Output Analysis of Configurable Port Simulation

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Output Analysis of Configurable Port Simulation

by

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Abstract

Output Analysis of Configurable Port Simulation

Ravikiran Jogu
Old Dominion University, 2003
Director: Dr. James F. Leathrum, Jr.

The Configurable Port Simulation (CPortS) is a simulation of military cargo moving through a commercial seaport during a force deployment. CPortS simulates cargo at the individual entity level of detail. Simulation at the individual entity level generates huge amounts of output data making the output analysis difficult. To understand the reasons as to why bottlenecks occur in the process of cargo clearance, an analyst needs to be able to partition the data during analysis, not a priori. This makes the estimation of required graph generation impossible, which demands a very dynamic output analysis tool that can enable the analyst to generate the required graphs by partitioning the data during analysis. A tool called the “Output Analyzer,” described in this thesis, is designed to be able to serve the purpose of analyzing the single run of a CportS simulation.
This thesis is dedicated to my mom
Anasuya Jogu.
Acknowledgements

Many people have contributed to the successful completion of this thesis. I extend many, many thanks to my committee members Dr. Roland R. Mielke and Dr. Rick McKenzie for their patience and hours of guidance on my research and editing of this manuscript. The untiring efforts of my major advisor Dr. James F. Leathrum deserve special recognition.
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CHAPTER I

INTRODUCTION

The Configurable Port Simulation (CPortS) is a simulation of military cargo moving through a commercial seaport during a force deployment [1]. This thesis describes an output analysis tool, called the Output Analyzer, for analyzing a single run of the simulation. The Output Analyzer is designed to identify the problems that cause bottlenecks in Port of Debarkation (POD) operations and assist in attaining faster closure after adjusting the parameters that correspond to the areas of bottlenecks. It presents predefined graphs and reports to help the analyst determine the possible areas of bottlenecks at a higher level. An interactive graph builder allows the analyst to view data associated with particular areas of the port and based on specific cargo characteristics in order to assist in finding the details corresponding to the bottlenecks.

CPortS models the ship offloading, staging, and port clearance of military equipment at the port of debarkation (POD). The model identifies system and infrastructure constraints and provides scenario specific, timed-phased, cargo clearance profiles. CPortS simulates cargo at the individual entity level of detail. Simulation at the individual entity level generates huge amounts of output data that make the output analysis difficult, but allows focusing on specific cargo characteristics during analysis that help identify the bottlenecks.

The output of each simulation run is different and probabilities and confidence intervals are calculated by running the simulation many times and plotting the output in terms of closure profile graphs [3]. These graphs give a high-level view of the simulation

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behavior, but it may be difficult to identify specific behavior such as might lead to bottlenecks. To improve the scenario's behavior, it is necessary to analyze the output of a particular run. Analysts desire the single run analysis tool that has the ability to generate various reports and graphs, the reports to help analyze the cargo behavior at the individual entity level of detail and the graphs to provide the visualization of this behavior. CPortS provides the ability to capture detailed output from any single run of a multiple run sequence should a particular run behave poorly. By guessing the probable reasons and changing the input parameters accordingly in the areas of bottlenecks, an analyst runs the simulation again to see if a better behavior has been achieved. It is impossible to derive the final graph requirements for this analysis due to the following reasons.

- The final graph requirements change for each simulation run depending on the areas of bottlenecks.
- The analyst does not know a priori how he wants to partition the data for analysis.

This requires a very dynamic output analysis tool that can perform data partitioning during analysis.

This thesis discusses an output analysis tool named the Output Analyzer for CPortS single run output analysis. The Output Analyzer is developed using MS Excel and VBA to facilitate a dynamic output graph creation. The Output Analyzer gets the input data generated by the simulation run for a particular port scenario identifying all activities for each individual piece of cargo and for each ship. The Output Analyzer mainly consists of three parts, the predefined reports and graphs generator, the Graph Creator and the Unit Info Generator.
The predefined reports and graphs generator performs the tasks of generating individual reports for each port area and the predefined port graphs to start the analysis. The individual report for a port area contains the data (cargo type, unit number, arrival time, departure time etc.) corresponding to each piece of cargo in different columns in an Excel sheet. This facilitates the easy reading of cargo for the user, as well as for the programmer to develop other applications using this cargo data.

The second function of the predefined report and graph generator is to generate the predefined graphs automatically. These graphs are the clearance profile graphs (for short tons, square feet and number or pieces), the Unit graph, and the Ships on Berth graph. Clearance profile graph shows the amount of cargo cleared from berth, staging, and the port at any point of time. The bottleneck areas are easy to identify in these graphs with a very high level of detail. These graphs show the total time to attain closure. An output analysis starts with these graphs to identify the detailed reasons for bottlenecks that cause delayed closure. The “Unit” graph gives the length of time each unit is in the port. When analyzing an individual unit, this graph is useful to identify the arrival and departure times of the unit. This is important when focusing on the movement of high priority units necessary to support the fighting force that must clear quickly. The “Ships on Berth” graph gives the berth length a particular ship is using and the time that the ship is on berth. This graph helps identify the idle time between ship arrival that causes the delay in cargo processing. For a particular port scenario, the ship arrival is fixed and the analyzer can only report to the decision makers about the problems regarding ship arrival.

The Graph Creator is the part that does the real analysis to analyze problematic areas. It consists of a user friendly GUI, where the user can filter cargo data by different
port areas, cargo type, vehicle type, transport mode, units, and ships to create the graphs for the areas of interest. These areas of interest are determined from analyzing the areas of possible bottlenecks in the predefined graphs. The Graph Creator can generate the output and the throughput graphs for the selected areas (port area, cargo type, unit, ship etc.). The process of an analysis is an iterative process, i.e. generating the graphs by figuring out the problematic areas in the predefined graphs, generating the graphs to figure out the problematic areas in the graphs generated, and repeating the process. The output graphs give the cargo arrival and departure profiles for the selected areas, an increasing slope indicating the arrival and a decreasing slope indicating the departure of cargo pieces. The throughput graphs give the throughput on a particular day for the selected areas. The output and throughput graphs are plotted for square feet (SQFT), short tons (STONS) and number of pieces individually to help the user see the details in terms of the three output parameters. At the end of analysis, the analyst figures out the specific areas of bottlenecks, guesses the possible input parameters to change and then, proceeds to run the simulation with new parameters to see the changes in the clearance profile.

Chapter 2 gives the reader background knowledge of the CPortS model and the output analysis tool. It discusses the output analysis tool called Simulink used in simulations. It discusses the CPortS model, the port structure and explains the different port areas in brief. It describes the advantages of software used to build the output analysis tool from the developer as well as the user point of view. It also gives the software architecture of the output analyzer.
Chapter 3 starts by discussing the requirements for output analysis and describes the design of the output analyzer in detail. Various features of the Output Analyzer are discussed in this chapter. All reports and graphs are shown as examples with a brief discussion following each of the reports and graphs. This chapter gives the reader a good understanding of the Output Analyzer's design and dynamic capability of generating graphs.

Chapter 4 presents an example analysis for the Port of Ad Dammam for a given port scenario. It shows how the analysis is done using the Output Analyzer to identify and fix the bottlenecks and to attain a faster closure at the POD.

Chapter 5 gives the conclusion and the future work that needs to be done for the output analysis of a simulation.
CHAPTER II

BACKGROUND

This chapter gives background knowledge of the CPortS model and the output analysis tool. It describes the output analysis tool called Simulink used for simulations. It discusses the CPortS model, the port structure, and explains the different port areas in brief. It describes the advantages of software used to build the output analysis tool from the point of view of the developer as well as the user. It describes the software architecture of the output analyzer.

2.1 Output analysis tools for simulation

Simulation is a tool that can enable an analyst to estimate the output of a long process within few minutes. An analyst runs the simulation many times in order to observe the possible results [3]. The input parameters used for the simulation play an important role in obtaining better results. To determine the input parameters that need to be changed, it is required to analyze the output of a single run, to find the reasons for bottlenecks in the performance of the simulation. Simulink is one of the many output analysis tools available.

Simulink is an interactive tool for modeling, simulating, and analyzing dynamic systems. Commonly used in control system design, DSP design, communication system design, and other simulation applications, Simulink enables the user to build graphical block diagrams, simulate dynamic systems, evaluate system performance, and refine the designs. With seamless integration to MATLAB, Simulink offers immediate access to an extensive range of analysis and design tools [4].
2.2 CPortS

The CPortS (Configurable Port Simulation Model) is a discrete event simulation tool developed to simulate and analyze the seaport operations of military units. Through CPortS, it is possible to study various factors such as port throughput, utilization of critical resources, etc. that affect the movement of a military force through the port it engages. This helps the planners in comparing and selecting the ports and in analyzing resource requirements.

2.3 Port Structure

The structure of the port can be defined as a set of port areas (berths, anchorage, staging, loading, etc.), resource pools, and the transportation of cargo between different port areas utilizing the resources. The various port areas are briefly described below [2].

Anchorage: Anchorage is where ships wait for a berth to become available and for a pilot and necessary tugs to become available.

Berths: Berths handle the docking of the ships and unloading of the cargo.

Staging Area: Cargo is stored in staging until resources become available to move the cargo out of the port. Inspection of the cargo is also done here depending on the user requirement.

Loading: Loading is where cargo is loaded onto highway transports.

Rail Spurs: Rail Spurs are same as loading except that the cargo is loaded on to rail cars instead of highway transports.
Interchange yards: Interchange yards are holding areas for rail cars where appropriate railcars from a train are passed to a rail spur for loading and it also is the place where the loaded railcars are constructed into a train to leave the port.

Gates: All highway transports must pass through the gate both to enter the port and to leave the port.

2.4 Flow of Cargo

The cargo flows between different port areas during different activities in the port. There is a certain path that the cargo moves whenever a resource is to be passed to another port area. The type of resources the cargo is using decides the path of cargo flow. Different resources can take different routes to move from a particular source to a particular destination. A route is defined as a sequence of port areas transited to reach the destination. Figure 2.1 gives the port structure and POD (Port of debarkation) flow [2].
Figure 2.1. Flow Of Cargo.
2.5 Port Operations

Each port area in the port has a common set of operations to be performed like the arrival and departure of the cargo and the resources. A cargo arrival operation handles the arrival of a resource carrying cargo, where the resource can be a ship, truck, train, etc. Cargo departs the port on a resource through a common departure operation. In addition to these common operations, there are some operations that are specific to a particular port area, along with resource pools holding the resources necessary for that process, that will be explained later [1].

There are two main modes of operation in CPortS, the embarkation mode and debarkation mode.

The embarkation mode, where the military force arrives by land, is called the port of embarkation (POE). The major activities that take place in this mode include the following.

- All processes needed to accept cargo items at the entry points of the port. The military force can arrive via road (highway) or rail. The entry points to the port are gates for highway entry and interchange yards for railway entry.
- All processes needed to park cargo items in appropriate locations in staging areas where the cargo is inspected before it can be loaded into the arriving ships.
- Loading of ships by the military force with cargo. All the cargo is brought to the berth areas and loaded onto the ships using appropriate loading resources.

In the debarkation mode, the military force arrives into the port of debarkation on the ships that started from the port of embarkation. The major activities include unloading of
the ship, staging activities and clearance. The following are the activities carried out in POD.

- The vessels containing cargo items are unloaded from ships to the berths.
- Then, the cargo items are moved to the staging areas. The debarkation staging activities are similar to the embarkation staging activities. The cargo is parked and inspected before it is cleared.
- The clearance activities include loading of cargo into the highway transportation objects, such as trucks, and railway transportation objects, such as cargo trains, depending on the type of clearance.

As far as the Output Analyzer is concerned, POD is the area of interest for the analysis. The purpose of the existing simulation model is to assist the user in knowing some important statistics such as the following [1].

- The total time taken for clearing all the cargo the moment ships arrive at the POD.
- The bottlenecks that seriously affect the throughput of the port.
- Why certain operations are not completed within the required time?
- How the performance is affected by the change of available resources?
- What is port throughput capability for different port scenarios and paths of cargo flow?

The Output Analyzer supports answering these questions utilizing a systematically developed graphical tool. The GUI that leads to the most useful graphs that an end user can analyze with ease is the topic of this thesis.
2.6 About EXCEL and VBA

The software source code for constructing the Output Analyzer was developed in VBA using MS Excel as a spreadsheet approach to displaying reports and graphs. Programming the software in Excel VBA makes the code highly accessible and extensible for users, which permits personalization and customization by anyone with Excel VBA skills [6].

2.6.1 Benefits to developers

Each VBA-hosted application exposes its functionality through an object model, expanding the ActiveX-based component set available for developers to use as building blocks for custom solutions. Organization of data is one of the most important tasks involved while building graphs for the analyzer. With the ability to write macros in Excel, it is far easier to write the code for organizing data. The following are some of the advantages to developers. There also are some disadvantages and they are discussed in the final chapter while discussing the future work.

- The ability to reuse code since Visual Basic is used in all Microsoft applications, as well as the applications of numerous other vendors.
- VBA enables customization of applications to provide solutions tailored to customers' needs.
- With the increasing availability of VBA-enabled applications, developers can now integrate these applications to share data and information more easily and seamlessly.
- Perhaps most dramatically, Visual Basic for Applications enables developers to build solutions that previously were cost-prohibitive, because functionality is now available through the integration of different applications or from different vendors.

- With VBA available across a broad range of applications, developers can customize and integrate line-of-business applications while leveraging their existing skill set.

2.6.2 Benefits to end-users

The following are some of the advantages to the end-users:

- Excel-based solutions perform faster, thanks to tight integration between VBA and Excel applications.

- Solutions look and work like the applications users are already familiar with, so less training is required.

- Solutions can be user-customized, with respect to print options or query creation, for example.

- There is greater participation in the solution design process—users can create the output, reports, and documents that they want automatically generated.

Overall, users will benefit the most from improved solution quality and customized functionality, as the applications they use today incorporate richer functionality and integration, and are tailored to meet their needs.
2.7 CPortS Software Architecture

To understand the role of the Output Analyzer, it is important to understand the CPortS software architecture. Figure 2.2 shows this architecture in the form of a block diagram. The CPortS main interface is developed in Visual Basic as shown in the second layer and contains three main portions of the GUI: the Port Scenario Builder, the External Transport Profile Builder, and the Output Analyzer. The Port Scenario Builder is used for building different scenarios for simulation of the port by changing the path of cargo flow and other factors. It is developed using MS access and VBA. The External Transport Profile Builder is used for building different external transport profiles. This is developed using MS access and VBA. The Output Analyzer is used for analyzing the output of the simulation in terms of sophisticated and easy to use graphs and charts shown in the upper layer [5].

The architecture is shown as four different layers, the bottom layer showing the actual simulation files containing source code developed in MODSIM. The CPortS model is developed in MODSIM, which is an object oriented simulation language [5]. MODSIM accesses Ships with Cargo JFAST Emulation in the PPF text files after building a port scenario. It accesses the port scenario data and external transports text files simultaneously as shown in figure 2.2. The simulation provides the output data in Cargo.csv and ships.csv files. Cargo.csv contains all the information regarding each piece of cargo, while ships.csv contains the information regarding the ships used.

As the Output Analyzer is the topic of this thesis, a detailed discussion focused on software architecture of Output Analyzer is given below.
Despite its numerous advantages, a simulation tool is a decision support tool, not a decision making tool. That means that the simulation output must be carefully analyzed. The port simulation model generates random outputs because of the randomness of the inputs. So, the simulation is run many times and the output needs to be analyzed carefully for each single run to arrive at the best possible result. The Output Analyzer is developed for this purpose—*to analyze the output of a single run through the help of automatically generated graphs and reports*. The Output Analyzer consists of two major parts—The Unit Info Generator and The Graph Creator. VBA code for the performance of these GUIs is organized in modules. One can refer to Appendices A, B, and C for the details of these modules. The data are accessed from Cargo.csv, ships.csv and OutputScenarioData.csv files, different modules performing different operations like report generation, closure profile graph generation, unit graph generation, etc.
Figure 2.2. CPortS Software Architecture.
CHAPTER III

THE 'CPortS' OUTPUT ANALYZER

The Output Analyzer is an analysis tool for analyzing the results from the CPortS simulation model. This chapter begins with the requirements for output analysis and discusses the architecture of this tool. It provides a detailed discussion of all the output reports and graphs that are created or can be created.

3.1 Requirements for Output Analysis

In a simulation context, output analysis involves the processing of raw data produced by the simulation and the presentation of the data to an analyst in an easily understood and useful format. The analysts want this analysis to be simple and straightforward, so that instead of wasting time to understand the complexities, they can focus on the decisions that need to be made to improve the processes modeled by the simulation. Moreover, an easily understandable output analysis tool will require a smaller training budget from the point of view of employers. The following are the basic requirements for an Output Analysis.

- Analyze a single run of a single scenario.
- Capture data at the cargo entity level.
- Provide predefined reports and graphs that are common to all scenario analyses.
- Support the ability to analyze reports based on cargo type, unit, ship, etc. (support provided directly by Excel).
- Support the ability to generate graphs based on cargo type, unit, ship, etc. (requires the construction of a graph tool utilizing Excel and VBA).
3.1.1 Analyze a single run of a single scenario

A simulation run gives one of the many possible results for the given input parameters. The result of a single simulation run can be anything between the worst to the best case [3]. To calculate the most probable output, it is important to run the simulation many times. In the process, it is also important to know the reason for bad results of a single run, so that the problems can be fixed to get better results for future runs. To analyze the huge amount of data is impossible without an analysis tool that can zoom in on the areas of bottlenecks at the lowest level of detail. So, an output analysis needs a very dynamic tool for analyzing the output of a single simulation run of a single scenario.

3.1.2 Capture data at the cargo entity level

In the CPortS simulation model, the output depends on many factors, such as the path of cargo flow, the amount of resources used and the type of transportation. The “what if” questions concerning the simulation are answered by changing these factors in a logical fashion. Depending on the changes made, the output analyst will be interested in looking into the details of only certain areas of the port for each different run. The areas of bottlenecks for each scenario will be different from the other. So, the analyzer’s areas of focus change for each scenario. Because of dynamically changing operations on the port, the user does not know a priori how he wants to partition the data for analysis. This makes it impossible to derive the final graph requirements. Therefore, it is important for the Output Analyzer to capture data at the cargo entity level to provide the flexibility of partitioning the data for the lowest level of detail.
3.1.3 Provide predefined reports and graphs

In order to figure out the reasons for bottlenecks, it is desirable, at the start of an analysis, to see some pre-defined graphs and port area reports for the scenario. It is important to determine these predefined graphs and reports that are common to all scenario analyses to assist the analyst in bottleneck identification. The Output Analyzer should be capable of generating these graphs for the scenario automatically. For CPortS, the predefined graphs are the Clearance Profile Graph, the Unit Graph, and the Ships on Berth Graph. The tool should be capable of generating these graphs automatically, along with the individual reports for all the port areas in the port.

3.1.4 Support the ability to analyze reports based on cargo type, unit, ship, etc

The predefined reports for each port area should be arranged in a fashion to easily analyze. MS Excel supports the ability to analyze the reports based on the cargo type, unit, ship, etc. The sorting and filtering options supported by MS Excel are very useful in analyzing the reports.

3.1.5 Support the ability to generate graphs based on cargo type, unit, ship, etc

As described in Section 3.1.2, it is impossible to derive the final graph requirements for the analysis of a single simulation run. The reasons for bottlenecks can be in any part of the port and are not clear when the cargo data are plotted on a single predefined graph. Thus, it is important to be able to partition the data as required and generate the graphs. An analysis normally includes partitioning the data depending on port area, cargo type, unit, ship etc. With the data in MS excel sheets, VBA provides the
ability to rearrange the data and partition it according to the requirements of the scenario generating the required graphs. Thus, a very dynamic graph generator tool using MS Excel and VBA is needed to analyze the output depending on the scenario at hand.

3.2 The Output Analyzer

The requirements stated above are for an analysis tool that is extremely dynamic in its operation and that allows the user to partition the data during analysis, not a priori. It needs to generate the detailed graphs for different situations. The Output Analyzer is an analysis tool developed in MS Excel and VBA to compliant these needs. It is extremely dynamic in its operation. It gives a broad view in terms of the predefined graphs so as to identify where the bottlenecks are. It allows partitioning of the data and plots graphs for different areas individually, thus giving the ability to view specific details. The following are some of the important performance information the Output Analyzer displays in terms of graphs and reports.

- Total time to clear all the cargo from the port and the possible areas of bottlenecks that delay closure.
- The output showing each piece of cargo on a daily basis, thus giving the smallest level of detail.
- The port throughput achieved for a given scenario for a set of input parameters
- The berth length the ships are using during POD
- Arrival and departure times and length of operation for each unit on the port

The Output Analyzer is easy to use in its operation. It is distinguished by its flexibility in creating the graphs for each piece of cargo on the port by giving the user the
flexibility of selecting the different port areas, cargo type, unit, ship etc. It is easy to use because of a very user friendly GUI. The Output Analyzer is a tool invented for easy and dynamic analysis of the output, from a single simulation run, at a high fidelity in terms of reports and graphs with a user friendly GUI. One can see the details of this tool in the later sections to find the architecture, uses, and analysis capabilities it provides.

3.3 The Output Analyzer Design

Output Analyzer accesses data from Cargo.csv, Ships.csv, and OutputScenarioData.csv. On opening the workbook, it rearranges the data and generates the reports for each of the port areas and generates some predefined graphs. Then, the user is allowed to use the graph creator and the unit info generator to analyze areas of interest. Figure 3.1 gives the high level flow of the output analyzer.

Figure 3.2 displays a high level view of the architecture of the Output Analyzer. It consists of three major parts: The canned report and graph generator generates individual reports for different port areas on opening of the workbook; The Graph Creator is a GUI that allows the user to select different port areas, cargo type, unit, ship etc. and plot the output and throughput graphs for analysis; and The Unit Info Generator gives the information about different port areas and ships that a particular unit is moving through.
Cargo.csv:
A text file defining the activity internal to the port for each individual piece of cargo.

Ships.csv:
A text file defining the activity internal to the port for each individual ship.

OutputScenarioData.csv:
A text file identifying the characteristics of the port used in the simulation.

Figure 3.1. High-level flow of Output Analyzer.

The canned Report and Graph Generator:
On opening the workbook,
- Access data from cargo.csv, ships.csv, and OutputScenarioData.csv.
- Generate the reports for each port area
- Generate the predefined clearance profile, ships on berth, unit info graphs.

Graph Creator:
Reorganize the data from the reports to generate the following graphs.
- Output graphs
- Throughput Graphs for quantities sqft, stons, #of pieces.

Unit Info generator:
- Reorganize the unit data from the reports to generate the unit info showing different port areas and ships that a selected unit is traveling through

Figure 3.2. High-level architecture of the Output Analyzer.
3.4 The Canned Report and Graph Generator

The name of the workbook containing the Output Analyzer is ‘PortsimOutputAnalysis.xls’. The canned Report and Graph Generator generates the reports for each port area and the predefined graphs given below, on opening ‘PortsimOutputAnalysis.xls’. An analyst uses these predefined reports and graphs as the starting point of an analysis. The automatically pre-generated reports and graphs include: Individual reports for every port area in the port, Clearance Profile graphs, The Unit Graph and The Ships on Berth Graph. These are discussed in detail in the latter sections.

3.4.1 Port Area Reports

The cargo.csv file contains information about the cargo moving in different port areas, each line of the file tracking the movement of an individual piece of cargo through the port. These data are organized in the cargo.csv file so that they can be accessed in a systematic manner to generate the reports. The OutputScenarioData.csv contains all the available port areas used in the scenario. Now, the job is to utilize these two files to generate the reports for each port area so that it is easy for the end user to read and analyze. The flow chart in Figure 3.3 gives the program flow of how the reports are generated. The function that performs these operations is ‘ReportGenerator ()’. Details are found in Appendix A and Appendix B.
Copy the data corresponding to a port area type from the cargo.csv file to 'Hidden Support'.

For each of the port area type, generate the individual excel sheets for each of the port areas in that port area type the information of which is available in OutputScenarioData.csv.

Copy the data of each port area of that port area type to the corresponding port area sheet and name the columns accordingly.

Repeat the process for each port area type until the reports for all the port areas are generated.

Figure 3.3. Generation of reports.

The output analyzer creates individual reports for the cargo in each of the port areas. These reports contain the arrival and departure times for each piece of cargo, along with the other information such as the unit number, number of short tons, square feet, etc. This facilitates improved analysis of the port area and is used by the graph creator to generate more detailed output and throughput graphs. An example report for a berth area is shown in Figure 3.4. As can be seen, it contains the information corresponding to each cargo piece that is being processed in the area.
3.4.2 Clearance Profile Graphs

A clearance profile graph shows the clearance of cargo through berth, staging and port as three different series. It gives the number of pieces of cargo clearing each area as a function of time. It helps to recognize the areas of bottlenecks in cargo clearance at a higher level so that an analyst can zoom in on these areas to view specific lower level details by using the Graph Creator. There are three clearance profile graphs that are automatically generated on opening the Output Analyzer: Clearance profile graph for number of pieces of cargo, showing time in days on the X-axis and number of pieces of cargo on the Y-axis; Clearance profile graph for Short tons (STONS) of cargo showing
time in days on the X-axis and STONS on the Y-axis; and the Clearance profile graph for square feet (SQFT) of cargo, showing time in days on the X-axis and SQFT on the Y-axis.

The data to generate these graphs include the following information: berth departure times, staging area departure times, port departure times of each piece of cargo, and cargo characteristics (number of cargo pieces, short tons and square feet). The Output Analyzer saves the Cargo.csv file containing these details in a crude form, in an Excel sheet named Cargo. The workbook contains the hidden sheets “Hidden Cargo” to hold the information from the cargo sheet, “Hidden Clearance Data” to hold the information corresponding to the clearance profiles, “Hidden Graph Scratch1” and “Hidden Graph Scratch2” to re-arrange the data in a required format to generate the graphs for detailed analysis. The first step consists of copying all the Clearance data needed to “Hidden Closure Data” from the cargo sheet. The next step includes creating the graphs for number of pieces, SQFT, and STONS using the departure times of cargo from the berths, the staging areas and the port.

The flow chart in Figure 3.5 presents how the data are organized in the “Hidden Closure Data” Sheet. The details of how the operations are carried out programmatically can be seen in Appendix A.
Copy the data (sqft, stons, arrival time, departure time) corresponding to berths, staging and port from *Cargo* to *Hidden Closure Data* sheet.

Sort the data in ascending order and calculate the totals of sqft, stons and #of pieces.

Arrange the data in *Hidden Closure Data* sheet; so that, the data corresponding to berths is together in adjacent columns A, B, C, D, the data corresponding to staging is together in adjacent columns E, F, G, H, etc.

Figure 3.5. Get clearance profile data.

Once the organized data are available in the sheet *Hidden Clearance Data*, the Clearance profile graphs, Clearance Profile (SQFT), Clearance Profile (STONS), and Clearance Profile (number of pieces) are plotted.

Figure 3.6 shows an example of a clearance profile graph for SQFT of cargo. There are three series in the graph distinguished by different colors. The series in blue shows the clearance profile for berth areas, the series in red shows the clearance profile for staging areas and the series in yellow shows the clearance profile for the port.

From an analyst’s point of view, there are two major areas of bottlenecks, one from the 1st day to the 19th day where the cargo clearance is low, and the other from the 31st to the 53rd day where the cargo clearance from the staging and the port is sluggish. By investigating the details of these bottlenecks, the problems can be found and fixed to attain a better clearance. The Graph Creator is used to find these details by partitioning
the data corresponding to these bottleneck areas and plotting the output and throughput graphs.

![Clearance profile graph](image)

Figure 3.6. The clearance profile graph.

### 3.4.3 Unit Graph

Each cargo piece is a member of a military unit. A unit graph is plotted with time in days on the X-axis and unit number on the Y-axis. Each series on the graph corresponds to a different unit. The series for any unit starts at the arrival time of the unit into the port and ends at the departure time, with time shown on the X-axis. A unit graph gives the total time taken for a unit to get processed and the duration of time a particular unit is in the port. One can see the units associated with the bottleneck areas, shown in
the clearance profile graphs, with the help of a unit graph. This helps to see the port areas and ships that these particular units are moving through using the Unit Info Generator explained later in the chapter. By knowing the different port areas and ships, the analyst uses the Graph Creator to partition the data corresponding to those areas and ships and plots graphs to find the details of bottlenecks.

The unit graph requires the arrival time of the first piece of cargo of each unit into the port and the departure time of the last piece of cargo of each unit from the port. These values for each unit are obtained by calculating the minimum arrival time corresponding to a particular unit and the maximum departure time of that unit in the processing of the unit. Figure 3.7 is a high-level flow chart that gives the program logic needed to get these data. The function that carries out this operation is units_at_dt(). The details of how this data is obtained from the available reports and how the graph is plotted programmatically can be seen in the Appendix C.

Copy the arrival and departure times of all the units available in cargo sheet to the sheet units_at_dt.

For each unit, find the minimum value of arrival time and maximum value of departure time. Place these values in the continuous columns such that max.departure time is below the min. arrival time of that unit.

Create an X-Y scatter graph named units_at_dt using these arrival and departure times for all the units.

Figure 3.7. Get unit data.
An example unit graph is shown in Figure 3.8. A different colored line on the graph corresponds to a different unit and shows the duration of that unit in the port. For example, the bottommost line in the graph (navy blue) is unit 1; this unit is in the port from day 19.3 to day 22.3, taking three days for its procession. A unit graph helps identify the units that take longer processing time so that an analyst can inquire as to the reasons. For example, the 73rd unit utilizes all 53 days of port operations. Potential reasons include:

1. Not getting the required resources on time,
2. Having a large number of cargo pieces requiring more time to clear the port,
3. Insufficient transports of the appropriate type to clear the unit, or
4. The unit's pieces are arriving on multiple ships spread out in time over the operation.
3.4.4 Ship Berth Usage Graph

Ship Berth Usage graph shows the amount of time a ship is on the berth and the amount of berth length it occupies. A uniform arrival of the ships over time is desired so that the process of downloading cargo from ships is continuous without any idle period.

A ship report is needed to extract the data for the Ship Berth Usage graph. A ship report gets the data from ships.csv file. It contains the arrival and departure times of the ships to and from the anchorage and berth areas. It also contains the departure times of the ships from the port and the berth length the ship is using. The data from this report are copied to the “Hidden Ship” sheet in an ordered manner so as to be able to produce the graph easily. Figure 3.9 is a high-level flow chart that shows how the ship report and the ships on berth graph are generated from the ships.csv file. Figure 3.10 shows an example ship report. The details of the generation of the ship report and the Ship Berth Usage graph are given in Appendix C.
Rename *Ships.csv* as *ShipReport.xls*.

Insert new sheet named *Hidden Ship*.

Calculate the number of ships and the service time (see appendix for details) and copy to Ship report and Hidden ship.

Copy the 'ship names', 'berthing' and 'de berthing' times of *Ship Report*.

Arrange the service time and berth length used, below the name of the ship in columns G, H of *Hidden Ship* such

Format and name the report

Selecting columns 'G: H' add a chart type 'xlXYScatterLinesNoMarkers' and name it as "Ships on Berth" such that each series corresponds to a different ship.

Figure 3.9. Ship Report and Ship Berth Usage Graph Generation.
Figure 3.10. Ship Report.

Figure 3.11 shows an example Ship Berth Usage graph. Two ships arrive on the first day and they leave the port on the same day. There are no more ships arriving until the 19th day. The remaining ships arrive at the port between days 19 and 32. More ships arriving between days 2 and 19, thus better distributing the arrivals, will help in clearing all the cargo earlier.
The three graphs explained above are generated automatically once the workbook is opened. These graphs are used as the starting point for an analysis. The detailed analysis is carried out by using the Graph Creator that has the capability to dynamically generate the output and throughput graphs for the desired partition of data.

3.5 The Graph Creator

Graph Creator is the most important and complicated part of the Output Analyzer. It is designed to be able to generate output and throughput graphs in a very dynamic manner, giving the user the ability to partition the data during analysis to look into the
details of the bottlenecks that are identified in the canned graphs discussed in the previous sections. The discussion of the Graph Creator is divided into three parts, the GUI, the output graphs and the throughput graphs. The following sections discuss the design of the Graph Creator in detail.

3.5.1 The Graphical User Interface (GUI)

The GUI model of the graph creator is designed to generate the output and throughput graphs by partitioning cargo data during analysis. Figure 3.12 shows the graphical user interface of the Graph Creator. It has the capability to generate the graphs by partitioning the data by specific port area type, port areas, cargo type, transport mode, vehicle type, units and ships. It shows different partitions of data on a single graph as different series, with different names, to make it easy for comparison. The partitioning of cargo data is done according to the area of interest (the area of bottlenecks) in the predefined graphs shown above. Appendix E shows the programming details of GUI design.

3.5.2 Output Graphs

The output graphs are generated for a particular partition of data selection to show the arrival and departure of each piece of cargo. An output graph gives the ability to track the time of operation for any particular selection combination and helps decide how to speed up the operation if there is any sluggishness. An output graph is plotted with time in days on the X-axis. There are three output graphs showing SQFT, STONS and Number of Pieces on the Y-axis.
The data to plot these graphs are not in a desired format. It is necessary to reorganize the data to be able to create these graphs for the selection criteria entered in the GUI. Figure 3.13 gives a high level flowchart showing the reorganization and generation of the graphs for each port area selected. Hidden Graph Scratch1 and Hidden Graph Scratch2 are the excel sheets used to store the reorganized temporary data used to generate the graphs. The details of the output graph generation process can be seen in Appendix D.
Copy Cargo Type, Transport mode, Vehicle Type, Unit Number, Ship, SQFT, STONS, Arrival Time and Departure time columns to *Hidden Graph Scratch 1* from the selected port area report.

Calculate the cumulative values of SQFT, STONS and number of pieces for each cargo piece.

Use advanced filter action to filter the data by the selected values of list boxes showing Cargo Type, Transport mode, Vehicle Type, Unit Number, Ship.

Cut and paste the values to the sheet *Hidden Graph Scratch 2*.

Create three X-Y Scatter charts showing SQFT, STONS and number of pieces on Y-axes and time in days on X-axes using the data in the columns of the sheet *Hidden Graph Scratch 2*. Use the names given in the text boxes 1 and 2.

Figure 3.13. Generation of Output graphs.

If the user needs to plot more series, the above operations, shown in figure 3.13 are repeated and the new data are placed adjacent to the previous data in *Hidden Graph Scratch 2*. A blank column separates these data blocks. Each block of data gives a new
series to the graph with the name given in the box named series name shown in the GUI. Thus, multiple series can be plotted for comparison.

Figure 3.14 is an example of an output graph with the number of pieces for staging areas of the port. The orange and blue colored series show the output of the staging areas Stage1 and Stage2. The pink colored series shows the output of both the staging areas together. In an output graph, increasing slope indicates the arrival of cargo and decreasing slope indicates the departure. It can be seen that the cargo starts arriving into Stage1 on the 21st day and all the cargo leaves Stage1 on the 33rd day. The cargo operations are faster in Stage1 and no sign of any serious bottlenecks is seen. There are a large number of pieces of cargo flowing through Stage2 compared to Stage1. One phase of cargo entering and leaving staging occurs during days one to three. There is no cargo entering or leaving stage2 between the third and the 19th day. This is because of no ship arrival during this time. A major area of bottleneck occurs after the 32nd day, where clearing of cargo from Stage2 has slowed down, indicated by the slowly decreasing slope. A graph plotted for different transport modes in Stage2 will be able to reveal the details for this bottleneck. A detailed example analysis is carried in Chapter 4 to give the reader a better understanding of how an analysis is done using the Graph Creator.

The other two output graphs are similar in shape. One of them shows square feet and the other shows short tons on the Y-axis with time in days on the X-axis. The output graph showing square feet gives the area of the cargo pieces at any point of time. The output graph showing the short tons gives the weight of cargo pieces at any point of time. These graphs give the analyst an understanding of the type of transport needed to clear the cargo. Based on this information, he can partition the data for further analysis.
3.5.3 Throughput Graphs

A throughput graph is a bar chart plotted with time in days on the X-axis and the square feet, the short tons or the number of pieces clearing a port area on the Y-axis. There are three throughput graphs with each of them showing one of the above three quantities on the Y-axis. A throughput graph gives the work done (in terms of the number of pieces or SQFT or STONS of cargo processed) on any particular day with each bar on the graph corresponding to a particular day. It helps for day-by-day analysis of the cargo processed.

Figure 3.14. Output Graph showing number of pieces for staging areas.
The filtered data required to generate the throughput graphs are available in the sheet named *Hidden Graph Scratch 2*. The SQFT, STONS and number of pieces of cargo are calculated for each day and are placed in columns. The corresponding number of days is also placed in a column. The throughput graphs are plotted with SQFT, STONS and number of pieces on the Y-axes and time in days on the X-axes. Appendix D gives the details of the programming logic involved to generate these graphs.

The following is an example throughput graph for the number of pieces for the selected combination of staging areas. One series shows the data of all the staging areas, while the other two show the data corresponding to stage1 and stage2 respectively. As can be seen from the graph, the throughput during days 4 to 19 and 34 to 54 is very low for Stage2 area and an analysis should be carried out to find the details that can help fix this problem.

The throughput graphs for SQFT and STONS are similar to the one with number of pieces and show the information in terms of SQFT of the area used and STONS of cargo. The graphs described above give the output of a simulation in a simple and effective manner for the analyst to understand the details of bottlenecks by portioning the data as required.
Figure 3.15. Throughput graph of number of pieces for staging areas.

3.6 The Unit Info Generator

Each cargo piece is associated with a specific military unit in the port operations. It is important for analysts to know the details, such as the port areas and the ships a particular unit is traveling through, to be able to effectively analyze the data corresponding to that unit. The unit graph gives the duration of time a particular unit is processed but not the different areas, vehicles and ships the unit is moving through. The Unit Info Generator accomplishes this task. In addition to giving the arrival and departure times of a cargo unit at the port, it gives the different port areas, ships, etc. the unit is passing through.
As can be seen in Figure 3.16, the user can select the unit he is interested in from the drop down box showing units. Pressing the GO button will display the ships and the port areas in the corresponding list boxes, through which, the cargo corresponding to the selected unit is moving through. It shows the port arrival and departure times of the unit in text boxes named IN and OUT, respectively. Figure 3.17 gives the programming logic for unit info generator’s operation.

Figure 3.16. Unit Info Generator.
Sort column ‘G’ of cargo sheet containing the unit numbers in ascending order.

To fill each list box corresponding to ships and port areas, filter the data using the selected unit number as the criteria.

Get the data (ships & port areas) into different no dupes collections from the corresponding columns.

Fill the list boxes with the data in the corresponding no dupes collections such that the ships list box contains all the ships and port area list boxes contain corresponding port areas.

Get the minimum arrival time and maximum departure time corresponding to the unit into text boxes IN and OUT.

Figure 3.17. Programming logic for Unit Info Generator.
CHAPTER IV
EXAMPLE ANALYSIS

This chapter presents analysis for a given scenario. It begins by discussing the scenario and the problem that needs to be solved. It explains the automatically pre-generated graphs and the important areas to look for in these graphs. A detailed analysis is carried out to determine the reasons for bottlenecks. The results of a modified simulation run targeted to alleviate bottlenecks are shown in which it is shown that a faster closure has been attained.

4.1 Problem Statement

To conduct an example analysis using the Output analyzer, a scenario for the Port of Ad Dammam (Figure 4.1.) is considered. The following are the details of the port scenario.

*Port Areas:* The following table shows different port areas in Ad Dammam utilized in the scenario.

<table>
<thead>
<tr>
<th>Port Area Type</th>
<th>Port Areas</th>
<th># Of Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>BERTH</td>
<td>Berth30, Berth31, Berth32, Berth33, Berth34, Berth35</td>
<td>6</td>
</tr>
<tr>
<td>STAGING</td>
<td>Staging, Container Staging</td>
<td>2</td>
</tr>
<tr>
<td>HELO</td>
<td>Re-Assembly, Aviation Staging, Take-Off</td>
<td>3</td>
</tr>
<tr>
<td>LOADING</td>
<td>Commercial Truck Loading, Container Loading Area</td>
<td>2</td>
</tr>
<tr>
<td>CCAs</td>
<td>Convoy Construction</td>
<td>1</td>
</tr>
<tr>
<td>RAIL SPURS</td>
<td>RS1, RS2</td>
<td>2</td>
</tr>
<tr>
<td>INTERCHANGE YARDS</td>
<td>IY1, IY2</td>
<td>2</td>
</tr>
<tr>
<td>GATES</td>
<td>Main Gate</td>
<td>1</td>
</tr>
</tbody>
</table>
Other Parameters: The following table gives the different parameters used to run the simulation for the present scenario.

Table 4.2. Cargo parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of cargo pieces</td>
<td>25,491</td>
</tr>
<tr>
<td>Convoy cargo pieces</td>
<td>18,812</td>
</tr>
<tr>
<td>Motor Host cargo pieces</td>
<td>5,916</td>
</tr>
<tr>
<td>Rail cargo pieces</td>
<td>213</td>
</tr>
</tbody>
</table>

The problem is to investigate the reasons for any bottlenecks, and attain a faster closure time by running the simulation with modified parameters. The analysis should help to attain closure within 50 days instead of 65.

Figure 4.1. The port of Ad Dammam.
4.2 Initial Scenario Results

As explained in the previous chapters, the following graphs are generated automatically once the workbook is opened.

- Clearance Profile graphs
- The Unit Graph
- Ships On Berth Graph.

These are the graphs where the analyst normally starts the analysis. Figure 4.2 shows the clearance profile graph for number of pieces of cargo for the given scenario.

Figure 4.2. Clearance Profile (number of pieces).
A clearance profile graph is a good point to start the analysis, as it is easy to see the possible areas of bottlenecks, which, the analyst can then locate the details to fix the problems.

Figure 4.3 is the Unit Graph showing the period of time each unit is in the port for the given scenario. In this graph, each series corresponds to a different unit showing the arrival and departure times of units of cargo in the port.

The ships on berth graph shows the interval of time each ship is on the berth and the berth length it occupies. There are 33 ships arriving at the port for the given scenario. Figure 4.4 shows the ships on berth graph for the given scenario.
As described in the previous chapters, 'The Output Analyzer' is a single run analysis tool developed to view the details and determine the specific areas of the port, where there are bottlenecks in the activities carried out. This helps the analyst look into reasons for the bottlenecks and change the parameters of the simulation for better performance. These parameters normally consist of the resources handling cargo and the transports that carry cargo items. The graphs shown above are the starting point of analysis. The analyst looks for the following features in the pre-generated graphs shown above.

Figure 4.4. Ships on Berth graph.

4.3 The Analysis
• Sudden changes in the slope of the series
• Areas of no activity

The analyst then creates graphs that highlight the corresponding data to confirm any serious bottlenecks.

With these basic graph features in mind, the analyst proceeds to find the reasons for bad performance and bottlenecks. The following is an analysis of the scenario given in the present problem using the Output Analyzer to identify problems and to assess solutions.

In the clearance profile graph in Figure 4.5, the three different series shown are the number of pieces clearing the berth, the staging and the port. There are two areas of interest where there are reasons for delayed clearance, which means, two different areas where the analyst can conduct the analysis using the graph creator to see the reasons for bottlenecks. The possible areas of bottlenecks are shown in Figure 4.5 to assist the reader.

**Area 1: Area of almost no activity till the 22nd day.**

In the Clearance Profile graph, it is obvious that there is no activity prior to the 22nd day. The reason for this is obvious as one looks at the Ships on Berth graph showing that no ships arrive prior to the 22nd day. This means that there is no cargo to be operated on during this period. The total time for clearance could be reduced by almost 22 days had ships arrived in this period. Arrival of cargo during this time can solve the problem for the current scenario thus clearing the port within 50 days. It also can reduce resource requirements by spreading out their use over a longer period of time.
But this is the ship arrival profile provided for analysis. The analyst can only report to the decision makers about this problem. So, it is important to see the other areas where there are bottlenecks and then run the simulation again for better results. For a given scenario, it is assumed that the analyst can only change the number of resources and transport objects allotted but cannot decide on the arrival time of ships.

Figure 4.5. Clearance Profile Graph showing Area 1 and Area 2.

Area 2: Area of low slope after the 34th day for the staging series.

A close look at the clearance profile graph reveals that the rate cargo pieces clear staging decreases after the 46th day and also that all the pieces of cargo have already cleared the berths by the 46th day. This means there is something that is slowing down the
rate of clearing the cargo pieces in staging. This is not enough information to fix the problem. It is necessary to know the exact reasons for late clearance to fix the problem. These reasons can be determined by using the graph creator to create individual graphs for the staging areas. There are two staging areas, Staging and Container Staging, for the given scenario. Figure 4.6 shows the number of pieces arriving (increasing slope) and leaving (decreasing slope) these areas.

![Graph showing Staging areas in staging](image)

Figure 4.6. Staging areas in staging (number of pieces).

In this graph, the blue line corresponds to Container Staging and the green line corresponds to Staging. It is obvious that the Container Staging area does not have many cargo pieces and the cargo clearance has been fast; whereas nearly 23,000 pieces of cargo
are processed through the Staging area. The cargo clearance looks satisfactory until the 46\textsuperscript{th} day in staging. After the 46\textsuperscript{th} day, clearance has slowed down. As all the pieces of cargo have cleared berth by this day, there is something that is slowing down the clearance from the Staging area. It is necessary to know the exact reasons for this delay in order to fix the problem. The only cargo type in Staging is vehicle. The delay in clearance can be because of any of the transport modes. To find out the transport mode that is affecting the clearance, another graph showing the number of pieces of cargo traveling by different transport modes is needed. Figure 4.6 shows three series, each corresponding to different transport modes in staging. The series in green corresponds to the Convoy Organic transport mode. The cargo clearance is acceptable for the cargo traveling in this mode of transport. The series in yellow shows the rail cargo. There is not much cargo traveling on rail and cargo clearance is satisfactory. The blue line shows the Motor Host cargo. It is obvious that the cargo clearance is delayed for this transport mode.

Thus, the analyst can now say that the problem is in the motor host transport mode of staging. By adjusting the different parameters that can affect this, the analyst can identify the culprit. Possible reasons include external transports, available PSA drivers, available end ramps and cranes to load the cargo on trucks, or the processing times to load the trucks. It is advantageous to plot the Staging Motor Host graphs for different type of vehicles.
Figure 4.7. Transport modes in Staging (number of pieces).

Figure 4.8 shows three series corresponding to different Motor Host vehicle types. The red and green series correspond to self propelled and towed vehicles respectively. It can be seen that there is little cargo traveling on these vehicle types and the cargo cleared reasonably fast on these vehicles. The blue series corresponds to the tracked vehicles. It can be seen that after the 46th day, the cargo is moving slowly on tracked vehicles.

Now, it is easy to say that the reason for sluggishness after the 46th day is because of the lack of enough Heavy Equipment Transports (HETS) available to out load the cargo to clear Staging area. As the reason for late clearance of cargo is known, the analyst
can increase the number of Heavy Equipment Transports and run the simulation again to see the effect on the new clearance profile graph.

Figure 4.8. Motor Host Vehicle types in Staging (number of pieces).

4.4 Results

Once the areas of bottlenecks are located, the simulation is run again after changing the parameters that were shown to cause the problem. A new set of graphs is plotted to see the difference of the change. Analysis can be carried out again if there are any bottlenecks in the new graphs.

Figure 4.9 is a new clearance profile graph generated after doubling the number of transports. The new total time for closure is 50 days. So, the closure is attained 15 days
early after the analysis that helped to fix the problem. Figure 4.10 shows the new unit graph. It can be seen that all the units clear the port within 50 days. It should be noted that the number of transports were doubled in order to demonstrate the impact they have on the scenario. However, the increase in the number of transports is highly dependent on their availability.

Figure 4.8. New clearance profile graph.
4.5 Summary

In this chapter, a detailed analysis of an example scenario for the Port of Ad Dammam is performed. The important areas to look for bottlenecks in the pre-generated graphs are discussed. It is shown how the Output Analyzer is used to determine the problem areas and, after the problem for late clearance was found, the simulation is run again with the increased number of transports. The results show that the time for closure is reduced by 15 days to clear all the cargo through the port in 50 days instead of 65. This chapter should give the reader an understanding of the ability of the Output Analyzer to perform a dynamic analysis.

Figure 4.9. New Unit Graph.
CHAPTER V

CONCLUSION

In this thesis, a dynamic output analysis tool for analyzing the output of a single run CPoRTS simulation is explained. The knowledge required for understanding CPoRTS is discussed. The design of the tool is explained in detail. The dynamic ability of the tool is demonstrated by conducting an output analysis for a given scenario, the port of Ad Dammam. In the sample analysis, it is shown that after changing the corresponding input parameters, as identified by the analysis, the time for closure is actually reduced by 15 days.

5.1 Accomplishments

By providing the predefined reports and graphs, the output analyzer helps identify the areas of the bottlenecks at a high level. They serve as the starting points of an analysis. As the user does not know how he wants to partition the data during analysis to view the details of bottlenecks, it was very important to design a tool that allows partition of data during analysis to generate the required graphs. The Output Analyzer was able to perform as dynamically as required.

The output analyzer helps track the movement of a particular unit through different ships and port areas through its Unit Info generator. Knowledge of different port areas a unit is moving through helps in identifying the bottleneck areas at a high level and the data corresponding to those areas can be analyzed to find the specific reasons for bottlenecks.
In an industry environment, training is very important and the more complex the training is, the higher the costs. The Output Analyzer has a user friendly GUI that consists of an easily understandable concept of generating the graphs as needed, thus making training very simple.

The software code for the tool is written in VBA in a very understanding manner with comments as needed. For future enhancements, it is easy to understand the VBA code. The code is macro-based and editing them is simple.

Even though this tool serves the purpose of analyzing the output of the simulation satisfactorily, there are some issues that need to be addressed to make this tool widely acceptable and dynamically robust.

5.2 Future Work

MS Excel is a very basic data storage and maintenance application. An Excel sheet contains 256 columns and 65,536 rows, limiting the dataset that can be handled without crossing sheet boundaries. Programming becomes unnecessarily complex when there are more than 65,536 cargo pieces. In the future, a tool needs to be developed using a database, such as MS SQL or ORACLE, which can incorporate larger data sets [7].

This tool performs the operations needed without taking into account the speed of performance. The tool was built as a prototype to prove the concept of use. Performance is a function of the amount of data and is particularly slow when there is a considerable amount of data as observed: The performance is actually acceptable to the users. By the use of databases like MS SQL and ORACLE, the process of querying the data should become extremely fast. Tools like Seagate Crystal reports [8] and Intelliview reports [9]
have the capability to query any kind of database and generate the needed reports and graphs at a much faster rate.

The tool needs to be more robust in its operation. Although many of the errors that can occur are taken into account, the tool is not 100% robust. For example, consider the Port named Corpus Christi where the berth areas are, Bulk Terminal 1, Cargo Dock10, Cargo Dock 14/15, and Cargo Dock8. The Output Analyzer gives an error while generating the report for the berth area named Cargo Dock 14/15. This error is due to the fact that a sheet name cannot contain a “/” operator. Errors like this are not accounted for. A rigorous testing can help fix this kind of error to make the tool more robust.

As the tool is used in a military environment, proper security is a must. Allowing the users with proper training to use the tool will be appropriate.

With the above enhancements in mind, future work needs to be conducted to provide a dynamic and robust output analysis tool for CPortS.
REFERENCES


APPENDIX A

Report Generation

The report generator is a function written in VBA, which is run automatically once the workbook is opened. The flow chart in Figure A1 gives the various operations carried out by this function, which are discussed in detail latter in the section.

![Flow Chart]

Figure A1. High-level flow chart of the report generator.

Prepare the System

Preparing the system includes declaring the variables, changing the drive to the drive in which the workbook is located and setting the status bar and the display alerts.
Declare the variables *drive, psimXLInterfacePath, berthname, stagingName, i, j, k, l, t and path*

- Set the ScreenUpdating and Displayalerts to false
- Let Status bar show "Please wait... Cargo data being read..."

**Figure A2. Prepare the System.**

**Read ‘Cargo.csv’ and ‘OutputScenarioData.csv’ Files**

This operation includes opening the *Cargo.csv* and *OutputScenarioData.csv* files and moving them to the active workbook as excel sheets named ‘Cargo’ and ‘Hidden Support’ respectively. The block diagram in Figure A3 shows these operations.

**Figure A3. Read Cargo.csv & OutputScenarioData.csv.**
Create Clearance profile Data

Clearance profile data contains the following information: Port arrival and departure times of each piece of cargo, short tons and square feet. This data is obtained from the cargo sheet. The workbook contains the hidden sheets “Hidden Cargo”, “Hidden Closure Data”, “Hidden Graph Scratch1” and “Hidden Graph Scratch2”. “Hidden Closure Data” contains the clearance profile data. “Hidden Graph Scratch1” and “Hidden Graph Scratch2” are two excel sheets that are used to save the manipulated data in order to generate the graphs. The block diagram in Figure A4 shows the required operations in order to generate the data.
Copy Column ‘U’ From Cargo sheet to column ‘A’ of Hidden Closure Data


Sort Column ‘A’ of Hidden Closure Data in Ascending Order

\[ k = \text{Total No. of positive values in column ‘A’} \]

Insert column ‘C’ after column ‘B’.

\[ C_1.\text{value} = B_1.\text{value} \]

Use formula

\[ C_2.\text{Formula} = C_1 + B_2 \]

to fill column ‘C’ down to ‘Ck’ to get the STONS of the Berth.

Delete column ‘B’

\[ D_1.\text{value} = C_1.\text{value} \]

Use formula

\[ D_2.\text{Formula} = D_1 + C_2 \]

to fill column ‘C’ down to ‘Ck’ to get the SQFT of the Berth

Delete column ‘C’
Copy Column ‘AG’ From Cargo sheet to column ‘F’ of Hidden Closure Data (Berth data)

Sort Column ‘F’ of Hidden Closure Data in Ascending Order

i=Total No. Of positive values in column ‘F’

Copy Column ‘BN’ From Cargo sheet to column ‘R’ of Hidden Closure Data (Staging data)

Sort Column ‘R’ of Hidden Closure Data in Ascending Order

j=Total No. Of positive values in column ‘R’

j>0

Range("R1:T" & j).Cut;
Range("F" & (i + 1)).paste;

i=i+j

Sort Column ‘F’ of Hidden Closure Data in Ascending Order

Insert Column ‘H’ after ‘G’

H1.value=G1.value

Use formula
H2.Formula = H1+G2 to fill column ‘H’ down to ‘Hi’ to get the STONS of the Staging Area
Delete column ‘G’

Insert Column ‘I’ after ‘H’

I1.value=H1.value

Use formula
I2.Formula = I1+H2 to fill column ‘I’ down to ‘Ii’ to get the SQFT of the Staging Area

Delete column ‘H’

Copy Column ‘CL’ From Cargo sheet to column ‘K’ of Hidden Closure Data (Port data)

Sort Column ‘K’ of Hidden Closure Data in Ascending Order

j=Total No. Of positive values in column ‘K’

Insert Column ‘M’ after ‘L’

M1.value=L1.value

Use formula
M2.Formula = M1+L2 to fill column ‘M’ down to ‘Mj’ to get the SQFT for the port

Delete column ‘L’

Insert Column ‘N’ after ‘M’
N1.value = M1.value

Use formula
N2.Formula = N1 + M2 to fill column ‘N’ down to ‘Nj’ to get
the STONS for the port

Delete column ‘M’

k > 0

Range("D1").Value = 1
Range("D2").Formula = "=D1+1" down to Dk (pieces of cargo in berth)

i > 0

Range("I1").Value = 1
Range("I2").Formula = "=I1+1" down to li (pieces of cargo in Staging)

j > 0

Range("N1").Value = 1
Range("N2").Formula = "=N1+1" down to Nj (pieces of cargo in the Port)

k = The highest row number + 1.
T = The highest time (will be in columns A or F or K)

Replace Ak, Fk and Kk values with ‘t’.
Insert Bk-1, Ck-1, Dk-1, Gk-1, Hk-1, Ik-1, Lk-1, Mk-1, Nk-1 INTO Bk,
Ck, Dk, Gk, Hk, Ik, Lk, Mk, Nk Respectively.
Delete Columns AZ, AT, AN, AK, AE, AB, Y, S, P, AND M.

Set status bar= "Please wait... Cargo Report Generation is in Progress..."

Figure A4. Create Clearance profiles Data.

With the clearance profile data being ready in the required form, the clearance profile graphs can be created. The creation of clearance profile graphs is discussed in Appendix B.
APPENDIX B

Preparation and creation of the cargo

Individual reports for all the available port areas need to be created in order to facilitate easy reading of the data and automatic graph creation. The various port areas available are, Births, Staging areas, Helo areas, Loading areas, Convoy Construction areas (CCA’s), Rail Spurs, Interchanging yards and the Gates.

Berths

The Berth reports are in the format shown in Figure B1. The flowchart in Figure B2 gives the corresponding program flow to generate this report.

Figure B1. Berth Report Format.
Copy Columns (A:R) from Cargo Sheet to Hidden Cargo Sheet

Delete Columns (J:R) in the Cargo Sheet.

Select Columns (A:R) in Hidden Cargo and sort column ‘J’ in descending order.

Delete columns D, O, M, K.

Insert column ‘B’ after column ‘A.’ In sheet “Hidden Support”

$j=A1.value$

If $j>0$ then

For $i=1$ to $j$

In Hidden Support Sheet, $k=$ total number of pieces through the berth in first row of column ‘J’ of Hidden Cargo. (Operating on the first berth after sorting the column.)

berthname=$C(1, I+2).value$ of Hidden Support.
Add new Sheet and name it with the value in berthname.

Copy the berth data from Hidden Cargo into the berth sheet, and name the report and the columns as shown above.

If there is no cargo passing through this berth, delete the other data in the report.

Next i

Delete Columns ‘A:R’ in “Hidden Cargo”. (i.e. Delete berth cargo)

Figure B2. Berth Report Generation.

**Helo Report**

Here, one Helo report for all the Helo areas is generated. The helicopter report is in the format shown in Figure B3. The flow chart in Figure B4 gives the operations performed.
Figure B3. Helo Report Format.

Sort column 'B' of Cargo Sheet in Ascending Order.

Copy Helo data from Cargo Sheet to the new sheet named 'Helo Report'. (See the code to know how this is done.)

Delete Helo data from Cargo sheet.

Select columns ‘A:L’ and sort column ‘G’ in ascending order.

Name the report and the columns, as shown in Figure. B3.

Figure B4. Helo Report Generation.

Staging Area Reports

All the staging area reports are generated in the format shown in Figure B5. The flow chart in Figure B6 gives the operations carried out to create these reports.

Figure B5. Staging Area Report Format.
Copy Columns (A:R) from Cargo Sheet to Hidden Cargo Sheet

Delete Columns (J:R) in the Cargo Sheet.

Select Columns (A:R) in Hidden Cargo and sort column ‘J’ in descending order

Delete columns D, O, M, K.

\[ j = \text{A2.value} \]

\[ j > 0? \]

For \( i = 1 \) to \( j \)

In Hidden Support Sheet, \( k = \) total number of pieces through the berth in first row of column ‘J’ of Hidden Cargo. (Operating on the first staging area after sorting the column.)

\[ \text{stagingname} = \text{C(2, I+2).value of Hidden Support.} \]

Add new Sheet and name it with the value in stagingname.
Copy the staging area data from Hidden Cargo into the staging area sheet, and name the report and the columns as shown above.

If there is no cargo passing through this area, delete the other data in the report.

Delete Columns ‘A:R’ in “Hidden Cargo”.
(i.e. Delete staging area cargo)

Figure B6. Staging Area Report Generation.

**Loading Area Reports**

All the staging area reports are generated in the format shown in Figure B7. The flow chart in Figure B8 gives the operations carried out to create these reports. It is obvious from the above discussion that the format for creating the reports for all the port areas is similar.
Figure B7. Loading Area Report Format.

Copy Columns (A:P) from Cargo Sheet to Hidden Cargo Sheet

Delete Columns (J:P) in the Cargo Sheet.

Select Columns (A:P) in Hidden Cargo and sort column ‘J’ in descending order

Delete columns O, M, K.

j=A4.value
For $i=1$ to $j$

In Hidden Support Sheet, $k$ = total number of pieces through the berth in first row of column ‘J’ of Hidden Cargo. (Operating on the first Loading area after sorting the column.)

loadingname = $C(4, i+2)$.value of Hidden Support.

Add new Sheet and name it with the value in loadingname.

Copy the loading area data from Hidden Cargo into the loading area sheet, and name the report and the columns as shown above.

If there is no cargo passing through this area, delete the other data in the report.

Next $i$

Delete Columns ‘A:R’ in “Hidden Cargo”.
(i.e. Delete loading area cargo)

Figure B8. Loading Area Report Generation.

CCA Reports

Figure B9 shows a Convoy Construction Area report. Figure B10 gives the logic.
Figure B9. CCA Report Format.

Copy Columns (A:N) from Cargo Sheet to Hidden Cargo Sheet

Delete Columns (J:N) in the Cargo Sheet.

Select Columns (A:N) in Hidden Cargo and sort column 'J' in descending order

Delete columns M, K.

j=A5.value
In Hidden Support Sheet, k=total number of pieces through the berth in first row of column ‘J’ of Hidden Cargo. (Operating on the first CCA after sorting the column.)

CCAName = C(5, i+2).value of Hidden Support.

Add new Sheet and name it with the value in CCAName.

Copy the CC area data from Hidden Cargo into the CC area sheet, and name the report and the columns as shown above.

If there is no cargo passing through this area, delete the other data in the report.

Delete Columns ‘A:R’ in “Hidden Cargo”. (i.e. Delete CC area cargo)

Figure B10. CCA Report Generation.
Gates Report

The Gate Area reports are generated in the format shown in Figure B11. The flow chart in Figure B12 gives the operations carried out to create Gate reports.

Figure B11. Gate Report Format.

Copy Columns (A:N) from Cargo Sheet to Hidden Cargo Sheet

Delete Columns (J:N) in the Cargo Sheet.

Select Columns (A:N) in Hidden Cargo and sort column 'J' in descending order
Delete columns M, K

\[ j = A8.value \]

\[ j > 0? \]

For \( i = 1 \) to \( j \)

In Hidden Support Sheet, \( k = \text{total number of pieces through the berth in first row of column 'J' of Hidden Cargo.} \)
(Operating on the first Gate after sorting the column.)

\[ \text{gatename} = C(8, i+2).value \text{ of Hidden Support.} \]

Add new Sheet and name it with the value in \text{gatename}.

Copy the berth data from Hidden Cargo into the gate sheet, and name the report and the columns as shown above.

If there is no cargo passing through this berth, delete the other data in the report.

Next \( i \)

Delete Columns ‘A:R’ in “Hidden Cargo”.
(i.e. Delete gate cargo)

Figure B12. Gate Report Generation.
Rail Spurs

The rail Spur Area reports are generated in the format shown in Figure B13.

The flow chart in Figure B14 gives the operations carried out to create CCA reports.

Figure B13. Rail Spur Report Format.

\[ j = A6.value \]

\[ j > 0? \]

\[ \text{For } i = 1 \text{ to } j \]

In Hidden Support Sheet, \( k = \) total number of pieces through the berth in first row of column ‘J’ of Hidden Cargo. (Operating on the first Rail Spur after sorting the column.)

\[ \text{RSname} = C(6, i+2).value \text{ of Hidden Support.} \]

Add new Sheet and name it with the value in RSname.

Copy the RS area data from Hidden Cargo into the RS area sheet, and name the report and the columns as shown above.

If there is no cargo passing through this area, delete the other data in the report.

\[ \text{Next } i \]

Delete Columns ‘A:Z’ in “Hidden Cargo”. (i.e. Delete RS area cargo)

Figure B14. Rail Spur Report Generation.
Interchange yards

The Interchange Yard Area reports are generated in the format shown in Figure B15. The flow chart in Figure B16 shows the program flow. The report generation for individual port areas ends with this report generation.

Figure B15. Interchange yard Report Format.

Copy Columns (A:O) from Cargo Sheet to Hidden Cargo Sheet

Delete Columns (J:O) in the Cargo Sheet.

Select Columns (A:O) in Hidden Cargo and sort column ‘J’ in descending order
Delete columns M, N, K.

\( j = A7.\text{value} \)

\( j > 0? \)

For \( i = 1 \) to \( j \)

In Hidden Support Sheet, \( k = \) total number of pieces through the berth in first row of column ‘J’ of Hidden Cargo. (Operating on the first Loading area after sorting the column.)

\( \text{IYname} = C(7, \, i+2).\text{value} \) of Hidden Support.

Add new Sheet and name it with the value in IYname.

Copy the IY area data from Hidden Cargo into the IY area sheet, and name the report and the columns as shown above.

If there is no cargo passing through this area, delete the other data in the report.

Next \( i \)

Delete Columns ‘A:Z’ in “Hidden Cargo”. (i.e. Delete IY area cargo)

Figure B16. Inter change yard Report Generation.
Now, as all the reports for different port areas are generated in the required format, the next step is to create the ships activity graph and then the clearance profile graphs for the berth, the staging and the port leaving cargos. Appendix C discusses the generation of these canned graphs.
APPENDIX C

Generation of the Canned Graphs

The automatically generated canned graphs are: the ships on berth graph, the clearance profile graphs, and the unit graph. These canned graph generation processes are explained in detail below.

Ships Report Graph

The procedure that carries out the job is, ‘ShipsReportGraph()’. The ships on berth graph gives the time of stay of each ship in the berth and the length of the berth the ship is using at any time. This helps in evaluating the delay in the operations and take necessary steps to speed up the clearance. As this can be the starting point of an analysis, this is one of the very important graphs for an output analyst.

Figure C1. Ship Report Format.
This VBA procedure that is used to generate the ships report and the graph is shown in Figure C2 in the form of a flow chart. The format in which the ship report is generated is shown in Figure C1.

Declare variables, shipname, i, j, k, l, m, numships, drive, psimXLInterfacePath

Set, psimXLInterfacePath = ActiveWorkbook.path

Set, StatusBar = "Please wait. Ship Report Generation is in Progress..."

Add new sheet with the name "Hidden Ship"

Open 'psimXLInterfacePath & "\Ships.csv"' and name it as, "Ship Report.xls"

Delete column 'B' of 'Ship Report' after copying it to column 'B' of 'Hidden Ship' Sheet.

Copy column 'B' of 'Ship Report' to column 'C' of 'Hidden Ship' Sheet.


Insert Column 'M'.

Calculate the number of ships using the formula, COUNTIF(B:B,">=0.0").

Calculate the Offload Rate (#/hr) using the formula, SUM(C1:E1)/((K1-J1)*24)
Insert column 'M' and calculate the service time using the formula, ‘=(K1-J1)’

Format and name the report and the columns as shown above.

Copy the 'ship names', 'berthing' and 'de berthing' times of Ship Report Sheet to Columns 'A', 'E', and 'F' of Hidden Ship Sheet

Use formula Di=Bi+Ci to fill column D, where I varies from 1 to numships.

Copy the already available data to columns G and H, so that, each ship operation can be drawn in a rectangular shape. This operation makes use of the variables, i, j and k. (for details, view code).

Selecting columns ‘G:H’ add a chart type ‘xlXYScatterLinesNoMarkers’ and name it as "Ships on Berth".

For each ship in column ‘G’, add a new series with the name of the ship (and a different color), with X_values containing the time duration of the ship and the Y_values containing the total berth length the ship occupies at the given time. (This data is already formatted in a convenient form in “Hidden Ship” Sheet.)

Figure C2. Ships Report and Graph Generation.
Clearance profile graphs

Three different clearance profile graphs are generated. Each for STONS, SQFT, and #Pieces. In each graph, there are three series corresponding to berth, staging, and Port. These clearance profile graphs help in comparing the leaving times of the cargo in berth, staging and port. These graphs help minimize the total time of operations by showing the possible areas of bottlenecks at a higher level. The flow chart in Figure C3 gives the operations to be carried out to generate this graph for number of pieces of cargo. Figure C4 gives the generation of clearance profile graph for SQFT of cargo and Figure C5 gives the generation of clearance profile graph for STONS. The data in the required format to generate these graphs is already generated in the sheet named “Hidden Closure Data” as discussed in the Appendix A.

Set, StatusBar = "Please wait... Closure Profiles being generated..."

Activate “Hidden Closure Data” sheet.

i = Range("P3").Value (total number of pieces in berth)
j = Range("P1").Value (total number of pieces in staging)
k = Range("P4").Value (total number of pieces in port)

Add chart type, xlXYScatterLinesNoMarkers with 3 series.
Figure C3. Clearance Profile Graph Generation for number of Pieces.
Series1.Name=Port  
X_Values= values in Column 'K'.  
Y_Values= values in Column 'M'.

Chart name="Closure Profile (SQFT)"
Chart title="Closure Profile"

X_axis title = "Time (Days)"
Y_axis title = "SQFT"

Figure C4. Clearance Profile Graph Generation for SQFT.

Add chart type, xlXYScatterLinesNoMarkers with 3 series.

Series1.Name=Berth  
X_Values= values in Column 'A'.  
Y_Values= values in Column 'B'.

Series2.Name=Staging  
X_Values= values in Column 'F'.  
Y_Values= values in column 'G'.

Series1.Name=Port  
X_Values= values in Column 'K'.  
Y_Values= values in Column 'L'.

Chart name="Closure Profile (STONS)"
Chart title="Closure Profile"
X_axis title = "Time (Days)"
Y_axis title = "STONS"
Set, StatusBar = "Done Closure Profiles..."

Figure C5. Clearance Profile Graph Generation for STONS.

The Unit Graph

The unit graph shows the length of time taken to process a cargo unit by showing the arrival and departure times of the unit. Figure C6 shows the operations carried to generate the unit graph.

Add sheet named units_at_dt

Copy the data in columns G, L, and CL of cargo sheet to the columns A, B, and C of sheet units_at_dt respectively.

Sort column A in ascending order.

The arrival time of the unit is the time that the first piece of cargo of that unit arrives the port and the departure time of the unit is the last piece of cargo that leaves the port. Store arrival and departure times in successive rows in column E while column H shows the unit number.

Create the graph names, The_Unit_Graph with time on the X-axis, and the unit number on the Y-axis.

Figure C6. The Unit Graph Generation.
APPENDIX D

CPortS Graph Creator

The CPortS Graph Creator is used to generate the output graphs and throughput graphs corresponding to STONS, SQFT and number of pieces of cargo. The analyst is able to select any port area type and then the port area, cargo type, transport mode, vehicle type, unit numbers and the ships. Figure D1 gives an idea of how the analyst can select the required data for graphs, and plots them. The comparison between different operations is possible because of the ability of the Graph Creator to plot different series for different selections on the same corresponding graphs.

Figure D1. CportS Graph Creator.
The List box under ‘Port Area Type’ lists all the port areas available in the port. The List box under ‘Port Areas’ lists the different areas in the selected port area type. The List box under ‘Cargo Type’ lists all the cargo types available in the selected port Area. The List boxes under Transport mode, Vehicle type, Unit Number, and Ship give the corresponding Transport mode, Vehicle type, Unit Number, and Ship available (or used) in that particular Port area.

There is one VBA procedure, which runs the show for each active ‘X’ button or box that is shown in the Figure D1. The discussion starts with explaining the option buttons. The flow chart in Figure D2 gives the Option Button 7’s (Port Area Type’s) operation.
If \( p=1 \) and \( z=0 \) (global variables)

\[ p=0; \; z=1 \]

Delete the previous output and throughput graphs if they exist.

Clear the contents of the sheet "Hidden Graph Scratch 2"

Clear the contents of the sheet "Hidden Graph Scratch 1"

\[ \text{ActiveWorkbook.Name} \leftarrow \text{"PortSimOutputAnalysis.xls"} \]
And \( p = 0 \) And \( z = 0 \)

\[ p=0; \; z=1 \]

Delete the previous output and throughput graphs if they exist.

Clear the contents of the sheet "Hidden Graph Scratch 2"

Clear the contents of the sheet "Hidden Graph Scratch 1"
sheet_adder = 0 And
ActiveWorkbook.Name = "PortSimOutputAnalysis.xls"

sheet_adder = 1

Add sheet and name it as "ReAssembly"

Copy column 'A' of Helicopter Report sheet to column 'A' of 'ReAssembly' sheet.

Copy columns 'B:C' of Helicopter Report sheet to columns 'C:D' of 'ReAssembly' sheet.

Copy columns 'D:F' of Helicopter Report sheet to columns 'G:I' of 'ReAssembly' sheet.


Copy columns 'G:H' of Helicopter Report sheet to columns 'L:M' of 'ReAssembly' sheet.
Add sheet and name it as "Aviation"


Add sheet and name it as "TakeOff"


Clear list box 7.


Set all the other option button values to false.

Figure D2. Operation of the Option Button ‘Port Area Type’.
One can select any one of the port area types. No multiple selections are allowed.

The flow chart in Figure D3 explains the procedure "OptionButton5_Click ()" that populates the Port area list box.

- **ListBox7.Value <> Empty**
- **p = 1 And z = 0**
- **p = 0; z = 1**
- Delete the previous output and throughput graphs if they exist.
- Clear the contents of the sheet "Hidden Graph Scratch 2"
- Clear the contents of the sheet "Hidden Graph Scratch 1"
- Clear list box 5.
- **ListBox7.ListIndex = 0**
- Get all the unique values in the range "C1:IV1" of ""Hidden Support" Sheet into the collection nodupes1. (See code for details.)
ListBox7.ListIndex = 1

Get all the unique values in the range "C2:IV2" of ""Hidden Support" Sheet into the collection nodupes1. (See code for details.)

ListBox7.ListIndex = 2

Get all the unique values in the range "C4:IV4" of ""Hidden Support" Sheet into the collection nodupes1. (See code for details.)

ListBox7.ListIndex = 3

Get all the unique values in the range "C5:IV5" of ""Hidden Support" Sheet into the collection nodupes1. (See code for details.)

ListBox7.ListIndex = 4

Get all the unique values in the range "C6:IV6" of ""Hidden Support" Sheet into the collection nodupes1. (See code for details.)

ListBox7.ListIndex = 5
Get all the unique values in the range "C7:IV7" of ""Hidden Support" Sheet into the collection nodupes1. (See code for details.)

ListBox7.ListIndex = 6

Get all the unique values in the range "C8:IV8" of ""Hidden Support" Sheet into the collection nodupes1. (See code for details.)

ListBox7.ListIndex = 7

Get all the unique values in the range "C3:IV3" of ""Hidden Support" Sheet into the collection nodupes1. (See code for details.)

Add items in NoDupes1 to list box 5.

Set message box to display "please select a Port Area Type"

Set OptionButton1, OptionButton3, OptionButton4, OptionButton2, OptionButton6, OptionButton7 values to 'False'.

Figure D3. Populate the Port Area List Box.
The remaining list boxes query the data in the selected port area(s) and get the information needed into the corresponding list boxes. i.e. Cargo Type, Transport mode, Vehicle Type, Unit Number and the ships are extracted from the corresponding port area report(s) selected in the list box 5 into the corresponding list boxes, 1, 2, 3, 6, and 4. The procedures carrying these operations are OptionButton1_Click(), OptionButton2_Click(), OptionButton3_Click(), OptionButton6_Click(), and OptionButton4_Click(). The flow charts in Figures D4, D5, D6, D7, and D8 give the operations of these procedures respectively.
i_checked = 0

i_check = 0 To ListBox5.ListCount - 1

Is Item "i_check" of list box 5 selected?

i_checked = 1

Exit loop.

Next (i_check)

i_checked = 1?

p = 1 And z = 0

Delete the previous output and throughput graphs if they exist.

Clear the contents of the sheet "Hidden Graph Scratch 2"

Clear the contents of the sheet "Hidden Graph Scratch 1"

Clear list box 1.
i = 0 To ListBox5.ListCount - 1

Is the ith item of list box5 selected?

Select the selected port area report and add column ‘B’ values to the collection NoDupes1.

Next i

Add items in NoDupes1 to list box 1.

Unselect all the items in list box 1.

Display "select port area type" in a message box.

Set OptionButton2, OptionButton3, OptionButton4, OptionButton5, OptionButton6, OptionButton7 Values to ‘FALSE’.

Figure D4. Populate the Cargo Type List Box.
i_checked = 0

i_check = 0 To ListBox5.ListCount - 1

Is Item "i_check" of list box 5 selected?

i_checked = 1

Exit loop.

Next (i_check)

i_checked = 1?

p = 1 And z = 0

Delete the previous output and throughput graphs if they exist.

Clear the contents of the sheet "Hidden Graph Scratch 2"

Clear the contents of the sheet "Hidden Graph Scratch 1"

Clear list box 2.
\[ i = 0 \text{ To } \text{ListBox5.ListCount} - 1 \]

Is the \( i \)th item of list box5 selected?

Select the selected port area report and add column ‘E’ values to the collection NoDupes1.

Next \( i \)

Add items in NoDupes1 to list box 2.

Unselect all the items in list box 2.

Display "select port area type" in a message box.

Set OptionButton1, OptionButton3, OptionButton4, OptionButton5, OptionButton6, OptionButton7 Values to ‘FALSE’.

Figure D5. Populate the Transport mode List Box.
i_checked=0

i_check = 0 To ListBox5.ListCount - 1

Is Item "i_check" of list box 5 selected?

i_checked = 1

Exit loop.

Next (i_check)

i_checked = 1?

p = 1 And z = 0

Delete the previous output and throughput graphs if they exist.

Clear the contents of the sheet "Hidden Graph Scratch 2"

Clear the contents of the sheet "Hidden Graph Scratch 1"

Clear list box 3.
Figure D6. Populate the Vehicle Type List Box.
i_checked=0

i_check = 0 To ListBox5.ListCount - 1

Is Item "i_check" of list box 5 selected?

i_checked = 1

Exit loop.

Next (i_check)

i_checked = 1?

p = 1 And z = 0

Delete the previous output and throughput graphs if they exist.

Clear the contents of the sheet "Hidden Graph Scratch 2"

Clear the contents of the sheet "Hidden Graph Scratch 1"

Clear list box 6.
\[ i = 0 \text{ To } \text{ListBox5.ListCount} - 1 \]

Is the \( i \)th item of list box5 selected?

Select the selected port area report and add column ‘G’ values to the collection NoDupes1.

Next \( i \)

Add items in NoDupes1 to list box 6.

Unselect all the items in list box 6.

Display "select port area type" in a message box.

Set OptionButton1, OptionButton2, OptionButton4, OptionButton5, OptionButton3, OptionButton7 Values to ‘FALSE’.

Figure D7. Populate the Unit Number List Box.
i_check = 0 To ListBox5.ListCount - 1

Is Item "i_check" of list box 5 selected?

i_checked = 1

Exit loop.

Next (i_check)

i_checked = 1?

p = 1 And z = 0

Delete the previous output and throughput graphs if they exist.

Clear the contents of the sheet "Hidden Graph Scratch 2"

Clear the contents of the sheet "Hidden Graph Scratch 1"

Clear list box 4.
i_checked = 0

i_check = 0 To ListBox5.ListCount - 1

Is Item "i_check" of list box 5 selected?

i_checked = 1

Exit loop.

Next (i_check)

i_checked = 1?

p = 1 And z = 0

Delete the previous output and throughput graphs if they exist.

Clear the contents of the sheet "Hidden Graph Scratch 2"

Clear the contents of the sheet "Hidden Graph Scratch 1"

Clear list box 4.
i = 0 To ListBox5.ListCount - 1

Is the ith item of list box5 selected?

Select the selected port area report and add column 'H' values to the collection NoDupes1.

Next i

Add items in NoDupes1 to list box 4.

Unselect all the items in list box 4.

Display "select port area type" in a message box.

Set OptionButton1, OptionButton2, OptionButton6, OptionButton5, OptionButton3, OptionButton7 Values to 'FALSE'.

Figure D8. Populate the Ships List Box.
Select all

The select all button is used when one wants to select all the items in any activated list box. Pressing select all button displays "you can only select one Port Area Type!" in a message box if one wants to select the items in list box 7. For all the other list boxes, when the corresponding option button value is true, one can select all the items in that particular list box by pressing ‘Select all’ button.

‘and’ operation

The ‘and’ button is used to create a series corresponding to the data partition selection in the present output and throughput graphs. The high level flow chart shown in Figure D9 depicts the program flow.

Start ‘and’

Copy the data selected in port areas to ‘Hidden Graph Scratch 1’. Calculate #STONS, #SQFT, and #pieces, arrange in required form.

Arrange the criteria for advanced filter operation in ‘Hidden Graph Scratch 1’.

Using the above criteria, filter the data.

Calculate the data for throughput (Stons, sqft, pieces vs days).

End ‘and’

Figure D9. High-level flow chart of ‘and’ Operation.
Plot Operation

Button ‘Plot’ generates the required graphs. ‘Plot’ in addition to performing the same operations as ‘and’, generates the graphs from the arranged data. A flow-chart in Figure D10 depicts its operation.

![Flow-chart diagram](image)

Figure D10. The ‘Plot’ Button Operation.
VITA

Ravikiran Jogu

Summary: Mr. Jogu has completed bachelors of technology (B. Tech.) from Jawaharlal Technological University (JNTU), Hyderabad, India. He has had the opportunity to learn operating systems (Windows and Unix), programming languages (FORTRAN, C, C++), Basics of Electrical Engineering (Motors, generators, and circuits), and the basics of Electronics Engineering. Bachelors have given the knowledge to select the field of study, Computers with a good knowledge of the hardware. He has pursued masters in Electrical Engineering at Old Dominion University (ODU) with software and hardware as the major field of interest. Has taken courses like, Solid State Electronics, Fault Tolerant computing, and Advanced Digital Design on the hardware side and developed software skills during the work on different projects for different courses. He has completed one year of internship at Ynotlearn.com before qualifying for the dream job with ExxonMobil Corporation.

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