POLITECNICO DI TORINO

Department of Electronics and Telecommunications

Master of Science Degree

in

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Analysis of Innovative automated warehouses through discrete event simulation

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ABSTRACT

Order picking (OP) is the most costly and labour-intensive action in warehouses. Some scholars argue that OP could employ up to fifty five percent of overheads in a warehouse for firms handling large volumes of items that are shipped frequently.

It is becoming increasingly challenging for order picking systems designers because of increases in labour costs, limited space, and increasingly frequent small orders with short delivery times. Consequently, considerable effort is devoted to developing new, innovative picking solutions that reduce operation costs, increase productivity, optimize space utilization, and improve customer service levels.

This project aims to provide a new solution for order picking and innovative ideas about evaluating and comparing different autonomous vehicle storage and retrieval systems (AVS/RS) through a simulation study of the systems operation in an automated warehouse. Eurofork, an Italian company that makes handling equipment, proposed the project. After several years of hard work, Eurofork has become a reference in the logistic automation field because of its ability to make high-quality machinery.

The first step in developing this study was to carry out an analysis of theoretical background regarding the warehouse process, focusing on the order picking process, classification of the order picking systems and automated systems. Further referenced in the literature were studies concerning automated storage and retrieval systems (ASRS) modelling and simulation, also the topics on research done on Robotic picking performance in comparison to different sorts in development, and the demand for mixed pallets and problems building them. There are three chapters culminating with the new order picking system and simulation models followed by experiment results, conclusions, and references.

Keywords: Order Picking Process, Autonomous Vehicle storage and Retrieval system, , Robotic Arm, , ASRS vehicle, Mixed pallet, Flexsim Simulation, Robot picking, Order picking inside the warehouse, Order picking outside the warehouse.

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List of Abbreviations

OP-Order Picking

OPP-Order Picking Process

OPS-Order Picking System

ASRS-Automated Storage and Retrieval Systems

AGV-Automated Guided Vehicle

ACP-Automated Case Picking

ACCPS-Automated Cellular Case Picking System

CBS-Conveyor Based Solutions

WCS-Warehouse Control Systems

WMS-Warehouse Management Systems

LIFO-Last In First Out

AMR-Autonomous Mobile Robots

SKU-Stock Keeping Unit

FIFO-First in First Out

CPS-Case Picking Systems

INTRODUCTION

Chapter 1

The following chapters explain warehouse automation, order picking processes, classification of order picking systems, and how to improve order picking efficiency.

1.1 Background

Optimizing the performance of a supply chain can occur when all milestones of that chain are executing as efficiently as possible. 'Logistics,' thus, is the management of products and services, including all aspects of the flow between vendors and consumers. Storage points or warehouses are used in supply chains for fluctuating lengths of time. For this reason, warehouses are incredibly important (1).

Warehouses no longer have limited roles in storing or buffering items such as raw materials, in-process items and finished goods. Currently, warehouses offer such features as product consolidation, quality-checking, packaging, and information services in addition to handling merchandise and storing it.

Taking a look at (2), these storage areas can be described as places where products are paused to better match supply and demand or to consolidate them to reduce transportation costs and to provide customer service.

Types of Warehouses

The three main types of warehouses are (3)

1. Distribution warehouses (products from one or many suppliers to many customers).
2. Production warehouses (for raw materials, semi-finished products and finished products in production plant).
3. Contract warehouses (servicing one or more customers).

According to review (4) the main warehouse activities can be classified in four stages.

1. Receiving
2. Storage
3. Order picking
4. Shipping.

1.2 Warehouse Automation

Automation of warehouses started around 1960 through automated storage and retrieval systems (AS/RS) which executed the storage processes in German warehouses. Although the picking process was still manual, it can now be fully automated by some systems. (5) The compound annual growth rate (CAGR) of the automated storage and retrieval system market between 2019 and 2024 is estimated to be 7.7%, growing from USD 7.6 billion to USD 11.0 billion (6).

In the ensuing years multiple automated picking systems have been developed, and they have been categorised as shown in Figure 1. Nevertheless, as pointed out by the author (5), most of them have not been studied in academic literature, even though their use in warehouses increases.

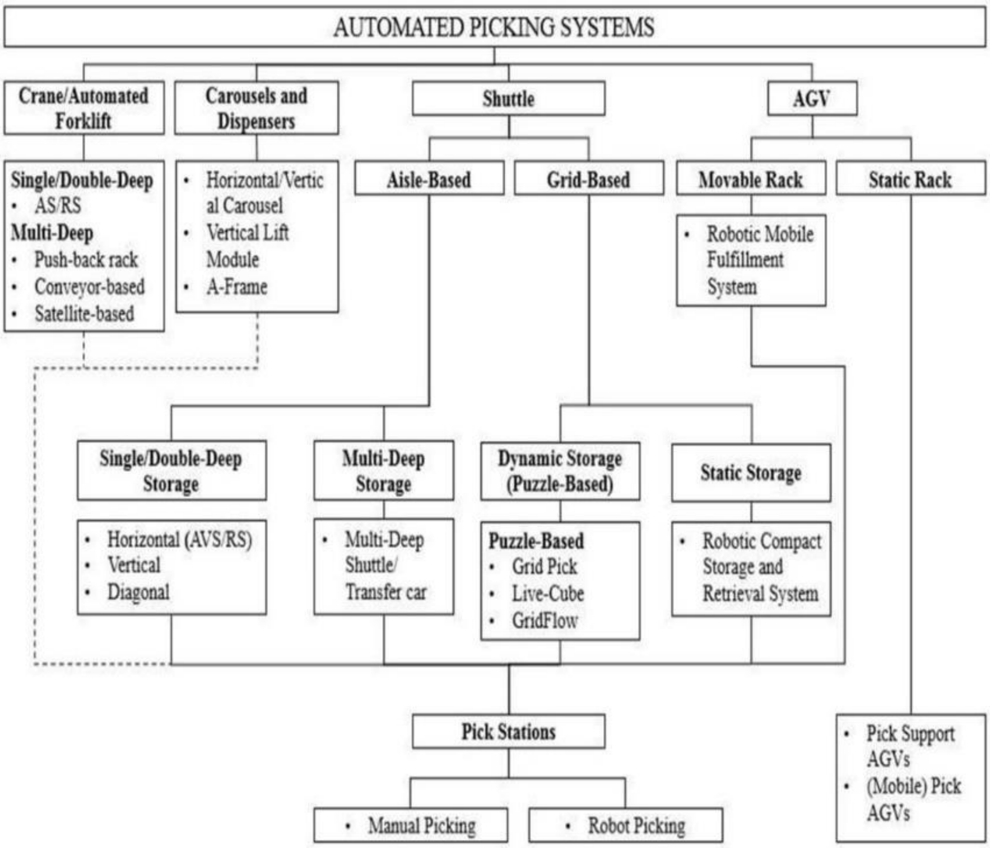


Fig 1. Classification of Automated picking systems

Credit: Azadeh, Koster e Roy (2019)

1.3 Order Picking Process

Order picking, also known as Order Picking (OP), is one of our most common warehouse activities. The purpose of Order Picking is to retrieve the requested items from storage location so that the customer's wish can be fulfilled. The order picking process (OPP) is a very labour-intensive process in manual systems and a very expensive one in automated systems (7). It may take up to sixty percent of all work tasks in the warehouse (8). In a typical warehouse, the price of the OPP may be as much as fifty five percent of the total operating cost of the warehouse.

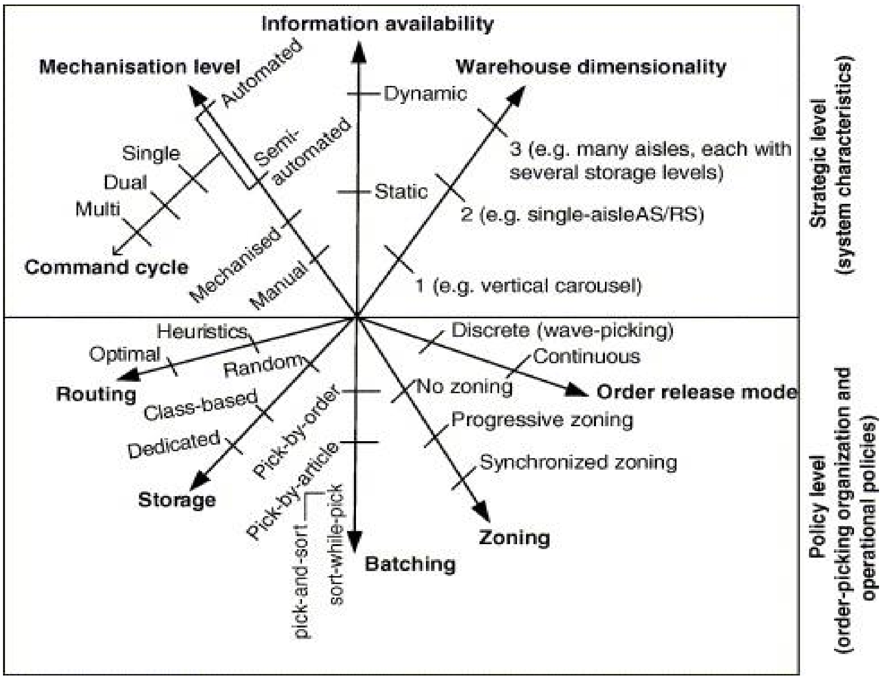


Fig 2. Design and control of warehouse order picking

Credit: De Koster, R., Le-Duc, T., and Roodbergen, K. (2007).

Following the review cited in “Design and Control of Warehouse Order Picking” (9). Fig 2 stated that order picking costs are projected to be as much as fifty five percent of the overall warehouse operating expenses. Therefore, underperformance in order picking will lead to unsatisfactory customer service and high operating costs. In this paper, we provide an overview of the literature on typical design and control problems faced in manual order-picking processes, particularly in regard to optimal layout design, storage allocation methods, routing methods, order batching and zone allocation.

Picking operators execute physical operations manually, semi-automated or fully automated. In manual picking operations, the picker moves to product storage locations and gathers the items desired by the customer. When using mechanical pick and place systems, the products are transported mechanically to the picker's position, and the picker gets the items he wants, products-to-picker. In an automatic pick and place system, the products are mechanically transported and picked up without any manual involvement.

In recent reviews (10) high expenses, constraints of the application domain, and the limited availability of OPSs have led to an absence of research on automated OPS. (3) the author argue that automation and robotic picking systems can only be used in unique situations, for example, when handling valuable, small, or delicate items.

This article (11) includes detailed information concerning the reasons for investing in picking process automation and offers a complete view of a variety of automated systems. There are a wide variety of automated equipment for case picking (ACP) such as traditional automated case picking, robot-based automated guided vehicle (AGV)/mobile robot case picking (CPS), conveyor-based solutions, automated storage and retrieval system (ASRS), gantry robot-based solutions and vertical cascading order release system, The warehouse management systems (WMS) and warehouse control systems (WCS) check on stock location and move inventory, overseeing materials flow, and controlling everything from order placement to delivery.

Based on review (9) they define order picking as a process in which goods must be assembled, and then ordered by customers, placing the stock directly in order lines, releasing the order downstream, and picking at the right time and place. So, OP is order fulfilment, which ranges from withdrawing items from storage to fulfilling a number of customer orders.

They describe (3) that the OPS within warehouses can be classified into three mains types with respect to level of automation.

1. Manual warehousing systems-picker-to-parts
2. Automated warehousing systems-parts-to-picker
3. Automatic warehousing systems-picker-less systems

In the review (Designing a Cellular based Fully Automated Case Picking System) (12) discussed in detail about Automatic cellular case picking system (ACCPS). ACCPS is a new ACPS where all OP activities are wholly automated. It is designed for labouring with products in plastic crates, bins, boxes, or bins on a daily basis, and must meet exceptionally high-speed requirements. The methodology to solve OPS design problem by the author (13) and (11) which is used as the basis to solve the proposed ACCPS design problem.

The ACCPS design is based on the cases of incoming pallets with only one SKU per pallet. However, each pallet contains many stacks, and each stack contains many crates. Every four full stacks are gathered on one pallet by an automated palletizer.

When a customer order is positioned on the main conveyor, the stacks emerge from it in batches, and the structure and time of each batch depends on the product availability in the cells and the customer order. The assumption is that only one type of product is stored in the storage cell, and a replenishment is performed if the cell is empty, with the number of crates in the replenished pallet depending on the cell's capacity. The anticipated required pallets are prepared near the input point of the ACCPS. A new full pallet is fed to the entrance of the ACCPS. see fig. 3.

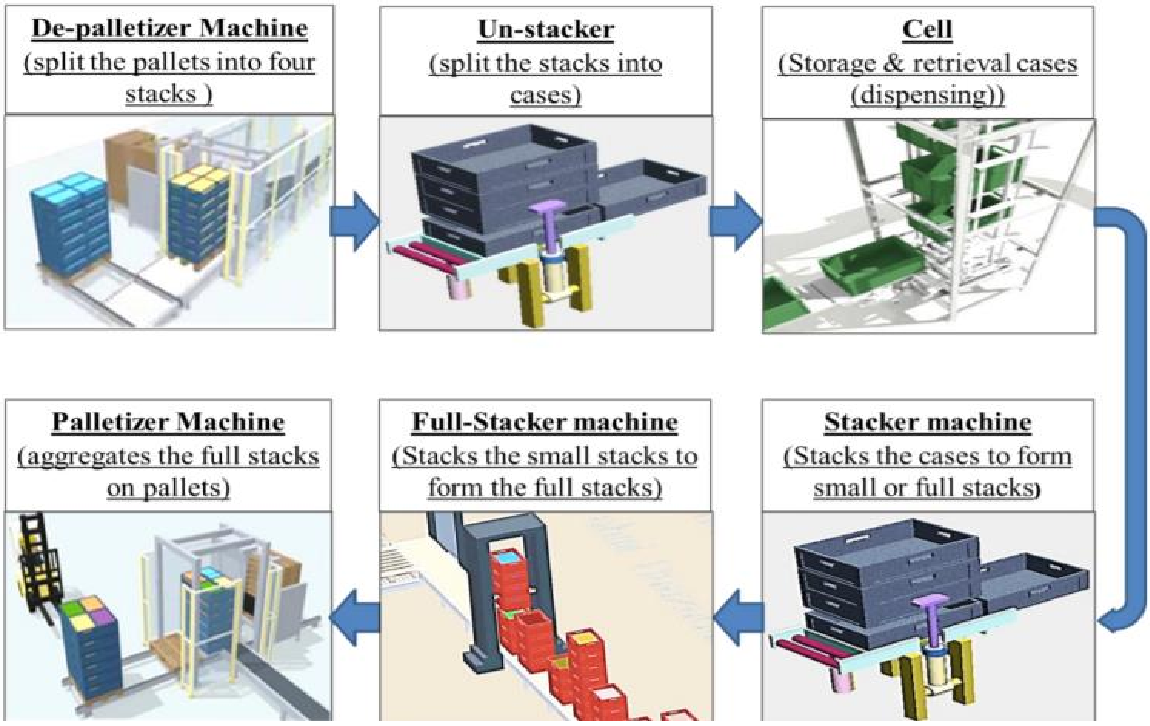


Fig 3. Stages of ACCPS operating principle

Credit: Mohammed Ruzayqat (2016)

1.4 Classification of order picking systems.

Without a uniform classification of order picking systems, there are different classification grounds based on which order picking systems can be categorized. (9) reviewed a system that has a taxonomy based on the dynamic elements in the system, with a basic employing structure that employs both humans and machines. See Fig. 4.

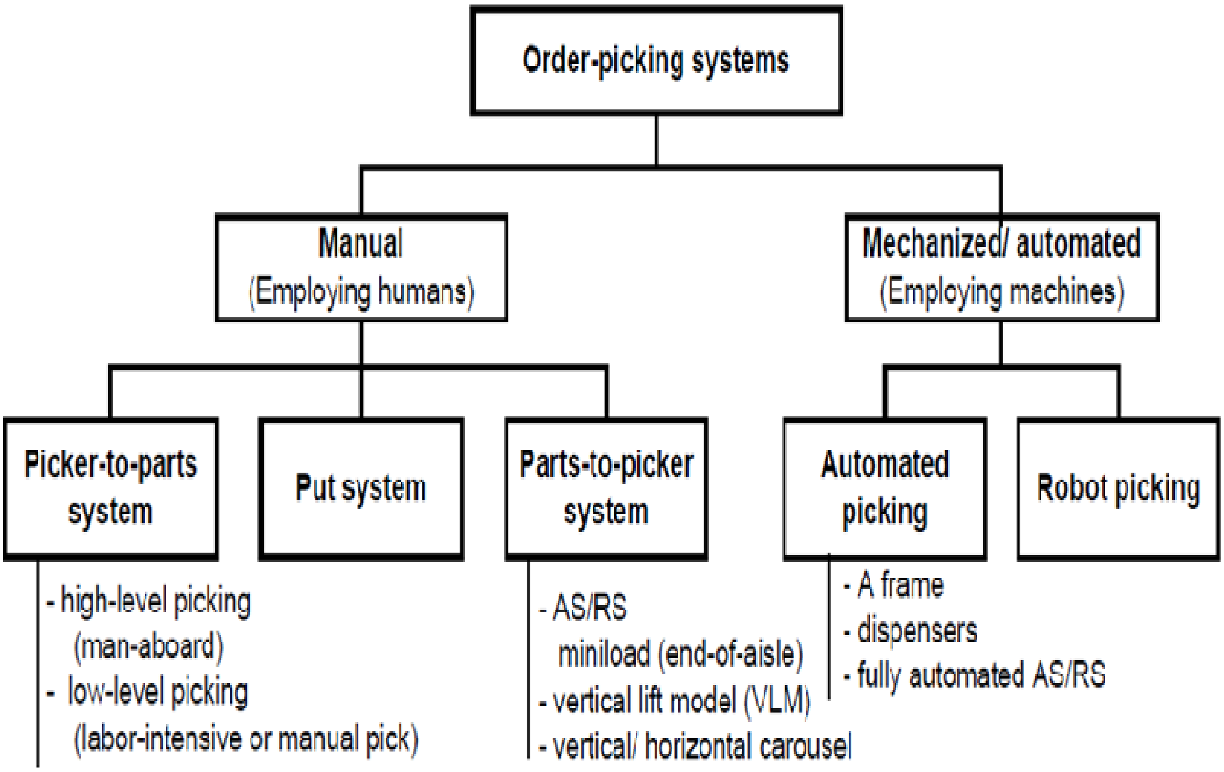


Fig 4. Classification of the Order picking Systems

Credit: De Koster et al., (2007)

In Figure 4, a new classification using the four major decisions was proposed. who picks the goods-humans/machines, who is in the picking area-pickers/goods, whether conveyors link each picking zone and what picking policy is with (picking by order or by item) see Figure 5.

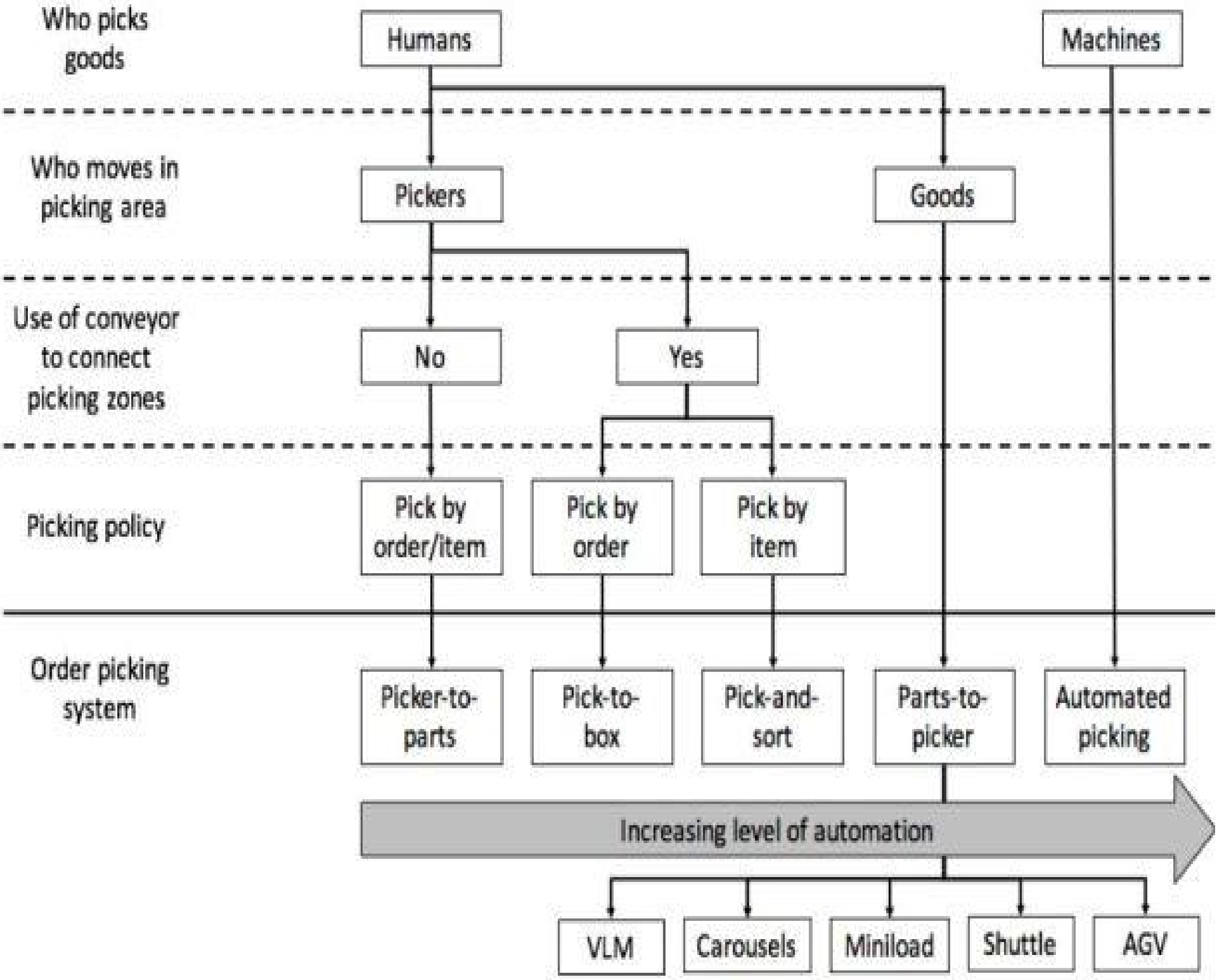


Fig.5 Classification of the Order Picking System

Credit: Dallari et al., (2009)

A number of order picking technologies and concepts are available today, and many solutions are available for improving accuracy, improving productivity, and boosting throughput. Nevertheless, there is still a great need for more improvements, more automation, and more strategies. Securing the best systems, the best technologies and the best processes remains the biggest challenge for OPS users.

Chapter 2

The chapter describes the literature review of ASRS in detail regarding its picking process and mixed palletizing. An explanation of research results and papers has also been included in this chapter.

2.Literature review

2.1 Automated storage and retrieval systems

The author (14) summarizes an automatic storage and retrieval system (AS/RS) as a type of storage system that is exploited for laying products in storage and retrieving those products from storage in distribution and distribution environments. ASRS systems utilize a variety of computer-controlled technologies to handle pallets and store them in the warehouses. The fully automated, fully customizable system can handle pallets without human assistance.

In their explication, the authors also highlight some of the shortcomings of the new design, including the requirement of higher investments, and the inflexibility to change the physical layout (14).

ASRS comprises mainly of racks, which store goods; cranes, which transport, pick up, and return items; aisles, connecting spaces where cranes can cross over; input/output points, locations where retrieved goods are left and those to be stored are picked, pick positions, where the ordered goods can be picked from retrieved packages. There are many possible configurations for these components of the system, resulting in several types of AS/RS, as discussed in (14).

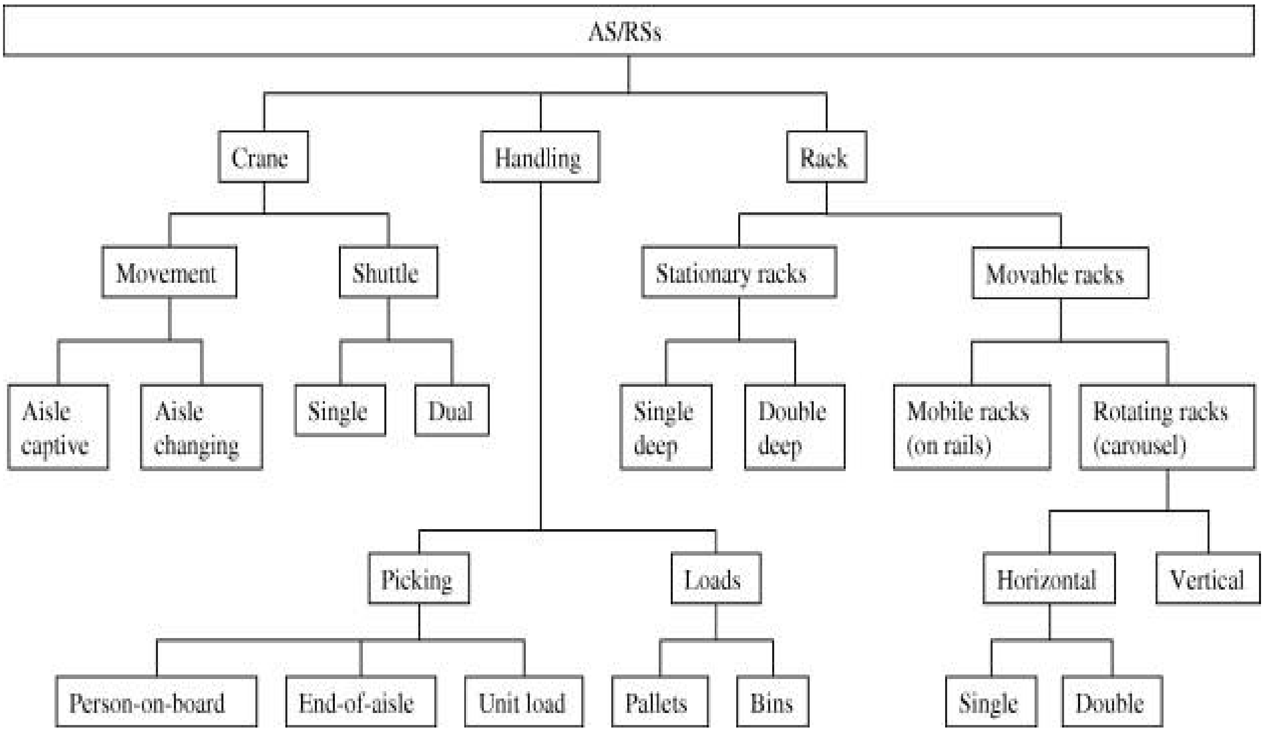


Fig 6. Overview of Automated Storage and Retreival System

Credit: Roodbergen and Vis (2009)

FIGURE 6 shows two alternatives in regard to the crane's movement and structure for loading and unloading. With respect to the equipment, it can be capable of handling only one load, termed a single shuttle, or deal with two loads at once, dual shuttle. They move the equipment between aisles, and the equipment in aisle-captive cranes travels between aisles, so each aisle requires one crane as well. Alternatively, aisle changers can transit goods across aisles. AVS/RS (14) is a special case of this in which autonomous vehicles may be retrieved in the case of a failure.

When it comes to AVS/RS, there are two options as to the shuttle movement. Tier-to-tier or Tier-captive. In the tier-to-tier system, vehicles can travel from one tier to another using the lift. However, in tier-captive systems vehicles are only allowed to travel from one tier to another and the lift only moves the loads, not the vehicles (15). One vehicle for each tier necessitates more vehicles, thereby making the tier-captive system more expensive, but it also has a higher performance compared to tier-to-tier system due to the independence of vehicles and lift. Allegedly, more efficient products are tier-captive single-aisle configurations according to the review (16).

In terms of the storage and retrieval components of the system, there are three options: two for the type of load stored and one for the way it is stored. It is possible to perform the picking activity by a person conveyed by the crane who will later pick the item up at the load's placement, sometimes called person-on-board. When the AS/RS is used, it can be at the picking location where the retrieved load is dropped off and the items of the customer's order gathered, this scenario is called an End-of-Aisle process, or AS/RS can deal with pallet or bin loads only, in which case the customer orders the whole load, thus there is no need to separate and separate items at the last moment. Also, depending on which type of load is being transported and handled, the AS/RS might be alluded to as a mini load AS/RS (14).

2.2 ASRS executing picking process.

In (17), the author recommended that one of the most useful ways to model ASRS is with simulation approaches.

On the one hand, warehouse systems can be best modelled using simulation techniques and on the other hand: using an analytical approach in order to simplify complex calculations and to achieve more accurate results, while modelling using simulation entails much more time to conceptualize and design. Significantly, performance is more reliably measured by the analytical models, even though they are not as precise as the simulation-based ones. Consequently, when numerous configurations need to be analysed, the analytical technique is preferred (5).

Regarding the review (18), they used simulation to help with the design, they emphasize that it is important to design the right autonomous vehicle storage and retrieval system from the start, since it is hard to modify it later due to its lack of elasticity. They achieved this by constructing a simulation model of the system on Arena 12.0 and reviewing the average cycle time for 21 simulated use cases.

To facilitate the design of the system, (19) author applied simulation to answer design questions. To design a rack, they built an optimal simulation model that can be reconfigured separately based on how many elevators and racks are needed. The authors used a virtual-reserve rack configuration to determine the throughput and cycle time of 81 various racks within 48 hours, for distinct retrieval rates.

By developing a research by the author (16), (20) not only the impact of diverse rack configurations was resolved, but also impacted by two other aspects: the velocity profiles of shuttle carriers and the table of gravity in elevators on the performance of a shuttle base storage system.

A Discrete event simulation was enacted to analyse the performance of the system by realizing the number of transactions happened in time on each scenario. The cases were created with 3 levels of aisles and 3 times the number of tiers and two distinct velocity profiles for the shuttle and the lift. According to the authors, the system's performance is substantially determined by two factors: the number of aisles and the throughput of the lift. Furthermore, the team noticed that although in general the bottlenecks are the lifts' lifting tables, when the number of columns is too high the shuttles could be the bottleneck depending on their pace.

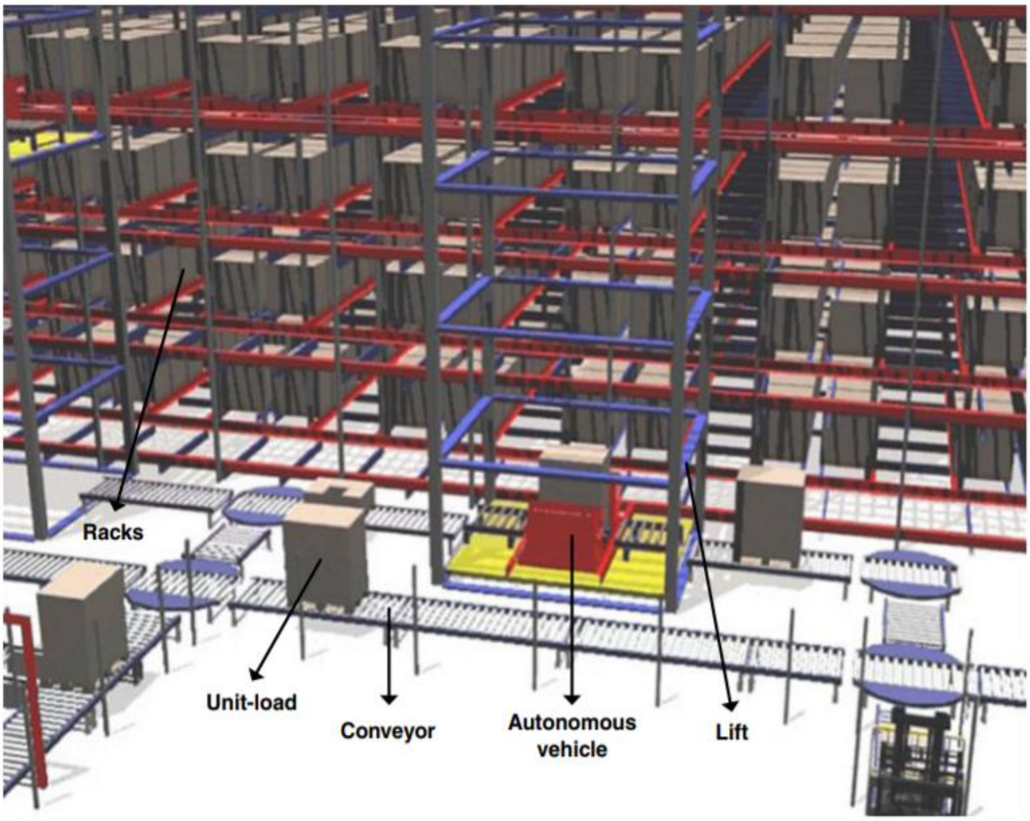


Fig 7. Main components of AVS/RS

Credit: EKREN, Banu Y. et al (2010)

Another study examining optimal designs by simulation was implemented by the author (18), with the peculiarity being that they seek to obtain an optimal combination of lifts and autonomous vehicles (AVs), taking into account some pre-specified rack configurations. Arena 12.0 was used for the simulation analysis. Seven rack arrangements were considered, along with two arrival rates, and nine or ten possible arrival rates for each rate.

The authors computed the average cycles of storage and retrieval transactions and the average utilization for lifts and elevators by simulating these transactions. They came to a better understanding of the system's performance under several scenarios and found the best technique for attaining maximum efficiency without surpassing the limits set by the system.

In the literature, an additional approach to improving operations involves evaluating the system's performance under different conditions. In the review, (21) attempted to assess the performance of a mini-load multi-shuttle order picking system when the order structure varies. For evaluation purposes, they collected data about the system's throughput and average cycle time per order as well as other simulation results. After employing simulation and analytical tools (2), Giulia Bruno and D' Antonio assessed the warehouse's performance across several scenarios. The assessment in this case took into consideration the system's usage, the average time invested in queue by the unit loads, and the average number of queued units.

Based on the review, simulation was another tool used to compare different solutions in the literature. (22) devised an analytical model to maximize storage placement, taking into consideration the energy consumed for loading and unloading the units. After the evaluation was completed, the decision made by the analytical model and the original storage configuration were modelled and simulated on Flexsim software, which resulted in data about the stay time, congestion time, unloading quantity, and no-load period.

2.3 Mixed Palletizing

From the website (23) Palletizing mixed goods means placing products that are different sizes and types in a single container on a pallet. Because of the rising costs of transportation and logistics, it is becoming more common to use multiple pallets to accommodate as many items as possible.

Fig 8. Mixed Palletizing

Credit: Optimized logistic solutions.

Mixed Pallets made of multiple products, such as blends and bars, are produced in order to serve a single customer. The objective of giving these pallets is to cater to clientesses who need lesser volumes of products than a full pallet. The review concluded (24) at that time, there was already a tendency toward ordering uniform pallets to attend a certain period of time, to ordering mixed pallets for supplying the same interval at a greater frequency. Mixing pallets may be used by customers who want to order more often or because they are too low to order full pallets. On the other hand, vendors can use mixed pallets to infiltrate small markets more efficiently.

(24) author yaman helped a liquor producer to solve the issue of the need to produce mixed pallets. As the producer was selling numerous brands not all of which were well known, orders of certain brands did not reach full pallets of them. One of the primary barriers to offering customized pallets was the limited ability to offer mix pallets, so the customer chose either one of the few mix pallets, better accommodating their needs. This solution proved effective; it had lower inventory and backlog costs than was feasible with just full pallets.

According to review (24) there were some restrictions that hindered the option of creating customized pallets for each client; the authors write that there is no technology and the manual production would be too complex. In a previous article, it was emphasized that automation increases efficiency and that manual execution of the process might result in more damage and errors. Even though mixing pallets may be beneficial over time, warehouses and distribution centres may hesitate when they build it.

2.4 Research Results

In this section magazines, articles, research papers and related information are mostly focused on different kind of robots and their picking operations.

Robotic Arm

In their publication 'Warehouse and Distribution Science' (25) explains that ASRS requires that human laborers be substituted by robotic vehicles that move in each aisle in the warehouse. These devices allow for movement in horizontal and vertical directions through a single command cycle or a dual command cycle, which enable the unit being stored or being recovered to be transferred.

Common robots used in manufacturing are the robotic arms. These metal arms have 4-6 joints, making them useful in many manufacturing processes, such as material handling and material removal.

Robots share many features with human arms – they have three joints – large wrist, petite wrist, elbow, and shoulder. The six-axis arm can move in six different ways, unlike an arm, which only has two joint places.

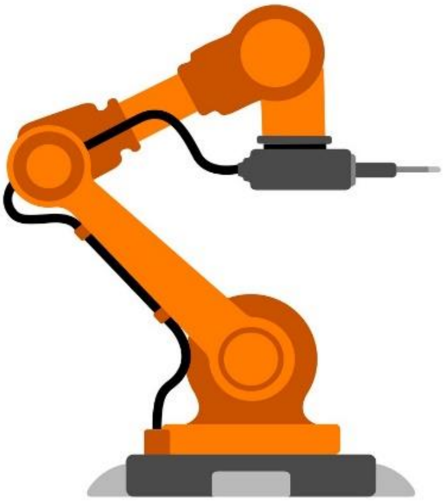


Fig 9. Robotic ARM

Credit: VectorStock

Manufacturing with an industrial robot arm not only increases the speed of a process, but it also additionally enhances accuracy. These robotic arms reduce the employee error rate and labour expenses of manufacture. A robot arm is built by uniting two or more joints. It usually consists of steel and cast-iron material. Motors are affixed to each joint through a robotic controller. Some large arms applied to lift heavy payloads are mechanically manipulated.

With robotic arms, manufacturers manoeuvre the end effector from one position to another, easily taking down and putting up pieces or eliminating the entire equipment. These robotic arms can be designed to do a number of different tasks, or one specific task, based on the manufacturer regulations. They also use these robots to lift heavy objects.

1.Robots in warehousing

According to the document Robotics in Production presented by (26) Larry M. Sweet PhD, also an executive of Symbotic LLC in Orlando Marriot Centre, the robot's purpose is to assist manufacturing tasks.

Fig 10. High Sku count mixed case palletizing.
Credit: Larry M. sweet (2013)

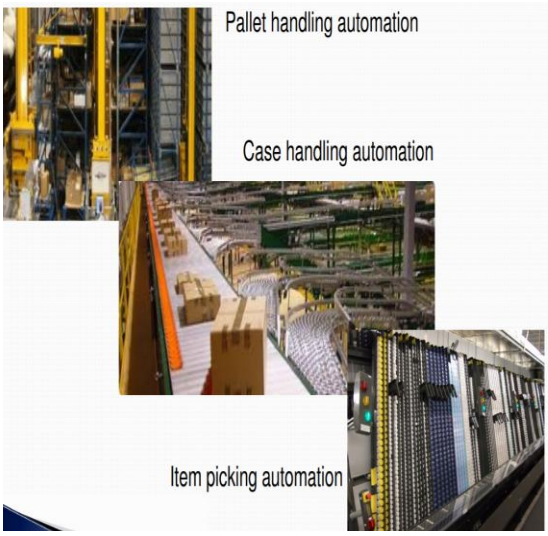


Fig 11. Traditional solutions for automated picking

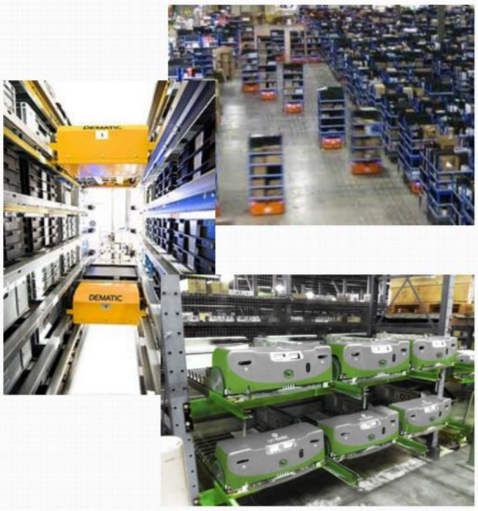


Fig 12. Mobile robot explosion

Credit: Larry M. sweet (2013)

Mobile robots' characteristics:

1. easy to re-configure.
2. 2D vs. 3D layout topologies
3. Variable vs. fixed storage spacing.
4. Manual vs. automated product handling
5. Sequencing vs. non sequencing product flow

2. Robotics in the Warehouse: Changing the Fulfilment Paradigm from Logistics management magazine. (27)

Article by Locus Robotics August 27, 2019: Locus Robotics CEO Rick Faulk describes how robots can change the productivity and structure of any fulfilment centre and why thinking outside the box can engender better results.

This ground-breaking methodology is driving today's revolutionary change and illustrates the significant productivity gains and scalability advantages of multi-bot picking.

Locus Robotics offers autonomous mobile robots (AMR) for fulfilment warehouses which can be disassembled and moved very easily. Each robot carries out part of the picking and transporting as the humans carry out all of the carrying. Each employee fills an order on multiple robots as they proceed to line up to pick online orders.

Fig 13. LOCUS ROBOT

Credit: Logistics Management (2019)

An employee using conventional carts or a similar motorized follow bot-style cart is limited to the orders they can physically carry in a single robot. Furthermore, using a multi-bot model, everybody is free to work on their skill set. Because they can pick to any robot, pick volume is not hindered by the capacity of a single robot.

3. Warehouse robots for retail Automation

Amazon Robots

According to (28), Amazon put retail automation technology in the spotlight with the 2012 acquisition of Kiva Systems. This company, based in Boston, developed warehouse robots, and related technologies, and it was acquired for $775 million. Autonomous mobile robots that combine the effects of sophisticated control software, language perception, power control, computer vision, depth-sensing, machine learning, object identification, and semantic comprehension of user demands.

Fig 14. Amazon Robots in Warehouse **fig 15. Amazon Robots order picking**

Credit: Amazon Robots

Today's tech startups are attempting to fill the vacuum generated by Amazon's buyout of Kiva and some have been profiled in their feature on industrial warehouse robots. Companies like invia robotics, an emerging innovator against warehouse automation and the brains behind cobots (cooperative robots), are developing warehouse robots that can function right alongside humans.

Invia Robotics

From the website (29) Since its foundation in 2015, InVia Robotics has rendered the next generation of warehouse automation solutions. They have taken in an undisclosed amount of financing to optimize a simple, intuitive, and inexpensive warehouse system while further enhancing your employees work environment.

Fig 16. inVia Runner and picker with a suction cup from article robotics and Automation

Credit: Invia Robots

The inVia Picker and the inVia Runner are two distinct robots that manage logistics. The Runner is able to literally transport items from one place to another, which either an individual can do or a robot will do. The Picker gets stuff by draining it up using suction cups. Taking robots as an example, inVia Robotics Management Software was designed to automate the workplace procedures between people and robots with artificial intelligence by generating all the itineraries that increase efficiency in both parties.

Skypod

Exoctec (30) based in Pittsburgh, was started in 2015 by former robotic and software engineers. Its robot armies can move like the Wonkavator, shifting up and down, sideways and slantways, in all directions, as well as frontways and squareways. It is also similar to the AVS/RS operation see fig 17. Technically, this can do this without having any intricate structures to support the robots.

Fig17. Skypod robot in Warehouse

Credit: Exoctec

Well, it is able to use a laser scanner to help it gather data across three-dimensional spaces, and that is how it can convert itself from horizontal to vertical. Skypod can ascend five times higher and move four times faster than traditional shelf-moving robots, it also can pick up twice as many items per hour and inhibit warehouse workers from walking at least 10 miles daily.

Arming warehouse robots

A startup company (31) based in San Antonio, Texas, has developed a robot arm that can move dynamically, almost quite naturally, to pick up packages, unlike the average warehouse robot arm that normally does repeated actions from a static position.

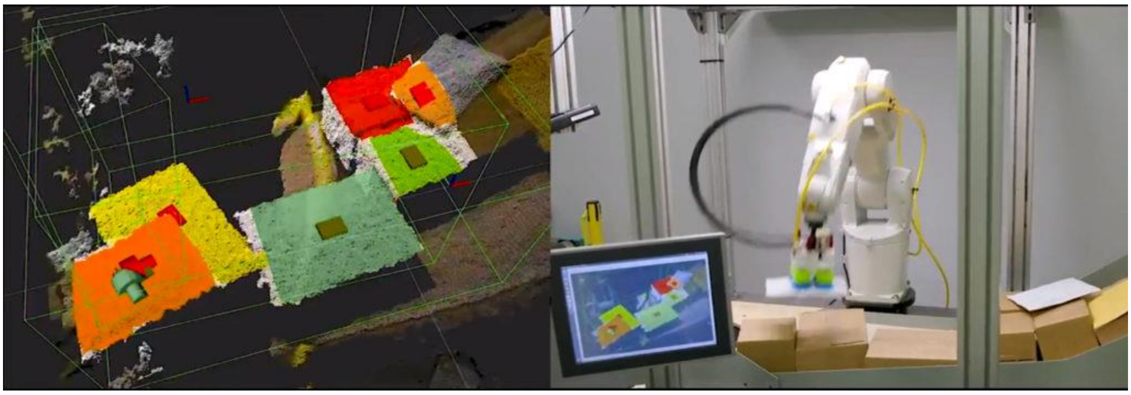


Fig18. The Pick-One robotic arm from Plus-One Robotics is a view of what the robot sees.

Credit: Plus One Robots

Digital cameras, developed into the Pick One's digital cameras, are capable of transmitting scans of made in China footwear in fractions of a second to select the right pick position for the arm, which can apply 25 picks per minute like a human.

Swift Warehouse robots

In 2012, Pittsburgh-based IAM Robotics (32) was established. The company recently secured just under $1 million for a warehouse robot based on the same platform and RobotiQ technology as Plus One Robotics. Swift is the firm's mobile control robot. It can travel through the warehouse autonomously and locate and locate products. It can then pick them up utilizing any of numerous grasping extensions that can lift up to 15 pounds.

Furthermore, their system encompasses SwiftLink software, which traces and supervises the robots, and Flash, a hightech inventory instrument that records a product's barcode, 3D dimensions, weight and a high-resolution image of any item stored within it.

Fig19. Swift

Credit: IAM Robotics

Swisslog Carry star & itempiQ

Swisslog (33) is a leading corporation amongst the Kuka group. They created a carry-stage order fulfillment system. See figure 20, on how transporting orders works.

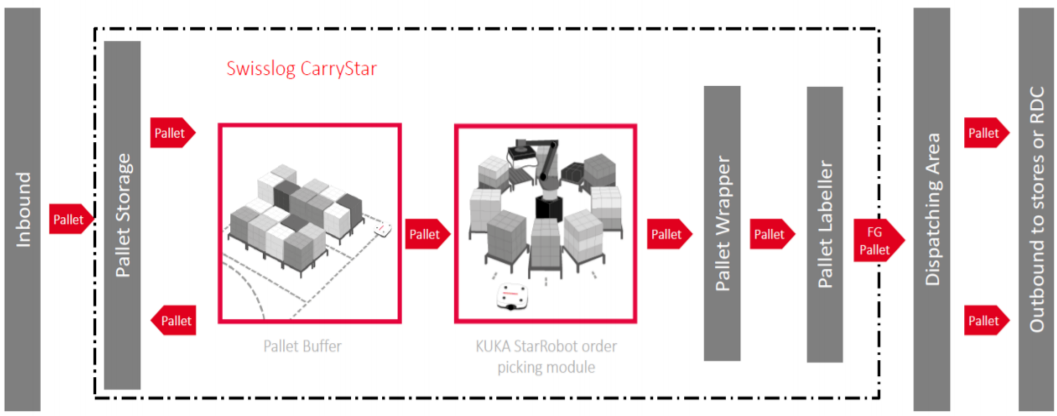


Fig 20. Carry star Process Description   Credit: Swiss Log (2019)

Carry Star utilizes no conveyor technology or automatic equipment on-site, thus being a fully automated system. This design opportunity is optimal, as it allows for a large number of alternatives for order fulfillment. The pallet builder robot will fabricate mixed pallets in roughly 200-300 layers an hour, and it can easily be configured on the basis of volume and product type.

Warehouse storage are able to receive pallets and retain carry star cells, although there is a lesser storage area near the building area then is utilized for pallet building. See Figure 21. Once the picking is done and the order is packed, locating the pallets for storage is not essential. They can be kept in the scheduled compartment until desired.

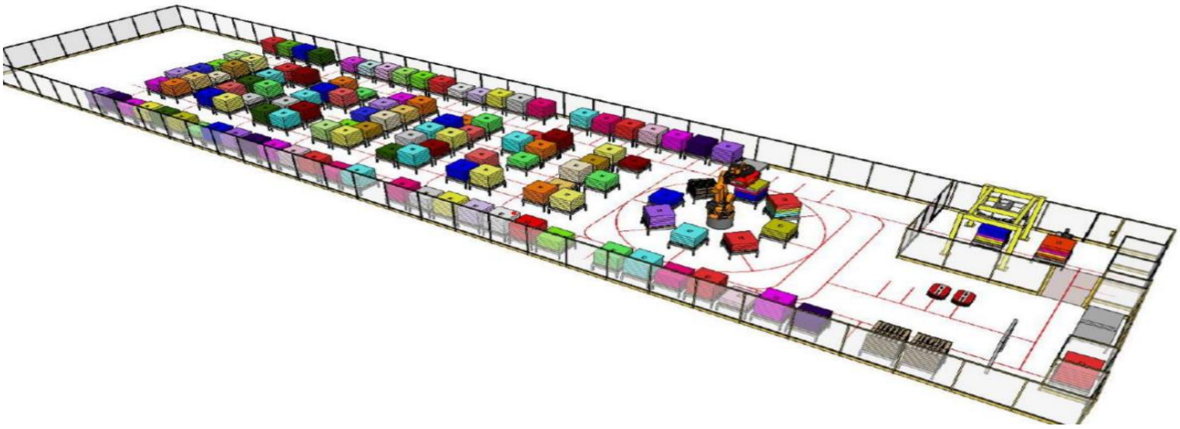


Fig 21. Carry star storage area

Credit: Swiss Log (2019)

Additionally, the system integrates the Carry robots, guided vehicles for the aim of transporting pallets around the area, and the wrapping machine. The Carry robots follow the pathways in Figure 16. At the exit of the system is the wrapping machine. The robots advance the pallets they have prepared to the wrapping machine. The pallets are constructed and wrapped, then sent to the container.

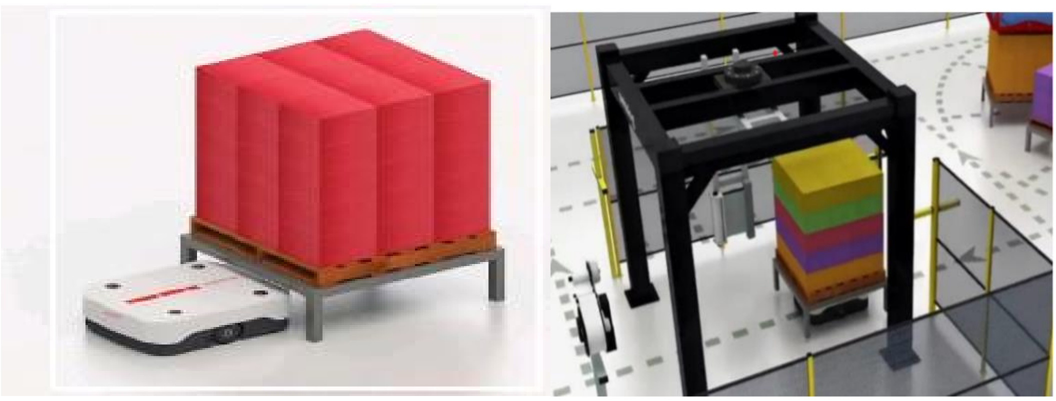


Fig 22. Carry AGV and it taking the mixed pallet to the wrapping area

Credit: Swiss Log (2019)

A Swisslog crew also supplied insights into how automation will generate increased productivity. During a recent automation project for AutoStore, the robots revolving up and down throughout the grid collaborate with each other to compensate for any downtime. In fact, ItemPiQ uses robotic automation technology used in challenging industrial environments. Blended with ItemPiQ, these systems offer the flexibility, availability and uninterrupted operation essential for 24/7 performance.

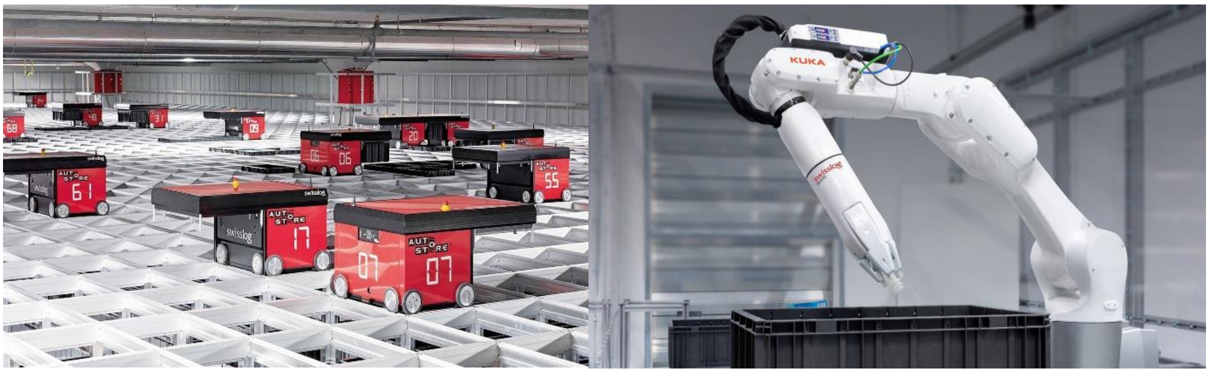


Fig 23. Autostore robot moving across the top of grid ItemPiQ Robot.

Credit: Swiss Log (2019)

ItemPiQ is intended for speed and reliability. Picking from an AutoStore bin and placing it in a target bin or carton, the robot runs at up to 1000 transactions per hour under ideal conditions. More conveyor systems will permit automatic relocation of the destination bin. Because ItemPiQ and AutoStore operate with the same platform, Swisslog's Sync, the system seamlessly interfaces. ItemPIQ has a standard interface that enables it to communicate with any WMS system accessible.

The grippers in SynQ are wise enough to understand through experience. When they encounter an item for the first time, they will automatically decide on the optimum way to grab it for them. In addition, the system would endeavor to recollect the last time the item was picked successfully and operate to develop upon the system in a way that results in a shorter cycle time and bigger pick success rates the longer the system has been running.

Toru Robot

In the Interview (34) Toru Robots of Magazino authored last year, Moritz Tenorth was interviewed, a founder and CEO of MitiGi, an inventive startup for mobile pick-and-place robots that are then used to conduct specific item-level logistics operations. The Magazino team has constructed perception control-based mobile robots that could be exploited in warehouses or manufacturing plants. The TORU robot consists of a mobile base, a retractable shelf, and a retractable and rotatable column with a gripping mechanism. It can identify objects using 3D and 2D cameras. It can handle rectangular items for example shoe boxes and lexicons, store them on shelves, then deliver them to wherever the robot selects it is necessary.

Fig24. Toru robot is picking and storing items from rack

Credit: Magazine by Toru Robots

Here's where TORU differs significantly from other systems: it does not demand custom warehouses or for manufacturers to retrofit existing warehouses to accommodate robots. Certainly, robots might indeed integrate into warehouses that already exist.

4.Warehousing and logistics Robot Shipments

A market intelligence business, Tractica (35) is part of Informa. It focuses on rapidly emerging technologies.

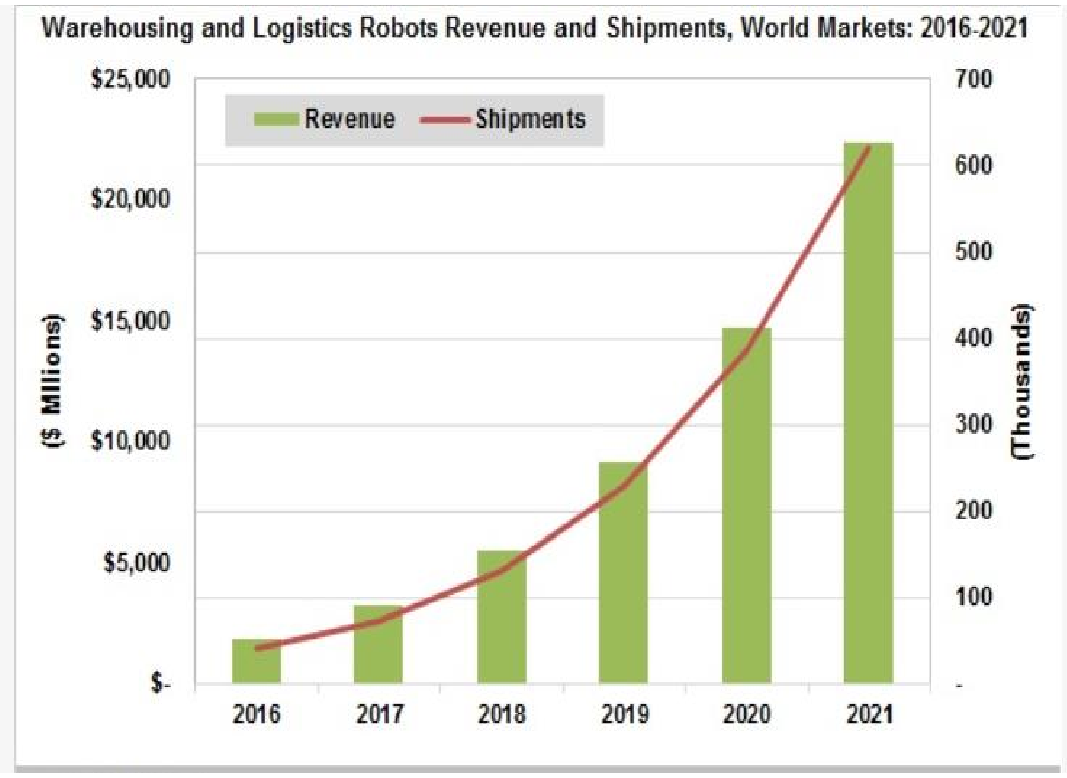


Fig 25 Warehousing and Logistics Robots

Credit: Article Tractica (2017)

The following figure 25 depicts Tractica Analysis survey of the warehouse and logistic robot's market. The report claims, (27) the warehouse and logistic robot's market is projected to expand by nearly 10% over the 2016-2021 period. In addition to valuing the most critical aspects that will influence the market, the report gives an analysis of the key market drivers and threats.

2.5 Research Papers

According to the paper “Performance evaluation of a new intralogistics systems” the author (36) had clearly discussed about the review of robot picking and building mixed pallets.

Robotic automated storage and retrieval system mixed pallet build system.

Bastian Solutions is an independent material handling system integrator supplying automated solutions for distribution, manufacturing, and order fulfilment centres around the globe. Its current patent (37) describes a robot that can generate several types of pallets and integrates them into single pallets.

We use a mixed pallet-build system in fig 36, that involves a series of pallet racks with multi segment dividers to store distinct assets and items. Most of the pallets will be the same items, but also the pallets can have varying stuff or be mixed. Further, different pallet build systems have robotic carts which can be moved vertically and horizontally among the racks in order to develop mixed pallets. Figure 27 shows a carriage that has an interior which can accommodate multiple pallets.

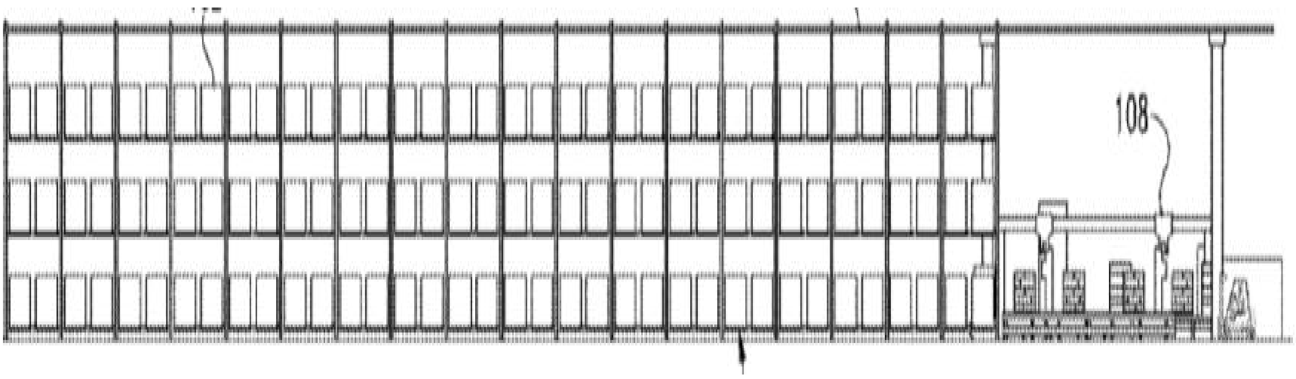


fig 26. Mixed pallet build system.

Credit: Patent by Bastian Solution LLC (2014)

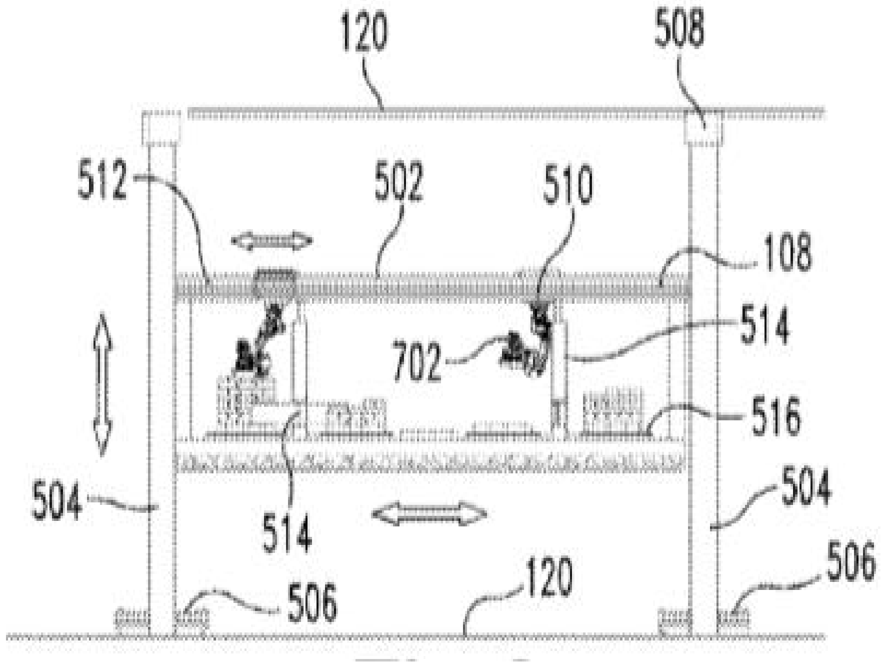


Fig 27. The robotic Automated Storage and Retrieval System (AS/RS)

Credit: Patent by Bastian Solution LLC (2014)

As each mixed pallet is assembled, the AS/RS carriage returns to the unloading area. Conveyors are activated to discharge the pallet onto the floor from the carriage AS/RS. With the assistance of pallet trucks and conveyors, pallets can be unloaded from the system discharge point or other mechanism. The turntables are installed on a three-dimensional robotic AS/RS carriage with rollers, drag chains, locating grippers, or other conveying mechanisms. Pallets are stored on conveyor belts, which are loaded on by forklifts. The forklift unloads pallets, and then reverses the process to replenish other products. Several aisles of robotic AS/RS can be used concurrently for throughput.

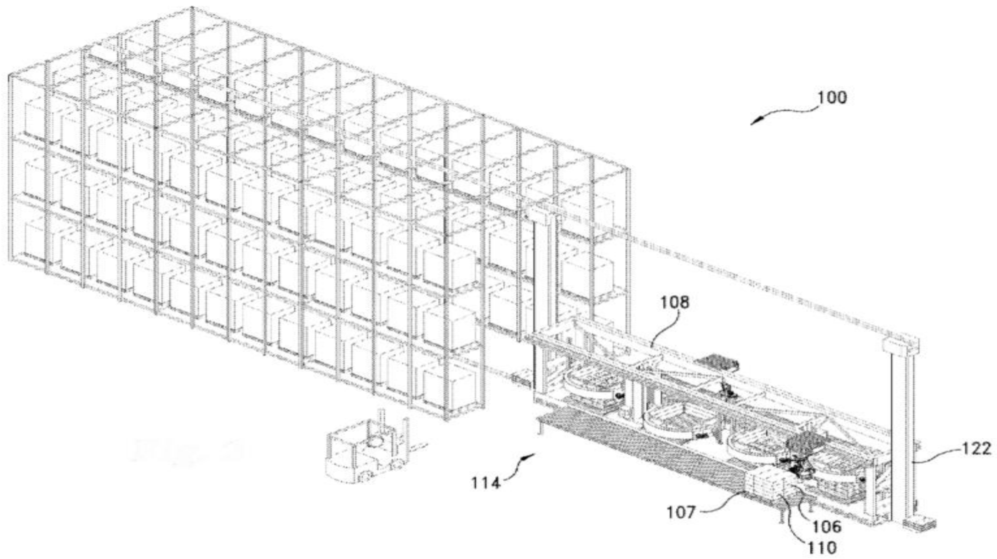


Fig 28. Mixed pallet build system at loading/unloading area

Credit: Patent by Bastian Solution LLC (2014)

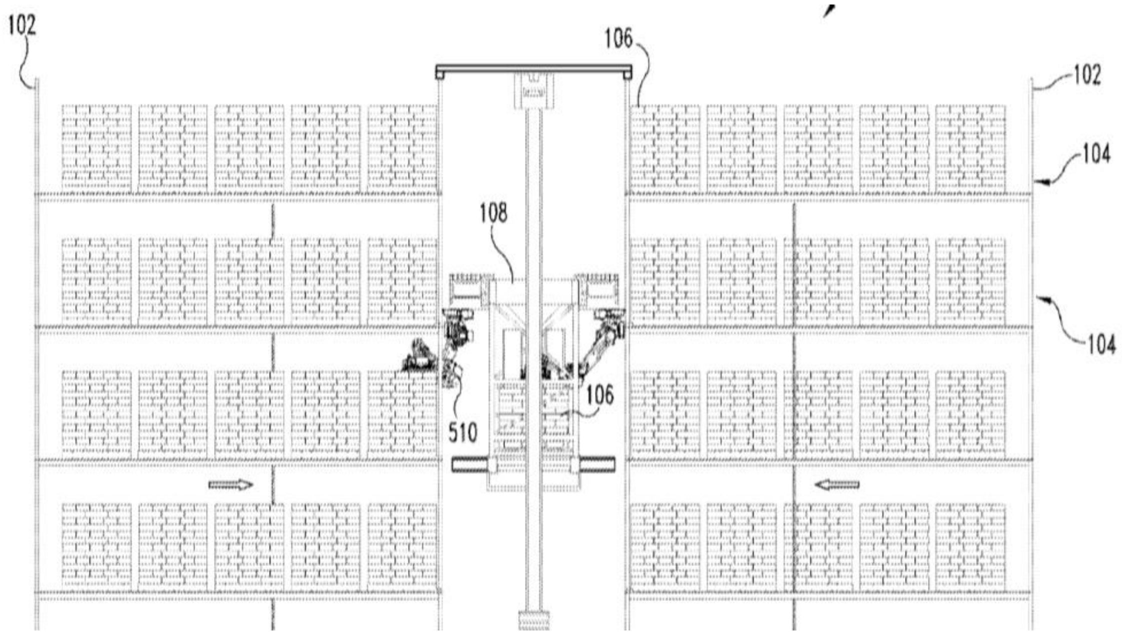


Fig 29. mixed pallet build system contains multi-deep pallets of items in every rack

Credit: Patent by Bastian Solution LLC (2014)

In this design, which is like the one demonstrated in figure 26, the rack can manage more than one pallet of identical, similar items. In other words, instead of a single pallet, there are several boxes at each level. Nevertheless, the function is the same as described above in figure 29.

This invention saves time since it does not demand to break down pallets, buffers or sequence each item. It furthermore assists save space in the warehouse, since complete pallets do not have to be crushed and mixed pallets are made of partial ones. It has also been demonstrated to be more cost-effective than other equivalent methods of the same type.

Robot in a pallet support shuttle

Upon reading the review (38) , from the patent by Axium Inc., which includes a shuttle to transport the pallets and possesses a robot that picks up items from full pallets kept in neighbouring stations. One of our primary concerns is that the system can only move horizontally along its path, needing the warehouse to harvest pallets from the shelves and place them along the feed conveyors that are situated near the shuttle's path. Although the robot can grab objects of varying sizes from pallets and use different implements, including vacuums, side grippers, forks, etc. this flexibility is beneficial to efficiency.

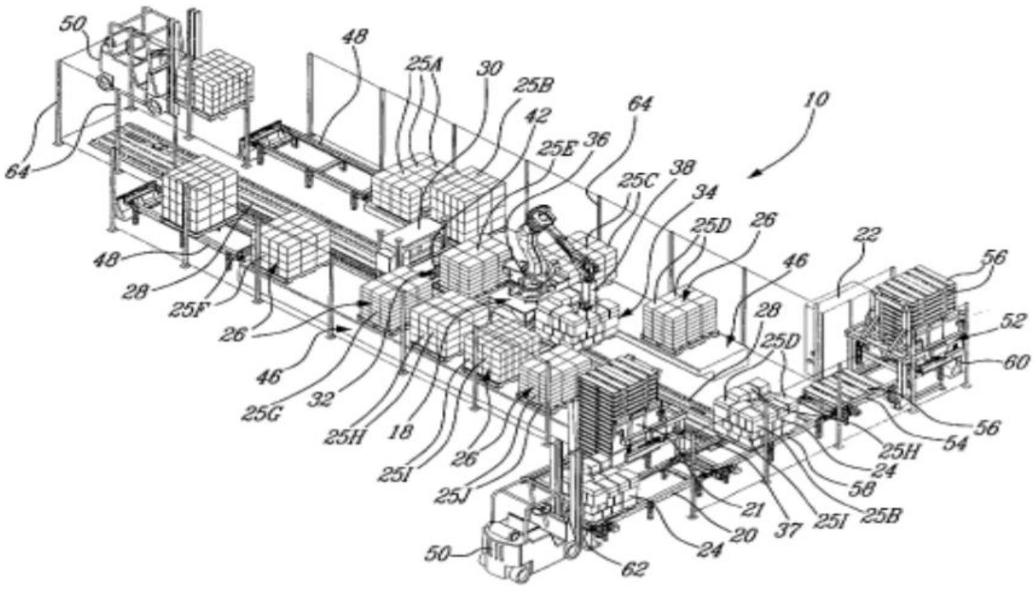


Fig 31. Robot picking in a shuttle system.

Credit: Morency (2008)

Automated Guided Vehicle (AGV) with Batch picking robotic arm

It was first patented by Bastian (39) in March 2017 using automated guided vehicles (AGV) which are deployed in warehouses and production environments to perform various material handling functions without human interference. Commonly, these types of aids are exploited to improve safety and minimise overhead by reducing the number of employees needed to complete specific material handling duties.

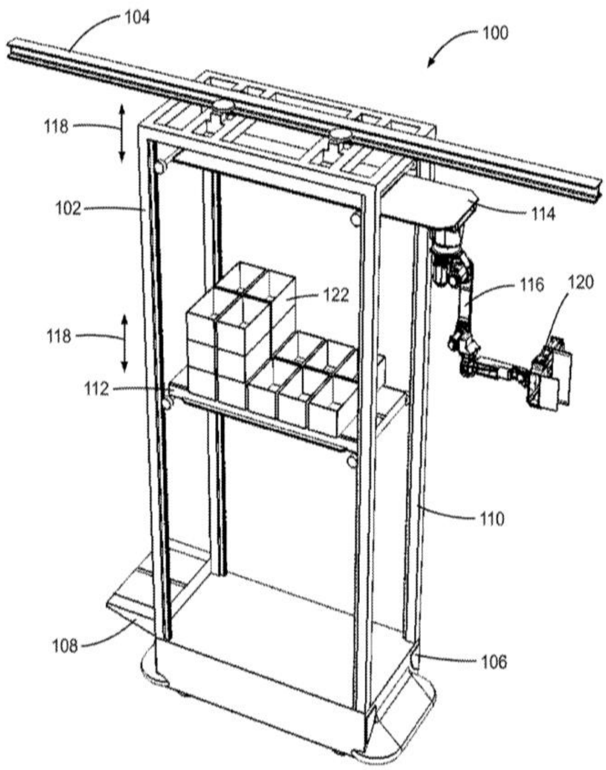


Fig 32. Front elevation of an AGV system.

Credit: Patent by Bastian Solution LLC (2017)

This figure 32 depicts the Drive Control System is equipped with a transport system for loading and discharging materials, such as totes, boxes, storage containers, SKUs, and other items, from and to the automated warehouse. The mechanism is constructed from a frame upon which a loader and an actuator can move in a vertical orientation, with the actuator containing (EoAT) engagement tools that grasp or otherwise engage the environment, Totes, for example, are put by the Robotic arm on the freight table. The robots have electro-mechanical grippers to load, unload, and reposition the totes on the loading table. The robots use detectors such as vision systems for smooth motion and exchanges with objects.

It mounts a loading table on the AGV. It is configured to accommodate several storage boxes. A frame stretches from the AGV, attaching the robot to that frame. The robotic arm's frame is built from a gantry which allows it to revolve in relation to the rest of the AGV, and the arm can also move toward or away from the gantry. AGV's can hold multiple storage containers, making picking or placing easier. The gantry is handy for hands-on manipulation.

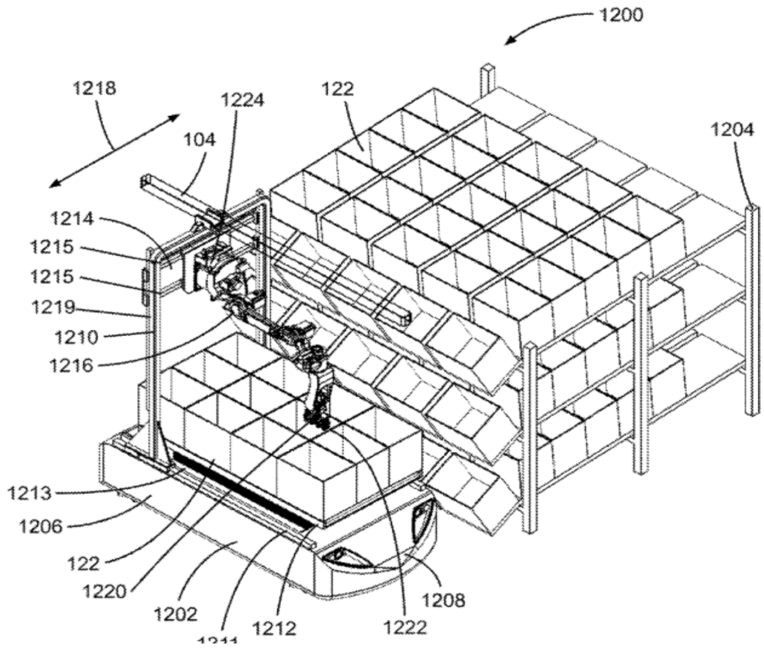


Fig 33. AGV planted to service a station performing batch picking.

Credit: Patent by Bastian Solution LLC (2017)

In reality see fig 34 of an AGV, which are the examples produced by Bastian Solutions, the robotic batch picking, and the robot palletized.

Fig 34. batch picking by Robot and AGV picking with robotic arm.

Credit: Bastian solutions

Chapter 3

In this chapter the statement of problem, objective of thesis and about methodology is discussed.

3.1 Statement of the problem

It has been previously studied by literature and research results relating to the storage and retrieval of products in warehouses. But the innovative project now emerges from Eurofork, which is innovating an intralogistics system that no one has seen before. ASRS delivered one new system which wholly utilized the shuttle and neither shuttle nor ASRS is needed anymore. A robot arm attached to shuttle will be deployed instead of shuttle up until transport as in current mobile devices.

Another company is wondering whether or not it would benefit from switching systems since multiple factors affect the economy of a system, such as the number of stock keeping units (SKUs), the number of orders and the length of time the ordering operation takes.

The purpose of this thesis is to compare the performance of automatic storage and retrieval systems in various scenarios. The aim of these comparisons is to assess if there is a better performance presented by the new system in multiple scenarios set in a synthetic atmosphere.

Given the early stages of the product development, the system has not been tested in a real-world environment. Accordingly, the problem addressed in this thesis is a comparison of two types of automated storage and retrieval systems under different scenarios. The thesis is formatted to make it simpler to read.

The proposed model is addressed as Eurofork's system, the other as new. For comparison, the models are described as OP for inside and outside the warehouse, respectively.

3.2 Objective of Thesis

The Italian company Eurofork offers an intriguing innovation, they propose a new way of making mixed pallets which is called a mixed pallet scheme. Because Eurofork is an Italian company that generates automated warehouses they are skilled in handling. The company's expertise in the area of manufacture of telescopic forks and its ability to produce a large quantity of telescopic forks sets it apart from the competition amongst its competitors. Further, it has developed its Esmart-shuttle division which practices the design and engineering of warehouse shuttle systems.

The ultimate objective of this thesis will be to model and develop a new innovative order picking system with an automated storage and retrieval system vehicle with a robotic arm that permits the construction of mixed pallets in the automated warehouse in order to fulfill orders.

There are two distinct objectives that will be elaborated in this study. One of the goals of this project is to evaluate new picking systems against Eurofork's one. The other aims to evaluate and compare the performance of two autonomous vehicle storage and retrieval system, which is building a mixed pallet inside the warehouse and outside of it.

As a means of achieving this objective, a warehouse storage and its operation will be simulated in a software program, Flexsim, providing performance measures as outputs. After obtaining all the required results, a comparison in between two ASRS simulation models will be then permitted to verify which one performs better.

Chapter 4

In this chapter, Eurofork's system, new system, components and requirements are discussed.

4.1 Eurofork's System

Several warehouses have racks that contain shelving with similar pallets and boxes. When the customer requests an order, the picking process starts by picking multiple pallets. Once the multiple pallets are picked, they are clustered into a single pallet. Since the Eurofork (40) Company has AVS/RS with shuttle-based system for order picking can be seen the figure 36.

Fig 36. Esmart Shuttle used in AVS/RS is loading/unloading a pallet.

Credit: Eurofork

System description

Three main types of vehicles are used in the AVS/RS:

1. A vertical lift that moves vertically and allows access to different rack tiers.
2. A shuttle making its way through the aisle of the operating tier.
3. A satellite drives itself through the channels in the rack to store and retrieve pallets.

The satellite loads the pallet into the rack for storage, and the shuttle follows. Consequently, the two vehicles travel under the lift, which moves vertically in the direction of the final destination at which point the shuttle departs the lift. After traveling through the aisle, the shuttle gradually pulls the satellite along the channel towards the destination, then pulls out of the channel.

As the satellite starts moving forward along the channel towards the destination, chosen according to a LIFO protocol, the satellite drops the pallet as soon as it reaches the location. The automated shuttles transfer similar pallets from rack space to the picking station, where the robot collects the ordered items from similar pallets and assembles the pallet.

New system

Esmart-shuttle is an intralogistics system that makes picking less complicated and makes the process simpler and faster. As more pallets are being constructed with mixed contents rather than full pallets, here we will discuss a method not based on shuttles.

The ASRS vehicle will find the pallets on its location with an attached robotic arm, assembling the products according to their positions rather than retrieving them to picking stations. See figure [37] & [38]. Therefore, it intends to speed up the delivery process by eliminating the need for retrieving the entire pallet and then storing it again once the product is picked. Besides that, it aims to increase the system throughput and reduce transit charges.

Order fulfilment process

1. The client requests an order.
2. The ASRS vehicle advances to the destination rack with empty pallets.
3. An ASRS vehicle with an attached robot arm begins to pick products from similar pallets on a rack and place them on the empty pallet.
4. After the robot picked the products, the empty pallet is loaded with various products, thus forming the mixed pallet.
5. The customer will receive a mixed pallet from the shipping department once it has been processed to fulfill your order.

6. A simulation tool, Flexsim, can be used for the development of a process in this type.

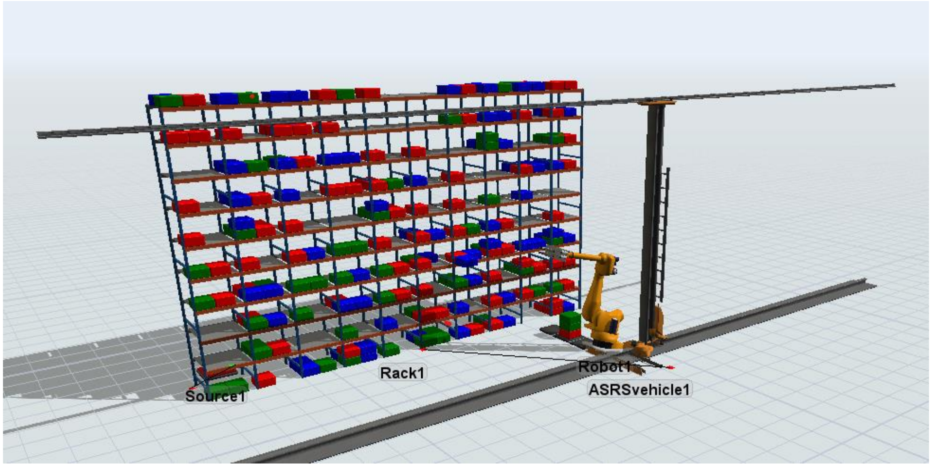


Fig37. An example of new technique with Robotic Arm attached to ASRS vehicle.

Credit: Flexsim

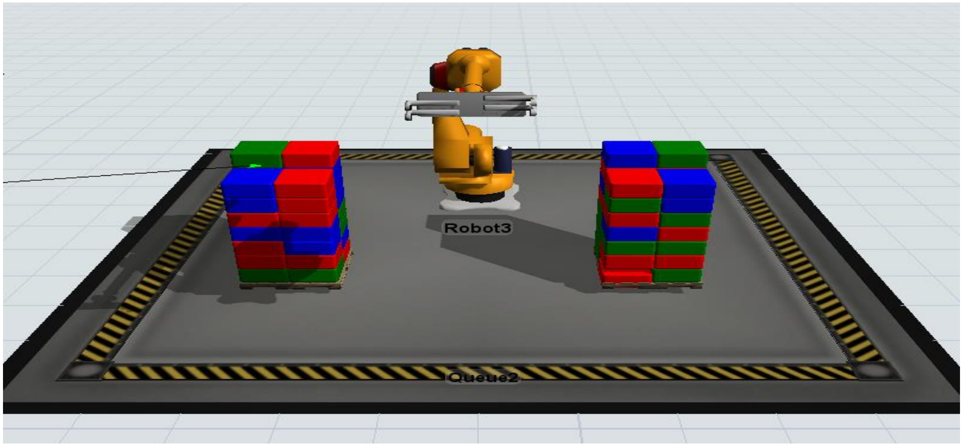


Fig38. mixed palletizing snapshot

Credit: Flexsim

4.2 Components and Requirements

As part of an automated warehouse considering our new ASRS system, there are a few components, which were used for the development of the simulation models in software flexsim. They are described below.

1. Rack
2. ASRS Vehicle
3. Robotic Arm
4. Pallet
5. SKU's

Rack

Storage and racking is an integral component of warehouse infrastructure, as it can obstruct or accelerate warehouse operations. Warehouse layout influences racking greatly by defining aisle widths, shipping areas, and storage space. Warehouse racking system configurations include selective racks, drive-in and drive-through systems, pushback, and flow-rack systems.

A software flexsim rack is stationary and double deep. The main features of the rack are its dimensions, which describes the height and depth of the rack, number of arrays in X and Z directions, number of rows per bay, and the width of the slots and bays. Order picking takes place in the rack.

ASRS vehicle

As the name suggests, the automated storage and retrieval system works with racks. ASRS vehicles are specific types of vehicles developed for operating with racks. They can glide back and forth between the racks picking items up or dropping them off. They implement offset travel by only traveling along their own x-axis. As the offset travels, it will reach perpendicular with the destination location, lifting its platform too. If the offset travel is for a load or unload task, then as soon as the offset travel is complete, the flow item will continue on its platform, or off of its platform to its destination spot, using the user-specified loading/unloading time.

The new system uses the task executor to retrieve loads from the destination rack using a robotic arm.

Robotic Arm

The robot must lift flow items from their starting points and place them at their ending points. Commonly, the base of the robot cannot move. Instead, six joints revolve the flow items. In addition, it executes multiple tasks that require a rotation of its joints. In the Aspect system it is attached to the ASRS vehicle to attain the destination rack to carry out order picking and to place the items on the pallet in order to build mixed pallets.

Pallet

Pallets are flat fragments of wood used to lay down foundations for the distribution of goods. The pallet stores protects and transports goods that are handled by the materials handling equipment such as forklifts and pallet jacks.

Pallets are bulky goods units that can be stacked on top of each other and stored in racks with the same piece of product, depending on the amount ordered. In the new system, the order picking process is done by ASRS vehicle with robotic arm to mix SKUs into pallets to meet client requirements.

SKU

Inventory management relies on an SKU to keep track of inventory items, notably color, size, and variants. Inventory management in conjunction with an SKU helps to identify inventory items over lists, invoices, manufacturing orders, and purchase orders.

With the new system, we have 20 distinct types of SKUs, which symbolize 20 different types of boxes, and they are stacked in their assigned slots with their corresponding quantities.

The FlexSim software was used to develop a simulation model based on the five component requirements, their interactions, and the packaging and palletizing requirements. According to Euroforks Inc., palletizing is a crucial procedure for the manufacturing process. In the new system it does not require palletizing area to execute the process of shipping to another pallet since the trolley picks all the items ordered and assembles the pallets.

4.3 System Operating

As such, it is a task that is similar to ASRS vehicles and robotic systems in its design, but order picking system is a devilishly tricky undertaking due to the enormous amount of design limitations and variables. Solving these difficulties requires integrating information about the number of sku's, number of orders, order filling times, and internal constraints into each process step from the moment the product arrives at the warehouse to the moment the product departs for shipment.It focuses on the pallets that are stored on the rack with the same sku per pallet and builds mixed pallets with different sku's for the individual orders.

The flowchart Fig 39 illustrates the way order picking occurs as shown in the receiving procedure in the flexsim software. The process starts at receiving and begins with laying homogeneous pallets with a given quantity and in a specific slot in a particular bay and area.Whenever the order picking operation takes off, the volume on the pallets will decrease. As a result, the rack filling process is implemented in the same periods of time as the FCFS method, ensuring that the rack never runs empty.

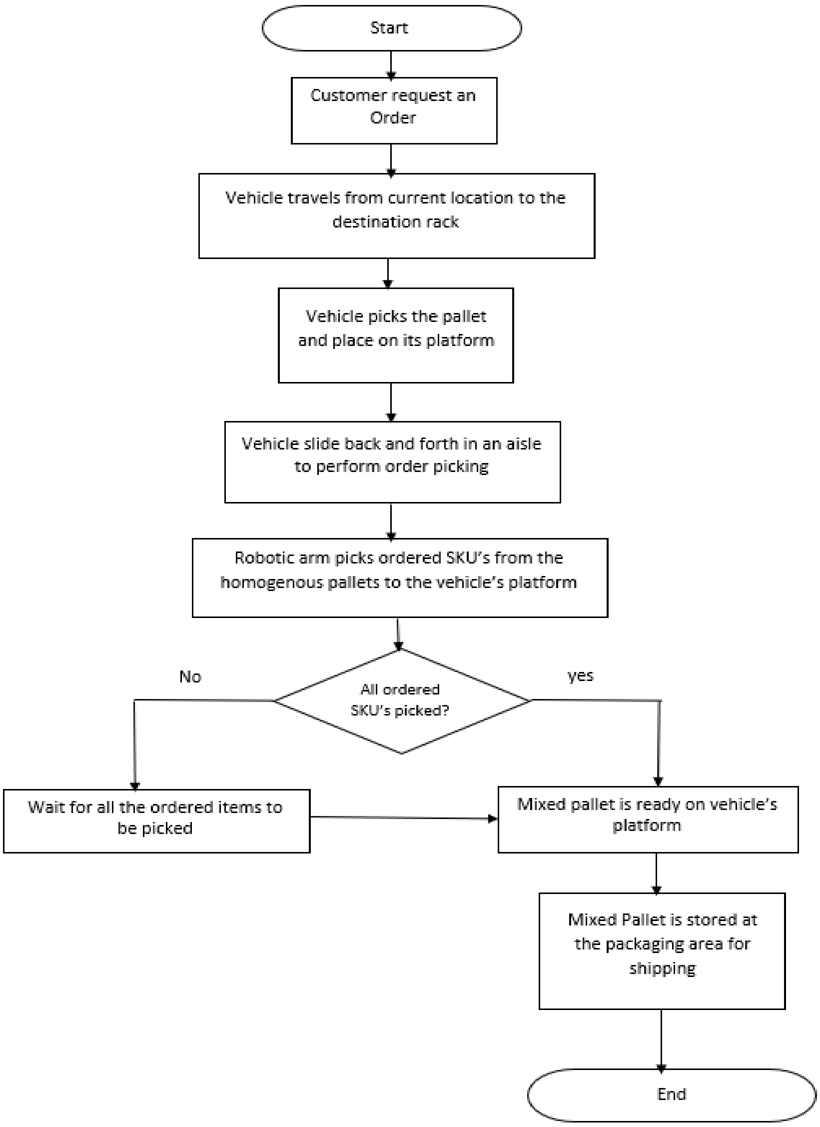


Fig 39. Flowchart of new order picking system.

Credit: Author

This flow chart suggests that the customer order request starts the process and then all the steps need to be completed. In the process, we assumed a robotic arm is connected to the ASRS vehicle to pick the items from stored pallets, as it would not be so convenient to execute manually. During the journey, the robotic arm picks the empty pallet from the picking area and places it on its platform. Meanwhile, along with the vehicle asrs, a robotic arm can pick the ordered sku from stored pallets and place them on the pallet.

ASRS containerized vehicles travel horizontally throughout aisles, pulling their platforms to the target bay and level of the rack for order picking. Once all the items are picked, an empty pallet is put together from various kinds of items, then put into a mixed pallet that will be stored next to the packaging area for storage.

Chapter 5

This chapter is all about Model conceptualization and explanation of 3D simulation models which implements new order picking.

4.3 Model Conceptualization

Conceptualizing the model is important to the development of a realistic model and the goal of the project. It involves many elements that are necessary to evaluate the performance of the new simulation model.

In this thesis, there are two simulation models developed using software flexsim to perform a pick-and-place operation in an automated warehouse. An excellent 3D simulation provided by flexsim, a powerful, versatile, and user-friendly tool, allows you to model and enhance existing and proposed systems. This software is employed in manufacturing industries in assorted production, assembly line, job shop and in material handling such as conveyor systems and material handling machinery, AGV, packaging, warehousing, mining, logistics etc.

It largely contributes to enhancing the effectiveness of products, staffing, resource allocation, floor design, and asset management in an enterprise, and many companies have been implementing the software to improve techniques for allocating resources efficiently and also to reduce expenditures. A final profit is that a stakeholder communication tool delivers an effective manifestation of new proposed changes to a business system.

Comparison implies both simulation models must perform experiments to get the results determining the performance through their output.

Process simulations can be constructed in Flexsim that work with process flows. Process flows include tools in flexsim that help us define logic in a project. This spares us hundreds of hours in project simulation and helps us model complex systems quickly.

If you are in the early stages of an improvement project, it is difficult to know what model you should chase. Michael Belote says, “You can get an idea at the high-level of which brainstormed idea will provide the best output, and then you can do detailed models in a much more focused way”.

As you use Process Flow, the logic can be placed in one location, using its library attributes like Task sequences, Shared assets, Task Executors, etc. As you create logic with Process Flow, connectors may be created to carry it out correctly, allowing the 3D simulation model to function correctly.

5.2 Explanation of 3D simulation model

The main objective of the project is to perform “order picking to build mixed pallets” to accomplish this goal simulation models are used to run their experiments and compare results to choose which model had better performance. Two simulations have been developed but are not yet implemented.

1. Order picking inside the warehouse.
2. Order picking outside the warehouse.

5.3 Order picking Inside the warehouse.

This model performs order picking inside the warehouse to build the mixed pallet by using the logic created with process flow see figure 40.

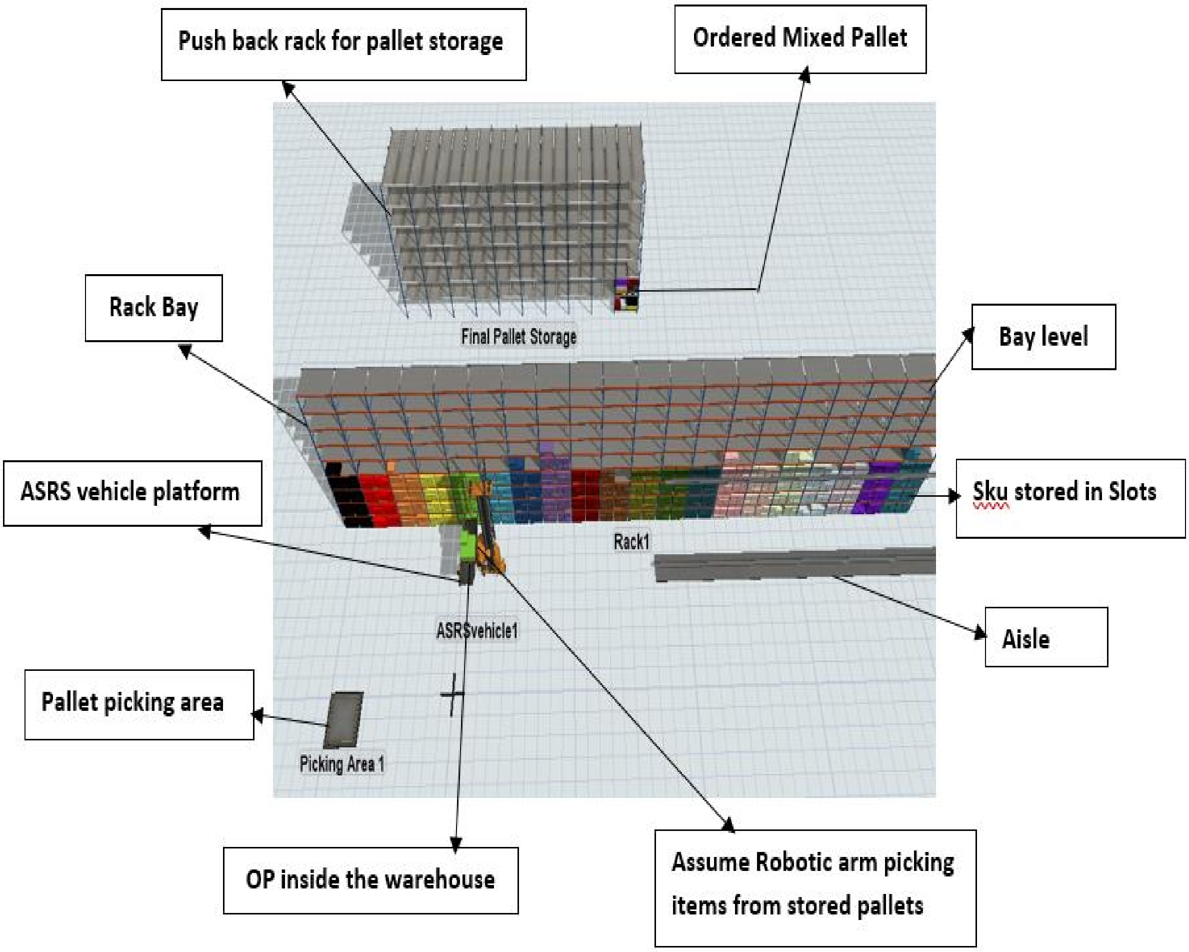


Fig 40: 3D layout of order picking inside the warehouse.

Credit: Flexsim

The layout of order picking inside the warehouse 3D simulation implemented with the process flow technique which has the following steps.

1. Arrival slot check
2. Random order creation
3. Order picking in the warehouse.

In the first stage, the rack storage can be the first step. See figure 41. In the flow chart of arrival slot check, the entire process of fulfilment is described in step by step. In our model, the rack has 20 bays with 10 levels and 2 slots per bay, each. We would be wondering how to store the sku's in the rack, right? Initially, the simulation starts with two arrivals defined in the source of quantity with the quantity of thousand items of twenty kinds of sku’s per source.

There are thousand items which will be divided into ten bays and get placed in their designated slots approximately after 30 seconds of delay. Furthermore, they will remain at the same destination location in its own respective SKU over the whole duration of the delay.

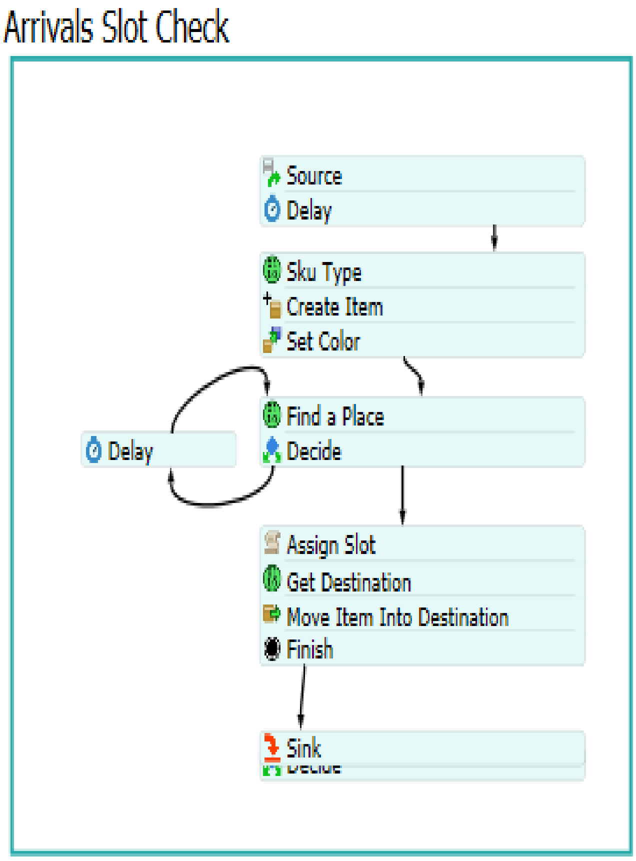


Fig 41. Arrivals slot check

Credit: Flexsim

The quantities of items are decreased when order requests are served, in consequence the sku's quantities are also reduced. In this system the quantity is updated as items are picked from the stored pallets in their place of delivery. When the quantity reaches zero, it is set back to the number of items available in a full pallet.

On the basis of this logic the arrival slot check process will again repeat the same logic to fill the rack by following all the steps starting from, locating a place to store the sku's with the same quantity, choosing the destination bay and slot and transferring the items into their storage slots.

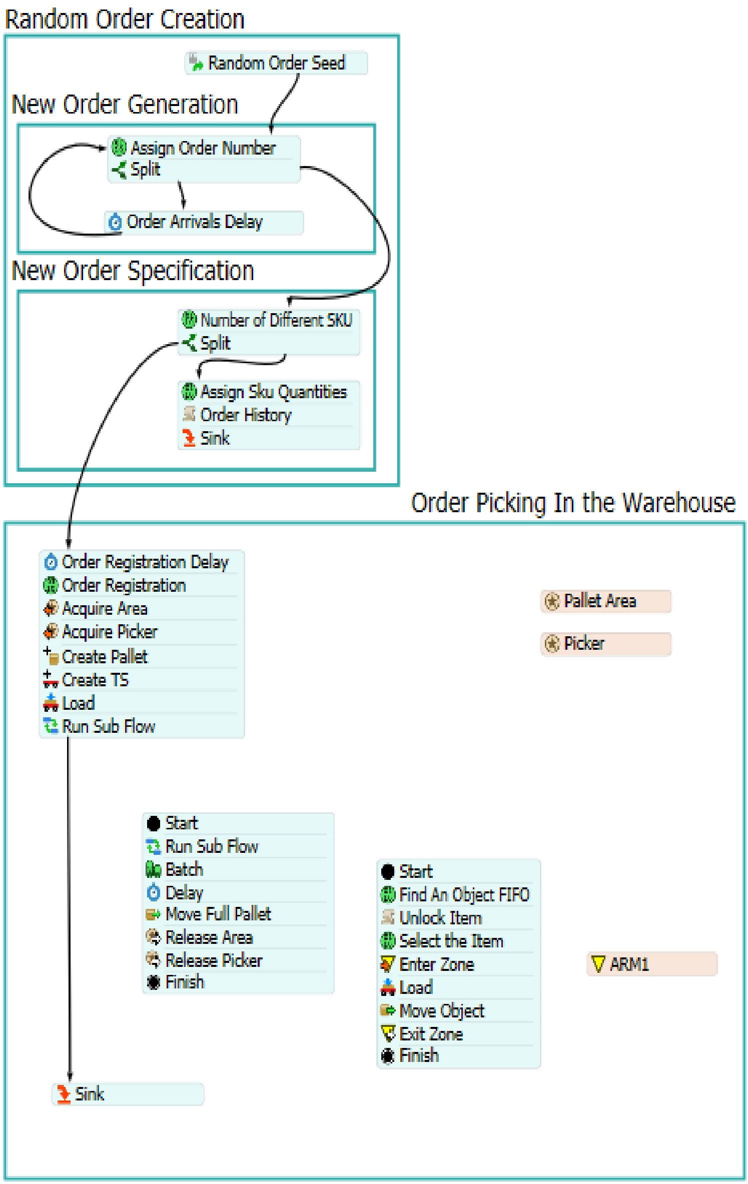


Fig 42. Random order creation and OP in the warehouse

Credit: Flexsim

In fig 42., you can see the synopsis of order creation and order picking is a snapshot of it as integrated in Flexsim (https://www.flexsim.com) to minimize the computational time, the process flow tool was applied. An interactive flowchart environment that can be used to develop model simulations in a short time with negligible computational effort. The top operation is ordering which handles order requests.

Every 70 seconds, orders are produced randomly using a random order seed used to create only one order at a time; once it has been created it is assigned with an order number and different type of sku along with quantity, and all the order data will be automatically presented and saved in an order history.

In order to execute order picking in the warehouse, there are three main resources: the pallet area, the picker, and the Arm. These three assets work together to complete the picking process. Picking area is where the pallet is picked, and picker is an ASRS vehicle and Arm is the robot. Once the order has been produced, the pallet is established at the picking area, and then picker (ASRS vehicle) will travel to the picking area and reach for the pallet.

We assumed that this arm was an ASRS component attached to the retrieval vehicle, thus starting the retrieval process along with the vehicle following the FIFO procedure. The vehicle enters the zone and then loads the item onto the pallet which is on the platform. It only displays one item at a time once picking all the ordered sku's from stored pallets. After picking all of them it then leaves the zone and makes the mixed pallet.

The sub flow will have order data such as order number, sku type, sku quantity, and order completion time. In this model, each order contains the maximum quantity of 1 unit to 4 units per sku. All these data are compiled in order history for every order and batch them to form a cycle. Cycle times are used to compute performance measures under different scenarios. Picking order inside the warehouse will be done when the mixed pallet is ready to be removed from the vehicle and later is placed into the pallet storage area to be shipped.

5.4 Order picking outside the warehouse

To build the mixed pallet, this model utilizes the logic set up in the process flow to pick orders outside the warehouse. This process has cache zones to organize order picking.

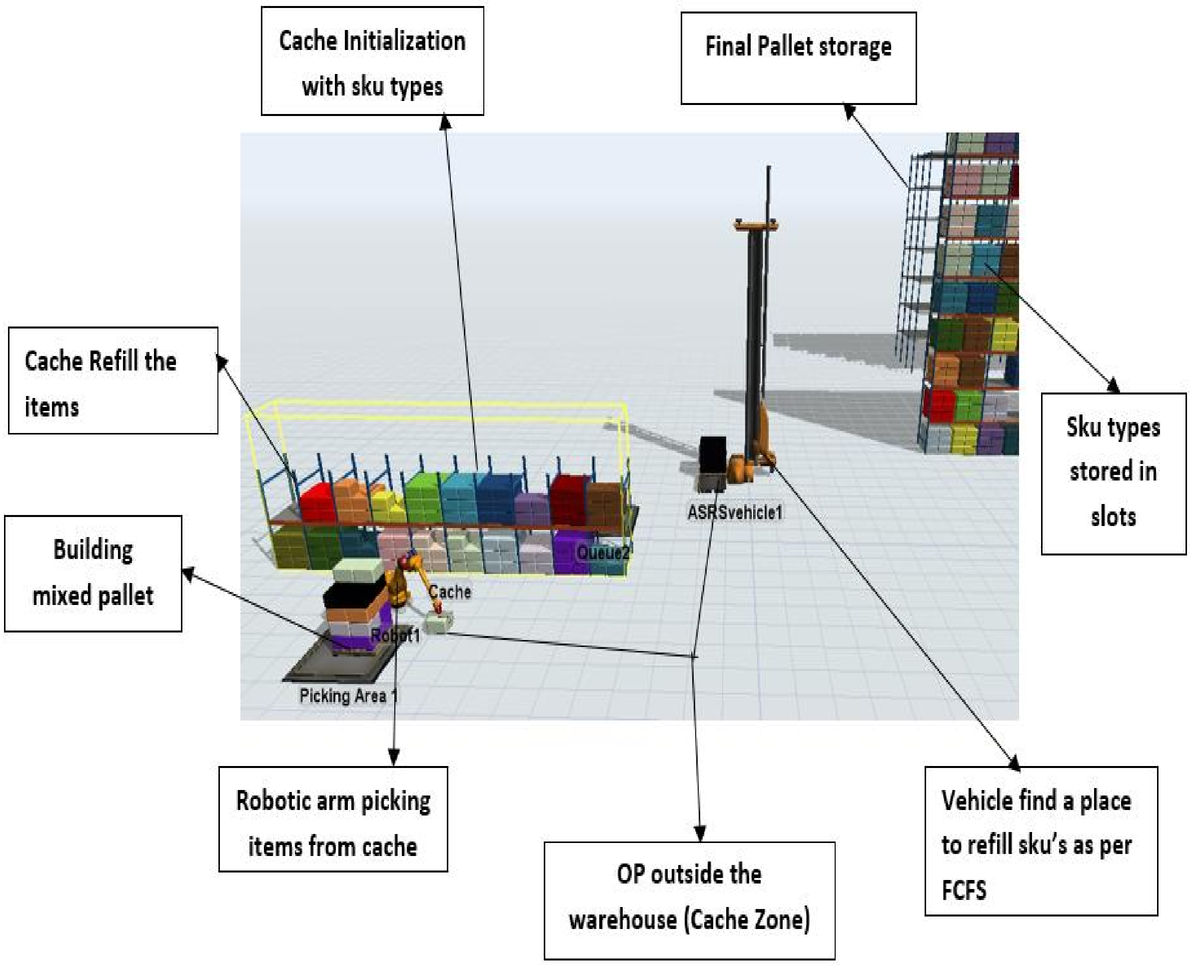


Fig 43: 3D layout of of order picking outside the warehouse (Cache Zone)

Credit: Flexsim

Within the design of order picking inside the warehouse, the 3D simulation was implemented with the process flow technique with additional steps.

1. Cache initialization
2. Arrival slot check
3. Cache Refill
4. Random order creation

5. Order picking in the cache zone

Figure 44 illustrates the system's initialization with cache initialization see description. The cache is a separate storage environment used to store all the SKU types in the warehouse. With initial simulations running, the cache zone is filled with the quantity of 12 items of each sku type, based on the sub flow. Each sku type was assigned with a different color, so we have entirely 20 sku types with 20 colors.

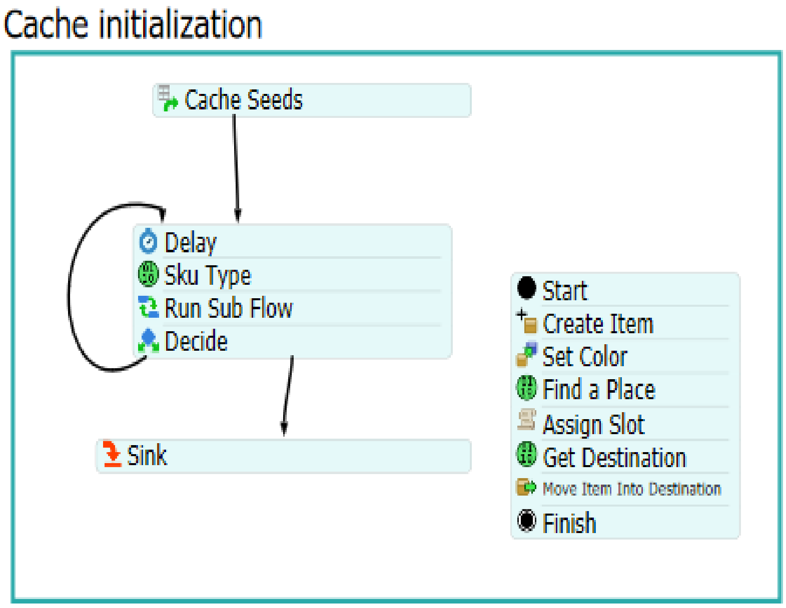


Fig 44. Cache initialization

Credit: Flexsim

While the cache is being filled, the rack storage will begin the process with one arrival with the quantity of 2500 items (as shown in the fig 42) in 20 sku types and all the quantity will be dispersed into 10 bays and get stored in their storage slots within 30 seconds of delay time and we assume those are the stored pallets where each pallet contains twelve items. Additionally, the SKUs remain the same throughout the entire simulation. Once the quantity reaches zero and the pallet is empty, the pallet content is set back to the number of items that are available in a full pallet.

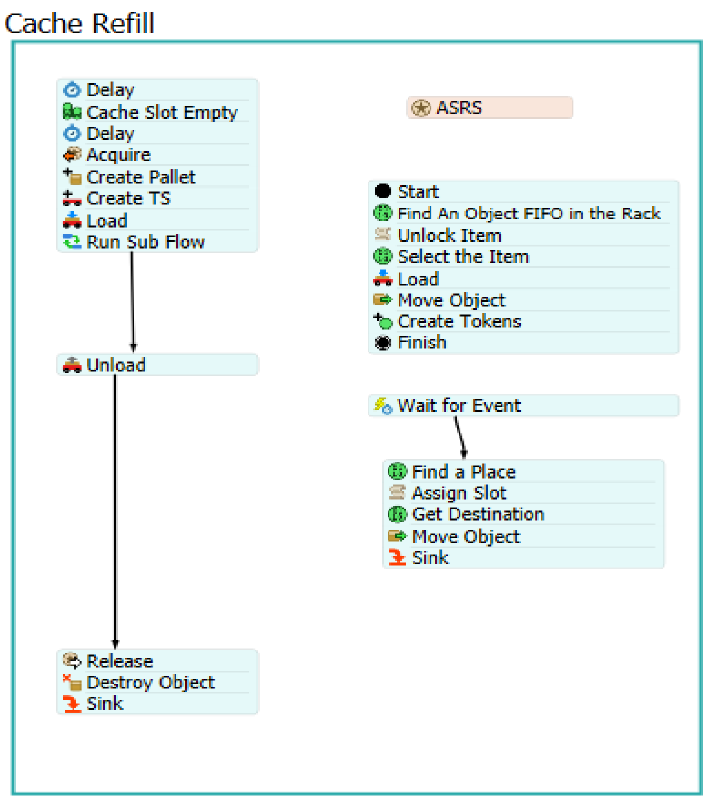


fig 45. Cache Refill

Credit: Flexsim

When the cache zone is empty, that is the process of refilling it. First, in each slot of the cache, a pallet is stored with the quantity of 12 items including the sku type. when order picking is being done, all the quantity data of the sku is batched in a cache slot, which clearly shows what type of sku is being picked and its quantity.

When the quantity in cache zone reaches zero, the ASRS vehicle drives in the aisle and picks up the pallets. Then it loads the quantity of 12 items of the SKU type on its platform according to the FIFO policy. After that, it waits for the slot to become empty. Once the slot is empty, it unloads the pallet into the destination slot. This process continues until all the orders are observed.

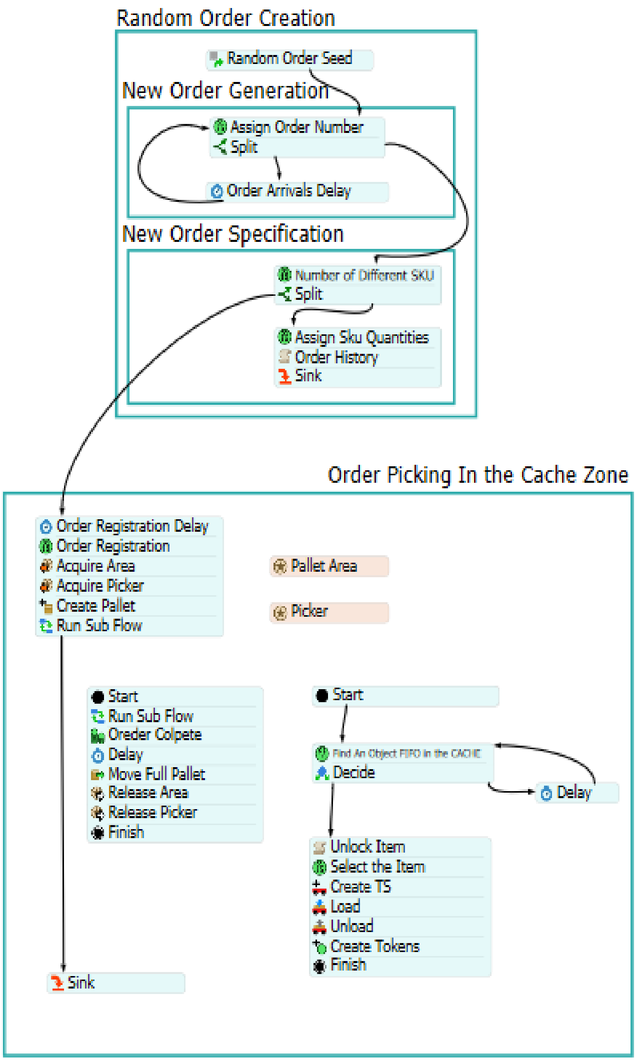


Fig 46. Random order creation and OP outside the warehouse

Credit: Flexsim

Fortunately, this process flow allows the picking of orders outside the warehouse to build mixed pallets. Since orders have been created randomly by random seed see fig 46, it only allows one order at a time to be created. Once the cache initialization is complete, it will be filled with different sku's at the given quantity.

Orders will be generated randomly following uniform distribution, with the variety of items between 1 to 10 and the minimum of 1 sku to 10 sku types from 20 sku's. Each time an order is generated, the robotic arm will pick the pallet from the picking area and begin loading the items from stored pallets from the cache zone and unload them to the mixed pallet by following FIFO policy.

By the same token, the ASRS vehicle will load the items from the storage rack to the cache zone as well to unload them. Both work at once only when the slots are empty. Once the Mixed pallet is ready with ordered sku's outside the warehouse (cache zone), it will be moved to the final pallet storage to perform shipping. Every order data will be stored and batched automatically in an order history to measure the cycle time.

Chapter 6

In this chapter complete analysis of experiments of two simulation models are explained with the results.

6.1 Analysis of Experiments

We used two simulation models developed to evaluate performance measurements. See fig 47. Analysis of experiment results is a step-by-step process used to retrieve raw data and show how results from the experiments are interpreted in flexsim.

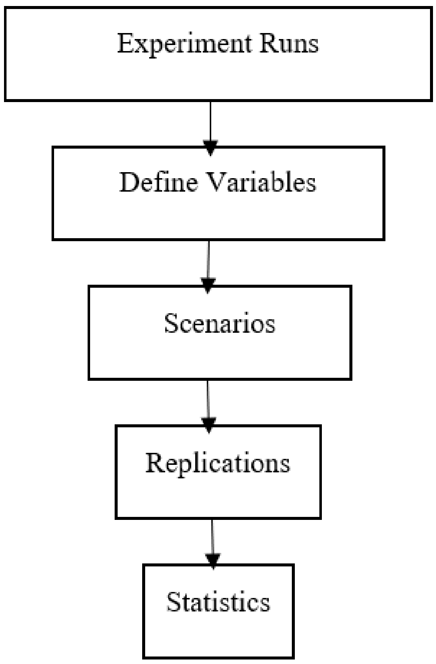
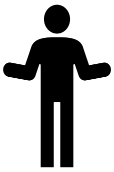


Fig 47. Analysis of experiment results

Credit: Author

In a nutshell, an experiment means a set of variables, replications and situations that are repeated using the same simulation model. We have performed two experiments for both inside and outside the warehouse simulation models using different scenarios.

 What is a Scenario?

In a simulation every time a simulation model is run, a scenario is defined. This means it's important to know how the variables will change. In our first experiment we are using five different variables with 32 different scenarios for two simulation models and 10 replications for each configuration. For the second experiment, variables were the same for two simulation models with 42 different scenarios and 15 replications of each configuration.

So, we have defined some fixed variables related to the system configuration for both the simulation models.

1. Number of Maximum Different SKU
2. Number of Maximum SKU
3. Order inter arrival time
4. Picking time
5. Number of Minimum Different SKU
6. Number of Minimum SKU

How the above-mentioned variables were used in scenarios and experiment tests will be discussed in the following sections.

6.2 Experiment Results

- Experiment 1

Picking inside and outside the warehouse with 32 scenarios

- Experiment 2

Picking inside and outside the warehouse with 42 scenarios

The two experiments we have done both were done for comparisons of the two simulation models from different scenarios, as opposed to the aforementioned outside Warehouse simulation model. See Fig 48. Picking inside the warehouse, below table illustrates that 16 different scenarios where defined, with 6 different variables each, and three variables changing four levels each, they are; number of maximum different sku (2,4,8,12) number of maximum sku (2,4,8,12) and the order inter arrival time in seconds (200,400,800,1200).

Starting from one pallet being built per time, robot picking time is (0) which means inside the warehouse, and the minimum number of different sku and the minimum number of sku variables are ranked as (1). Different dimensions of an order were used to lead the simulation from order arrival to the order fulfillment.

Scenarios	Number of Maximum Different SKU	Number of Maximum SKU	Order Inter Arrival Time	Picking Time	Number of Minimum Different SKU	Number of Minimum SKU
1	2	2	200	0	1	1
2	2	4	400	0	1	1
3	2	8	800	0	1	1
4	2	12	1200	0	1	1
5	4	2	200	0	1	1
6	4	4	400	0	1	1
7	4	8	800	0	1	1
8	4	12	1200	0	1	1
9	8	2	200	0	1	1
10	8	4	400	0	1	1
11	8	8	800	0	1	1
12	8	12	1200	0	1	1
13	12	2	200	0	1	1
14	12	4	400	0	1	1
15	12	8	800	0	1	1
16	12	12	1200	0	1	1

fig 48. Experiment 1 Picking inside the warehouse results.

Consider the scenario 1 to 16, where the quantity of the item was chosen randomly from minimum and maximum values for a single order which ranges from 1 to 12. Table 1 - Scenario 1 and Column 4 - Using exponential distribution to calculate order inter-arrival time divide it by the number of consecutive orders. Then we find the average 200 seconds that each order takes.

As outlined earlier, scenario (4,8,12,16) has the highest order completion time, 1200 seconds, when compared to the others because, as the quantity of sku has increased simultaneously, order arrival rate has increased. For these simulations, the minimum time required to complete the order is 200 seconds and the maximum is 1200 seconds for each scenario.

The figure 49 shows the picking outside the warehouse. It involves building a mixed pallet outside the warehouse, while using 16 simulation runs with 16 variables and 16 scenarios. All the dimensions of an order were the same when picking outside the warehouse but the robot picking time is intialised as (1). In the simulations, on average the minimum time required to complete an order is 200 seconds and the maximum time is 1200 seconds. As the number of skus has grown, the time needed to complete an order has grown as well.

Scenarios	Number of Maximum Different SKU	Number of Maximum SKU	Order Inter Arrival Time	Picking Time	Number of Minimum Different SKU	Number of Minimum SKU
17	2	2	200	1	1	1
18	2	4	400	1	1	1
19	2	8	800	1	1	1
20	2	12	1200	1	1	1
21	4	2	200	1	1	1
22	4	4	400	1	1	1
23	4	8	800	1	1	1
24	4	12	1200	1	1	1
25	8	2	200	1	1	1
26	8	4	400	1	1	1
27	8	8	800	1	1	1
28	8	12	1200	1	1	1
29	12	2	200	1	1	1
30	12	4	400	1	1	1
31	12	8	800	1	1	1
32	12	12	1200	1	1	1

Fig 49. Experiment 1-Picking outside the warehouse results.

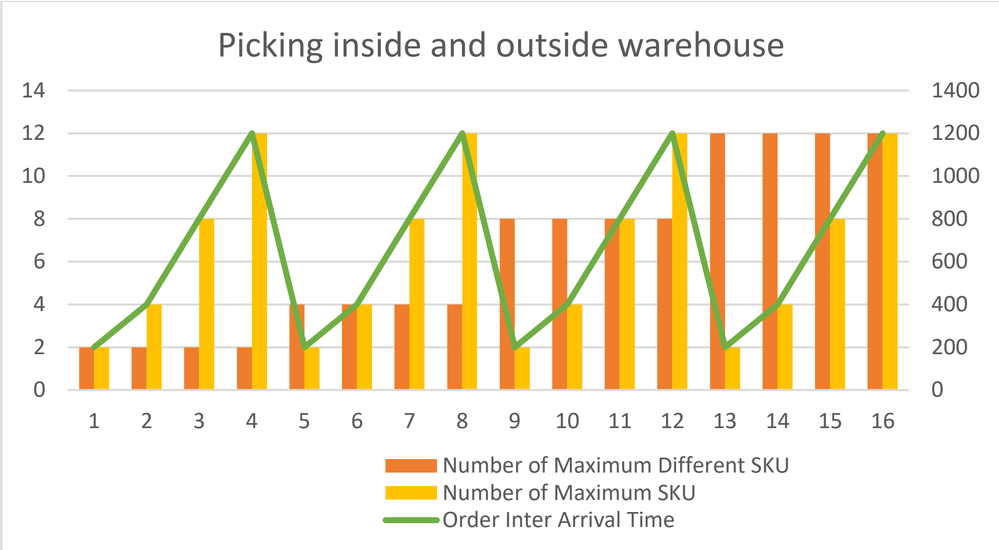


Fig 50. Clustered column chart effects of 16 scenarios

The above figure 50 shows the effects of three variables of experiment 1 performance in clustered column charts., related to the first three vertical columns in figures 48 and 49. The green line, which represents the order inter arrival time, yellow line is the number of maximum sku and orange line is the number of maximum different sku indicates the performance of the system by the interaction of all three variables considered in the analysis. Thus, these variables are critical to evaluate the system's performance.

Scenarios	Number of Maximum Different SKU	Number of Maximum SKU	Order Inter Arrival Time	Picking Time	Number of Minimum Different SKU	Number of Minimum SKU
1	2	4	400	0	1	1
2	2	8	800	0	1	1
3	2	12	1200	0	1	1
4	4	4	400	0	1	1
5	4	4	400	0	1	1
6	4	8	800	0	1	1
7	8	12	1200	0	1	1
8	2	12	1200	0	1	1
9	2	4	400	0	1	1
10	2	8	800	0	1	1
11	4	12	1200	0	1	1
12	4	4	400	0	1	1

13	4	8	800	0	1	1
14	8	12	1200	0	1	1
15	20	12	1200	0	1	1
16	20	12	1200	0	1	1
17	4	4	400	0	2	2
18	4	8	800	0	2	4
19	4	12	1200	0	2	6
20	8	12	1200	0	4	6
21	20	12	1200	0	10	6

Fig 51; Experiment 2-Picking inside the warehouse results.

In Experiment 2, there are 42 scenarios divided into 21 scenarios in which half the data is utilized for within the warehouse and half of the data is utilized for outside the warehouse which automatically shows the difference regarding the picking time. If the picking time is "0" then it is considered picked inside the warehouse and if it is "1" then it is considered picked outside the warehouse. It is clearly shown in both Fig 51 and 52.

Additionally, there are significant differences between the system's performance in terms of its results compared to experiment one: 21 different scenarios were defined with 6 different variables as in experiment one, and each of the 5 variables were changing at different levels, they are number of maximum different sku (2,4,8,20) number of maximum sku (4,8,12) order inter arrival time in seconds (400,800,1200) number of minimum different sku (1,2,4,10) number of minimum sku (1,2,4,6).

In regard to scenarios, every scenario has different order dimensions with different variables to fulfill a single order. It has been discussed earlier that whenever the quantity of sku has been increased, simultaneously the order inter arrival time has increased. As a special case, take a scenario where the number of sku's are 20 and the maximum quantity is 12, and in scenario 14, the number of sku's are 8 and the maximum quantity is 12.

For both the scenarios 14 and 15, there is still no difference in order inter arrival time since both scenarios are executed in 1200 seconds, since it is verified that it does not impact the order cycle time since the cycle time is computed from the moment the ASRS vehicle starts processing the order not from the time the order arrives.

The scenario 17 demonstrated that the number of different and minimum sku was not the same, they altered depending on the order dimensions but in relation to the effect of the number of sku's stored, they observe that the higher the quantity of sku as the longer the order cycle time. Even though variables were changing between order dimensions, the order cycle time remained unchanged. It was higher when the quantity of sku had increased and lower when the quantity of sku was decreased.

Scenarios	Number of Maximum Different SKU	Number of Maximum SKU	Order Inter Arrival Time	Picking Time	Number of Minimum Different SKU	Number of Minimum SKU
22	2	4	400	1	1	1
23	2	8	800	1	1	1
24	2	12	1200	1	1	1
25	4	4	400	1	1	1
26	4	4	400	1	1	1
27	4	8	800	1	1	1
28	8	12	1200	1	1	1
29	2	12	1200	1	1	2
30	2	4	400	1	1	4
31	2	8	800	1	1	6
32	4	12	1200	1	1	2
33	4	4	400	1	1	4
34	4	8	800	1	1	6
35	8	12	1200	1	1	6
36	20	12	1200	1	1	1
37	20	12	1200	1	1	6
38	4	4	400	1	2	2
39	4	8	800	1	2	4
40	4	12	1200	1	2	6
41	8	12	1200	1	4	6
42	20	12	1200	1	10	6

Fig 52; Experiment 2-Picking outside the warehouse

If you examine the scenarios 22 to 42, the order dimensions are similar. However, the picking was carried out outside the warehouse. Therefore, there is no difference between scenarios 1 to 22. However, if you look at scenario 29, variable 6 of the table of fig52, the number of minimum sku has changed from 1 to 2 and it has been increasing its value to 6 until scenario 42.

As a consequence, both scenarios 21 and 42 have the highest order dimensions including a maximum of 20 different sku's and a minimum of 10 different skus. For a maximum quantity of 12, the order interval time is 1200 seconds, a maximum value as per our order dimensions.

Significantly, the order cycle time was the same between scenarios 21 and 42 for picking inside and outside warehouses with same order dimensions. While there is no major difference between picking by robots and placing an order, it is anticipated that the number of the mixed pallets is set to increase, therefore the ASRS vehicle will have to travel to the rack locations to pick and store all the items ordered.

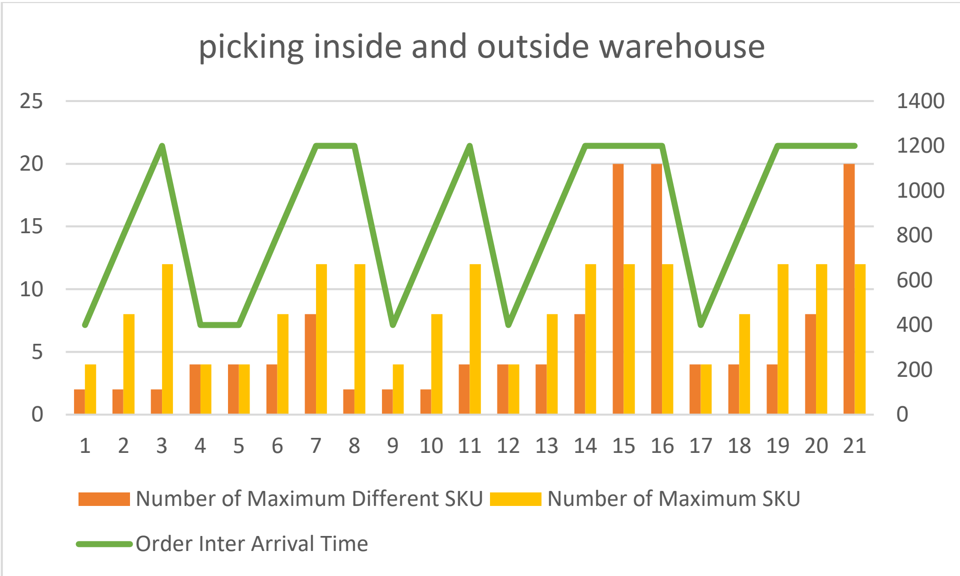


Fig 53. Clustered column chart effects of 21 scenarios

As we see the above fig 53, the effects of three variables of experiment 2 performance are illustrated in the clustered column charts., in relation to the first three vertical columns of fig 51 and 52. Considering the green line which is the order inter arrival time, yellow line is no. of max sku and orange line is no. of max different sku shows their performance by all three variables considered in the analysis. See the Scenarios 15,16 and 21 has the max sku limit is '20' and the order arrival time curve has been changing from higher to lower and from lower to higher depending upon the quantity of sku's. The least order cycle time to complete a single order is 400 seconds and highest is 1200 seconds for different scenarios in both inside and outside the warehouse simulations.

6.3 Evaluation of Performance Measures

Finally, four different performances measures were collected they are:

1.ASRS Distance

2.Mean Service Time

3.Output

4.Mean Picking time

The above four are the key performance indicators (Kpi's) used to get the statistical outputs for two simulation models. For every kpi, the raw data has been gathered and transformed into a data table that was generated by statistics collector. Usually, A statistic collector would gather the raw data from the objects and events which were specified during a simulation run. Replication plots and frequency histogram graphs have been generated by using the data table for all the kpi's.

For comparison, we used only Mean service time data for two experiments to evaluate the performance of both inside and outside warehouse simulation models. Other kpi's data tables were collected and presented in the Appendix section below for the reference. After the data collection, it was carried an analysis of mean and variance to identify the factors that impacts the performance, Finally, the data were exported and recorded into an Excel file. Using this data, it was verified if the inside or outside warehouse picking method was equal or higher after comparison process finished.

Summary								
	Mean (90% Confidence)					Sample Std Dev	Min	Max
Scenario 1	133.5	<	141.2	<	149.0	14.9	116.4	171.9
Scenario 2	128.4	<	137.5	<	146.5	17.5	110.7	169.4
Scenario 3	160.3	<	169.2	<	178.1	17.2	139.9	204.0
Scenario 4	194.1	<	212.8	<	231.5	36.1	148.3	279.7
Scenario 5	240.1	<	263.5	<	286.8	45.0	199.1	344.6
Scenario 6	225.3	<	240.6	<	255.8	29.4	203.5	309.3
Scenario 7	257.3	<	287.1	<	317.0	57.5	184.6	362.0
Scenario 8	326.9	<	359.2	<	391.6	62.4	272.8	465.0
Scenario 9	785.3	<	979.0	<	1172.8	373.7	464.6	1462.6
Scenario 10	537.1	<	604.8	<	672.5	130.5	414.8	854.5
Scenario 11	537.7	<	661.2	<	784.7	238.2	371.0	1314.5
Scenario 12	544.0	<	731.7	<	919.3	361.9	365.1	1738.3
Scenario 13	1666.8	<	1959.3	<	2251.9	564.2	1009.9	2707.4
Scenario 14	872.4	<	1130.0	<	1387.6	496.8	408.3	1954.3
Scenario 15	853.0	<	1148.6	<	1444.3	570.3	588.1	2239.3

Scenario 16	875.2	<	1209.1	<	1542.9	643.9	454.9	2446.9
Scenario 17	51.7	<	54.8	<	57.9	6.0	48.1	69.0
Scenario 18	67.6	<	74.6	<	81.6	13.5	58.5	105.4
Scenario 19	115.7	<	139.7	<	163.7	46.3	76.0	236.3
Scenario 20	166.9	<	191.3	<	215.7	47.0	128.0	254.7
Scenario 21	102.0	<	133.1	<	164.2	60.0	71.2	257.6
Scenario 22	135.1	<	166.3	<	197.5	60.3	83.6	291.6
Scenario 23	229.0	<	258.8	<	288.6	57.5	198.5	354.4
Scenario 24	324.8	<	354.2	<	383.7	56.9	262.8	497.5
Scenario 25	373.0	<	505.7	<	638.5	256.1	195.8	944.1
Scenario 26	367.7	<	452.1	<	536.5	162.9	223.2	735.2
Scenario 27	446.3	<	510.9	<	575.5	124.6	368.3	730.7
Scenario 28	596.1	<	752.2	<	908.4	301.2	436.6	1495.8
Scenario 29	897.5	<	1065.2	<	1232.8	323.4	584.9	1712.8
Scenario 30	797.1	<	993.1	<	1189.2	378.2	414.3	1472.9
Scenario 31	902.6	<	1077.3	<	1251.9	336.9	485.1	1796.0
Scenario 32	1073.8	<	1275.8	<	1477.9	389.7	982.2	2294.4
TEST1	392.2	<	431.4	<	470.6	75.6	315.3	572.6
TEST2	345.2	<	422.2	<	499.3	148.6	265.9	754.1

Fig 54. Mean Service time data table of experiment 1

Considering the data of above fig 54; There were four factors used for statistics called Mean, sample standard Deviation, Minimum and maximum. The mean service time is the time where number of mixed pallets have been served under a fixed time period. Basically, in statistics, The confidence level indicates the probability. So, here the confidence interval is 90% that implies that we expect 90% of the interval which estimates there would be a statistically significant difference between the data. Sample standard deviation is the measurement of a distance between each data point and the mean. Simply we can say how much our sample data is distributed over the mean time.

At last, two statistical tests have done which is a way of mathematically proving that a certain statistic is reliable. It is to make a decision based upon the experiment result and the main intention is to determine whether we have got enough evidence to reject or accept a conclusion.

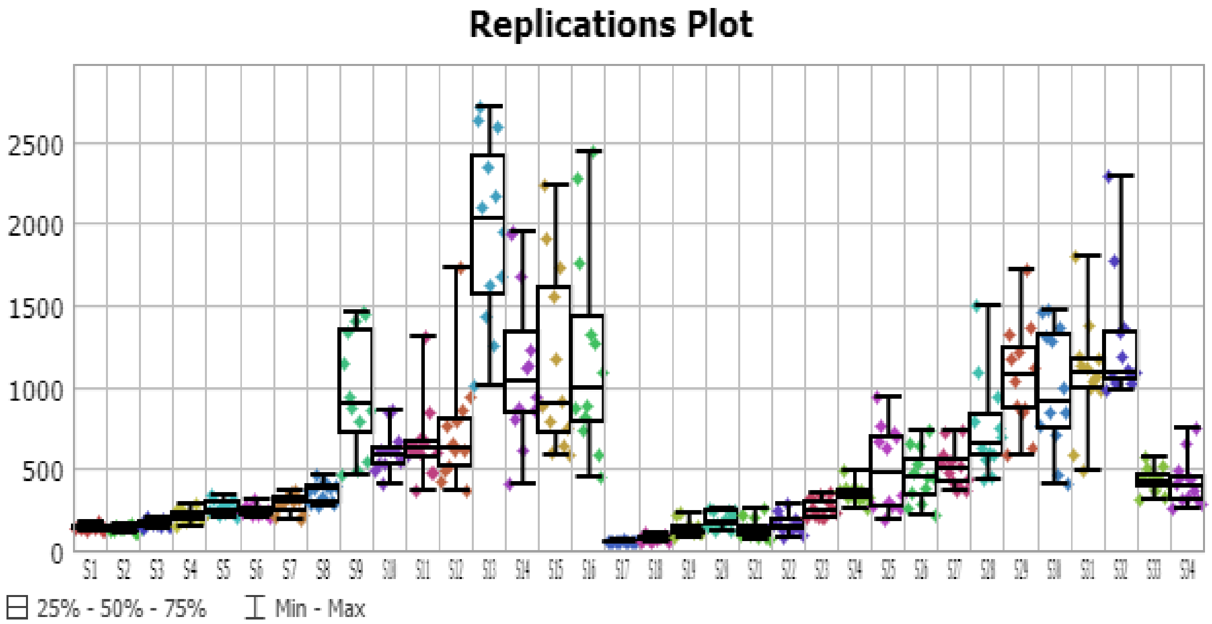


Fig 55. Box chart of replications for scenarios and tests

Replications are nothing but getting the exact result when an experiment is repeated and also it is a single run of a simulation for a specific scenario. we have run the experiment with 32 scenarios and two statistical tests to verify whether the same result was obtained to detect smaller changes if needed. For each scenario, the data of maximum and minimum values ranging from 0 to 2500 were clearly shown in fig 54; by using box chart.

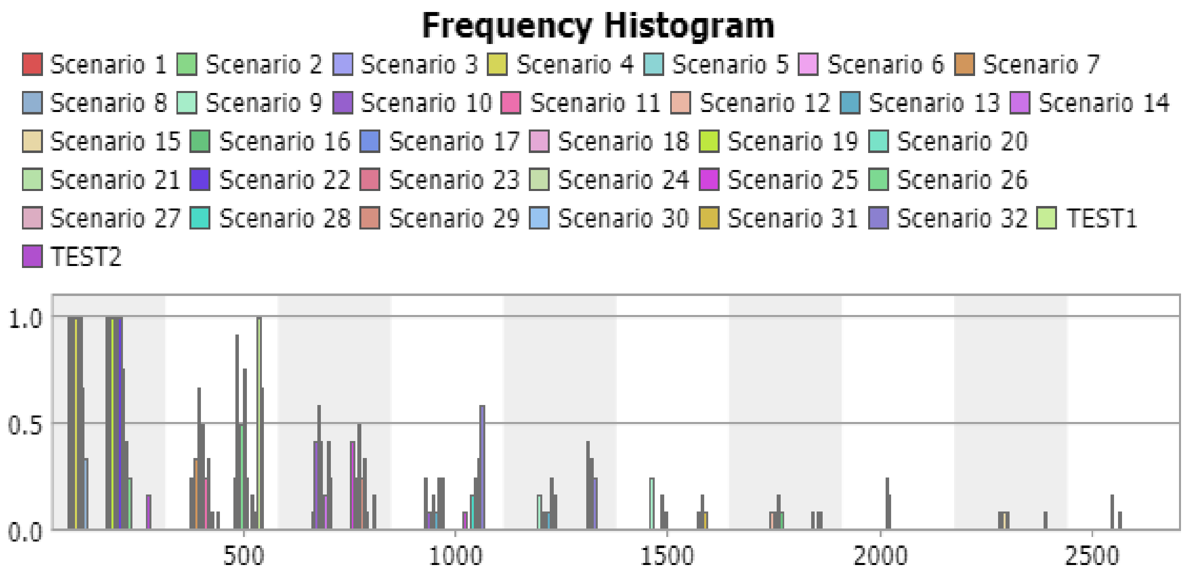


Fig 56. Histogram chart for frequency of scenarios

From fig 54; The data of the second column was taken as 'Mean' until scenario 16 which was considered as the picking inside the warehouse and from 17 to 32 as picking outside the warehouse. Same applies for standard deviation see the fig 55.

	Mean			Standard Deviation		
Scenarios	Inside	Outside	Mean I/O	Inside	Outside	Std.Dev I/O
1	141.2	54.8	258%	14.9	6	248%
2	137.5	74.6	184%	17.5	13.5	130%
3	169.2	139.7	121%	17.2	46.3	37%
4	212.8	191.3	111%	36.1	47	77%
5	263.5	133.1	198%	45	60	75%
6	240.6	166.3	145%	29.4	60.3	49%
7	287.1	258.8	111%	57.5	57.5	100%
8	359.2	354.2	101%	62.4	56.9	110%
9	979	505.7	194%	373.7	256.1	146%
10	604.8	452.1	134%	130.5	162.9	80%
11	661.2	510.9	129%	238.2	124.6	191%
12	731.7	752.2	97%	361.9	301.2	120%
13	1959.3	1065.2	184%	564.2	323.4	174%
14	1130	993.1	114%	496.8	378.2	131%
15	1148.6	1077.3	107%	570.3	336.9	169%
16	1209.1	1275.8	95%	643.9	389.7	165%

Fig 57. Mean and standard deviation results of experiment 1

As per the data table of Fig 57. Mean and standard deviation results of experiment 1, it clearly shows in the 4th column "Mean I/O" and 7th column "Std.Dev I/O" about the percentage level of both inside and outside warehouse picking. If we compare the percentage of both mean and standard deviation of each scenario, we consider below or equal to 100% is best to perform picking inside the warehouse and more than 100% is best for outside picking.

Looking at the scenario 16, it has got 96% which is best among all and scenario 12, 8, are also showing better results. We can also consider the scenarios 4, 7, and 15, But if we take a look on standard deviation scenario 3 has almost 37% which is faster to perform picking inside the warehouse. Also, the scenarios, 4,5,6,7 and 10 are showing better results. If we compare the results of both mean and variance together scenario 7 has best output results.

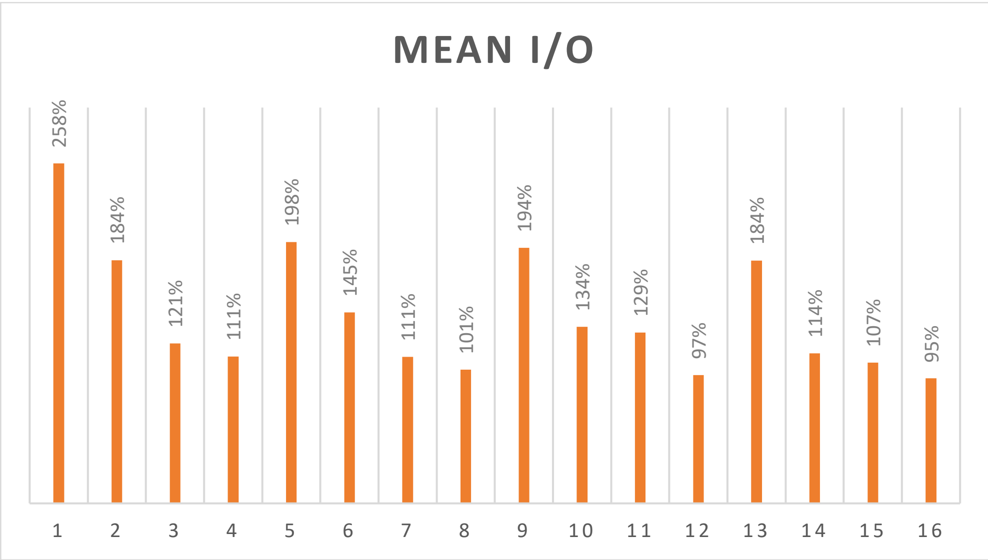


Fig 58: Clustered column chart of Mean I/O of Exp-1

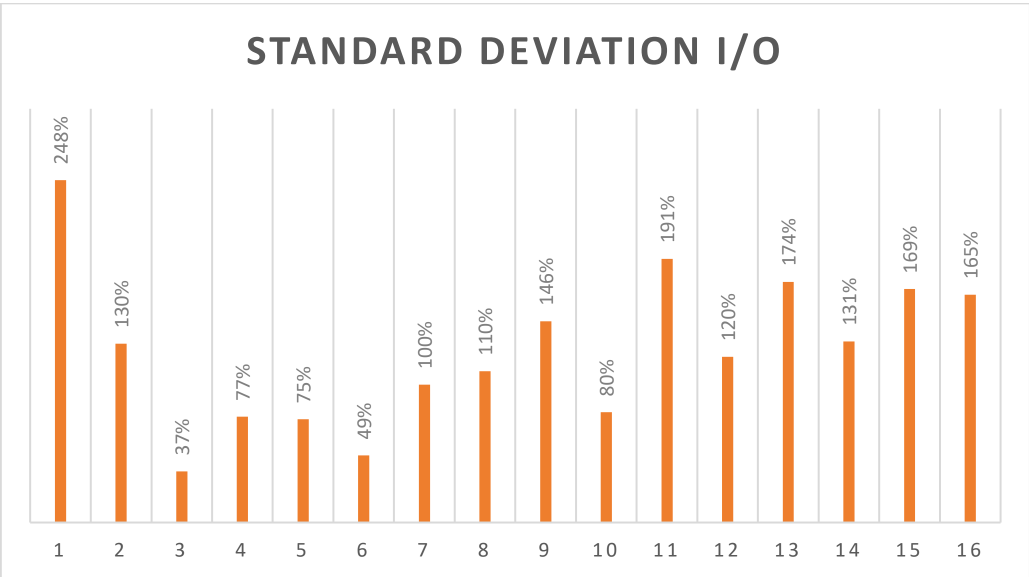


Fig 59: Clustered column chart of Standard Deviation I/O of Exp-1

At last, two statistical tests have done which is a way of mathematically proving that a certain statistic is reliable. It is to make a decision based upon the experiment result and the main intention is to determine whether we have got enough evidence to reject or accept a conclusion.

Test 1	392	431	471	76	315	573
Test 2	345	422.2	499	149	266	754

Fig 60: Test Results of Service Time

Test 1	204	205	206	2	201	208
Test 2	214.5	222.6	230.8	16	202	261

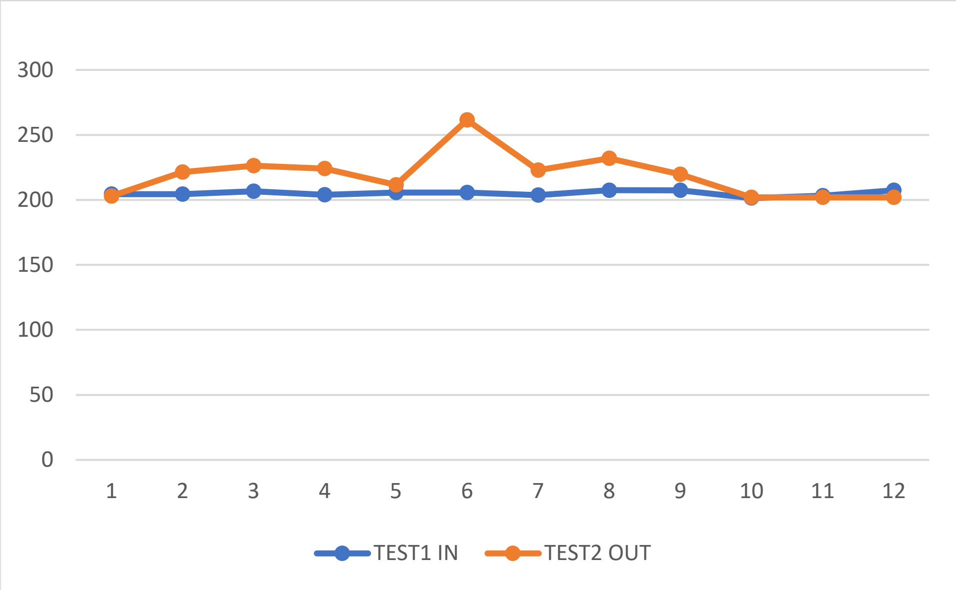
Fig 61: Test Results of Picking Time

Regarding the results of service time and picking time in fig 60&61, we got the same statistical output for two tests in service time i.e., 0.183013 then there is no significant difference. But we see the different output for picking time i.e., -3.670097 is for test 1 and 3.670097 is for test 2.

TEST 1 IN	TEST 2 OUT
204	203
204	221
207	226
204	224
206	212
206	261
204	223
207	232
207	220
201	202
203	202
207	202

Fig 62: Test results of Inside and Outside picking

From the fig 63. To perform the tests for both inside and outside simulation models, order dimensions are same and the real time to pick the object is also same for two models. See the fig 64; blue line is the result of test in and orange line is the result of test out. According to the line chart outside picking is a bit faster compare to the inside picking.



63. Line chart results of Test In and Test Out

See the fig 64; Results of experiment 2 which is creating a pallet outside the warehouse. The data of mean and standard deviation has taken from the experimentation report of service time provided in appendix. As verified by the results, it is considered that if mean and standard deviation I/O result is below 100% then it is better to perform picking inside the warehouse or it is greater than 100% it will be best to perform picking outside the warehouse.

	Mean			Standard Deviation		
Scenarios	Inside		Mean I/O	Inside		Std.Dev I/O
1	143.7	85.3	168%	10.9	11	99%
2	183.1	141	130%	19.1	25	76%
3	225.5	195.9	115%	26.8	36.3	74%
4	253	167	151%	34.7	25	139%
5	301.2	264.5	114%	43.1	53.9	80%
6	374	372	101%	61.2	100.3	61%
7	770	709.4	109%	225.3	216.4	104%
8	143.7	104.5	138%	10.9	13.6	80%

9	183.1	195.3	94%	19.1	22.2	86%
10	225.5	280.7	80%	26.8	38.5	70%
11	295.4	222.8	133%	48.1	43.2	111%
12	393.7	375.7	105%	56	77.4	72%
13	506.8	511.4	99%	81	121	67%
14	1162.4	1087.8	107%	409.1	380.9	107%
15	2797.4	2568.8	109%	933.5	1152.9	81%
16	3979.3	3750	106%	1315.8	1576.6	83%
17	351.3	256.5	137%	49.6	36.6	136%
18	458.8	427.4	107%	61.7	78.2	79%
19	609.8	582	105%	74.5	131.4	57%
20	1879.8	1493.1	126%	676.7	404.8	167%
21	5546.8	5428	102%	1172.4	1085.7	108%

Fig 64. Mean and standard deviation results of Experiment 2

Looking at the data table, scenario until 21 which was considered as the picking inside the warehouse and from 22 to 42 as picking outside the warehouse. Same applies for standard deviation. Scenario 10 has 80% of mean and 70% of variance among all the scenarios, it has best results. In this case it is best to perform picking both inside and outside because most of the scenarios has better results. But comparing to the mean standard deviation results are showing best output and almost 80 percent of the scenarios are showing below 100%.

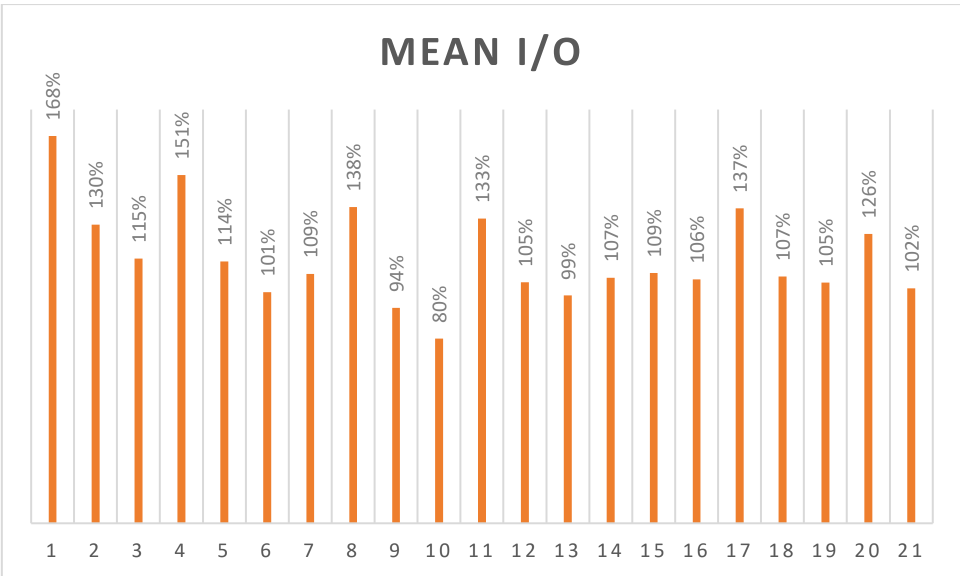


Fig 65: Clustered column chart of Mean I/O of Exp-2

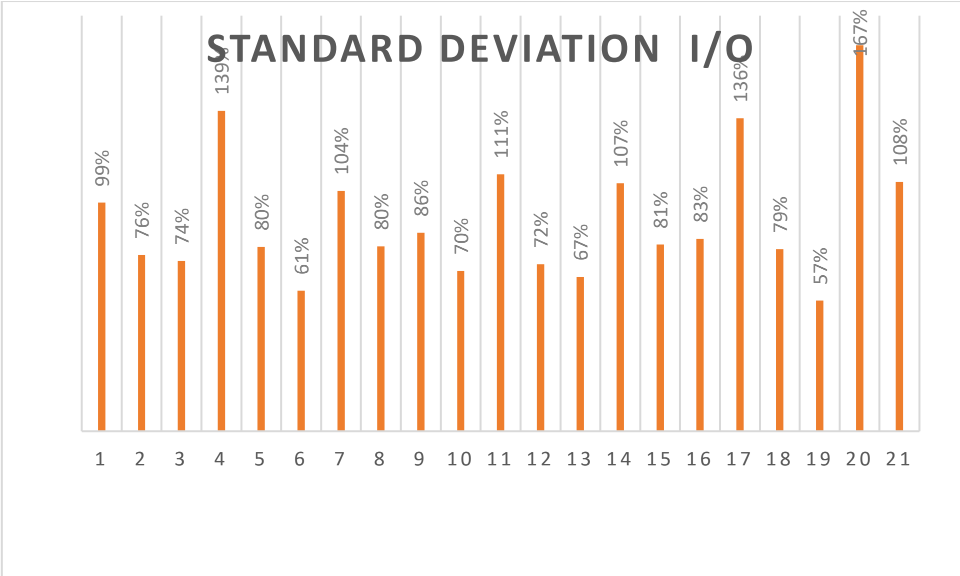


Fig 66: Clustered column chart of Standard Deviation I/O of Exp-2

6.4 Comparison between the simulation models

Comparing the results of both simulation models when perform order picking, it was verified that both the models shown better results but picking outside the warehouse simulation presents a better performance than the picking inside the warehouse simulation in all scenarios analysed. Additionally, the picking outside the warehouse simulation model is less impacted by an increase in the number of SKU's stored. Which shows that this model works better than the other model in warehouses that deals with a higher number of SKU's.

Regarding the order inter arrival time as verified by the results, it also shows a higher performance than the first model when the order arrival rate increases. For smaller arrival rate the system does not present good performance in relation to the quantity of orders completed. This happens because both the models are able to build the mixed pallets during the interval between arrivals. The higher the arrival rate the more performance is shown.

About the robotic arm picking, it is a crucial variable for both the models to measure the performance. As the travelling process are connected to the picking and palletizing the items from the rack. When the results are verified it has shown that robotic arm picking items and making a mixed pallet outside the warehouse has better performance than the inside the warehouse, because storing the items in the cache zone and picking the ordered items from the cache zone happens simultaneously. So, this model can execute both the process at the same time.

Besides, in the simulation model maximum and minimum number of sku's are stored based on the order requirements. As a conclusion both the simulation models were developed in this study, the results show that the second model tends to work better than the first one when the operation involves a high quantity of SKU's.

7.Conclusions

This study was designed to compare the features of euro fork's system with the new autonomous vehicle storage and retrieval system (AVS/RS) system and evaluate their performance to make comparisons between the two simulation models. As the demand for mixed pallets by warehouse customers increases, a new system was developed and designed. The "Eurofork" an Italian company wishes to combine the picking and palletizing processes in a better way to streamline the warehouse operations.

On both systems, order picking operations are mandatory and are performed by robotic arm. In the new system the order picking process occurs in front of storage racks and in the cache zone. In the new system, picking operations show impact on overall performance compared to eurofork's system as two simulation models are used to build mix pallets inside and outside the warehouse.

This is why the new system's performance was measured through simulation to perform its operation in a virtual warehouse, and the experiment results were used to make comparison and evaluation between the two simulation models to verify whether the new system will outperform the euro fork's system. Simulations were conducted under different scenarios to see how the variables impact on its performance and how the performance measures were calculated to get the output data to be compared.

In the end, experiments were conducted on two simulation models in order to compare which model gave better results. A quantitative analysis was done in determining which of the simulation models performs better, taking into consideration the data from all the scenarios and performance measures. Their results demonstrate that the new system has demonstrated superior results in order picking both inside and outside the warehouse.

However, the picking outside of the warehouse simulation model has better performance than the inside warehouse as it involves order picking operation with high quantity of sku. However, both the simulation models are equally good as they are not manually tested and examined, so we can implement both the models as per company needs.

However, the picking outside of the warehouse simulation model has better performance than the inside warehouse as it involves order picking operation with high quantity of sku. However, both the simulation models are equally good as they are not manually tested and examined, so we can implement both the models as per company needs.

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Appendix

```
/////////////////TO RANDOMIZE SLOTS/////////////////
int Nrack = 1;
int Nbays = 20;
int Nlevels = 10;
int Nslots = 2;

string SNodeA;
string SNodeB;

int value;


for(int Crack=1;Crack<=Nrack;Crack++)
{
for(int Cbays=1; Cbays<=Nbays; Cbays++)
 {
       for(int Clevels=1; Clevels<=Nlevels; Clevels++)
       {
              for(int Cslots=1; Cslots<=Nslots; Cslots++)
              {

              value = duniform(1,20);




              SNodeA =
concat("/Rack",numtostring(Crack),">variables/bays/",numtostring(Cbays),"/levels/",
numtostring(Clevels),"/slots/",numtostring(Cslots),"/slotLabels/Sku");
              treenode NodeA = model().find(SNodeA);
              NodeA.value = value;

              SNodeB =
concat("/Rack",numtostring(Crack),">variables/bays/",numtostring(Cbays),"/levels/",
numtostring(Clevels),"/slots/",numtostring(Cslots),"/resetLabels/Sku");
              treenode NodeB = model().find(SNodeB);
              NodeB.value = value;
              }
       }

 }
}
return 0;


/////////////////ONE BAY FOR SKU/////////////////


int Nrack = 2;
int Nbays = 20;
int Nlevels = 10;
int Nslots = 2;

string SNodeA;
string SNodeB;

int value;


for(int Crack=1; Crack<=Nrack; Crack++)
{
       for(int Cbays=1; Cbays<=Nbays; Cbays++)
       {
              for(int Clevels=1; Clevels<=Nlevels; Clevels++)
```

```
                {
                        for(int Cslots=1; Cslots<=Nslots; Cslots++)
                        {

                        value = Cbays;


                        SNodeA =
concat("/Rack",numtostring(Crack),">variables/bays/",numtostring(Cbays),"/levels/",
numtostring(Clevels),"/slots/",numtostring(Cslots),"/slotLabels/Sku");
                        treenode NodeA = model().find(SNodeA);
                        NodeA.value = value;

                        SNodeB =
concat("/Rack",numtostring(Crack),">variables/bays/",numtostring(Cbays),"/levels/",
numtostring(Clevels),"/slots/",numtostring(Cslots),"/resetLabels/Sku");
                        treenode NodeB = model().find(SNodeB);
                        NodeB.value = value;
                        }
                }

        }
}
return 0;
```

Experimentation Report

Number of Scenarios:	34
Number of Replications Per Scenario:	12
Warmup Time:	0

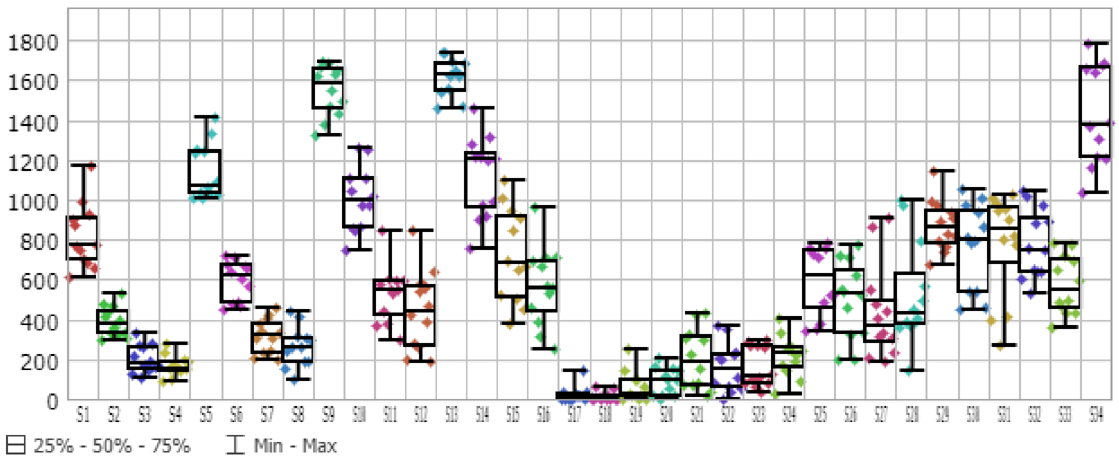
ASRS distance

Summary

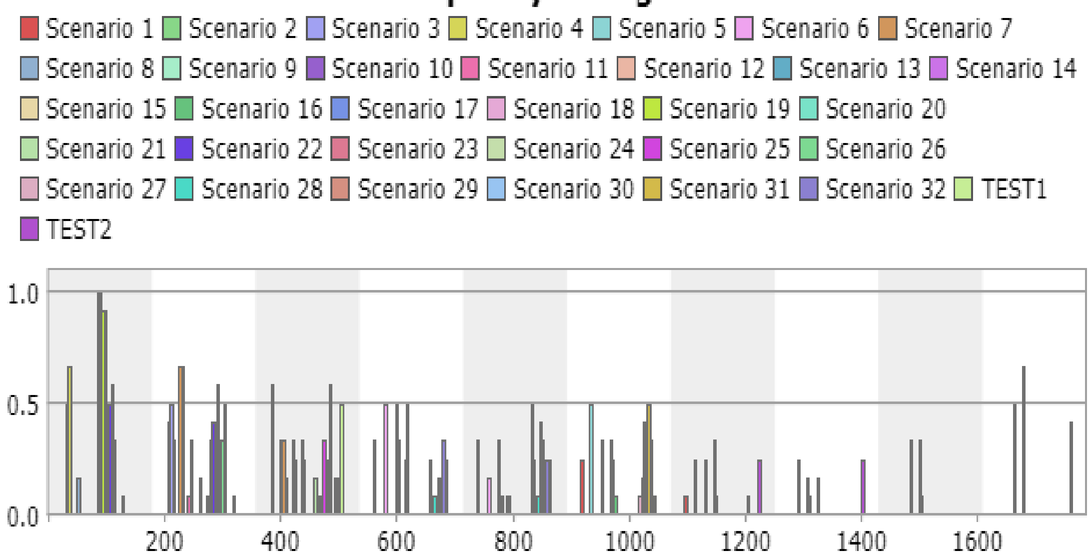
	Mean (90% Confidence)					Sample Std Dev	Min	Max
Scenario 1	735	<	818	<	901	160	615	1172
Scenario 2	351	<	390	<	430	76	301	533
Scenario 3	167	<	203	<	239	69	111	331
Scenario 4	141	<	168	<	194	51	92	275
Scenario 5	1072	<	1146	<	1219	142	1006	1417
Scenario 6	543	<	595	<	647	101	450	724
Scenario 7	273	<	318	<	363	87	194	457
Scenario 8	212	<	265	<	317	102	95	443
Scenario 9	1485	<	1551	<	1617	127	1328	1692

Scenario 10	922	<	1005	<	1088	161	749	1264
Scenario 11	454	<	528	<	603	143	299	846
Scenario 12	345	<	448	<	552	199	191	849
Scenario 13	1569	<	1617	<	1666	93	1462	1738
Scenario 14	1012	<	1119	<	1227	207	756	1461
Scenario 15	601	<	723	<	845	236	381	1099
Scenario 16	465	<	568	<	670	198	251	962
Scenario 17	2	<	23	<	45	42	0	148
Scenario 18	3	<	14	<	26	23	0	63
Scenario 19	23	<	62	<	101	75	0	250
Scenario 20	57	<	92	<	127	68	0	210
Scenario 21	126	<	204	<	282	150	20	434
Scenario 22	96	<	160	<	224	123	0	370
Scenario 23	111	<	165	<	218	103	32	298
Scenario 24	163	<	216	<	270	103	24	407
Scenario 25	501	<	592	<	683	175	340	788
Scenario 26	394	<	497	<	599	198	199	774
Scenario 27	314	<	437	<	560	237	189	909
Scenario 28	393	<	529	<	665	262	149	1001
Scenario 29	805	<	873	<	940	130	673	1146
Scenario 30	655	<	767	<	880	217	454	1053
Scenario 31	639	<	775	<	912	264	273	1028
Scenario 32	690	<	781	<	873	176	528	1041
TEST1	498	<	574	<	650	146	362	787
TEST2	1298	<	1428	<	1558	251	1032	1786

Replications Plot



Frequency Histogram



Raw Data

	1	2	3	4	5	6	7	8	9	10	11	12
Scenario 1	614.683348	898.383348	873.783348	770.133348	746.033348	987.983348	704.533348	684.533348	927.933348	1172.383348	660.433348	778.133348
Scenario 2	300.833348	476.083348	412.483348	431.283348	332.783348	470.983348	360.183348	327.883348	400.783348	533.208348	330.483348	305.583348
Scenario 3	123.733348	219.933348	331.483348	270.683348	110.683348	257.333348	171.483348	144.883348	189.633348	282.133348	158.833348	170.033348
Scenario 4	92.133348	231.783348	275.483348	155.308348	98.533348	168.833348	151.633348	157.233348	139.783348	194.233348	156.683348	192.783348
Scenario 5	1009.433348	1234.833348	1256.183348	1035.683348	1005.783348	1241.783348	1062.233348	1040.333348	1329.883348	1416.758348	1089.333348	1025.233348

Scenario 6	449.733348	723.733348	678.833348	636.583348	481.633348	714.433348	488.983348	465.383348	606.733348	670.833348	653.633348	571.783348
Scenario 7	206.733348	302.183348	374.383348	341.683348	231.283348	404.683348	419.783348	239.933348	306.983348	457.183348	193.983348	337.133348
Scenario 8	151.183348	242.033348	442.683348	265.733348	95.483348	317.433348	417.183348	257.933348	188.833348	306.433348	192.233348	297.033348
Scenario 9	1327.633348	1624.808348	1665.708348	1692.283348	1377.933348	1688.233348	1469.133348	1550.933348	1635.033348	1652.233348	1434.583348	1491.683348
Scenario 10	748.933348	1109.233348	1047.083348	858.933348	846.583348	1263.733348	863.833348	971.283348	1110.933348	1248.783348	974.583348	1016.783348
Scenario 11	371.133348	579.183348	846.133348	444.033348	377.683348	604.283348	551.383348	529.533348	593.383348	546.408348	299.483348	598.683348
Scenario 12	194.033348	423.133348	849.433348	276.783348	260.533348	540.133348	582.633348	561.783348	389.983348	468.483348	191.283348	641.933348
Scenario 13	1462.233348	1542.633348	1737.483348	1738.133348	1555.933348	1624.233348	1691.533348	1644.733348	1635.383348	1619.583348	1469.383348	1688.333348
Scenario 14	756.183348	1282.983348	1461.133348	1215.283348	902.783348	1212.633348	976.783348	914.983348	1202.183348	1314.783348	988.383348	1204.683348
Scenario 15	520.483348	1007.583348	1098.633348	693.533348	380.733348	943.083348	849.233348	503.933348	644.783348	913.283348	451.133348	669.633348
Scenario 16	457.883348	692.083348	962.483348	386.733348	318.733348	665.233348	710.183348	569.333348	533.983348	556.683348	250.933348	710.833348
Scenario 17	0	34.338348	0	0	0	0	23.938348	19.538348	21.338348	147.968348	0	34.338348
Scenario 18	0	3.333348	63.348348	7.733348	0	19.538348	0	21.471652	0	57.481652	0	0
Scenario 19	0	142.768348	249.988348	23.938348	19.538348	95.758348	100.158348	0	19.538348	66.881652	0	26.538348
Scenario 20	19.538348	159.168348	209.778348	0	19.538348	118.158348	100.758348	57.148348	150.901652	19.538348	103.086652	144.568348
Scenario 21	75.348348	308.503348	322.536652	227.116652	69.348348	422.028348	82.453348	154.773348	293.493348	433.833348	19.738348	36.938348
Scenario 22	77.481652	370.323348	207.911652	195.978348	0	351.208348	60.548348	31.738348	224.988348	237.188348	103.691652	55.548348

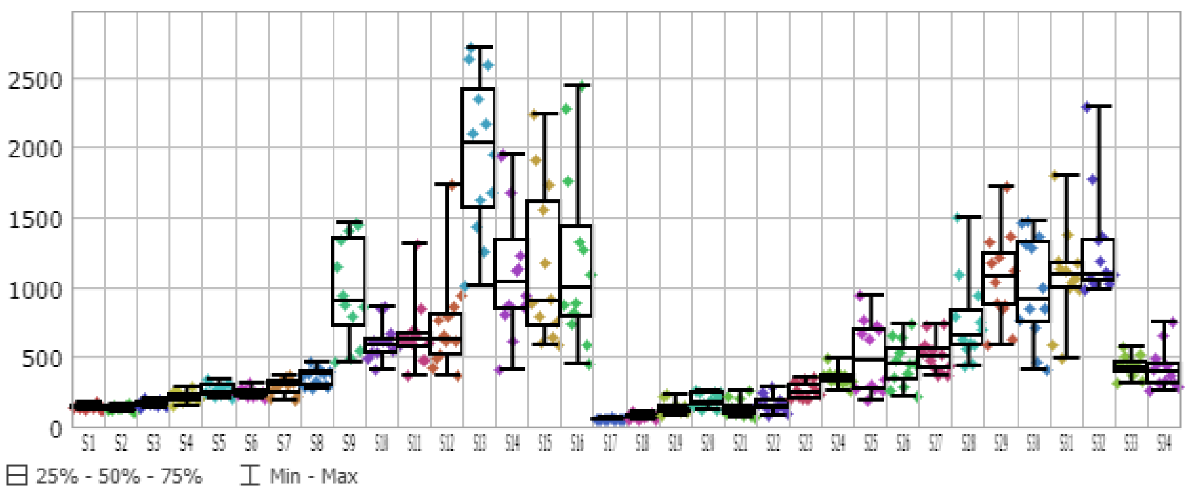
Scenario 23	80.548348	286.131652	268.998348	101.758348	62.548348	274.398348	105.491652	31.738348	261.798348	298.198348	77.948348	125.958348
Scenario 24	23.938348	407.028348	335.808348	168.706652	147.168348	255.193348	274.598348	236.588348	193.578348	224.578348	87.548348	240.388348
Scenario 25	340.008348	754.313348	745.908348	730.303348	355.646652	715.608348	379.428348	482.381652	761.108348	787.518348	525.253348	526.196652
Scenario 26	198.711652	722.736652	546.853348	540.553348	457.343348	715.898348	326.313348	202.378348	621.178348	774.308348	523.653348	333.008348
Scenario 27	211.711652	552.491652	866.118348	476.543348	404.818348	314.408348	333.951652	189.178348	441.038348	908.728348	307.598348	236.321652
Scenario 28	364.351652	1001.348348	976.633348	387.751652	148.501652	365.846652	450.628348	386.941652	405.618348	792.008348	494.838348	571.058348
Scenario 29	673.126652	991.163348	1145.988348	975.863348	795.756652	896.143348	739.408348	761.518348	825.928348	936.143348	907.843348	821.528348
Scenario 30	453.543348	1053.473348	969.396652	811.323348	539.858348	788.318348	792.708348	537.658348	934.976652	1005.263348	862.133348	459.443348
Scenario 31	400.766652	1008.658348	980.348348	948.548348	273.331652	806.113348	955.453348	413.333348	898.033348	1028.263348	816.118348	775.846652
Scenario 32	604.863348	1040.963348	1021.753348	754.336652	528.291652	645.573348	880.228348	643.611652	636.406652	976.348348	748.631652	893.861652
TEST1	362.133348	786.583348	644.283348	489.783348	464.083348	717.933348	435.283348	498.633348	774.083348	694.233348	429.133348	594.983348
TEST2	1031.758348	1659.906652	1785.716652	1370.366652	1164.388348	1641.363348	1220.598348	1304.836652	1678.973348	1680.688348	1207.721652	1388.333348

Mean Service Time

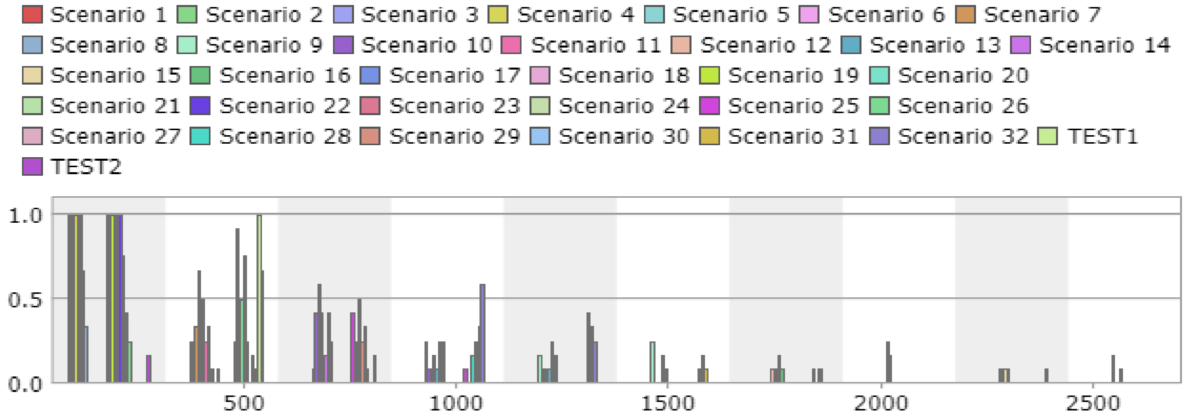
Summary								
	Mean (90% Confidence)					Sample Std Dev	Min	Max
Scenario 1	133.5	<	141.2	<	149.0	14.9	116.4	171.9
Scenario 2	128.4	<	137.5	<	146.5	17.5	110.7	169.4
Scenario 3	160.3	<	169.2	<	178.1	17.2	139.9	204.0
Scenario 4	194.1	<	212.8	<	231.5	36.1	148.3	279.7
Scenario 5	240.1	<	263.5	<	286.8	45.0	199.1	344.6

Scenario 6	225.3	<	240.6	<	255.8	29.4	203.5	309.3
Scenario 7	257.3	<	287.1	<	317.0	57.5	184.6	362.0
Scenario 8	326.9	<	359.2	<	391.6	62.4	272.8	465.0
Scenario 9	785.3	<	979.0	<	1172.8	373.7	464.6	1462.6
Scenario 10	537.1	<	604.8	<	672.5	130.5	414.8	854.5
Scenario 11	537.7	<	661.2	<	784.7	238.2	371.0	1314.5
Scenario 12	544.0	<	731.7	<	919.3	361.9	365.1	1738.3
Scenario 13	1666.8	<	1959.3	<	2251.9	564.2	1009.9	2707.4
Scenario 14	872.4	<	1130.0	<	1387.6	496.8	408.3	1954.3
Scenario 15	853.0	<	1148.6	<	1444.3	570.3	588.1	2239.3
Scenario 16	875.2	<	1209.1	<	1542.9	643.9	454.9	2446.9
Scenario 17	51.7	<	54.8	<	57.9	6.0	48.1	69.0
Scenario 18	67.6	<	74.6	<	81.6	13.5	58.5	105.4
Scenario 19	115.7	<	139.7	<	163.7	46.3	76.0	236.3
Scenario 20	166.9	<	191.3	<	215.7	47.0	128.0	254.7
Scenario 21	102.0	<	133.1	<	164.2	60.0	71.2	257.6
Scenario 22	135.1	<	166.3	<	197.5	60.3	83.6	291.6
Scenario 23	229.0	<	258.8	<	288.6	57.5	198.5	354.4
Scenario 24	324.8	<	354.2	<	383.7	56.9	262.8	497.5
Scenario 25	373.0	<	505.7	<	638.5	256.1	195.8	944.1
Scenario 26	367.7	<	452.1	<	536.5	162.9	223.2	735.2
Scenario 27	446.3	<	510.9	<	575.5	124.6	368.3	730.7
Scenario 28	596.1	<	752.2	<	908.4	301.2	436.6	1495.8
Scenario 29	897.5	<	1065.2	<	1232.8	323.4	584.9	1712.8
Scenario 30	797.1	<	993.1	<	1189.2	378.2	414.3	1472.9
Scenario 31	902.6	<	1077.3	<	1251.9	336.9	485.1	1796.0
Scenario 32	1073.8	<	1275.8	<	1477.9	389.7	982.2	2294.4
TEST1	392.2	<	431.4	<	470.6	75.6	315.3	572.6
TEST2	345.2	<	422.2	<	499.3	148.6	265.9	754.1

Replications Plot



Frequency Histogram



Raw Data

	1	2	3	4	5	6	7	8	9	10	11	12
Scenario 1	135.865109	149.654143	142.825734	143.716831	127.128866	147.573463	149.450287	142.299865	147.483646	171.916126	116.396688	120.688766
Scenario 2	122.823783	138.670235	123.931895	152.644735	132.800473	140.601962	142.80229	146.151495	155.223947	169.394727	110.704455	113.722836
Scenario 3	139.9467	176.316886	204.037555	175.927227	165.819749	178.368495	162.955511	156.081063	184.71135	178.209577	156.304819	151.676241
Scenario 4	148.257776	252.723898	255.686159	193.891456	180.422677	220.208465	206.546645	199.531581	279.716064	218.160694	189.592783	209.041856
Scenario 5	249.973539	344.550141	318.445357	225.084045	217.068598	267.310532	232.025294	292.754155	249.699919	314.0396	251.81335	199.051101
Scenario 6	227.807248	255.107936	272.313668	253.854917	215.588946	309.273205	212.077283	240.428671	225.444031	227.001328	244.293891	203.490248

Scenario 7	211.38151	252.597634	292.769277	296.871671	306.891115	339.04996	358.370386	297.5722	361.992125	319.099659	184.641828	224.202045
Scenario 8	370.943109	288.285244	384.315077	465.030612	272.802415	328.500173	427.436586	399.246995	386.8328	304.632287	283.006447	399.476161
Scenario 9	464.639664	1145.158741	1332.035283	941.610497	871.308672	1399.566514	491.43515	789.520616	1462.604295	1447.614417	546.191189	856.403419
Scenario 10	493.681725	528.768591	607.202425	414.825882	525.63113	839.748984	609.200442	854.511622	602.430832	670.66502	545.916013	564.92483
Scenario 11	635.249286	614.460684	642.251317	371.048932	597.735313	692.887543	659.424172	1314.536349	848.578334	476.467047	483.485693	598.350179
Scenario 12	423.423249	497.055655	761.696275	524.479112	650.281663	613.936992	794.205611	1738.33507	856.232691	611.930055	365.082101	943.343283
Scenario 13	1009.917205	2632.742841	2707.393505	2105.831109	1435.950781	2349.777684	1616.328011	1255.872667	2172.062887	2595.191537	1681.470749	1949.536929
Scenario 14	408.3155	1942.32337	1954.266247	809.64983	875.985762	1683.392645	614.411506	1117.149053	1126.491595	1223.022045	861.822317	943.090111
Scenario 15	892.822131	2239.322434	1909.114542	791.792967	597.322049	1559.931351	1179.70043	1736.020583	908.113784	635.564115	745.802471	588.129185
Scenario 16	869.439639	2274.894889	1759.006072	730.375096	815.715863	888.577624	1327.487947	2446.918026	1264.824163	586.543595	454.920531	1089.915458
Scenario 17	48.074273	58.687995	52.952607	54.090987	59.055277	48.661247	68.970813	55.330041	50.988697	59.704011	49.407533	51.955687
Scenario 18	60.331746	74.386686	105.384526	67.358546	61.033449	73.588304	70.629772	78.637485	75.849428	92.461547	76.994875	58.518219
Scenario 19	76	217.239995	236.261575	116.204089	129.25	149.961924	153.342676	118.125514	113.243746	150.16846	109.2	107.538462
Scenario 20	149.333333	254.700262	251.746614	128	168.666667	168.808646	167.492566	195.875856	241.124296	128	198	243.6
Scenario 21	96.704291	220.090931	134.102903	122.019012	95.080445	198.295423	116.121675	82.572518	121.870077	257.607478	81.642223	71.21624
Scenario 22	168.755529	244.967805	202.38744	139.111945	83.64377	291.599763	132.079595	129.144624	189.102835	181.909564	137.519289	95.425789
Scenario 23	208.256394	329.838454	252.70093	222.570253	198.5	339.471619	206.627995	205.625639	296.592728	354.429991	265.750581	225.367532

Scenario 24	368.346122	497.452412	377.133837	333.142857	373.666667	324.327648	385.480782	319.848613	363.346518	322.092484	262.789014	323.167205
Scenario 25	274.030115	944.087388	673.719293	764.855086	195.779254	626.57681	301.176287	277.015606	727.956256	691.035905	252.536929	340.189611
Scenario 26	259.376724	649.971545	355.696006	477.592919	525.411717	638.520814	288.182799	375.264664	451.630323	735.242355	445.177837	223.207134
Scenario 27	537.506394	590.70308	727.29418	484.049632	548.326457	428.060729	374.104882	392.527326	518.229574	730.663359	368.30154	431.154003
Scenario 28	794.012788	1495.80745	1088.439515	621.733391	436.583496	564.745448	597.49574	449.989989	589.719374	937.019646	750.969363	700.200774
Scenario 29	584.945988	1324.914128	1171.665546	1030.015792	888.883345	1220.625974	842.196311	879.574228	1712.849105	1367.151716	634.003731	1125.088301
Scenario 30	765.344101	1464.868524	1308.015053	1472.900242	838.952655	1282.471975	703.994038	461.820647	1364.313891	999.81683	840.666388	414.326935
Scenario 31	584.293022	1796.009898	1185.452392	1129.368592	485.145133	1120.594717	1384.279177	998.263262	1032.284031	1057.707863	1173.738246	979.87041
Scenario 32	982.211036	2294.414249	1059.771017	1777.317166	1018.28784	1331.863717	1184.89973	1358.950449	1106.660807	1084.52108	1023.6	1087.554971
TEST1	315.280537	449.239835	572.624224	505.736614	422.953169	422.102604	370.370707	443.742972	418.613539	522.357357	329.551951	403.762488
TEST2	265.9095	414.182787	484.904491	445.760914	318.979218	651.376257	329.824879	430.349897	364.124984	754.130073	317.344561	290.093148

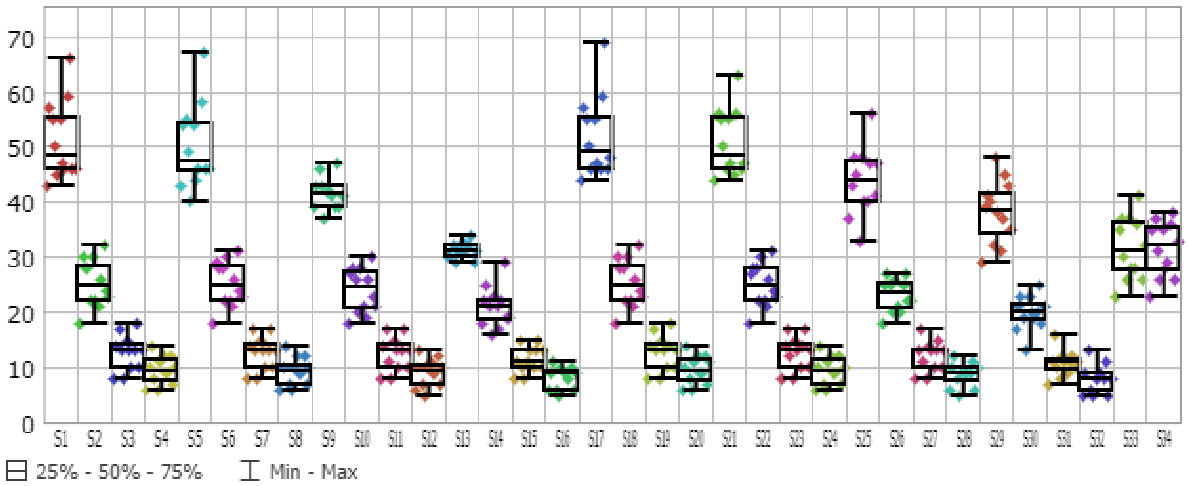
Output

Summary

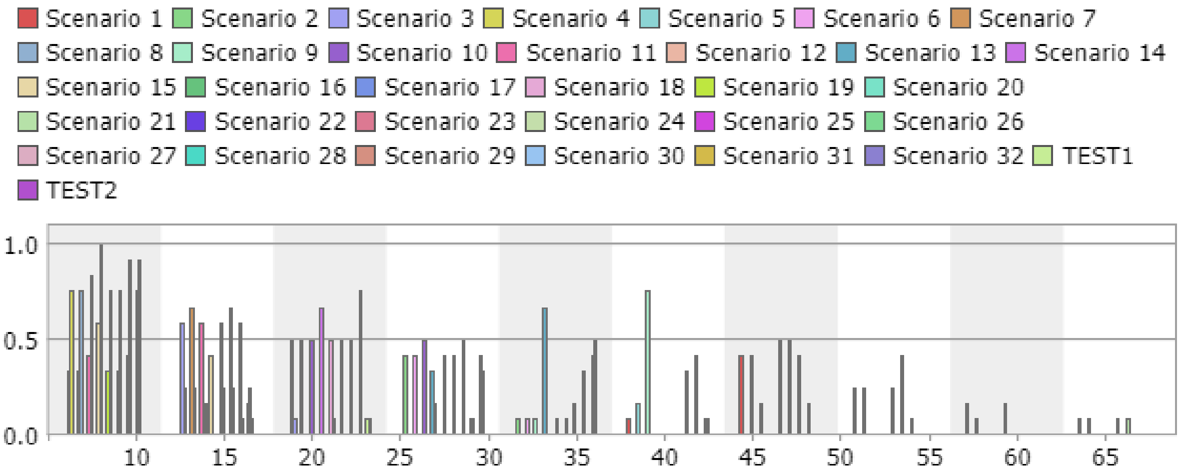
	Mean (90% Confidence)					Sample Std Dev	Min	Max
Scenario 1	47.59	<	51.25	<	54.91	7.06	43.00	66.00
Scenario 2	23.10	<	25.33	<	27.57	4.31	18.00	32.00
Scenario 3	11.01	<	12.67	<	14.33	3.20	8.00	18.00
Scenario 4	8.20	<	9.50	<	10.80	2.50	6.00	14.00
Scenario 5	46.20	<	50.17	<	54.13	7.65	40.00	67.00
Scenario 6	23.05	<	25.17	<	27.29	4.09	18.00	31.00
Scenario 7	11.00	<	12.58	<	14.17	3.06	8.00	17.00
Scenario 8	8.02	<	9.33	<	10.65	2.53	6.00	14.00
Scenario 9	40.06	<	41.58	<	43.11	2.94	37.00	47.00

Scenario 10	21.81	<	23.92	<	26.02	4.06	18.00	30.00
Scenario 11	10.82	<	12.42	<	14.02	3.09	8.00	17.00
Scenario 12	7.82	<	9.08	<	10.34	2.43	5.00	13.00
Scenario 13	30.30	<	31.08	<	31.86	1.51	29.00	34.00
Scenario 14	19.12	<	21.00	<	22.88	3.62	16.00	29.00
Scenario 15	10.18	<	11.42	<	12.66	2.39	8.00	15.00
Scenario 16	7.16	<	8.17	<	9.18	1.95	5.00	11.00
Scenario 17	48.01	<	51.83	<	55.65	7.37	44.00	69.00
Scenario 18	23.10	<	25.33	<	27.57	4.31	18.00	32.00
Scenario 19	11.08	<	12.75	<	14.42	3.22	8.00	18.00
Scenario 20	8.27	<	9.58	<	10.90	2.54	6.00	14.00
Scenario 21	47.73	<	50.83	<	53.93	5.98	44.00	63.00
Scenario 22	22.95	<	25.00	<	27.05	3.95	18.00	31.00
Scenario 23	10.98	<	12.58	<	14.18	3.09	8.00	17.00
Scenario 24	8.08	<	9.42	<	10.75	2.57	6.00	14.00
Scenario 25	40.60	<	43.75	<	46.90	6.08	33.00	56.00
Scenario 26	21.59	<	23.17	<	24.74	3.04	18.00	27.00
Scenario 27	10.66	<	12.08	<	13.51	2.75	8.00	17.00
Scenario 28	7.58	<	8.67	<	9.76	2.10	5.00	12.00
Scenario 29	35.19	<	38.17	<	41.15	5.75	29.00	48.00
Scenario 30	18.29	<	19.92	<	21.55	3.15	13.00	25.00
Scenario 31	9.49	<	10.67	<	11.84	2.27	7.00	16.00
Scenario 32	6.71	<	8.00	<	9.29	2.49	5.00	13.00
TEST1	28.69	<	31.58	<	34.48	5.58	23.00	41.00
TEST2	28.84	<	31.42	<	33.99	4.96	23.00	38.00

Replications Plot



Frequency Histogram



Raw Data

	1	2	3	4	5	6	7	8	9	10	11	12
Scenario 1	43	57	55	50	45	55	47	46	59	66	46	46
Scenario 2	18	30	28	28	22	30	22	21	26	32	24	23
Scenario 3	8	14	17	13	8	15	13	10	13	18	10	13
Scenario 4	6	10	14	8	6	11	12	9	9	12	7	10
Scenario 5	43	54	55	49	40	54	44	46	58	67	46	46
Scenario 6	18	29	28	28	22	30	22	21	26	31	24	23
Scenario 7	8	14	17	13	8	15	13	10	13	17	10	13
Scenario 8	6	10	14	7	6	10	12	9	9	12	7	10
Scenario 9	39	43	46	43	37	42	42	41	39	47	39	41

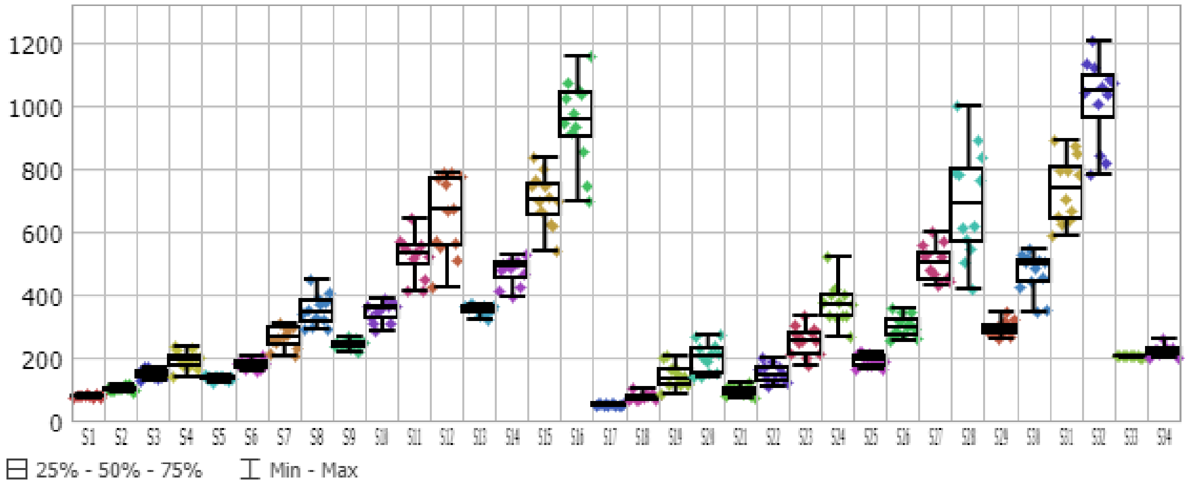
Scenario 10	18	27	28	26	20	28	21	19	26	30	23	21
Scenario 11	8	14	17	11	8	15	13	10	13	17	10	13
Scenario 12	6	10	13	7	5	10	11	9	9	12	7	10
Scenario 13	30	30	32	29	31	31	33	31	32	34	29	31
Scenario 14	18	22	25	21	16	23	21	17	22	29	19	19
Scenario 15	8	11	15	10	8	11	13	10	13	15	10	13
Scenario 16	6	9	11	6	5	10	9	9	8	10	6	9
Scenario 17	44	57	55	50	46	55	47	46	59	69	46	48
Scenario 18	18	30	28	28	22	30	22	21	26	32	24	23
Scenario 19	8	14	17	13	8	15	13	10	14	18	10	13
Scenario 20	6	10	14	8	6	11	12	9	9	12	7	11
Scenario 21	44	56	55	50	46	55	47	45	56	63	46	47
Scenario 22	18	27	28	28	22	30	22	21	26	31	24	23
Scenario 23	8	14	17	12	8	15	13	10	14	17	10	13
Scenario 24	6	10	14	7	6	11	12	9	9	12	7	10
Scenario 25	37	43	48	45	33	48	40	40	47	56	41	47
Scenario 26	18	25	27	25	20	26	21	20	25	27	22	22
Scenario 27	8	13	17	11	8	14	13	10	13	15	10	13
Scenario 28	6	10	12	8	5	9	9	9	9	11	6	10
Scenario 29	29	39	41	40	32	48	38	31	37	45	43	35
Scenario 30	17	21	23	19	13	23	20	19	20	25	18	21
Scenario 31	7	11	16	10	8	12	11	9	11	12	10	11
Scenario 32	5	9	13	6	5	8	9	9	8	11	5	8
TEST1	23	35	37	30	26	37	28	28	36	41	26	32
TEST2	23	35	37	31	26	35	28	29	36	38	26	33

Mean Picking Time

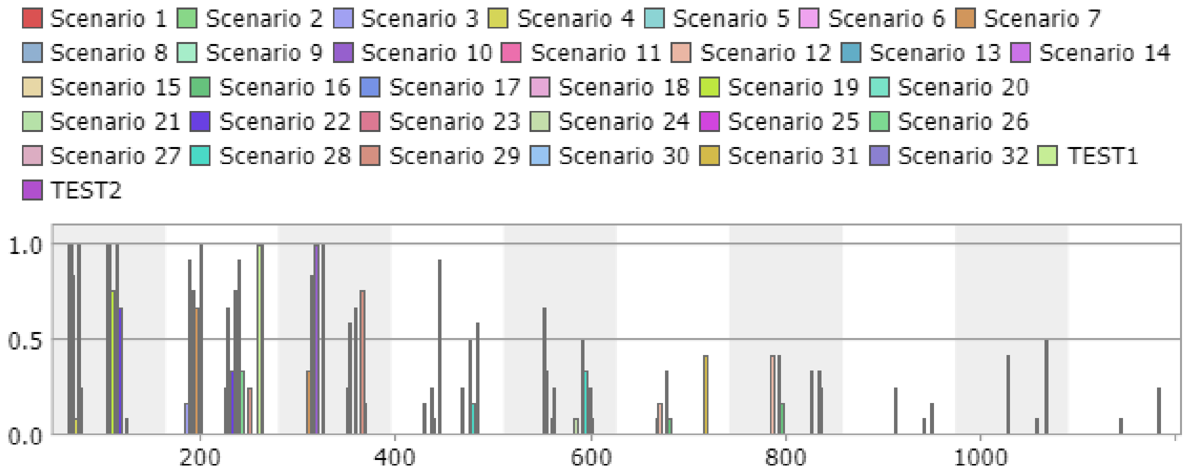
Summary								
	Mean (90% Confidence)					**Sample Std Dev**	**Min**	**Max**
Scenario 1	77.5	<	79.4	<	81.3	3.7	73.4	85.0
Scenario 2	97.3	<	100.9	<	104.6	7.0	89.3	112.6
Scenario 3	141.9	<	148.1	<	154.3	11.9	130.0	168.8
Scenario 4	177.7	<	192.3	<	206.9	28.1	139.5	238.6
Scenario 5	132.1	<	135.7	<	139.2	6.9	122.9	143.2
Scenario 6	171.7	<	179.0	<	186.2	14.0	158.7	205.9
Scenario 7	245.3	<	263.4	<	281.4	34.8	204.2	311.5
Scenario 8	325.3	<	351.0	<	376.7	49.6	288.6	449.1

Scenario 9	237.7	<	244.7	<	251.7	13.5	216.0	264.6
Scenario 10	329.9	<	346.0	<	362.1	31.0	286.9	387.9
Scenario 11	487.1	<	521.7	<	556.4	66.9	413.2	640.8
Scenario 12	589.0	<	653.8	<	718.6	125.0	425.5	790.0
Scenario 13	346.9	<	355.0	<	363.2	15.7	321.9	372.6
Scenario 14	452.9	<	474.8	<	496.7	42.2	396.1	529.2
Scenario 15	660.6	<	703.9	<	747.1	83.4	538.7	837.5
Scenario 16	882.2	<	951.8	<	1021.4	134.2	696.2	1158.5
Scenario 17	49.7	<	50.8	<	51.9	2.1	47.5	54.2
Scenario 18	69.3	<	75.4	<	81.5	11.8	64.1	106.0
Scenario 19	123.7	<	142.2	<	160.8	35.8	86.4	203.8
Scenario 20	176.6	<	200.7	<	224.8	46.5	140.7	271.6
Scenario 21	87.9	<	95.2	<	102.5	14.1	74.9	118.9
Scenario 22	135.3	<	150.2	<	165.1	28.8	107.1	201.3
Scenario 23	229.1	<	253.4	<	277.7	46.8	175.4	333.4
Scenario 24	338.2	<	370.8	<	403.3	62.8	267.7	519.5
Scenario 25	182.5	<	193.2	<	203.8	20.6	160.9	220.1
Scenario 26	282.5	<	300.2	<	317.9	34.2	253.5	356.0
Scenario 27	471.2	<	500.8	<	530.4	57.1	428.8	599.2
Scenario 28	604.6	<	696.0	<	787.3	176.1	417.3	1003.0
Scenario 29	281.3	<	294.1	<	307.0	24.8	262.1	347.2
Scenario 30	434.2	<	468.1	<	502.1	65.5	344.5	544.1
Scenario 31	684.2	<	738.0	<	791.8	103.8	590.6	889.1
Scenario 32	948.5	<	1018.0	<	1087.5	134.1	780.7	1206.6
TEST1	204.1	<	205.1	<	206.1	1.9	201.4	207.5
TEST2	214.5	<	222.6	<	230.8	15.7	202.0	261.4

Replications Plot



Frequency Histogram



Raw Data												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Scenario 1	73.430053	81.581351	80.050465	79.379568	77.323454	84.53212	79.130159	74.918366	78.613703	84.971822	75.681144	82.641007
Scenario 2	103.280532	95.051585	97.745541	95.604992	104.18053	100.239526	101.927936	112.646643	103.772304	112.623501	89.271646	94.987551
Scenario 3	130.001348	154.528658	168.757378	166.914099	155.348948	150.557588	136.945029	135.268703	148.527295	141.587921	144.985197	143.623189
Scenario 4	139.510117	238.589899	222.580454	195.407996	176.450836	187.190134	172.494549	182.984116	229.416398	198.199955	166.695967	198.215625

Scenario 5	143.237412	130.601995	141.06914	122.911922	139.835704	141.277368	138.162383	139.408914	130.653211	124.68433	141.400753	134.716827
Scenario 6	180.775912	173.68146	186.126434	162.19147	172.943376	195.63463	178.844053	185.654214	158.748703	162.690628	205.929431	184.361095
Scenario 7	214.371773	253.35191	246.701888	262.882315	311.528532	267.498146	296.832642	275.04468	296.822706	299.703689	204.175297	231.559703
Scenario 8	342.0096	288.558596	348.969087	449.094624	298.128341	329.220822	388.938062	369.733544	322.955411	376.44424	290.216346	407.938228
Scenario 9	234.486535	251.513298	242.306666	245.216753	249.694953	264.619957	228.996279	250.719092	261.285912	215.987203	241.044763	250.630309
Scenario 10	361.608443	330.485044	308.774079	286.948924	345.526955	357.733996	364.748128	387.85622	361.48245	306.554356	374.2923	366.171976
Scenario 11	573.048281	558.485756	546.937213	413.166286	640.805854	516.730191	534.730838	536.322901	558.107437	415.278411	447.478986	519.462547
Scenario 12	425.455971	572.966353	767.86692	554.768495	787.76722	750.251764	668.245871	789.983393	675.77409	561.657076	512.5501	777.844919
Scenario 13	366.138921	359.918272	372.591415	369.339907	360.217926	349.104761	334.898798	366.839154	340.656724	321.874589	352.192894	366.774481
Scenario 14	409.711743	481.588874	497.783217	491.910066	503.405923	486.247444	396.082824	505.474186	503.730864	423.931466	468.235723	529.233719
Scenario 15	744.419195	837.485687	765.025123	696.50088	666.43053	799.210579	747.138574	711.257101	622.907223	620.365641	538.690481	697.215052
Scenario 16	945.532448	1024.789545	1074.606464	916.913025	975.710732	935.711143	1052.156857	1036.70084	856.408569	748.748145	696.150305	1158.515243
Scenario 17	47.770492	52.021978	51.846154	49.272727	52.666667	47.463415	52.657143	54.169014	49.069767	50.90566	49.529412	51.72973
Scenario 18	67.043478	70.734694	106	65.02439	66	72.297872	71	83.69697	76.8	84.745098	77.282051	64.068966
Scenario 19	86.444444	199.75	203.84	112.947368	163.090909	166.909091	150.181818	131.6	114.8	137.62963	123	116.588235
Scenario 20	142	267.75	229.047619	140.666667	200.222222	187.777778	153.666667	211.846154	238	152.117647	213.333333	271.647059
Scenario 21	79.019231	106.696296	98.715328	101.0722	88.150943	111.934211	92.163934	84.361905	105.862595	118.893082	80.579439	74.932039

Scenario 22	162.47619	201.308642	168.787879	135.75	107.142857	190.909091	129.862069	127.019608	167.661538	148.876712	143.968254	118.651163
Scenario 23	209.652174	305.212121	275.767442	250	252.285714	333.45	203	175.4	277.555556	293.348837	254.357143	210.916667
Scenario 24	375.866667	519.538462	330.83871	401.789474	420.4	326.25	374.230769	335.909091	398	331	267.714286	367.615385
Scenario 25	166.746479	218.605769	220.130841	198.71028	174.195804	213.225225	173.063291	190.16	207.514019	204.104348	160.857143	190.689266
Scenario 26	253.466667	356.01626	269.636364	284.867925	314.122449	343.424242	272.390244	300.026667	309.423423	344.608	292.470588	262
Scenario 27	558.777778	522.566667	527.305556	479.26087	599.227273	465.541667	428.772727	435.74359	522.689655	570.129032	454.097561	445.25
Scenario 28	790.8	1003.038462	785.2	615.297297	500.782609	577.266667	545.357143	417.272727	617	893.836735	765.555556	840.108108
Scenario 29	287.866667	292.059072	284.838951	272.898437	297.578475	262.098113	280.168142	314.650485	347.176923	266.492308	299.187739	324.382222
Scenario 30	424.252252	528.385093	504.055556	517.850932	544.121212	445.869565	485.75	344.54902	507.057971	455.031447	505.953125	354.60177
Scenario 31	590.604651	889.054054	647.758242	794	627.727273	701.970149	794.617284	639.142857	670.257143	872.027027	846.545455	782.222222
Scenario 32	1044.424242	1135.396226	780.655738	1206.595745	1123.675676	1005.625	842.196078	1058.938776	820	1037.5	1088.04878	1072.627451
TEST1	204.485748	204.379114	206.571311	203.916561	205.719991	205.671978	203.622258	207.480216	207.459721	201.424293	203.212035	207.467359
TEST2	202.869565	221.428571	226.324324	224	211.615385	261.428571	222.740741	232	219.777778	232	215.461538	202

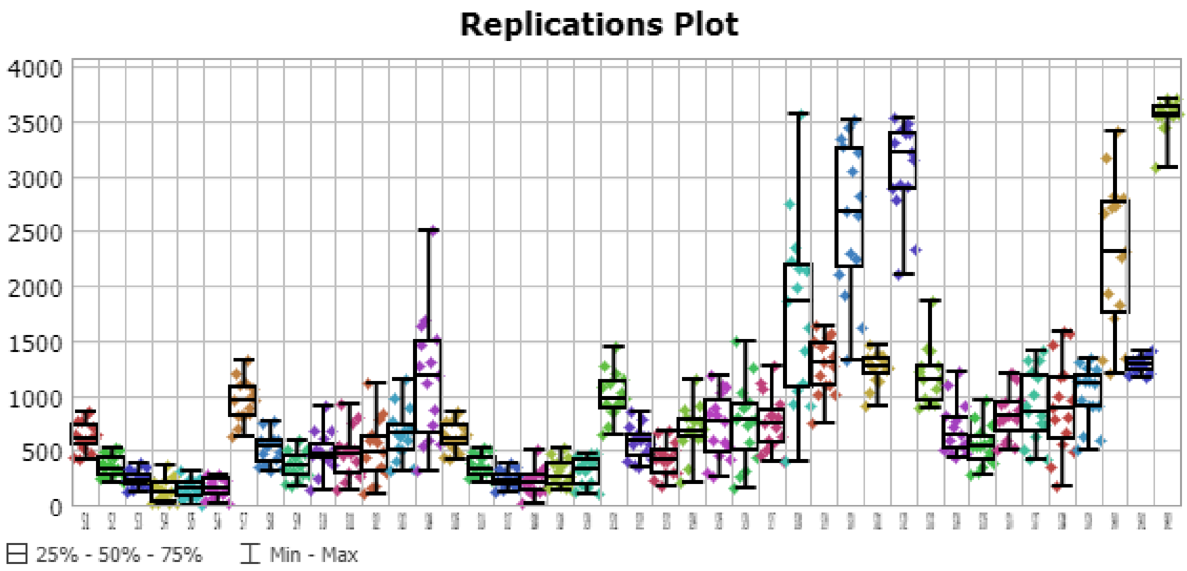
Experimentation Report

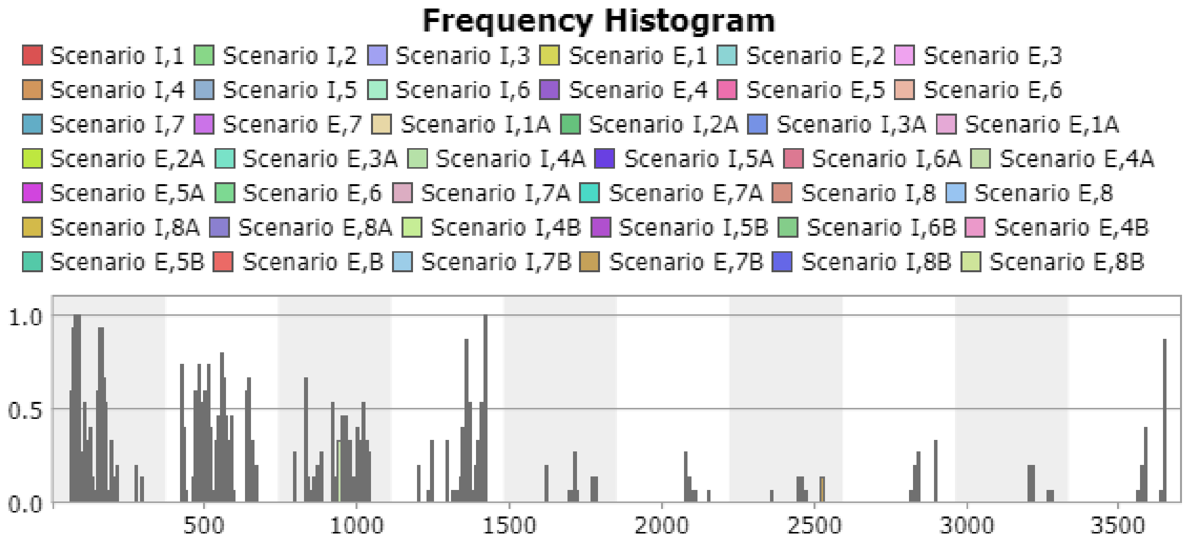
Number of Scenarios:	42
Number of Replications Per Scenario:	15
Warmup Time:	0

ASRS distance

Summary								
	Mean (90% Confidence)					Sample Std Dev	Min	Max
Scenario I,1	571	<	633	<	695	136	426	845
Scenario I,2	311	<	358	<	404	102	211	526
Scenario I,3	203	<	237	<	272	76	130	380
Scenario E,1	90	<	138	<	187	107	20	359
Scenario E,2	110	<	149	<	187	84	0	311
Scenario E,3	128	<	168	<	208	88	21	279
Scenario I,4	863	<	948	<	1034	189	634	1324
Scenario I,5	449	<	514	<	578	142	308	768
Scenario I,6	303	<	361	<	419	127	175	599
Scenario E,4	409	<	492	<	575	183	145	913
Scenario E,5	370	<	471	<	572	222	146	926
Scenario E,6	371	<	498	<	625	280	106	1116
Scenario I,7	545	<	650	<	755	231	311	1145
Scenario E,7	893	<	1155	<	1417	576	306	2512
Scenario I,1A	571	<	633	<	695	136	426	845
Scenario I,2A	311	<	358	<	404	102	211	526
Scenario I,3A	203	<	237	<	272	76	130	380
Scenario E,1A	163	<	217	<	271	118	20	506
Scenario E,2A	241	<	297	<	354	124	141	520
Scenario E,3A	260	<	318	<	377	129	105	476
Scenario I,4A	912	<	1007	<	1102	209	649	1441
Scenario I,5A	506	<	574	<	642	150	352	849
Scenario I,6A	352	<	419	<	487	148	177	674
Scenario E,4A	587	<	689	<	791	224	206	1151

Scenario E,5A	589	<	724	<	860	299	269	1185
Scenario E,6	580	<	748	<	915	367	154	1497
Scenario I,7A	645	<	760	<	875	252	394	1274
Scenario E,7A	1393	<	1767	<	2142	823	408	3572
Scenario I,8	1167	<	1282	<	1397	253	743	1642
Scenario E,8	2319	<	2633	<	2948	692	1329	3516
Scenario I,8A	1181	<	1247	<	1314	146	897	1465
Scenario E,8A	2892	<	3086	<	3279	426	2113	3535
Scenario I,4B	1059	<	1176	<	1293	257	896	1864
Scenario I,5B	597	<	703	<	808	232	439	1216
Scenario I,6B	458	<	543	<	628	187	275	951
Scenario E,4B	731	<	837	<	943	233	503	1205
Scenario E,5B	748	<	900	<	1052	335	410	1412
Scenario E,B	712	<	908	<	1104	431	171	1589
Scenario I,7B	882	<	1002	<	1121	263	497	1332
Scenario E,7B	1967	<	2284	<	2601	697	1194	3412
Scenario I,8B	1253	<	1286	<	1319	73	1174	1409
Scenario E,8B	3486	<	3556	<	3625	152	3081	3705





Raw Data

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Scenario I,1	431.283348	652.133348	758.683348	578.683348	426.183348	771.708348	519.483348	600.033348	840.583348	845.033348	463.683348	617.783348	718.258348	612.658348	652.683348
Scenario I,2	239.333348	388.733348	480.083348	302.133348	262.933348	445.033348	359.483348	275.633348	441.933348	526.483348	289.708348	327.883348	510.133348	304.383348	210.583348
Scenario I,3	130.083348	226.283348	337.133348	205.783348	139.033348	293.483348	229.983348	192.333348	250.833348	379.533348	184.883348	217.533348	352.433348	260.733348	162.183348
Scenario E,1	19.538348	208.978348	177.368348	19.538348	71.948348	146.168348	65.081652	103.558348	225.121652	358.618348	21.471652	115.891652	255.893348	264.988348	21.338348
Scenario E,2	155.768348	310.998348	59.881652	103.358348	119.958348	190.673348	230.521652	67.548348	226.721652	158.368348	69.481652	106.958348	249.388348	182.178348	0
Scenario E,3	29.138348	278.998348	159.301652	201.978348	71.948348	244.121652	153.968348	112.958348	276.398348	265.998348	110.491652	121.091652	241.388348	225.788348	21.338348
Scenario I,4	633.533348	958.233348	1200.583348	824.333348	698.983348	1095.958348	821.433348	818.733348	1121.683348	1324.483348	828.633348	889.933348	997.408348	1054.358348	955.783348

Scenario I,5	342.533348	587.483348	745.733348	464.733348	368.083348	542.433348	551.583348	307.683348	599.483348	768.333348	597.908348	426.083348	587.083348	481.083348	332.983348
Scenario I,6	188.733348	317.033348	509.233348	390.733348	174.733348	310.233348	435.533348	208.933348	372.783348	598.883348	361.583348	281.783348	477.833348	507.183348	277.133348
Scenario E,4	144.901652	451.438348	673.421652	508.848348	244.988348	480.248348	447.638348	476.838348	605.801652	913.243348	425.028348	450.571652	674.478348	358.818348	525.248348
Scenario E,5	145.701652	538.248348	925.871652	449.638348	208.178348	515.058348	523.858348	287.398348	470.371652	740.898348	509.781652	397.751652	797.708348	289.398348	259.588348
Scenario E,6	105.996352	431.628348	1116.158348	596.268348	155.968348	637.211652	609.068348	175.901652	569.991652	788.508348	354.941652	485.571652	828.508348	320.408348	294.731652
Scenario I,7	310.883348	761.283348	976.033348	656.333348	393.683348	521.683348	630.483348	496.533348	672.733348	1145.333348	597.283348	670.883348	886.483348	697.533348	336.783348
Scenario E,7	305.998348	1269.198348	1635.478348	1469.838348	544.058348	1691.801652	1112.568348	600.201652	1311.641352	2512.418348	737.098348	878.461652	1518.043348	1188.921652	553.658348
Scenario I,1A	431.283348	652.133348	758.683348	578.683348	426.183348	771.708348	519.483348	600.033348	840.583348	845.033348	463.683348	617.783348	718.258348	612.658348	652.683348
Scenario I,2A	239.333348	388.733348	480.083348	302.133348	262.933348	445.033348	359.483348	275.633348	441.933348	526.483348	289.708348	327.883348	510.133348	304.383348	210.583348
Scenario I,3A	130.083348	226.283348	337.133348	205.783348	139.033348	293.483348	229.983348	192.333348	250.833348	379.533348	184.883348	217.533348	352.433348	260.733348	162.183348
Scenario E,1A	19.538348	206.378348	220.511652	135.168348	202.178348	244.788348	110.491652	135.368348	278.331652	506.048348	115.558348	282.731652	312.208348	339.408348	142.768348
Scenario E,2A	155.768348	474.238348	375.151652	240.588348	239.788348	386.218348	316.941652	174.873348	361.351652	519.653348	158.368348	200.511652	444.038348	268.598348	140.968348

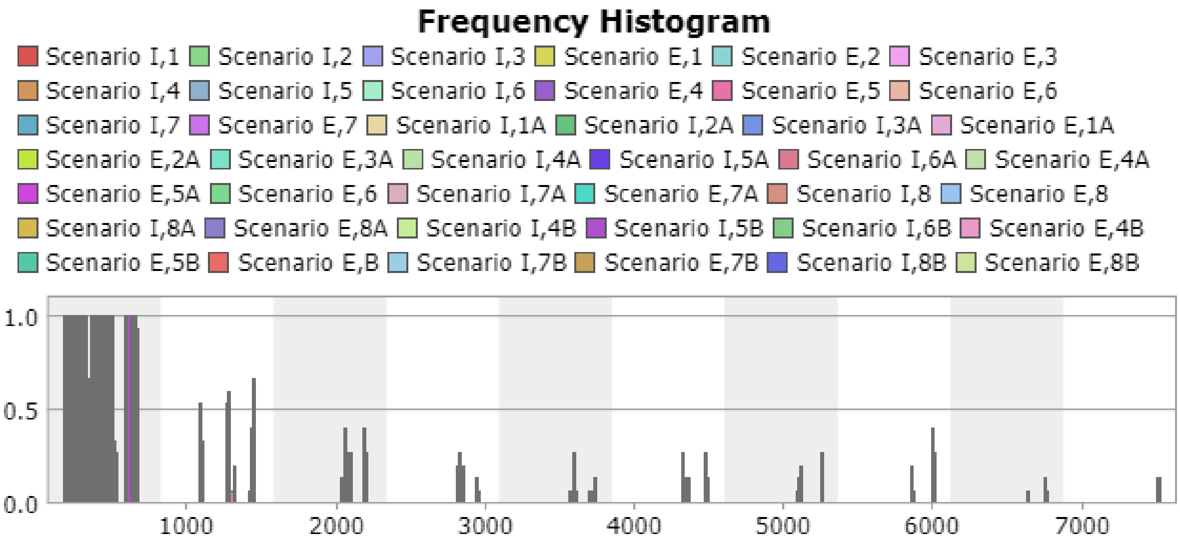
Scenario E,3A	127.758348	334.808348	461.438348	329.608348	191.778348	375.951652	312.008348	159.168348	394.223348	476.238348	207.178348	391.818348	439.628348	469.238348	105.158348
Scenario I,4A	649.083348	1078.283348	1273.133348	914.383348	717.183348	1116.658348	858.983348	854.283348	1194.533348	1440.783348	917.833348	931.533348	1035.508348	1141.708348	980.133348
Scenario I,5A	398.783348	712.983348	848.633348	555.733348	370.633348	622.583348	667.233348	351.783348	596.083348	792.233348	623.708348	485.483348	621.583348	549.633348	412.633348
Scenario I,6A	221.233348	416.433348	653.933348	488.183348	177.333348	394.283348	466.283348	289.133348	405.683348	674.183348	437.883348	293.983348	507.383348	576.783348	287.533348
Scenario E,4A	206.183348	589.463348	866.566652	802.308348	324.608348	674.888348	657.888348	684.688348	769.641652	1150.693348	610.668348	767.641652	897.323348	627.678348	705.088348
Scenario E,5A	303.941652	843.718348	1185.321652	587.468348	268.593348	891.338348	819.613348	448.038348	1033.891652	1089.573348	773.041652	582.191652	1080.158348	544.058348	415.951652
Scenario E,6	154.168348	790.708348	1496.628348	796.108348	254.588348	1029.291652	892.928348	305.798348	733.626652	947.138348	570.791652	764.631652	1257.093348	789.698348	429.828348
Scenario I,7A	450.283348	1106.383348	1064.383348	746.333348	510.583348	599.733348	825.383348	559.733348	816.083348	1274.033348	721.983348	793.083348	917.608348	619.433348	393.883348
Scenario E,7A	408.018348	1870.118348	2745.068348	2229.878348	927.738348	2349.921652	1986.528348	1049.168348	2156.263348	3572.393348	1120.588348	1418.228348	2148.958348	1619.901652	907.128348
Scenario I,8	742.833348	1499.683348	1641.633348	1006.433348	1179.933348	1448.783348	1451.583348	1310.033348	1099.733348	1532.483348	1104.333348	1569.333348	1350.583348	1273.633348	1017.883348
Scenario E,8	2104.568348	3336.996652	3277.868348	1912.871352	1328.828348	2687.801652	3445.388348	2297.008348	3055.528348	3515.903348	2245.188348	3219.053348	2641.391652	2817.293348	1615.811652
Scenario	896.983348	1334.933348	1465.483348	1030.233348	1274.283348	1259.183348	1150.733348	1374.508348	1129.583348	1357.483348	1362.983348	1321.633348	1265.783348	1239.883348	1246.233348

I,8A															
Scenario E,8A	2889.298348	3534.836652	3312.988348	2788.093348	2113.178348	2931.273829	3424.783348	3405.198348	3388.993348	3489.503348	2908.613348	3393.988348	3219.463348	3154.948348	2332.513348
Scenario I,4B	895.533348	1226.783348	1270.883348	1142.983348	981.583348	1424.708348	925.733348	944.533348	1411.133348	1864.333348	920.733348	1065.833348	1276.833348	1156.458348	1129.933348
Scenario I,5B	499.083348	812.483348	1090.483348	597.533348	476.033348	709.583348	774.883348	439.233348	793.133348	1215.933348	650.908348	532.533348	899.783348	569.533348	477.483348
Scenario I,6B	274.583348	545.333348	797.433348	533.083348	302.833348	538.483348	664.683348	341.683348	550.533348	950.583348	436.583348	495.783348	731.483348	595.983348	390.783348
Scenario E,4B	502.848348	768.898348	921.281652	781.708348	554.658348	932.338348	585.163348	813.918348	1200.321652	1204.698348	529.048348	777.841652	1147.188348	877.928348	959.881652
Scenario E,5B	506.248348	901.328348	1330.351652	861.528348	409.928348	1221.526652	1011.053348	630.473348	1160.216652	1325.613348	751.231652	815.451652	1411.638348	739.688348	419.361652
Scenario E,B	348.408348	887.851652	1455.428348	792.308348	171.368348	1000.881652	1159.568348	550.791652	1176.911652	1588.848348	665.411652	809.708348	1573.668348	963.338348	480.038348
Scenario I,7B	496.883348	1137.183348	1298.333348	957.283348	634.083348	1129.533348	1256.683348	899.783348	1124.233348	1332.283348	906.583348	1122.133348	1234.883348	897.733348	596.733348
Scenario E,7B	1330.818348	2669.458348	3161.728348	1936.223348	1193.988348	2719.996652	2829.268348	1699.058348	2735.068348	3412.453348	1832.308348	2271.588348	2802.583348	2317.921652	1348.608348
Scenario I,8B	1188.533348	1313.933348	1328.758348	1241.083348	1230.183348	1337.233348	1290.533348	1249.733348	1280.133348	1293.083348	1173.583348	1369.033348	1390.783348	1200.233348	1408.733348
Scenario E,8B	3081.358348	3551.951652	3643.833348	3556.113348	3601.608348	3448.926652	3443.408348	3704.528348	3657.438348	3571.618348	3545.008348	3609.961652	3643.233348	3704.423348	3570.923348

Mean Service Time

Summary								
	Mean (90% Confidence)					Sample Std Dev	Min	Max
Scenario I,1	138.8	<	143.7	<	148.7	10.9	121.2	165.1
Scenario I,2	174.5	<	183.1	<	191.8	19.1	156.5	217.0
Scenario I,3	213.3	<	225.5	<	237.7	26.8	185.1	280.9
Scenario E,1	80.3	<	85.3	<	90.3	11.0	69.1	104.0
Scenario E,2	129.7	<	141.0	<	152.4	25.0	99.8	187.3
Scenario E,3	179.4	<	195.9	<	212.4	36.3	129.3	260.6
Scenario I,4	237.2	<	253.0	<	268.7	34.7	202.1	336.6
Scenario I,5	281.7	<	301.2	<	320.8	43.1	246.7	399.5
Scenario I,6	346.1	<	374.0	<	401.8	61.2	294.1	496.0
Scenario E,4	155.6	<	167.0	<	178.3	25.0	110.8	198.1
Scenario E,5	239.9	<	264.5	<	289.0	53.9	173.2	371.5
Scenario E,6	326.4	<	372.0	<	417.6	100.3	168.0	497.6
Scenario I,7	667.5	<	770.0	<	872.4	225.3	434.1	1201.4
Scenario E,7	611.0	<	709.4	<	807.8	216.4	289.5	1131.7
Scenario I,1A	138.8	<	143.7	<	148.7	10.9	121.2	165.1
Scenario I,2A	174.5	<	183.1	<	191.8	19.1	156.5	217.0
Scenario I,3A	213.3	<	225.5	<	237.7	26.8	185.1	280.9
Scenario E,1A	98.3	<	104.5	<	110.7	13.6	86.4	129.7
Scenario E,2A	185.2	<	195.3	<	205.4	22.2	162.4	229.8
Scenario E,3A	263.2	<	280.7	<	298.2	38.5	202.3	331.7
Scenario I,4A	273.6	<	295.4	<	317.3	48.1	227.5	409.7
Scenario I,5A	368.3	<	393.7	<	419.2	56.0	306.0	481.8
Scenario I,6A	470.0	<	506.8	<	543.6	81.0	342.8	628.2
Scenario E,4A	203.1	<	222.8	<	242.4	43.2	135.9	292.9
Scenario E,5A	340.5	<	375.7	<	410.9	77.4	227.5	485.9
Scenario E,6	456.4	<	511.4	<	566.4	121.0	244.5	675.2
Scenario I,7A	976.4	<	1162.4	<	1348.4	409.1	599.1	1897.4
Scenario E,7A	914.6	<	1087.8	<	1261.0	380.9	385.8	1756.5
Scenario I,8	2372.9	<	2797.4	<	3221.8	933.5	1318.0	4319.6
Scenario E,8	2044.6	<	2568.8	<	3093.1	1152.9	1203.2	4979.0
Scenario I,8A	3381.0	<	3979.3	<	4577.6	1315.8	1896.8	5979.9
Scenario E,8A	3033.2	<	3750.0	<	4466.8	1576.6	1776.1	6615.1
Scenario I,4B	328.8	<	351.3	<	373.9	49.6	307.4	462.0
Scenario I,5B	430.8	<	458.8	<	486.9	61.7	381.4	571.0
Scenario I,6B	575.9	<	609.8	<	643.6	74.5	498.4	726.7
Scenario E,4B	239.9	<	256.5	<	273.2	36.6	208.8	341.5

Scenario E,5B	391.9	<	427.4	<	462.9	78.2	304.8	541.7
Scenario E,B	522.3	<	582.0	<	641.7	131.4	390.5	845.1
Scenario I,7B	1572.2	<	1879.8	<	2187.5	676.7	994.9	3539.9
Scenario E,7B	1309.0	<	1493.1	<	1677.1	404.8	1035.7	2510.2
Scenario I,8B	5013.7	<	5546.8	<	6079.9	1172.4	3556.6	7630.1
Scenario E,8B	4934.3	<	5428.0	<	5921.6	1085.7	3831.5	7273.5



Raw Data

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Scenario I,1	130.965286	151.780404	165.130214	148.71913	121.209377	138.453802	145.217553	140.413377	141.948997	155.679442	135.769251	135.875426	153.857789	142.613028	148.295909
Scenario I,2	197.469503	178.549135	217.026838	169.454003	193.150906	167.78558	178.202031	188.706361	188.223645	211.543838	168.665135	165.526095	206.354341	156.511467	159.866071
Scenario I,3	205.286307	185.060869	280.902237	205.539681	232.212164	202.477333	227.814996	243.479125	238.997055	266.494749	243.149864	206.129159	217.970316	194.018394	232.390168
Scenario E,1	76.452784	94.848857	83.798141	75.660243	84.260549	83.309096	91.972275	80.654169	84.157303	102.124799	69.100951	75.752202	103.972392	100.169448	73.495019

Scenario E,2	139.837831	166.353699	106.092309	115.198293	156.32361	122.609222	187.292502	141.33483	154.350006	170.457757	124.235294	127.333333	147.828955	156.473789	99.846154
Scenario E,3	147.25	216.142857	158.556564	180.075364	194.75	195.409552	235.65307	188.975481	260.625748	249.390774	189.6	174.769231	217.233776	200.757101	129.333333
Scenario I,4	202.122486	267.572924	263.974914	233.850799	216.009448	250.107278	266.738719	227.724607	233.738906	301.224223	252.175957	234.73568	228.223159	336.604099	279.673652
Scenario I,5	259.278225	326.512495	296.160355	287.37603	289.177814	279.287166	330.495819	266.29438	270.969986	399.47947	320.515747	246.72029	296.278189	377.874363	272.263978
Scenario I,6	334.787657	333.867378	368.574151	390.94597	327.070348	297.972412	457.428041	353.040231	359.899402	496.030669	391.409674	294.131607	383.355585	477.822657	342.994774
Scenario E,4	131.090969	150.009666	195.929111	193.137406	110.803774	149.245662	171.104301	184.88964	172.377869	198.084449	158.537193	161.054158	191.107398	176.608238	160.485467
Scenario E,5	209.171164	269.339644	371.497022	244.930579	173.215076	236.301242	301.025603	248.346003	265.427618	289.474738	281.853283	232.010394	371.366285	243.54427	229.421866
Scenario E,6	168	272.592346	487.014668	410.075364	213.5	379.008009	497.591636	329.674706	428.71226	487.781325	389.125872	343.207177	484.215462	347.135774	342.504111
Scenario I,7	494.587697	862.145963	864.9903	528.520024	621.418961	434.106307	619.874715	1035.746399	882.507757	955.272776	855.189676	695.429276	954.606066	1201.417678	543.921878
Scenario E,7	289.5	676.518908	842.722515	749.749967	526.75	950.748287	959.853522	659.106973	873.204969	1131.71341	517.683824	529.151485	722.952739	659.265926	551.905016
Scenario I,1 A	130.965286	151.780404	165.130214	148.71913	121.209377	138.453802	145.217553	140.413377	141.948997	155.679442	135.769251	135.875426	153.857789	142.613028	148.295909
Scenario I,2 A	197.469503	178.549135	217.026838	169.454003	193.150906	167.78558	178.202031	188.706361	188.223645	211.543838	168.665135	165.526095	206.354341	156.511467	159.866071
Scenario I,3 A	205.286307	185.060869	280.902237	205.539681	232.212164	202.477333	227.814996	243.479125	238.970555	266.494749	243.149864	206.129159	217.970316	194.018394	232.390168

Scenario E,1A	86.397526	102.828882	89.529007	98.755377	109.771515	93.841082	104.372275	101.602326	103.688245	129.742313	98.249323	115.173442	128.127012	119.025058	87.095019
Scenario E,2A	190.104498	205.677115	178.772116	177.097244	203.203868	176.647626	212.637929	194.125596	210.738734	229.765449	164.823529	176.777778	217.723077	229.195447	162.437374
Scenario E,3A	202.25	274.220245	242.5827	288.2921	256.25	268.669226	318.525735	261.463752	328.582748	322.353846	294.525872	291.384615	303.876644	331.702214	225.905016
Scenario I,4A	227.473105	327.812706	311.513075	281.839946	243.406566	277.587655	311.167662	251.414639	267.706189	358.005485	300.758837	276.204881	255.457154	409.653235	331.185447
Scenario I,5A	334.354773	456.258618	429.197803	390.337988	355.177337	367.268287	468.406082	372.602646	340.622946	472.228212	408.166366	305.951251	350.508483	481.761994	373.025455
Scenario I,6A	446.084545	520.229112	520.658052	572.534364	415.84577	438.881224	628.235357	541.359931	481.364533	615.149241	515.774878	342.84867	474.770171	620.100939	468.235283
Scenario E,4A	135.93294	187.615554	221.289093	252.329409	160.516223	196.349656	237.262989	280.163848	213.289259	292.90652	218.689774	225.949772	234.60563	207.505608	277.466975
Scenario E,5A	283.837831	402.395004	475.337544	366.970624	227.500791	344.432264	485.927405	331.817037	450.289764	427.667716	361.402819	296.050065	460.289362	412.23777	308.848051
Scenario E,6	244.5	402.311699	671.809807	578.155659	325	529.631735	675.171069	476.218703	561.344361	568.781325	525.925872	446.400119	626.759833	568.265926	471.170777
Scenario I,7A	743.433522	1703.323951	1494.154288	658.62111	821.383836	599.097983	891.247136	1897.35648	1257.318328	1425.74464	1428.563699	979.274648	1524.498345	1231.134794	780.697652
Scenario E,7A	385.75	1020.240484	1756.470642	1090.673137	767.0378	1410.435464	1435.238137	997.823919	1251.876975	1745.632354	870.343969	747.920716	1116.819406	971.217148	749.905016

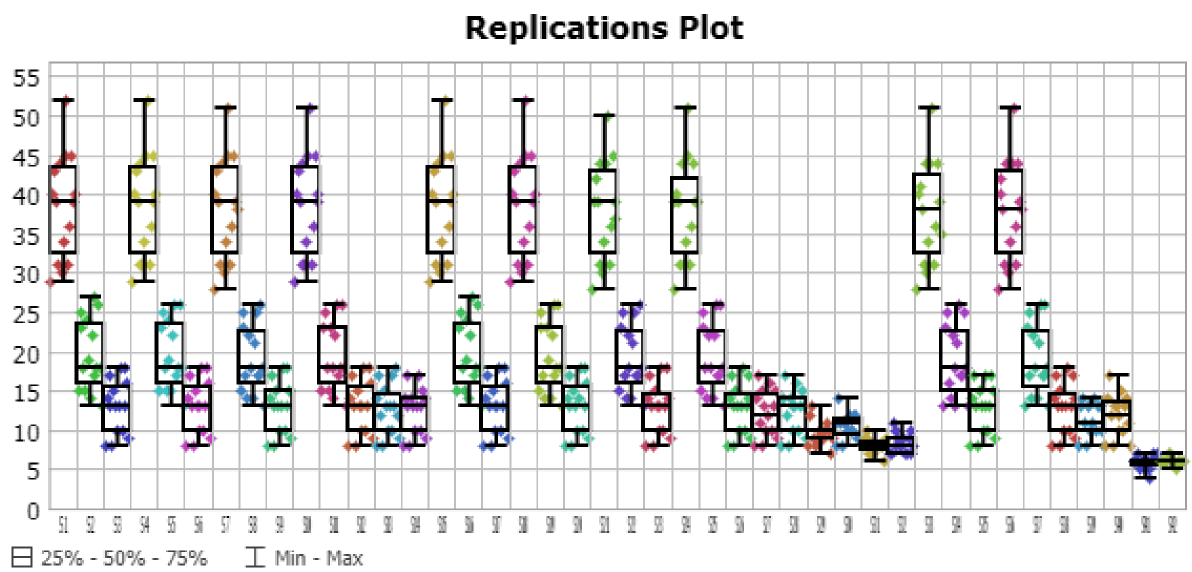
Scenario I,8	1317.992651	3185.393869	3880.086451	1955.612779	2088.704917	2945.873325	3981.202353	4268.789331	1984.749281	4319.583985	2247.303001	2700.369568	2503.767059	2286.83038	2294.192816
Scenario E,8	1737.068164	4206.988698	3473.927157	1203.152721	1293.4677	1657.730123	4092.037157	3035.137424	2355.766325	4978.957432	2428.818649	2493.456887	1871.719373	2137.425674	1567.079462
Scenario I,8A	1896.751094	5930.131565	5194.37493	2875.640725	3521.912489	3951.08955	4958.999754	5612.318391	2331.171917	5979.884718	3422.188258	4484.884013	2801.76696	3101.142784	3626.911825
Scenario E,8A	2680.215954	5836.040832	5272.4372	1776.081309	1852.489397	2232.492155	5320.682725	5205.763709	3896.131343	6615.085851	2797.359982	4215.096939	2219.488195	3495.180299	2835.404488
Scenario I,4B	325.436259	338.719729	388.483195	336.389014	314.267265	342.238139	307.400058	326.710803	322.524853	391.21922	309.822645	324.644269	327.30572	452.873371	461.959906
Scenario I,5B	397.443544	432.692899	571.013978	395.271132	381.371734	395.465946	491.093447	455.75376	454.26414	565.217957	452.557991	401.319508	510.175676	520.529079	458.357493
Scenario I,6B	547.856053	538.254007	697.56006	540.473991	554.716245	498.405598	726.719844	610.001944	691.17147	632.630217	577.28542	531.561387	665.741565	706.858379	627.157081
Scenario E,4B	208.759393	252.321106	255.067874	240.810206	218.396008	233.011538	259.366836	259.184048	321.431819	264.520526	213.910571	238.037678	277.748639	264.088684	341.514562
Scenario E,5B	304.773166	422.548555	541.685437	387.58011	369.545178	477.808997	507.474013	449.681816	495.946788	520.510803	348.455061	337.563024	509.693932	397.962012	339.689618
Scenario E,B	390.509591	526.832949	679.097777	599.386428	404.364685	491.293017	725.367774	621.096535	845.051123	700.887085	546.809089	471.219778	717.320917	545.991666	464.571683
Scenario I,7B	994.933041	1609.345486	3539.933479	1361.590851	1265.905878	1755.999369	2587.085958	2969.622352	1860.471081	2076.373442	1862.590879	1521.984278	1757.16123	1472.790085	1561.801117
Scenario E,7B	1114.818164	1532.736632	2510.169689	1123.839803	1035.6799	1222.299311	2023.264624	1872.537424	1640.033389	1707.846696	1413.818649	1170.094922	1392.945316	1420.412517	1215.558967

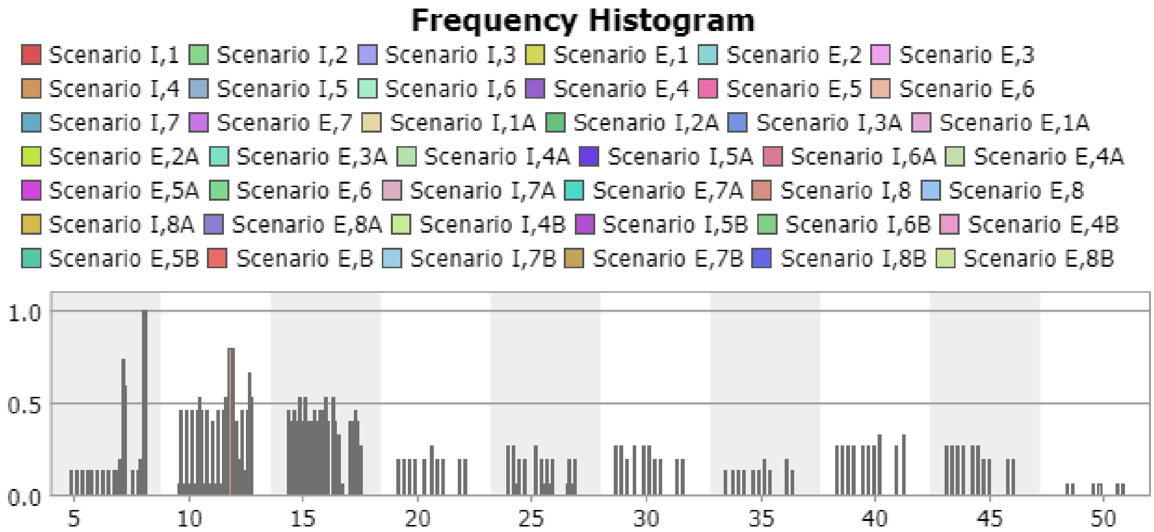
Scenario I,8B	3939.458272	6007.403549	7051.333761	4507.018443	5721.049617	4216.451303	6275.03249	7630.073406	5490.102154	5863.533907	6054.013956	5727.016072	4562.17878	3556.62028	6600.417017
Scenario E,8B	3847.010445	5589.591871	7273.541824	6048.650499	3831.538631	4938.790538	6311.722886	7266.017719	5033.366773	6094.980781	4341.302594	5122.463903	5313.31774	4412.713258	5994.411956

Output

Summary								
	Mean (90% Confidence)					**Sample Std Dev**	**Min**	**Max**
Scenario I,1	35.50	<	38.53	<	41.57	6.67	29.00	52.00
Scenario I,2	17.52	<	19.60	<	21.68	4.58	13.00	27.00
Scenario I,3	11.44	<	13.00	<	14.56	3.42	8.00	18.00
Scenario E,1	35.60	<	38.60	<	41.60	6.59	29.00	52.00
Scenario E,2	17.60	<	19.60	<	21.60	4.39	13.00	26.00
Scenario E,3	11.44	<	13.00	<	14.56	3.42	8.00	18.00
Scenario I,4	35.25	<	38.27	<	41.28	6.63	28.00	51.00
Scenario I,5	17.02	<	19.00	<	20.98	4.36	13.00	26.00
Scenario I,6	11.40	<	12.93	<	14.47	3.37	8.00	18.00
Scenario E,4	35.60	<	38.53	<	41.46	6.45	29.00	51.00
Scenario E,5	17.39	<	19.40	<	21.41	4.42	13.00	26.00
Scenario E,6	11.44	<	13.00	<	14.56	3.42	8.00	18.00
Scenario I,7	11.13	<	12.60	<	14.07	3.22	8.00	18.00
Scenario E,7	11.20	<	12.53	<	13.86	2.92	8.00	17.00
Scenario I,1A	35.50	<	38.53	<	41.57	6.67	29.00	52.00
Scenario I,2A	17.52	<	19.60	<	21.68	4.58	13.00	27.00
Scenario I,3A	11.44	<	13.00	<	14.56	3.42	8.00	18.00
Scenario E,1A	35.50	<	38.53	<	41.57	6.67	29.00	52.00
Scenario E,2A	17.28	<	19.33	<	21.39	4.51	13.00	26.00
Scenario E,3A	11.51	<	13.07	<	14.63	3.43	8.00	18.00
Scenario I,4A	35.04	<	37.93	<	40.83	6.36	28.00	50.00
Scenario I,5A	17.02	<	19.00	<	20.98	4.36	13.00	26.00

Scenario I,6A	11.35	<	12.87	<	14.38	3.34	8.00	18.00
Scenario E,4A	35.18	<	38.07	<	40.96	6.35	28.00	51.00
Scenario E,5A	17.17	<	19.20	<	21.23	4.48	13.00	26.00
Scenario E,6	11.33	<	12.80	<	14.27	3.23	8.00	18.00
Scenario I,7A	10.74	<	12.07	<	13.39	2.91	8.00	17.00
Scenario E,7A	11.06	<	12.33	<	13.60	2.79	8.00	17.00
Scenario I,8	8.90	<	9.60	<	10.30	1.55	7.00	13.00
Scenario E,8	9.79	<	10.53	<	11.28	1.64	8.00	14.00
Scenario I,8A	7.55	<	8.00	<	8.45	1.00	6.00	10.00
Scenario E,8A	7.75	<	8.33	<	8.92	1.29	7.00	11.00
Scenario I,4B	34.80	<	37.73	<	40.66	6.44	28.00	51.00
Scenario I,5B	16.63	<	18.73	<	20.84	4.64	13.00	26.00
Scenario I,6B	11.36	<	12.80	<	14.24	3.17	8.00	17.00
Scenario E,4B	35.07	<	38.00	<	40.93	6.44	28.00	51.00
Scenario E,5B	16.83	<	18.93	<	21.03	4.62	13.00	26.00
Scenario E,B	11.33	<	12.80	<	14.27	3.23	8.00	18.00
Scenario I,7B	10.27	<	11.27	<	12.26	2.19	8.00	14.00
Scenario E,7B	10.64	<	11.87	<	13.09	2.70	8.00	17.00
Scenario I,8B	5.49	<	5.87	<	6.25	0.83	4.00	7.00
Scenario E,8B	5.86	<	6.07	<	6.27	0.46	5.00	7.00





Raw Data

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Scenario I,1	29	40	43	39	31	44	30	34	45	52	31	36	45	39	40
Scenario I,2	15	23	25	18	15	24	19	14	22	27	17	18	26	18	13
Scenario I,3	8	14	17	13	8	15	13	10	13	18	10	13	18	16	9
Scenario E,1	29	40	43	39	31	44	31	34	45	52	31	36	45	39	40
Scenario E,2	15	23	25	18	15	24	19	15	22	26	17	18	26	18	13
Scenario E,3	8	14	17	13	8	15	13	10	13	18	10	13	18	16	9
Scenario I,4	28	40	43	39	31	44	30	34	45	51	31	36	45	39	38
Scenario I,5	15	23	25	17	14	22	18	14	21	25	17	17	26	18	13
Scenario I,6	8	14	17	13	8	15	13	10	13	18	10	13	18	15	9
Scenario E,4	29	40	43	39	31	44	31	34	45	51	31	36	45	39	40
Scenario E,5	15	23	25	18	15	23	18	14	22	26	17	18	26	18	13
Scenario E,6	8	14	17	13	8	15	13	10	13	18	10	13	18	16	9
Scenario I,7	8	14	17	12	8	15	13	10	13	17	10	13	18	12	9
Scenario E,7	8	14	17	13	8	14	13	10	13	17	10	13	15	14	9
Scenario I,1A	29	40	43	39	31	44	30	34	45	52	31	36	45	39	40
Scenario I,2A	15	23	25	18	15	24	19	14	22	27	17	18	26	18	13
Scenario I,3A	8	14	17	13	8	15	13	10	13	18	10	13	18	16	9
Scenario E,1A	29	40	43	39	31	44	30	34	45	52	31	36	45	39	40
Scenario E,2A	15	23	25	17	14	23	19	14	22	26	17	18	26	18	13
Scenario E,3A	8	14	17	13	8	15	13	10	14	18	10	13	18	16	9
Scenario I,4A	28	39	42	39	31	44	30	34	44	50	31	36	45	39	37
Scenario I,5A	15	23	25	17	14	22	18	14	21	25	17	17	26	18	13

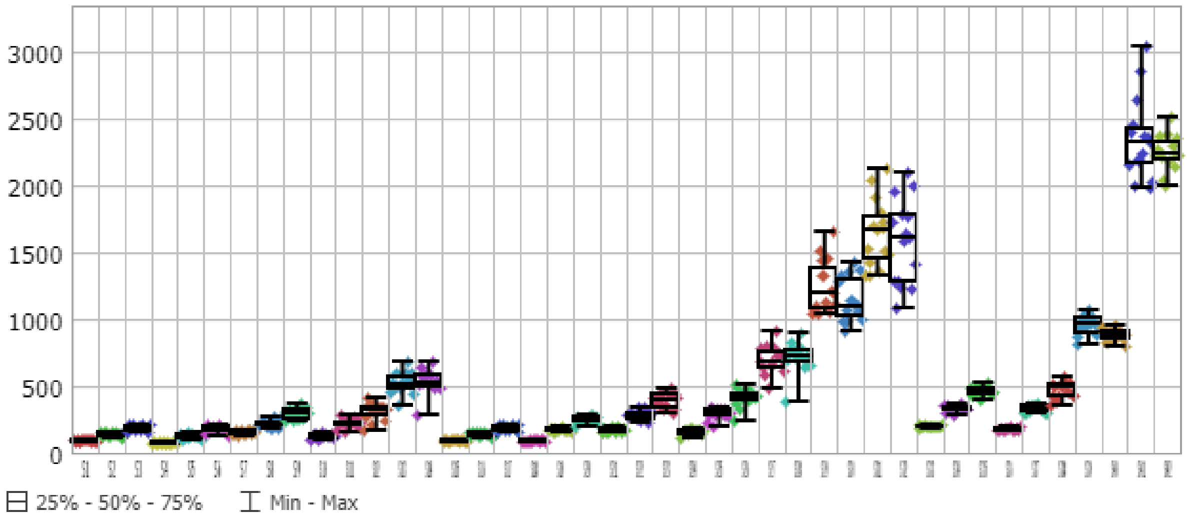
Scenario I,6A	8	14	17	13	8	15	13	10	13	18	10	13	18	14	9
Scenario E,4A	28	39	40	39	31	44	31	34	45	51	31	36	44	39	39
Scenario E,5A	15	23	25	18	14	22	18	14	22	26	17	17	26	18	13
Scenario E,6	8	14	17	13	8	15	13	10	13	18	10	13	17	14	9
Scenario I,7A	8	14	17	11	8	15	13	10	12	16	10	13	15	10	9
Scenario E,7A	8	14	17	12	8	14	13	10	13	16	10	13	15	13	9
Scenario I,8	8	12	13	9	8	9	10	10	9	9	10	11	10	7	9
Scenario E,8	8	11	14	11	8	11	11	10	12	10	10	12	12	9	9
Scenario I,8A	8	9	10	9	7	7	7	8	8	8	8	8	8	6	9
Scenario E,8A	7	7	11	10	8	9	8	8	9	7	7	9	10	7	8
Scenario I,4B	28	40	41	38	31	44	30	34	44	51	31	36	44	39	35
Scenario I,5B	13	23	25	16	14	22	18	13	21	26	17	17	25	18	13
Scenario I,6B	8	14	17	13	8	15	13	10	13	17	10	13	17	15	9
Scenario E,4B	28	40	42	38	31	44	30	34	44	51	31	36	44	39	38
Scenario E,5B	13	23	25	17	14	22	18	14	21	26	17	17	26	18	13
Scenario E,B	8	14	17	13	8	15	13	10	13	18	10	13	17	14	9
Scenario I,7B	8	13	14	11	8	13	13	10	11	14	10	13	13	10	8
Scenario E,7B	8	14	17	12	8	13	13	10	12	15	10	13	14	11	8
Scenario I,8B	6	6	6	7	5	6	6	5	6	5	4	6	7	6	7
Scenario E,8B	6	6	6	6	6	7	7	6	6	5	6	6	6	6	6

Mean Picking Time

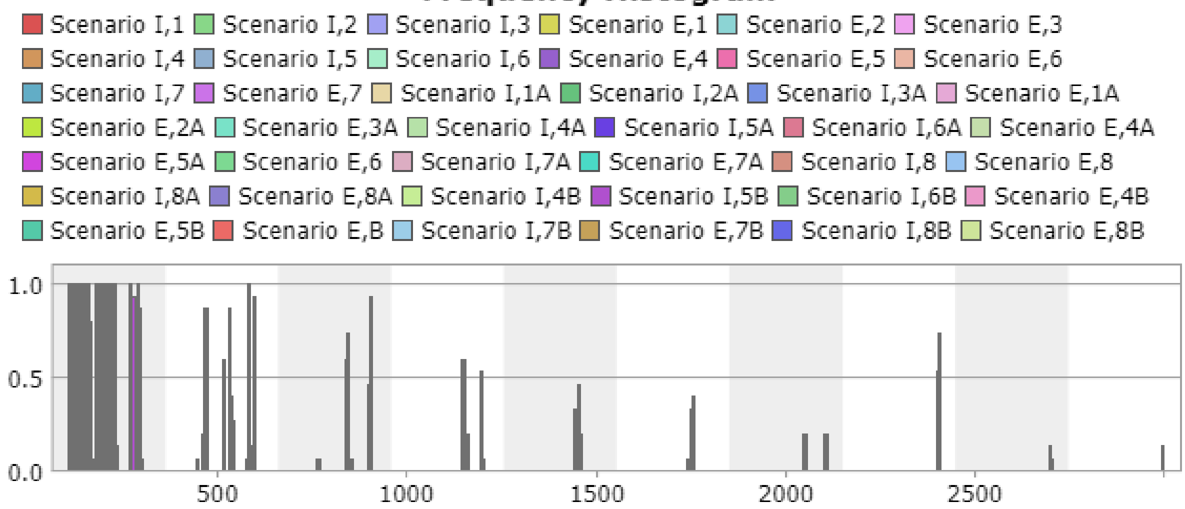
Summary								
	Mean (90% Confidence)					**Sample Std Dev**	**Min**	**Max**
Scenario I,1	92.0	<	94.1	<	96.3	4.7	85.0	100.9
Scenario I,2	135.8	<	141.0	<	146.2	11.4	115.6	156.7
Scenario I,3	177.4	<	186.6	<	195.8	20.2	152.4	216.9
Scenario E,1	72.7	<	76.0	<	79.4	7.4	65.2	89.9
Scenario E,2	120.8	<	128.4	<	136.0	16.7	99.8	158.3
Scenario E,3	168.6	<	179.6	<	190.6	24.2	129.3	218.2
Scenario I,4	147.6	<	154.3	<	161.0	14.8	132.7	178.1
Scenario I,5	211.0	<	222.4	<	233.8	25.0	188.6	278.4
Scenario I,6	277.2	<	295.8	<	314.4	40.8	239.8	366.3
Scenario E,4	122.3	<	129.1	<	135.9	15.0	102.8	156.6
Scenario E,5	207.3	<	222.1	<	236.8	32.4	159.0	287.6

Scenario E,6	282.8	<	311.8	<	340.9	63.9	168.0	407.2
Scenario I,7	487.2	<	523.1	<	558.9	78.8	357.2	686.6
Scenario E,7	491.8	<	532.4	<	573.0	89.3	289.5	690.0
Scenario I,1A	92.0	<	94.1	<	96.3	4.7	85.0	100.9
Scenario I,2A	135.8	<	141.0	<	146.2	11.4	115.6	156.7
Scenario I,3A	177.4	<	186.6	<	195.8	20.2	152.4	216.9
Scenario E,1A	87.0	<	90.9	<	94.9	8.7	79.1	102.6
Scenario E,2A	167.8	<	173.1	<	178.4	11.7	156.5	193.1
Scenario E,3A	242.2	<	253.6	<	265.0	25.1	202.3	292.4
Scenario I,4A	166.3	<	174.0	<	181.6	16.8	152.0	206.4
Scenario I,5A	268.6	<	283.5	<	298.4	32.8	227.9	340.0
Scenario I,6A	367.5	<	393.3	<	419.1	56.8	302.1	484.6
Scenario E,4A	150.3	<	159.3	<	168.3	19.8	112.9	185.6
Scenario E,5A	276.6	<	293.4	<	310.1	36.8	206.7	336.5
Scenario E,6	383.3	<	413.3	<	443.3	65.9	244.5	511.9
Scenario I,7A	649.2	<	696.1	<	743.0	103.1	478.5	912.3
Scenario E,7A	664.3	<	716.7	<	769.2	115.3	385.8	905.6
Scenario I,8	1155.1	<	1245.0	<	1335.0	197.8	1036.7	1659.2
Scenario E,8	1077.3	<	1151.1	<	1224.9	162.3	910.7	1428.6
Scenario I,8A	1527.7	<	1642.3	<	1756.8	251.9	1324.8	2124.3
Scenario E,8A	1439.1	<	1582.2	<	1725.4	314.8	1082.6	2092.6
Scenario I,4B	196.6	<	200.6	<	204.5	8.7	189.0	218.3
Scenario I,5B	321.3	<	331.9	<	342.5	23.3	283.6	373.5
Scenario I,6B	450.7	<	467.2	<	483.7	36.3	394.7	529.7
Scenario E,4B	176.0	<	181.0	<	186.0	11.0	166.6	201.5
Scenario E,5B	323.8	<	335.2	<	346.7	25.2	299.7	369.0
Scenario E,B	446.4	<	473.0	<	499.7	58.5	360.0	572.5
Scenario I,7B	927.3	<	959.7	<	992.0	71.2	817.8	1063.9
Scenario E,7B	860.2	<	882.4	<	904.5	48.7	793.8	959.5
Scenario I,8B	2210.4	<	2349.5	<	2488.6	305.9	1987.9	3043.5
Scenario E,8B	2190.1	<	2249.4	<	2308.6	130.3	2005.4	2515.6

Replications Plot



Frequency Histogram



Raw Data

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Scenario I,1	95.26157	91.79586	100.456979	90.04887	84.976982	93.989437	95.469275	100.899959	97.015507	96.622232	92.695095	100.397361	93.161056	86.386164	92.769173
Scenario I,2	156.682608	129.740523	150.726836	140.204721	154.528669	135.372434	131.695088	151.632769	141.220265	155.144734	138.934046	140.40345	141.538964	115.556646	131.74696

Scenario I,3	180.163663	159.748488	216.88797	180.417036	207.089519	175.854797	178.887358	201.410887	175.7453	200.93076	215.547789	181.006514	166.230181	152.374301	207.267523
Scenario E,1	70.965517	86.6	71.906977	66.205128	78.967742	76.045455	79.733333	74.764706	78.044444	80.153846	65.258066	69.555556	84	89.897436	68.45
Scenario E,2	127.733333	148.086957	102.64	111.333333	144.933333	118.75	158.315789	128.133333	141.619048	134.153846	124.235294	127.333333	118.615385	140.555556	99.846154
Scenario E,3	147.25	216.142857	152	170.307692	194.75	191.733333	186.307692	178.2	218.153846	197.888889	189.6	174.769231	170.444444	177.125	129.333333
Scenario I,4	144.161494	139.174234	170.868781	132.654365	141.178381	152.116469	171.682648	149.644602	143.52488	166.062441	178.13176	167.550907	137.036585	167.517048	153.242446
Scenario I,5	214.598892	212.909401	232.085799	225.075099	227.781595	204.208038	235.188438	188.646001	189.601004	247.82973	278.386797	211.726011	191.580209	252.547135	223.758996
Scenario I,6	309.665012	248.005365	296.684865	323.849659	290.093821	239.83086	330.216877	255.169617	256.489741	350.146993	366.287029	256.596021	269.139844	344.015455	300.725779
Scenario E,4	104.928571	117.45	145.44186	141.128205	102.774194	114.863636	136.129032	156.647059	133.022222	136.039216	135.419355	134.722222	136.133333	119.025641	122.717949
Scenario E,5	175.733333	209.73913	287.6	241	159	206.782609	236	230.923077	227.545455	225.769231	266.352941	219.555556	233.615385	188.444444	223.230769
Scenario E,6	168	266.714286	407.176471	373.384615	213.5	324	370.307692	299.4	329.076923	340.111111	348.6	329.846154	339.555556	244.75	322.666667
Scenario I,7	456.886723	529.50315	486.162594	499.825766	596.296316	357.247539	479.867726	531.969901	517.381395	602.174113	686.643137	547.906191	518.469674	595.333879	440.206069
Scenario E,7	289.5	514.571429	585.764706	637.846154	526.75	587.142857	532.615385	514.4	592.307692	690	515	481.230769	539.066667	495.571429	484.444444
Scenario I,1A	95.26157	91.79586	100.456979	90.04887	84.976982	93.989437	95.469275	100.899959	97.015507	96.622232	92.695095	100.397361	93.161056	86.386164	92.769173
Scenari	156.682608	129.740523	150.726836	140.204721	154.528669	135.372434	131.695088	151.632769	141.220265	155.144734	138.934046	140.40345	141.538964	115.556646	131.74696

o I,2A															
Scenario I,3A	180.163663	159.748488	216.88797	180.417036	207.089519	175.854797	178.887358	201.410887	175.7453	200.93076	215.547789	181.006514	166.230181	152.374301	207.267523
Scenario E,1A	80.142857	92.55	79.16279	80.410256	98.129032	85.590909	88.933333	94.941176	95.6	99.653846	84.903226	102.555556	100.4	101.538462	79.65
Scenario E,2A	170.533333	184.173913	158.96	156.470588	192.285714	168.782609	175.789474	183.142857	193.090909	174.076923	164.823529	176.777778	164.4	176.111111	157.230769
Scenario E,3A	202.25	269.857143	224.588235	244.769231	256.25	257.333333	254.307692	239.4	271.384615	258	292.4	291.384615	249.333333	273	219.777778
Scenario I,4A	160.646239	161.554704	189.457683	155.682261	159.247474	169.18194	196.00634	164.289789	162.976985	187.681565	206.397535	185.583982	152.015863	189.075682	169.717115
Scenario I,5A	279.942393	282.128894	305.067328	292.096566	277.142727	258.766841	336.480588	254.556801	238.326826	294.336225	340.003638	256.062467	227.890805	310.045412	300.166674
Scenario I,6A	417.439116	369.784186	403.08179	446.710528	362.962227	327.107577	462.10562	354.700859	335.767367	445.11327	484.618148	302.050106	331.767494	446.489503	409.44214
Scenario E,4A	112.928571	138.153846	166.35	170	136.903226	151.545455	184.774194	185.647059	155.644444	174.705882	172.709677	164.666667	165.045455	142.923077	167.74359
Scenario E,5A	229.466667	284.695652	336.48	334.235294	206.714286	288.454545	323	307.692308	325.090909	297.230769	326	281	293.461538	273.333333	293.538462
Scenario E,6	244.5	368.428571	511.882353	487.384615	325	419.6	462.153846	414.2	399.230769	397.888889	476	417.692308	431.764706	417.714286	426.222222
Scenario I,7A	687.483087	785.334157	644.67337	582.802832	793.647652	478.466103	651.761781	689.091987	658.728684	784.843274	912.324466	724.22333	737.393424	702.632088	607.788579
Scenario	385.75	702.142857	774.588235	830	750.5	748.428571	760.615385	703.4	799.230769	905.625	710.2	640.615385	728.666667	651.076923	660.222222

E,7A															
Scenario I,8	1036.709061	1074.79287	1095.506245	1041.346384	1511.30629	1326.900675	1448.17839	1323.437777	1121.034621	1453.723187	1057.74856	1219.454056	1193.44906	1659.247814	1112.614701
Scenario E,8	1282.5	1324.545455	989.142857	910.727273	981.75	1077.454545	1349.636364	1149.2	1141.666667	1428.6	1099	1099.166667	1057.833333	1374.666667	1000.888889
Scenario I,8A	1326.236378	1530.939587	1428.659792	1324.778621	2049.021731	1703.365227	1907.361977	1674.167362	1358.7573	1795.20816	1683.192789	1734.861187	1509.973218	2124.290381	1482.956506
Scenario E,8A	1728.857143	1963.142857	1288.727273	1082.6	1288	1239.333333	1791.25	1586	1644.888889	2092.571429	1777.142857	1617.111111	1225	2001.142857	1407.75
Scenario I,4B	218.32662	188.95398	202.081339	193.548208	213.927831	195.560411	198.863989	193.52206	199.138195	198.701519	200.923544	199.791651	193.557208	195.876005	215.692556
Scenario I,5B	353.224328	301.467345	349.950839	342.437425	327.114763	283.641535	340.543287	304.012481	337.484429	358.525473	373.5449	329.425354	322.625629	326.067409	328.751035
Scenario I,6B	485.058714	430.086723	486.795555	474.015846	501.832701	394.738489	496.35926	415.675857	485.739937	495.822544	529.667154	471.828833	443.401344	446.43013	450.332375
Scenario E,4B	166.571429	171.6	191.902439	173.210526	178.516129	168.909091	180.866667	191.411765	201.454545	176.196078	170.967742	185.944444	192.318182	171.076923	193.631579
Scenario E,5B	299.692308	305.826087	361.92	332.235294	313.428571	352.909091	356.777778	363.142857	369.047619	358.769231	334	333.294118	344.230769	302.444444	300.923077
Scenario E,B	360	432.571429	513.529412	497.384615	391.75	425.2	513.230769	506	572.461538	520.333333	511.8	463.846154	523.294118	439.857143	424.444444
Scenario I,7B	817.765738	877.868172	949.331894	990.069387	1033.76635	946.439591	1058.573772	1063.85816	1002.30019	971.566754	1015.430796	972.469747	885.814739	911.015272	898.765324
Scenario E,7B	946	897.428571	825.764706	823.5	866.5	899.384615	936.307692	838.2	959.5	923.866667	912.2	870.769231	863.571429	878.727273	793.75

Scenario I,8B	2161.370033	2398.456272	2452.166749	1993.676404	2647.439855	2177.927968	2193.883604	2862.579274	2238.285609	2369.84601	3043.47026	2363.020456	1987.889327	2325.212786	2027.445958
Scenario E,8B	2234	2271.333333	2370.333333	2212.666667	2236.666667	2046.571429	2005.428571	2383.333333	2183.333333	2515.6	2306	2247.333333	2139.666667	2356.666667	2231.333333

The End