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SIMULATING THE PANAMA CANAL: PRESENT AND FUTURE

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ABSTRACT

This paper presents the methodologies and preliminary results of the project to develop a simulation model of the Panama Canal, one of the most famous waterway and locks system of the world. The case is based on the project conducted by Rockwell Software and Paragon Consulting Solutions, helping Panama Canal Authority design a strategic planning tool, based on Arena Simulation Software.

1 INTRODUCTION

The Panama Canal Authority (Autoridad del Canal de Panamá – ACP) is in the process of developing a Master Plan that will guide the future developments, investments and direction of the Panama Canal. A critical part of this planning process has required the assessment of a number of marketing, capital, and operational scenarios to determine their impact on capacity and customer service.

These alternatives have involved a wide range of options, including changes to operational rules and procedures, improvements to the existing locks and navigation channels to increase draft capacity and vessel throughput, and construction of additional locks and navigation channels to allow transit of larger vessels.

It was decided that the development of an operational simulation of canal operations was a critical component of the Master Planning process, in order to assess and compare alternatives in an objective, measurable and replicable fashion.

This simulation model, developed with ARENA software, is being used as a planning tool, in order to assess the system's throughput capacity and level of customer service under different market strategies, capital investment options and operating rules.

2 SIMULATION SYSTEM CONCEPT

The simulation system can be represented by the steps:

- Scenario input – variables and setup data.
- Model logic – Interface, logic and animation.
- Scenario Output – Statistics, graphics and validation.

Results obtained are used for capacity planning and scenario evaluation. Figures 1 and 2 describe the system.

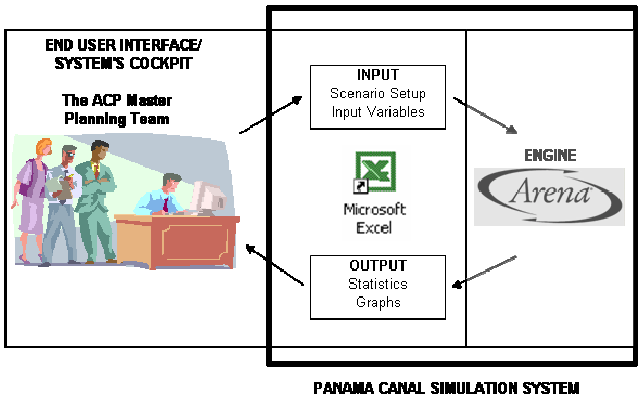

Figure 1: Panama Canal Simulation System

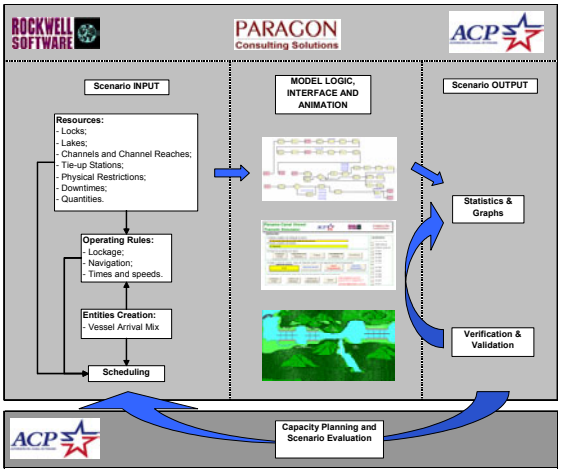

Figure 2: Simulation Model Concept

3 INPUTS

The inputs and the model structure itself are divided into three main parts:

- Vessel Arrival Mix.
- Traffic Rules.
- Vessel Pre-sequencing

At the beginning of the simulation run, the model calculates the Time between Arrivals of the vessels per Market Segment both for the Northbound and Southbound traffic on a monthly basis either based on historical or on forecasted demand. The main attributes of arriving vessels – such as the vessel's type, size and restrictions – will be assigned based on a mix of rules and theoretical distributions.

4 TRAFFIC RULES AND VESSEL SEQUENCING

The traffic rules are mainly defined with a focus on assuring safe crossings through the Canal. They are assigned based on the canal and locks configurations, navigational restrictions and vessel characteristics, among others. They drive operating behavior and scheduling procedures.

Restriction Codes, Precautionary Designator and High Mast Lighting assignment rules are modeled in detail, as well as other important aspects related to traffic, such as fog probability, scheduled and unscheduled downtimes, locks operating modes and the way traffic lanes are chosen.

The vessel scheduling routine – also known as the pre-sequencer – is a simplified logical way to mimic actual scheduling process presently carried out by the Scheduler every morning. Its main goal is to make best use of the Canal resources in a safe manner, overcoming constraints and attending rules, while striving to increase the system's throughput.

Basically, timetables are preliminary suggested by the "Pre-sequencer" software, to the model that then sequence the ships that are ready for transit, based on their Navigation Restrictions and on the scenario of the day.

5 ANIMATION

The animation of the model contains:

- Continuous movement of northbound and southbound vessels through the Panama Canal.
- The position of vessels within the system.
- Different color and size for each vessel type.
- The queue size (number of vessels) for each component.
- An idle/busy graphical indicator for all components.
- 24-hour continuous digital clock and calendar.
- Calendar with the current date of the simulation run.
- Continuous counters for vessels exiting the Canal.

The main goal of the animation is to allow the user to verify that the system is behaving correctly and according to the inputs set by the user. Figures 3, 4 and 5 describe the animation.

Figure 3: Simulation Model – Animation Menu

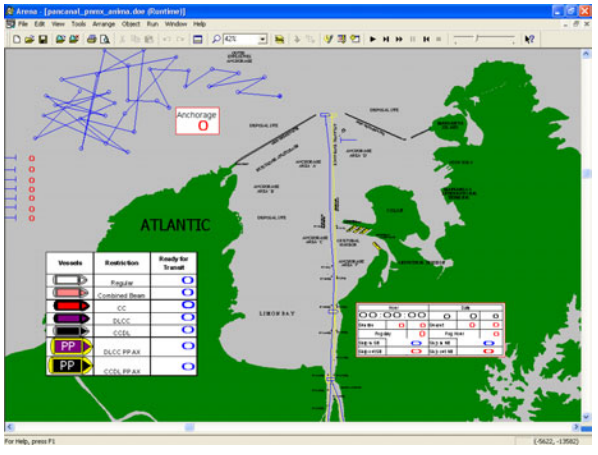

Figure 4 : Panama Canal Animation - Atlantic

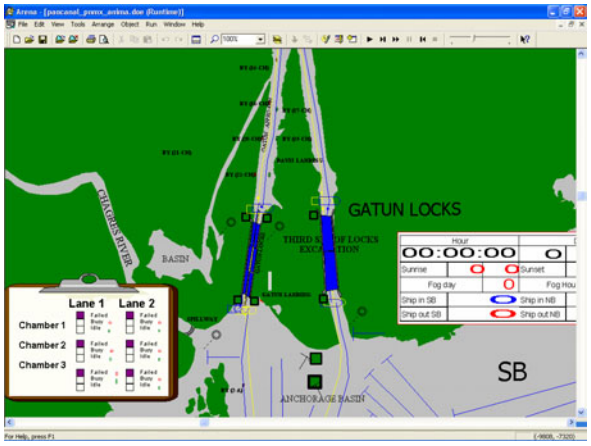

Figure 5: Panama Canal Gatun Locks

6 OUTPUTS

Through the output tables, the analyst is able to access averages and standard deviation for the key performance parameters obtained from the simulated scenario, aggregated per year, per month, and per transit for ships heading southbound and northbound:

- Canal Waters Time per Restriction Code, monthly and yearly averages.
- In-transit Time per Restriction Code, monthly and yearly averages.
- Waiting Times at anchorages and tie-ups, monthly and yearly averages.
- Billing Tons per Market Segment and totals per month and year.
- # of Transits per Market Segment and totals per month and year.
- Locks Occupation.
- Queue Length before the main resources.

7 VERIFICATION AND VALIDATION

Historical data of 2002 was used for validation, and the outputs show that around 99% of the vessels meet the navigational restrictions as stated in the tables below, which indicate the total number of occurrences and its percentage over the total number of transits.

In terms of monthly throughput per Market Segment, the Basic Model accounted for more than 95% accuracy if compared to the historical throughput, thus satisfying the criteria established by PANAMA CANAL Authority, as shown in Table 1 below.

Table 1: Comparison between Number of TRANSITS Completed and Forecasted per Month and Market Segment for Northbound Traffic

		# of Transits Northbound (in x out)									
Year #	Month	Container		Dry Bulk		General Cargo		Others		Passengers	
		Abs	%	Abs	%	Abs	%	Abs	%	Abs	%
2002		-3.5	-0.4%	-5.0	-0.4%	-3.5	-0.9%	-4.3	-0.7%	0.1	0.2%

8 RESULTS AND CONCLUSIONS

This simulation project has produced a powerful and precise simulation tool, allowing the Panama Canal Authority to conduct several experiments with existing and future canal resources, up to the year 2025, while testing different strategies for lock operations, Panamax and new Post-Panamax vessels, as well as new proposed locks and navigation channels.

Although the analysis of Canal capacity is still in its preliminary stages, the simulation model has already allowed the ACP to develop a clear understanding of the limitations of the existing Canal regarding throughput capacity and level of service.

Based on these analysis, the ACP has concluded that the Panama Canal will face significant capacity constraints in the next 5 to 10 years, which will have a negative impact on the Canal's level of service and its long term competitiveness. Also, the simulation model has allowed the ACP to analyze different strategies to increase the capacity of the existing infrastructure, and to ultimately expand the capacity of the Canal through the construction of a third set of Post Panamax locks.

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