CHAPTER SIX

CONCLUSIONS

6.1. SUMMARY

This work was carried out with the objective of using discrete event computer simulation modeling to help solve some logistic terminal related problems. One of the problems related to use of simulation is that of the multiplicity of models needed to study different problems. There is need for development of methodologies related to conceptual modeling which will help reduce the number of models needed. For this some form of problem clustering and model clustering were members from problem cluster use models from model cluster is a possible approach. We have followed this approach in this thesis.

Conceptual modeling for simulation is in its early stages of development. Literature on classification of problems related to logistics revealed that the classification of problems into strategic, tactical and operational problems was often used. We decided to use this classification for our problems. Three different logistic terminal systems Viz. a railway yard, container terminal of apart and airport terminal were selected as cases for this study. The standard methodology for simulation development consisting of system study and data collection, conceptual model design, detailed model design and development, model verification and validation, experimentation, and analysis of results, reporting of finding were carried out.

Simulation models were successfully used to help solve strategic, tactical and operational problems related to three important logistic terminals as set in our objectives. Conceptual modeling and simplification were used to reduce the number of models needed to solve the problems studied.

Before developing simulation models, the ways of clustering problems and systems modelled was considered. In this case after considering different ways of categorising problems we found that clubbing problems on the basis of
whether they are operational, tactical or strategic would 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 made it easier to develop models that were used to solve similar type problems. 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. Three types simulation models (called TYPE 1, TYPE 2 and TYPE 3) of various terminal operations were created in the simulation package Extend. All models were of the type discrete-event simulation.

In the third chapter we have presented the development of simulation models of the operations of a container terminal in a South Indian Port and demonstrated its use for decision support for system design and fixing operational policies. The model computes ship turnaround time and determines resource utilization at a high level of detail; this will help planners view the performance of the system much before implementation. The model allows planners to see operational constraints and bottlenecks through statistical reports, graphs and charts.

Under strategic problems, effect of adding a berth and QC was studied. Providing an additional berth with an additional quay crane could take all the load (nearly hundred percent) and handle all ships when ship arrival rate is less than or equal to one ship per day. The second strategic problem studied was to determine the area of storage for containers at import side required for smooth operations. It was found there should be enough space for at least 250 containers at the import side.
Determination of the necessary number of transport vehicles to transport containers in time was the first tactical problem studied. It was found that under most favorable conditions of operational times and equipment availability we require about 3 trucks each for import and export so that the turnaround times were kept low. The next tactical problem considered was to determine the queue space for inbound trucks. It was seen that when queue size capacity was about 15 numbers, performance was near peak and above this there was no appreciable gain in productivity, with addition of trucks.

For the operational problem of finding everyday crane deployment plans, the simulation model showed the ship turnaround time under various crane deployment options allowing the manager to select the most appropriate for the day. For the case studied, deploying two TC's and getting a ship turnaround time of 1.08 days was recommended.

The work related to a railway yard is presented in the fourth chapter. For this study the Ernakulam marshalling yard was selected. The simulation model was used to find the level of utilization of major facilities. It was found that pit and waiting lines were facilities with high utilization and tended to be bottleneck facilities. A comparison of two train time tables to ascertain its impact on yard performance using the simulation model show that the current time table was slightly better than an equi-spaced time table tried out. In order to study the effect of different operating strategies scheduling at pit according to EDD and FIFO rules were tried out and it was found that EDD rule gives 3 number of trains late and average lateness of 15.6 minutes while the FIFO rule gives 3 number of late trains and 24.9 minutes of average lateness which is higher. Hence it recommended that EDD rule be used for pit scheduling. Similarly other rules can be checked using the model.

Rakes with different coaches are put into service. Normally these coaches require only water servicing and minor electrical, mechanical and AC maintenance. These can be done without detaching the coach from the rake. However at times when major work is required the coach has to be detached.
from the rake and send to the coach care center. In such cases the coaches so detached have to be replaced by spare coaches from the stock of extra coaches with marshalling yard. The simulation model was used to find how many such extra coaches are required in the yard. It was found from our experiments that at least four sleeper coaches should be provided to ensure no shortage.

In fifth chapter we have presented the use of simulation modeling to study strategic, tactical and operational problems related to an airport. Under strategic problems we have considered the effect of additional flights on runway capacity. We have found that the airport with a single runway will not be able to handle an aircraft arrival rate above 3 per hour on average-if turnaround time at runway is to be kept below 60 minutes. When two runways were used (without changing other facilities like parking bays), it was found that the improvement was marginal. For the problem of deciding the number of parking bays, our analysis show that in order to meet the forecasted demand for accommodating more flights, there is a need to augment type 1 bays from present number of two to three.

Determination of number of X-ray machines required is one of the tactical problems discussed. The analysis shows that three x-machines simultaneously deployed could reduce average passenger wait times at given loads near to zero. Another problem considered is the estimation of maximum occupancy of an area to determine Heating/Ventilation system requirements. A DE plotter attached to the resource pools for international terminal gave the nature of occupancy inside the terminal facilities. This number and its variability could be used for designing heating/ Ventilation Systems.

Under operational problems we have discussed the case of rearranging schedules/passenger reporting times to level peak load. From the DE plotters we have observed a heavy queue formation at X-ray machine on a particular day. The model was used to test rearranged schedules to reduce queue. The model was also used to deciding shift timings, preparing pit schedules. The simulation model for operational problems offers good graphical tools for investigating the
possibility of permitting additional schedules by airlines and assigning x-ray machines to flight.

As described above we have successfully developed and used computer simulation models to solve problem related to three types of logistic terminal namely railway yard, container terminal of a port and airport terminal. From the point of contribution to conceptual modeling we have demonstrated that clubbing problems into operational, tactical and strategic and matching them with tightly pre-scheduled, moderately pre-scheduled and unscheduled systems is a good workable approach which reduces the number of models needed to study different terminal related problems.

6.2. SIMILARITIES AND DIFFERENCES IN THE THREE CASES

Of the three terminal systems examined the simplest was the case of rail yard. In this there is the service providing facility which is the rail yard into which rakes arrive according to fixed schedules, these have to be serviced and released to meet fixed departure schedules. The fixed entities in this system are the facilities such as pits, waiting lines, coach care centre etc. The variable facilities are number of spare coaches allotted, number shunter engines etc. The transient entity in this case is the rakes that arrives and departs after service. The holding times of the rakes in this system is long, reducing the pressure on the service system. There are spare coaches in the system to take care of large repair times for sick coaches.

The case of the container terminal is more complicated. Here the fixed entities are the QCs, Berth, Storage space etc. The variable entities are TCs and internals trucks. The transient entities that pass through the system are the ships, containers and external trucks. On sea side ships come in with import containers which are unloaded by QCs, carried to the storage yard by internal trucks and stored there by TCs. These are later taken away by external trucks. The external trucks also bring in export containers which are unloaded and kept in the export yard from where they are taken and loaded onto ships for export. There exits a buffer called container storage yard that delinks the export and import truck
arrival and departure from the ship loading and unloading operations. This helps in decreasing the ship turnaround time which is key performance measure for the container terminal. Ships that come in also serviced with bunkers, water, provisions and minor repairs. This could be viewed as similar to the service provided to a rail rake in a railway yard. But here the number of ships received at a time are fewer and their arrival is not tightly scheduled. The additional elements here is the containers that have to be loaded and unloaded from the ship when compared to the railway yard.

The airport is the most complicated of the three cases. In an airport the fixed entities are runways, parking bays, terminal waiting spaces for passengers etc. The variable facility entities include X-Ray machines, Check-in, Customs, Emigration and Security Check counters. The main transient entities here are the aircrafts, the passengers and cargo. The aircrafts is the most important entity in the system and the system is designed to provide the shortest turnaround time for aircrafts. But since passengers are also an important entity in the system and they cannot be made to wait too long passenger and their baggage handling has to be synchronized with aircraft arrival and departure. Therefore on one hand, on the airside aircrafts have to be received, passengers disembarked, baggage and cargo unloaded, the airplane serviced and made ready for next flight. The passenger handling side has to ensure quick flow of disembarked passengers from the flight, make their baggage available in time for them collect the same and leave the airport in the shortest possible time. Passengers coming to catch flight have to be checked in, their luggage handled and they have to be put on to their flights with minimum inconvenience and delay. In this system also the airplane that comes in has to be fuelled, cleaned, inspected and minor repairs done to prepare it for the next flight. So in this case we see that the aircraft has to be serviced, the cargo loaded and unloaded and passengers disembarked and embarked. This increases the complexity of the system when compared to the earlier cases of rail yard and container terminal.

Though these three terminals were very different, the analysis of the service providing system to identify fixed entities, variable entities, and the transient
entities that pass through the service system and get service was an approach used by us in conceptual modeling. This approach helped us in designing and developing the simulation blocks in models. This approach also helped us to bifurcate the Models into TYPE 1, TYPE 2 and TYPE 3 models and use them to help solve problems of strategic nature related to fixed facility, tactical problems related to variable facilities, and operational problems related to transient entities and their schedules.

Verification and Validation of the three types models developed for each of the terminal systems were slightly different. For TYPE 1 models, scheduled times of entities in and out from blocks were thoroughly checked due tight nature of schedules in TYPE 1 models. For TYPE 2 models, scheduled times in and out from blocks as well as longer term behavior was also checked on output, since some times entities were also serviced as per time schedules. For TYPE 3 models longer term behaviour were checked on output. This way validation help in solving problems in a categorized way, at the same time help in use for a few problems that lie on the boundaries of Strategic, Tactical and Operational problems.

A performance measure that was used by us in all three cases was related to turnaround times and waiting times of the transient entities. Utilization of key fixed and variable facilities was monitored and bottlenecks detected, de-bottlenecking was carried out by examining the effect providing additional fixed or variable facility. The capacity of the system was determined by changing the quantum and/or schedules of transient entities processed by the system. Thus we could demonstrate the usefulness of a common approach to conceptual modeling, model building, verification and validation, experimentation and use in the case of three diverse logistic terminal system that were studied. This approach can be used for study of logistic and manufacturing systems.
6.3. LIMITATIONS OF THE STUDY

The standard limitation of any modelling study is related to the assumption made during modeling. This study also has these limitations. Hence generalizing the findings from the model will not be correct. More specifically TYPE 1 models are least flexible, more case specific and therefore most difficult to generalize. Flexibility increases as we go through from TYPE 1 through TYPE 2 through TYPE 3 models, making TYPE 3 models the easiest to generalize. The time distributions and process logic used in the models are specific to the cases studied. In case of time distributions for many activities enough time data to fit and use the most accurate distributions were not available. Hence approximate distributions were used. Though this is an important limitation, it was not found to significantly affect the parameters that we have studied. For conducting experiments on the models we have used simple techniques most of the time since the same met our needs. It is possible to use more sophisticated experimentation techniques to understand system behavior using the model. Since the study was primarily simulation based, and intended only as a decision support system, cost and economic viability aspects were not considered. The will have to be done separately using inputs for costs and benefits from output provided by the model. Problems of each category was identified and selected based on expert advice and convenience. Formal methods for problem identification and selection were not used.

We have presented a scheme of clustering problems and models during conceptual modeling to reduce the number of models needed to solve the problems studied. This clustering method has not been compared to other possible methods to evaluate its performance.

6.4. SCOPE FOR FUTURE WORK

The first area of extension of this work relates to demonstration that the framework for conceptual modelling that we have suggested works in many more case in logistics and manufacturing. Another area of work could be to search and find other ways of clustering problem types and making model types that match
with these clusters. The performance of such clustering methods could also be compared to add to the body of knowledge in the area of conceptual modeling.

The next area of work is related to the development of models and use of different simulation packages for the same. Comparison of simulation packages for solving logistics problems could be one type of work. The models that we have built could themselves be used to study new problems.

Research could be carried out to develop an integrated system which has the ability to support strategic level decisions with the finer elements of local schedules. This DSS framework insulates the decision maker from the type of models and by using a user-friendly interface. The basis for classification of models in a model base (collection of models) and developing a logic for selection of the model for the decision problem involved will be the result of extensions of this work. This will be necessary to make an integrated DSS from which, depending upon the problem at hand, an appropriate model will be selected from the model base by the DSS.