation models of each type of terminal. The simulation models were then verified and validated and then used for experiments. As a conclusion, commonalities and differences between the models are discussed and inferences regarding a framework for conceptual modeling to be used for terminal system modeling are given.
Figure 1.6: Methodological framework of research
1.4. ORGANISATION OF THESIS

In this chapter we have provided an introduction to Logistics and enumerated the objectives of the study and explained the methodology adopted. In chapter two, a detailed review of literature related to basics of simulation and use of simulation in design and improvement of terminal systems is given. In chapters three, four and five the study of three different transport terminals using simulation models are presented. Chapter three deals with the case of a Container Terminal. Chapter four is devoted to the study of a Railway Yard. In chapter five, study related to an Airport is presented. The sixth chapter brings out the limitations of the thesis, and presents our conclusions and scope of future work.

Two appendices are given at the end. Appendix I gives a listing of various popular simulation language with the desirable features required for our type of modelling and analysis. A list of various features available in these languages is also given. In Appendix II a brief description of various features available in Extend Simulation Language is given.