

## Performance Analysis of a Southern Mediterranean Seaport via Discrete-Event Simulation

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*Modeling & Simulation (M&S) has proved to be a day-to-day highly indispensable tool for complex systems design, management and monitoring. Therefore, the proposed research study aims to develop a simulation model to recreate the complexity of a medium-sized Mediterranean seaport and analyse the performance evolution of such system with particular reference to the ship turnaround time. After the input data analysis, simulation model development, verification and validation, a design of experiments (according to a 24 factorial experimental design) was carried out in order to evaluate how some critical factors (i.e. inter-arrival times, loading/unloading times, number of cars and trucks to be unloaded/loaded) may affect the seaport's performance. To this end an analysis of variance is performed and an analytical input-output meta-model was created to evaluate the system's performance.*

**Keywords:** logistics, marine ports, supply chain, modeling & simulation

### 0 INTRODUCTION

Despite the economic and financial crisis, statistics show that merchant fleets are growing: more than 138,000 seagoing commercial ships are currently in service [1]. These data prove the crucial role of seaports for both national and international trade. In this framework, the Mediterranean Sea represents one of the most strategic areas with 15% of global shipping activities taking place at mainly western and central Mediterranean ports [2]. Therefore decision making in seaports requires the support of powerful tools allowing performance measurement and analysis. To this end, the main goal of this research work is to propose a simulation-based tool of a medium-size Mediterranean seaport that could be used by the main port administrators (i.e. port managers, the port authority, etc.) to support decision making and process management. Indeed, all port stakeholders need to monitor their performance taking into account quantitative and qualitative aspects, determining whether their strategies produce the desired outcomes, and correcting any misallocations and malfunctions [3].

Performance measurements can be considered in terms of three kinds of indicators: key result indicators (KRIs), performance indicators (PIs), and key performance indicators (KPIs) [4]. As reported in [3], port performance measurements – usually recommended to the port community stakeholders – are divided into five categories: market trends and structure; socio-economic impact; environmental performance; logistic chains; and operational performance and governance. In such a context, modeling and simulation (M&S) has proved to be a

valuable methodology for performance assessment, as well as enhancement and monitoring activities in complex systems. Indeed its first applications in industry and logistics dates back to 1980 [5] to [7]. Among others, discrete-event simulation (DES) is a leading simulation paradigm used to study operational and planning processes within domains like industry [8], logistics and supply chains and more specifically within seaports. In effect, DES is able to capture and recreate the highly dynamic evolutionary processes that are typical of complex real systems. A simulation model of an inland port can be found in [9], whereas [10] and [11] propose simulation models devoted to evaluating logistical and operational processes in marine terminals. Considering the port terminal capacity, [12] and [13] propose simulation models to investigate the capacity increment that can be achieved through new management strategies applied to the devices and equipment available, while avoiding additional capital costs. With reference to security issues in marine ports, namely inspection procedures within container terminals, it has been proved that simulation can be an effective tool for supporting decision, which can be easily integrated into the day-to-day container terminal operations [14] and [15]. Furthermore, in this field, simulation has been successfully applied in conjunction with artificial intelligence techniques for systems performance optimization [16] to [19]. Although it has been proven that M&S is able to support seaport management at various levels (even when combined with agent based approaches [20] such as multi-agent systems [21] or when the simulation model is designed to reproduce the microscopic, stochastic, real-time environment of a part of the container

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