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Container Terminal Automation in Port of Santos – A Business Case Analysis

by

Rodrigo Muricy Souza Silveira

Acknowledgements

This report is the final outcome of the Master of Science in Maritime Economics and Logistics at the Erasmus University Rotterdam.

This thesis dissertation is fruit of my own work and complies with the Erasmus University of Rotterdam regulations on Plagiarism.

The goal of this study is to be a useful tool for the academic sector as well as the terminal operators, engineers and consultants when analyzing the possibilities of container automation on developing countries, in special Brazil.

On a more casual spirit, I would like to thank those that contributed to my work one way or another.

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Abstract

This study presents a business case analysis regarding the automation of container terminals in Brazil, more specifically in the Port of Santos, offering an economic model as a tool that allows and support the analysis and decision making towards the implementation of an automated container terminal.

For that, a solid path was built by studying the background and development of automation around the world, with the pros, cons, misconceptions and truth behind the facts. Moreover, the specifics of the Brazilian current regulations were presented, and an extent discussion of the political and economic drivers, and obstacles (including union and labor) was conducted to mirror the possibilities of automation in Brazil with was occurred or is still happening in other countries.

The first main step into the method used was to design two hypothetical terminals with manual and automated operations, with all its peculiarities, equipment choice & fleet to be able to model its elements in an economic way. More specifically using a cash flow analysis to evaluate the financial performance of the terminals throughout the years given the Brazilian government conditions.

With the terminal designed and the model calibrated, it was possible to see the benefits and full potential that automation in container terminal can bring to the Brazilian scenario, even if Brazil isn't a country with high wage costs. Moreover, it was possible to conclude that not only the automation can reach a breakeven point in the Brazilian situation, but also that it outperforms the conventional container terminal operations.

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List of Abbreviations

ANTAQ – Agência Nacional de Transporte Aquaviário (Stands for the National water transport regulatory agency in Brazil)

AShC – Automated Shuttle Carrier

AGV – Automated Guided Vehicle

ASC – Automated Stacking Crane

ARMG – Automated Rail Mounted Gantry Crane (also known as ASC - see above)

C-ASC – Side-loading cantilever Automated Stacking Crane

CAPEX – Capital Expenditures

E-ASC – End-loading Automated stacking crane

ILA – International Longshoremen's Association

ILWU – International Longshore and Warehouse Union

IRR – Internal Rate of Return

ITV Abbreviation for internal transport vehicle, a generic term denoting vehicle used for container transport within terminals

NPV – Net Present Value

OCR – Optical Character Recognition

OHBC – Overhead Bridge Crane

OPEX – Operational Expenditures

QC – Quay Crane

RFID – Radio Frequency Identification

RMG – Rail Mounted Gantry Crane

RTG – Rubber Tired Gantry Crane

ShC – Shuttle Carrier

SC – Straddle Carrier

STS – Ship to Shore Cranes

TOS – Terminal Operating System

WACC – Weighed Average cost of Capital

Chapter 1 Introduction

1.1. Initial Background

Automation and basically any related subject in that matter is currently a trendy topic among several different work fields, and it is no different within the ports and container terminals industry. Despite having more than 2 decades of the first relevant unmanned container terminal being implemented in the world – ECT Delta Terminal in 1993 in Rotterdam, a facility that ran with unmanned equipment such as ARMG (Automated Rubber Tired Gantry) and AGV (Automated Guided Vehicles) (Cederqvist, 2012), this concept of operation is still not globally consolidated yet, despite the recently state of the arts terminals implemented in China (Wells & Yongcui, 2017) and USA (Patrício, 2014).

In 2015 only 44 terminals in the world had some kind of operational automated equipment installed, and less than 60 were planned (Saanen, 2018). However, this is a market that is growing at a fast pace in recent years and is already is a multi-billion dollar industry that currently handles USD 9 billion and will reach approximately USD 11 billion per year in 2023 with a CAGR (Compound Average Growth Rate) of 3.7% in this period (PRNewswire, 2018).

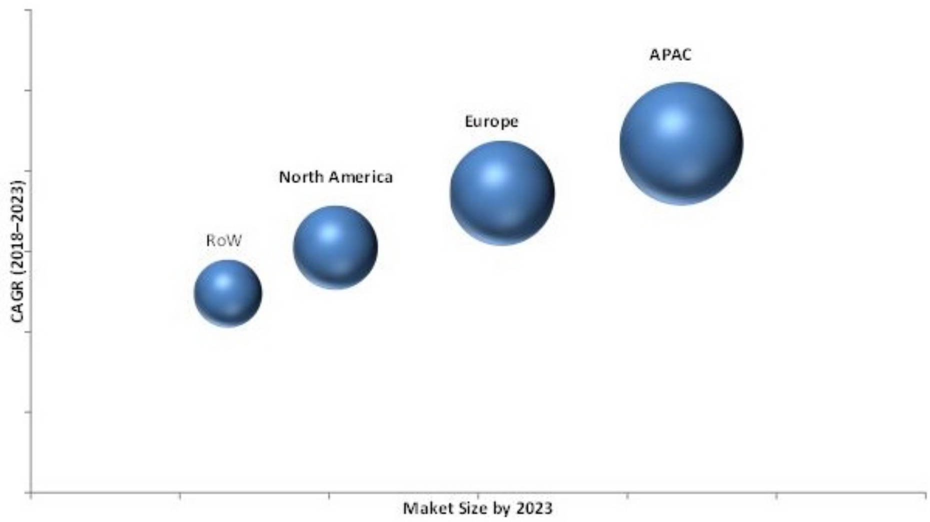


Figure 1-1 Automated Container Terminal Market - By Region, 2023 **(PRNewswire, 2018)**

The main reasons for this increase include the mega-vessel trend, bringing constantly bigger and bigger vessels to the terminals, the rise of labor cost in developed countries and the classic competition between the terminals seeking benchmarks performances, among others.

Recently automation of terminals became a synonym of higher productivity, better operational performances, and efficiency with the main obstacle for the further dissemination being the considerably higher investments at the beginning of the project.

For Brazil, container terminal automation is obviously still an innovative topic that is becoming more and more relevant with the consolidation of the technology among container terminals around the world. The more mature and reliable the automation gets on developed countries, the more the country tends to look towards this industry as an opportunity, analyzing the success cases as well as the fails, studying the main drivers necessary for the automation to be worth it.

Another critical aspect to be taken into account is the current political scenario, which has been changing quite rapidly since the former president began to drop in terms of public approval in 2013. Several corruption scandals have arisen since her mid first term. With the economy slowly deteriorating the government made a few changes in the regulations in 2013 with the called Port Law Nº 12.815 of June 5th, 2013 (Brazilian Port Ministry, 2013a), followed by a new presidential decree Nº 8.033 of June 27th of 2013 (Brazilian Port Ministry, 2013b).

Through his new regulations, the government tried to attend the terminal operators' demands and renew some aspects that were outdated by the old law from 1993, as well as seek more investments from the private sector by new leases and favorable renewals of the existing ones to balance their accounts and hope for an increase in the popular approval rate. From a financial perspective, this had a slightly favorable effect with some contract renewals from the existing terminal operators, but far from the government's expectations. Together with other unsuccessful moves at that moment, the economic crisis hit the country pretty hard and culminated with her Impeachment.

The vice president, Michel Temer, took over in August of 2016 with a pro-business perspective and tried to unlock the private investments in the port sector also by, once again, changing the regulations. With less than 1 year in charge, he made a new decree Nº 9.048 of May 10th 2017 (Brazilian Port Ministry, 2017), by adding some exciting possibilities such as more extended contracts (up to 35 years compared to the previous 20-25 years) among others changes that will be explored in the following chapter of this study.

There is still not a single automated container terminal in Brazil most likely because either it doesn't make sense financially yet to implement such a terminal with the current economic scenario or the unions are still too strong to accept the innovative changes, or both, but it is essential to keep this on the radar, because the pioneer of automation in the country might guarantee a great position in terms of competitive advantage among its competitors, especially in the Port of Santos, the biggest in container throughput not only in Brazil but also in Latin America.

With all the pro-business developments that occurred on the last five years, there is not only room for economic research regarding this topic but also an increase in interest locally and internationally with possible foreign investors trying to identify the real possibilities of breaking-even with automated container terminals in Brazil on the next coming years.

1.2. The goal of the study

There are various doubts and an intense debate surrounding the container automation sphere, and with those debates, several questions arise. Given the fact that in Santos, and all over Brazil, this is still a recent discussion, the main questions to be answered are on a fundamental level such as:

- Is it economically feasible to develop an automated container terminal in Brazil?
- Can this problem be analyzed with the regular Terminal Design and Cost Benefit analysis approach?
  - What design should be considered for the analysis?
  - Which elements go into the cost benefit analysis?
  - Do these elements sufficiently cover the Brazilian situation?

All these queries are commonly asked as a part of strategic and operational decisions that the management and board of terminal operators have to make. However, these decisions can be profoundly complex and have high risk and an uncertainty level given all the variables and alternatives involved.

With that being said, this research has some ambitions. The first and main one is to develop an economic model capable of analyzing the economic performance of a terminal (both manned or automated) following all the rules and regulations imposed by ANTAQ (National Agency of Water Transportation – in a free translation) and the Transportation Ministry for public port terminal leases. The model shall follow the government procedures and will determine the remuneration of investors and, as a consequence, the remuneration of the Port Authority with the total lease value (ANTAQ, 2007), providing enough information to analyze the economic viability of the terminal.

The second ambition is to promote the discussion and reflection regarding the hindrances and complexities that this change in the traditional operational mindset might bring.

Yet, as an outcome of this study, a suggestion will be presented, using different means, for a simplified stepwise approach towards terminal automation in Brazil, which might add value and contribute even further to the academic community, primarily related to container terminal management, current lacking technical and scientific studies within the country.

1.3. Outline

The chapter 1 is intended for initial considerations, a brief background of the theme chosen, the introduction of the problem followed by the study's goals and a concise outline of the overall structure.

Aiming to bring more technical and theoretical knowledge to the thesis, the chapter 2 – literature review, will start bringing some historical background to the container automation around the world. Discussions will be made regarding the advantages and disadvantages of this type of operations, the reasons to automate and well as some truth and misconceptions surrounding the topic. The review will also cover the main Brazilian regulations updates and the discussions regarding automation around the world, including Brazil.

Later we will go through a stepwise methodology journey on that will start on chapter 3, followed by the terminal design and analysis on chapter 4 with the design of two terminal layouts (both manned and automated) based on Port of Santos Benchmark container terminals, going from the berth & yard size, fleet calculations and annual throughput that in the sequence, shall be the foundation for the economic model on chapter 5 that will be created with input of all the theoretical terminals values (CAPEX, OPEX, etc.), allowing to analyze the cash flow of both options.

This will allow a thorough discussion of the results on chapter 6 that will focus on summarizing, analyzing and presenting the main findings and results obtained by the method used.

Lastly, the conclusions, observations, and recommendations will be brought in the chapter 7 which will be accompanied by the 8th and final chapter that will bring suggestions for different ways to approach a similar problem, as well as possible future studies regarding the topic.

Chapter 2 Literature Review

This section will start bringing some historical background to the container automation around the world, as well as the operations in Brazil. Moreover, analysis will be made with regards to the advantages and disadvantages of this type of operations, the reasons to automate and well as some truth and misconceptions surrounding the topic. In the end the chapter will cover some changes in the Brazilian port regulations and how automation is happening around the world, briefly covering the current situation in Brazil.

2.1. Container Port Automation - Background and Development

For automation to become a reality, further development was required so that technology could reach acceptable levels before this system could take off. This is precisely what has been happening over the past 20 years with the development and improvement of sensors, GPS and laser technology for instance, that allowed the use container handling equipment without an operator on its cabin (or even having a cabin per se).

Equipment began to be operated either autonomously with a fully robotized operation, or by a remote operator during some steps of the handling process (Cederqvist, 2012) being basically a follow up of the technology that was already in use on warehouses with the particularity of being an external activity, exposed to several other agents, which proved to be challenging.

The same drivers that applied for a regular container terminal would also be valid for automation projects. Terminal operators are always looking into the efficiency and economics of the projects, and this will always be, no matter the solution.

However, it took a long way to get there, with four decades between the invention of the container as a standard unit and the container automation handling operations (Moghadam, 2006). As it is widely known, the primary container port automation project implemented in the world is the ECT Delta Terminal in Rotterdam on 1993 (Rintanen, 2017), with the combination of Automated Rail Mounted Gantry Cranes (ARMG) and Automated Guided Vehicles (AGVs), this terminal revolutionized the industry and was one of its kinds for several years. Several years passed until the terminal Pasir Panjang partially replicated this in Singapore with an Overhead Bridge Crane combined with the use of manned Terminal Tractors (TT) for the horizontal transport in 1997, and the London Thamesport in 2000 implementing a mixture of both, ARMGs with terminal tractors.

With the container volumes growing at a fast pace during the last decade, approximately 11% CAGR (Davidson, 2016b), and with the new generation of mega vessel that came to keep up with these volumes (Mohseni, 2011), this added some pressure on the container terminals to follow the same path, grow and reinvent themselves, and/or modernize.

That is when automation really started to spread around the world. It took roughly nine years for the initial solution to be replicated again with both yard equipment and horizontal transport fully robotized, and this happened in Hamburg in 2002 at the

Hamburg CTA Terminal with again the use of ARMGs and TTs. The unique feature of this terminal is the fact that on every container block, designed perpendicularly to the quay wall, two ARMGs were operating simultaneously, and they could overlap each other because they ran in different tracks and had different sizes, allowing one equipment to pass on top of the other.

Figure 2-1 – Automated overlapping RMGs at the CTA terminal in Hamburg (Saanen, 2018)

After that slow start, as expected whenever there is a new technology available, the other terminals wait to see how automation would perform and how the industry would continue evolving on more recent years, there was an exponential growth in terms of container terminal automation projects and implementations making it possible for the number of automated terminals doubles by the end of 2020. (McLean, 2018)

Currently, the ASCs together with the AGVs are becoming the norm regarding container automation, being a somewhat standard solution with plenty of terminals having this setup deployed. The end loaded ASCs, which are implemented on blocks perpendicular to the berth, have the advantage of separating two different flows, waterside and landside, reducing the interference of external actor on the terminal, allowing the full control of the operation and traffic flow to / from the berth (Rintanen, 2017). This increases the safety of the operations

On the berth, due to a higher complexity, it took a while longer for the technology to follow the same level as on the yard. Currently there are plenty of Automated Quay Cranes (QC) or Ship to Shore Cranes (STS), and similarly to ASCs they can be either fully robotized or also operated from a remote position.

Figure 2-2 - STS remotely controlled operation (Rintanen, 2017)

Overall, the decision to go for an automated terminal passes through similar drivers such as the cost of operations ($ / TEU handled), maintaining a certain operational level to keep the clients satisfied. For that reason, this was a process that in the beginning only made sense in places with high labor costs, to compensate for the more significant investment in equipment, with lower wages expenses. However, everything has to be considered, from the price of fuel, energy, up to the value of the square meter. Still, with a considerably larger CAPEX, investors tend to perceive this as riskier business and demand either higher returns or more reliable results over the years. Moreover, that is what the next section sill cover, detailing the pros and cons of automation in container terminals.

2.2. Advantages and Disadvantages of Automation

Although the first part of this chapter might make it look as if automation is all about exceptional features and full of benefits, there is more to it than it might appear, and this is a traditional debate in the industry with valid arguments for both sides and it doesn't fit a question of whether automation is a positive or a negative thing.

Even more importantly is what are the strengths and weaknesses of container automation so that terminals can analyze objectively and make rational decision if it is worth it or not to automate, the gains and its limitations.

As stated by Davidson (2016a), automation on a container terminal can reach several parts, from the quay cranes, passing through to the horizontal transportation and the yard equipment, up to the terminal gates. Also, within those areas, there are plenty of drivers in favor and against automation.

2.2.1. Automation Advantages

Starting the advantages with one that is probably the most recognized argument: Operational Expenditures reduction. Because robots can do the job on their own, or at least the most of it, the necessity of humans involved in the operations reduces drastically, being sometimes limited to work behind the scenes supervising from behind a computer and sometimes pressing some buttons.

The OPEX is a very beneficial aspect, especially in those places where the labor costs are high. The majority of the container operations consist of repetitive movements from place A to B and are not the most intellectually demanding activities, therefore, when a terminal can put machines to do the job instead of humans, this tends to pay off on the long run because they avoid paying the stevedoring and high port wages (Davidson, 2016a).

Removing the humans from the equation also brings benefits regarding the inefficiencies of the human nature and also the labor regulation barriers that impose a limit of hours on which it can work productively, number of meal breaks, shift changes, an everything else that happens, reduce de time that a human is operating the machine, while the robotized equipment can operate with none of those breaks and only needs to stop due to maintenance requirements (Bottema, 2018).

Still, because of the absence of humans per se inside the operations, it is a much safer environment, and most of the incidents that might occur would just be concerning materials and equipment, not human health or life. As reported by (McLean, 2018), automated terminals can easily go over more than one year without any time loss due to injuries.

With robots in taking care of the container handling, there is a much higher precision and reduction of the human error possibility, which is the cause of most operational problems as well as accidents. With this accuracy, the terminal operations become more reliable a predictable.

The automated equipment also faces a decrease in the downtimes due to breakdowns since the complete movement is written on a coding line of a program, being repeated correctly every time, reducing the wear and tear, while the manual operation relies on the ability and precision of the operator that varies from one person to another, and even the same person performs differently on a daily basis (Rintanen, 2017).

Container handling equipment with remote operations allows one person to control several equipment without having to go up and down the cabin, as well as avoiding the operator to walk long distances on a risky environment like the yard or the berth improving the working conditions of the operators by shifting him from the uncomfortable small cabins to the regular office safe and well-controlled environment (Patrício, 2018).

Fully automated terminals still need operator’s assistance, however with the primary purpose of handling the exceptions. The digital world does not cover every situation on a terminal and operators are required to intervene in the operations to solve it manually. The most common issues are related to problems with twist locks, unreadable license plates or container numbers, poor quality of the container, among others (ABB, 2018).

Automated yard stacking solutions such as ASCs also tend to make a denser layout, especially if compared to Reach Stackers, Straddle Carries or even RTGs (Saanen, 2018). Therefore, it might be a useful solution when limited by landside availability, or even when the price of land is high.

If considered that most manual equipment is still running on fossil fuel while automated equipment is primarily electric cooperating with the energy transition (Vonck, 2017), this makes automation a more sustainable solution and might cooperate with the recent regulations pushing towards green solutions (ITF, 2018b).

Lastly, the automation has so many levels and layers that allows some flexibility and operators can choose to pursue an adequate level for their situation, knowing that there are semi-automated solutions out there that might fit their goals (Patrício & Botter, 2012).

2.2.2. Automation Disadvantages

On the other hand, container automation also has its inconveniences, and to mirror the first and foremost advantage presented before, automation biggest issue to overcome is the higher initial CAPEX. The investment required at the beginning of the project is considerably higher and usually an argument strong enough to drive investors always.

When compared to manual alternatives, automated terminals can be highly inflexible. Perhaps with the exceptions of the automated Straddle carries, most of the other automated designs (e.g., ASCs or ARGMs) require expensive and very particular infrastructure, most times on rail, which cannot be easily changed (Saanen & Rijsenbrij, 2018). For this reason, the terminal must take the planning phase that need to consider the terminal's demands decades ahead, so it can be planned accordingly because it is likely that they will be stuck with design choice for a very long period (Wells & Yongcui, 2017).

The automation investment is heavily based on volumes and constant services, this means that if the volumes of a terminal start to vary or there are some volume drops, the assets are all going to remain there, poorly utilized, while on a manned terminal there is the flexibility of adjusting the labor shift and scales, lay off and manage part of the assets (humans) until the volumes or the economy get back to normal and it is one of the most critical challenges to overcome when considering automation on less mature port economies (Patrício, 2018).

Terminals have on a daily basis a lot of specificities that makes operations run in an unstable manner, with differences that may change from season to season, daily or even more instantaneous changes for a singular operation These variations make it hard to keep the process predictable and repetitive, which would be the ideal environment for automation.

According to Davidson (2016a), a popular misconception regarding automation is that the robotized operation always comes with higher productivities. Although this might be the case for some terminals, in most cases, as stated by Saanen (2018), the productivities remain the same or even slightly decrease when compared to manned operations, that are already tried and tested for many more years and terminals, and this is one of the reasons that makes it riskier to carry out such projects.

With a high-end state of the art equipment and technology, automated terminals demand a highly prepared and trained staff to operate and manage, and this specific skilled labor is yet scarce on the market, so the terminals need to invest time and money to train and prepare the team (Ramos & Shah, 2015).

Another aspect where automation differs from manual operation is the fact that usually, the equipment has to be implemented on a larger scale altogether, being difficult to go on small steps like manned equipment, that can be installed and expanded almost one at a time if necessary (Davidson, 2016a).

Finally, the one that may be the biggest challenge to overcome in some places, including the Port of Santos, is union resistance. A common issue in many places, and it is not different in Brazil, with a considerably strong union in the port business, they would play a significant obstacle for the operators and politicians to overcome (Patrício, 2018). A further and detailed discussion on this topic will be made later in this chapter.

2.3. Brazilian regulation recent updates

After much debate, analysis and resistance regarding the Brazilian port regulation that was in force when the President Michel Temer took office, the new port law decree (Nº 9.048/2017) was finally edited and published, changing several rules from the previous law decree (Nº 8.033/2013).

In 2013, when the new regulatory rules came into force, the idea was to de-bureaucratize the port sector and make it more attractive to investors. However, even after more than three years, this effectiveness of this law is was being questioned (Piedomenico & Souza, 2017).

The discussion heated up again with the new president in 2016, when the port entities started negotiating a revision and update on the rules and the government understood that it was the right moment to reevaluate the mechanisms that were in place. To act on that, a task force was created to analyze the previous regulations in an attempt to make the system more interesting. Harvesting the fruits of this combined effort, on May 11th of 2017 the new Port Law decree was published, bringing some changes to the rules and the central and most significant change will be presented and discussed next.

- Extension of the Term of Leases and Port Concessions and the possibility of adaptation of existing contracts

By far the biggest change in the regulations and the one that brings more impact and grabs the investors' attention.

The previous regulation stated that the lease would have from 20 to 25 years of the contractual period, depending on the contract, and could be extended for a similar period. The new regulation extended lease period to up to 35 years with the possibility of renewal reaching the maximum limit of 70 years.

The time extension is a significant change and extremely positive because it allows that the port sector, which requires massive financial contributions and advanced planning, receives the due investments and planning.

Besides that, extending the lease terms reduces the imbalances and increases the competitiveness with the private terminals, bringing both into similar conditions since the private terminals do not have a time limit because they use their private areas.

Another interesting point is that this makes the port leases to the same grounds as the rail concessions. In the past, groups that were interested in bidding for ports and rail leases together gave up for considering that 25 years were not enough to amortize the rail investments, so the extension from 50 to 70 years of maximum lease period can benefit both sectors.

As for the extension period, another exciting update is that the renewal does not necessarily mean that it has to be done all at once as it used to be previously. In other words, the contract extension can be done in smaller parts as long as the maximum period of 70 years is respected. To exemplify, a contract that has initially 35 years duration on the first term could be followed by extensions of 10 years + 10 years + 10 years + 5 years, totaling the 70 years.

The significant advantage of this successive renewals' possibility is that they can be used by the terminal operators to ensure higher predictability of the investments. It is extremely hard to correctly predict how the market will be in 35 years concerning supply, demand, technologies employed, and other aspects.

Therefore, by using the possibility of smaller renewal periods, the lessee can better plan and prepare their financial schedule, investing at the right moment in the adequate way to fulfill the demand.

However, although very positive, this change in the lease period needs to be accompanied by another equal measure, without which it will not fully reach the goals the government is trying to propose. In the end, the new leases with extended deadlines (over 25 years) will require a new discount rate (WACC – Weighted Average Cost of Capital) to be set for the port sector.

- Discount Rate (WACC) for the Port Sector

As said before, just the increase of the lease and concessions period is not enough. With a more extended period, the leases will need a higher discount rate because the current WACC stipulated by the government is 10,00% will become unattractive for such long contracts, generating a relatively short discounted payback and as a consequence, a necessity to rebalance the contract that could be done either with the increase of Port Authority remuneration or with the decrease of terminal revenue.

Table 2-1 - Discount Rate (WACC) defined by the regulatory agency (ANTAQ, 2016)

YEAR	SEGMENT	WACC
2004	CARGO	12,70%
2005	CARGO	12,30%
2006	CARGO	11,89%
2007/08	CARGO	9,35%
2009/14	CARGO	8,30%
2013/15	PASSENGERS	8,84%
2015	CARGO	10,00%
2016	CARGO & PASSENGERS	10,00%

It happens that increasing what is paid (annually / monthly) to the Port Authority makes that the private investments are not directed to an improvement of the terminal itself, which is not interesting, especially in long-term contracts.

On the other hand, lowering the terminal's revenue, besides often not even be possible due to minimal costs or market reasons, means that the lessee has even fewer resources to reinvest in the terminal.

Therefore, for long-term leases (up to 35 years) it is imperative that the applicable discount rate (WACC) be increased because the risks of the investments are higher. Without due adjustment, investors may not be interested in the concessions, even having longer maturities.

Therefore, given the lengthening of the term and the investment return profile that exists in the sector, it is recommended that the Brazilian regulatory agency and the other governing bodies clearly state the need to increase the discount rate, which must be done before proposing to the market bids with a term of more than 25 years.

Davidson (2018f) shows that the EBITDA margins of terminal operators on recent years (2015-2016) are considerably high, ranging from 20% to 50%, due to the level of risk of these investments. With this longer period, the risks increase considerably and should be compensated with higher discount rates as suggested by Ligteringen (1999), reaching the 15%.

The Table 2-1 shows that the government had already used higher values in the past, and based on recent bids, is flirting with similar mistakes. In July of 2018 the government tried to bid three terminal areas, and for two of them, there was no investor interested.

Once again, the government alleging differences in the economic scenario lowered the WACC on these specific cases to 8,03%, reinforcing the idea that the government should indeed consider higher discount rates (10% or higher) if they want to keep the private sector interested (Collet, 2018).

2.4. Businesses, political, labor, and efficiency automation discussions around the world

To finalize all the background context that shall support the analysis and discussions made further ahead in the research, this section will cover some specific aspects and situations in locations where automation was implemented, the drivers and issues that occurred, and link that with the current Brazilian situation.

The same container terminal automation solution can have various motivations behind the decision depending on where on the globe will the terminal be located, and this leads to a very subjective discussion that can be political, economic, operational, regulatory, or a mixed combination of those factors and more.

2.4.1. Political & Business drivers

For Neil Davidson (2018g), Senior Analyst of Ports & Terminals for Drewry Maritime Research, a well-known advisory and consulting company in the shipping and ports business, the decision to automate terminals in the past was primarily a financial and business decision and it continues to be so.

Mr. Davidson does not believe that as a rule of thumb, there is much politics running behind the scenes, although sometimes politics and strong labor unions can get involved.

China is a particular case where the driver for automation in Shanghai (Qingdao) for instance, is very political and relates to the necessity of China showing they can do this, as a prestige thing and a clear statement to the world. There is also some business behind it, but the rationale in China is to be able to say "We've done it in China, so we can come to your country and provide you with a solution using Chinese ZPMC equipment and technology". That might be more macropolitical move trying to boost China as a country, making definitely the political aspect the primary driver.

In South Korea, this prestige could also be playing a similar role, but it is more of a mixture of business and politics like the case of the Port of Busan, implemented in 2010 (Martín-Soberón, et al., 2014).

Varying from country to country, in the Middle East region as a whole, there is some prestige behind it, as it might be the case in Abu Dhabi rather than a business choice, again as a country (UAE) trying to state that they are at the forefront and can do it as leaders in technology. Thus, just at a couple of places, particularly those with low wage costs are implementing for this reason and it is a fair argument that this is a geopolitical move more so than a business move.

The Figure 2-3 shows in a summarized manner the arguments presented above where the Greater China and the Middle East regions theoretically should not have such an appetite for automation given the low labor costs, with Europe and North America having more fundamental reasons. It is interesting to see that Brazil falls under a very neutral area, with the Latin America being just on the edge of having a higher labor wage cost or even a higher appetite for automation.

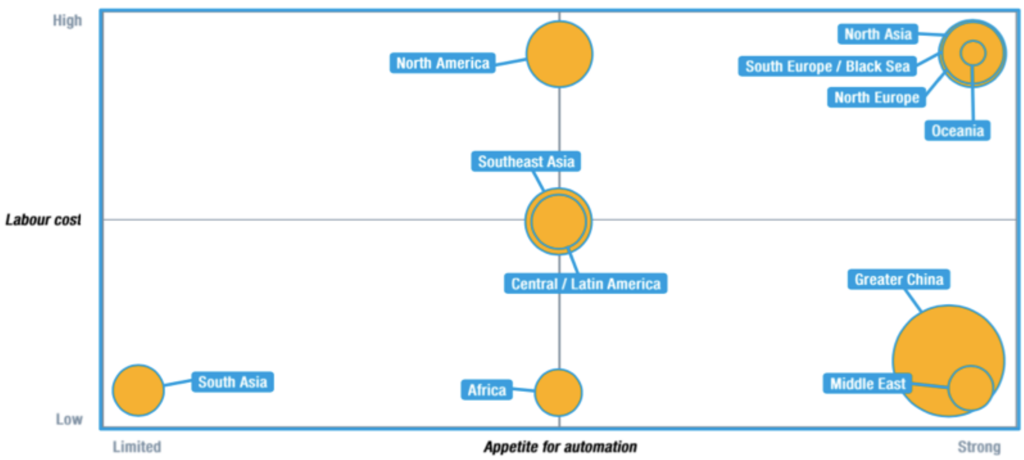


Figure 2-3 - Number of potential retrofit automation terminals by world region (Davidson, 2018a)

On the other hand, in Europe, according to Mr. Ulco Bottema (2018), Senior Commercial Executive at Hutchison Ports ECT Rotterdam, his company started early in the 90's with automation at their Delta Terminal foreseeing that in the future the demand for stevedoring terminal operations would grow in the coming decades, and so it did.

Whereas to stay in sync with overall cost, particularly with labor costs, ECT came up with the world's first fully robotized solution for container terminal operations in the yard with ASCs and horizontal transportation with AGVs from the yard to the quay cranes. At that time the remote control of quay cranes was not yet within the scope.

There are a couple of items that need to be addressed when considering investing in terminal automation. This is considered an excellent alternative for locations where there is a 24/7 operation and when there is some consistency regarding weekly vessel calls. While with only two or three calls per week, it is doubtfully that the initial CAPEX for the automation will be paying it back (Bottema, 2018).

However, there are more and more issues with labor coming up, particularly in Europe, that there is a significant responsibility for long time employment with their workers and the terminals need and want to provide a healthy and safe working operation environment for them. It is necessary to consider preventing workers from doing a very repetitive job at exhausting and fatiguing positions like straddle carriers' cabins, terminal chassis, RTG cockpits, among others.

Mr. Bottema also said that one of the reasons for ECT to do some types of automation at a very early stage, like the gate part, for example, was related to the improvement of the health care of their employees. The company should always avoid having people working in the gate, which is a very harmful place of the terminal because it is where the trucks will constantly start their engines and burn diesel, making the employees exposed 8 hours per week every day. In the long run, this can bring dangerous risks to the workers, a risk that can be avoided with a relatively low investment for what is obtained as an improvement.

Meanwhile, Marcelo Patrício (2018), which is a former manager at BTP Santos terminal, the current leader in container volume in Brazil, says that when it comes to occupational health, this is not yet an issue that plays a part in the argumentation for automation in Brazil. The same goes for the sustainability aspect. Both are considered interesting side effects, but not important enough to persuade the terminal operators.

Another trend that is happening with terminals operators in recent years is the structural business link with shipping lines. These terminal operators when belonging to a bigger company such a container liner could play a significant part in the verticalizing the logistic chain; however, they follow two similar primary commercial considerations: the price charged, and the service level provided for the vessels (Davidson, 2018f).

Both businesses run by very separated objectives with the terminals not suffering pressure towards or against automation just because of their possible relation container liners.

2.4.2. Operational Efficiency

A topic already discussed previously in 2.2; the operational efficiency also has different perspectives that can be seen as business drivers.

Bottema (2018), considers this a hard comparison to be made. By looking at productivity from a man-hour per move point of view, an automated terminal is by far much more efficient and better performing than a manual terminal, similar analysis can be gone with moves per square meter due to the highly condensed yard design.

As it is already known, many of the automated terminals have some worse performance if compared to manned operations regarding moves per hour and other commonly used KPIs. They find themselves in a slower operation situation basically, and up to this moment, there is no getting away from that and those that are banking on getting better over time they are taking a bet on this uncertainty (Davidson, 2018g).

For all those differences it is not recommended to look into only one aspect, but it is necessary to have a broader view of the big picture and add them all into the equation.

The problem that every terminal operator has is that the technology is moving on so quickly lately that it may be that within a year or two many of the issues that existed earlier would have been addressed, and if they wait until then, they lose a year or two, and then it comes to the question: What should terminal operators do?

It is a catch 22 situation proving that there is an element of risk taking to it. It also needs to be clear that Port Terminals are by nature a long-term investment and automation is undoubtedly a long-term project as well, and there is also some percentage of expectation that after the initial years things and technology will have moved on well enough to make it worthwhile so, to some extent there is also some gambling and risk-taking involved.

2.4.1. Automation vs. Unions

When it comes to the debate involving automation and unions, the discussion gets polarized, with conservative arguments on the union sides and innovative arguments on the automation side.

Overall this topic is considered nearly everywhere in the world and had different outcomes in each part of the globe.

Like explained before, in China, although the labor wages are not that high, automation already started to take place due to a strong geopolitical driver, and when the government supports it, it makes it easy to implement, especially in such a governmental protective nation.

In Europe, where the unions are not so powerful and militant when compared to other places, more progress has been made in countries like Germany, Netherlands, Belgium, and United Kingdom.

The path towards automation in the Netherlands was relatively slow, considering the potential. For instance, at ETC Delta Terminal in Rotterdam, the delivery from the landside yard to trucks could be also be initially included in the robotized operations. However, due to labor and union restrictions and safety concerns, ECT kept the terminal still manually delivering the containers to trucks, and on later generations, like the one implemented at ECT Euromax terminal, this was already done with an automated delivery.

Specifically, in this case, the ECT Euromax terminal came to life as additional capacity, just expanding the port volumes, not hampering the existent labor force at all and that made it easier (Bottema, 2018). When looking into places where there is already a significant amount of labor deployed, the terminals have bigger issues.

As for fear of job losses, a way to reduce the risks of friction with unions is to seek automation in markets where is possible to predict growth in the coming years, making it viable to keep the current workforce in place and change gradually to a different type of labor. There will be more maintenance positions, or a different type of maintenance, much more IT people in a more pleasant environment for the port workers. Anyhow, the work that these automated terminals tend to provide is more interesting for the younger generations.

On the other hand, in The United States has a unique situation. On the West Coast for instance, more specifically in Ports of Long Beach and Los Angeles, which had a somewhat fragmented capacity into too many small terminals, the Long Beach Container Terminal was recently automated because as part of a significant redevelopment of two terminals merging them into one and also adding some more land to it, making a much bigger terminal.

Therefore, the overall economics of automation could be viable because it allowed a new bigger terminal, rather than automating two smaller facilities. A quite specific reasoning behind this case that made it work. Also, the union on the West coast (International Longshoremen and Warehouse Union – ILWU) is more favorable when it comes to automation if compared to the East coast union.

The East coast union (International Longshoremen's Association – ILA) is considerably against automation. Trying to avoid major frictions with the unions, some east coast locations like Virginia and New Jersey, slowed down the speed and went for semi-automated solutions (Mongelluzzo, 2017).

In addition to that, the ILA recently blocked any further development regarding automation on the East Coast. Even on the West coast, there is also the necessity of employing some people that the terminals don't really need to comply with rules that are in place just to save or create a job. An example of that is the last move from the ASC onto a truck being often done by an operator manually although it doesn't need to be that way and ended up affecting the economics of the business (Davidson, 2018g).

This shows that there are many compromises, particularly in the US when it comes to automation. Several obstacles such as unions and terminals size, making it very challenging to become a reality even though it is quite rightly the ideal place for it because of the incredibly high wages of dockers in the country. Therefore, the place stands out as an oddity because it could be argued that without all this powerful unionized environment, basically every terminal could be automated when in fact is incredibly difficult to move forward with this agenda, and there might not be many more soon.

2.4.2. Brazilian Situation Overview

According to Patrício (2018) automation in Brazil has to take some small steps and go slow, perhaps starting with smaller or partial automation projects.

He classifies in his Thesis (Patrício, 2014) into smaller, medium and large-scale automation, and with that methodology, there are some examples already in place with a smaller scope like OCR at the gates for instance.

The higher level of automation in the Brazilian ports face 2 big issues: the usual low volume of container handling on most terminals (just Santos makes more than 1 million boxes per year whilst the remaining ports around the country handle less than 500.000 TEU per year); and the political climate in Brazil, especially when it concerns union relations, that still has much friction.

When it comes to government and port authority relations with the terminals concerning possible implications as collateral damage into the automation scenario, they do not intervene positively because this is not at all part of their agenda, nor they are concerned primarily with the performance changes of this shift to automation.

The port authority and government are still focusing on much more basic and rudimentary issues like severe infrastructure restrictions both on the landslide with rail and road work, as well as on the waterside with the never achieved promised depth on the port.

On the other hand, other public entities, like the IRS - Internal Revenue Service, that through a regulation (IN 3518) demanded the installation of OCR at the gates, the use of scanners, and the automatic transfer of the weighing information to the IT systems, but all smaller types of automation. Still, when the public sector moves towards digitization, this can slowly call for automation solutions regardless.

When considering high docker labor cost, which is an issue in many places including Brazil, the country still lags behind Europe for example, diminishing the appeal for automation.

Still on the Labor topic, Patricio (2018) has a similar view as Bottema (2018), praising the pool system (variable labor) that is commonly used around the world as an interesting solution for when those terminals with big variation in terms of vessels and volumes, not having a fix weekly call, or when the terminal is operating in a market with constant significant changes.

With regards to the aforementioned friction with the unions, Port of Santos, for instance, is facing a gradual reduction of the stevedoring labor, even though the federal supreme court has already determined that this labor relation is no longer mandatory.

Some terminals in Brazil are operating in a particular arrangement with the unions. DPW Santos is a fully private terminal that does not has to comply with the same regulations as the leased public terminals, but currently, have a deal to use the union stevedoring workers as part of their operations to make things run smoothly without any risk of strikes or any other possible issue with this regard.

Libra Terminal Rio, which is a public lease, gained in the justice the right to not use the union labor force but is still an ongoing debate with the union and brings some uncertainty. In Santos, most terminals use 25% to 50% of pool union labor force (Patrício, 2018).

With an outside perspective and with a correlated situation, Hutchison Ports is doing more and more terminal automation on several places throughout China and even Indonesia, with all of them going in the same direction because it is safer, much more predictable and reliable making the operations rather stable. With that being said, it is important to be aware that these changes will be confronted with labor shortages and unions at some point and level everywhere.

Terminal operators like Hutchison also look into this topic from two perspectives, the license to operate and the corporate social responsibility.

In many places in the world, the terminal must be aware of the environmental concerns, with all the pollution that it might create, including light and sound. Meanwhile, when looking into the automated terminals, they will mostly be electric, making a huge difference in terms of emission, much lower lighting requirements due to the robotized nature of the operations, as well as a reduction in terms of noise pollution as a result of a smoother operation from the machines.

Therefore, from these less tangible and more subjective issues, there isn't really an alternative if not moving forward with automation at some point, especially in those ports that are located within the city, like the Port of Santos.

Counter-arguing this speech, Davidson (2018g) believes that for Brazil and possibly other emerging markets, it is necessary to get back to basics and ask why one want to automate or why would they? Is it worthwhile? If there is nothing to be gained or something to be lost, simply do not do it.

Looking from several aspects there might be a downside at least in medium-term regarding productivity, and with the unions as they are, unless there is a radical change in the agreements, the terminal would probably be creating more trouble for themselves. Whereas with a manned terminal the resistances can be dealt more easily because basically by definition there is more flexibility.

Therefore, in Latin America, it must be wondered if this is a risk worth taking it when the potential downsides tend to outweigh the potential upsides by some margin.

Chapter 3 Methodology

As mentioned previously in the first chapters, this research is composed at some level of both qualitative and quantitative analysis. Observing from the problem approach perspective, the study has a quantitative research bias throughout its entire process, by inputting, analyzing things and support techniques like CAPEX, OPEX, Profit & Loss Statements, Cash Flows, Net Present Values, and Internal Rates of Return. (Patrício, 2014)

The present section will focus on the quantitative component, describing the techniques used and the steps carried out to reach the ultimate goals of comparing both manned and automated container terminals in Brazil and their economic viability.

This chapter will hold a succinct description of the methodology applied, followed by a description of the economic model built to support the decision of whether or not to go for an automation project or stick to the traditional manned operations project. By the end of the chapter, there will be enough evidence to analyze and discuss the results of such a study thus allowing to provide a thorough diagnosis of the current economic scenario and some sensitivities.

The methodology will also briefly encompass the considerations and assumptions taken to cover the qualitative bits, that were already provided in the literature review and shall be further discussed in the results, analysis and conclusion sections.

As for the objectives, it is an exploratory research because it aims to contribute to a bigger understanding of the problem, as well as make it explicit bringing greater awareness to the topic, create a hypothesis, and to involve a literature review and examples that stimulates the comprehension.

Finally, similarly to what Patricio, Moura & Botter (2016) did in their Brazilian container terminal automation evaluation model, this work used the following planning and research execution steps:

- Thesis topic choice;
- Relevance and motivation for the study;
- Research Question and sub-questions;
- Objectives establishment;
- Literature review;
- A Methodology of data collection;
- Results tabulation;
- Analysis and discussions of the results;
- Conclusions;
- Recommendations for future researches.

Thus, considering all that we can move to the economic model methodology itself. However, to get to the economic model it is necessary to go through an extensive roadmap before, and this path will include:

- Terminal Design and calculations

The basis for all the study lies on the terminal design choices that will provide a common ground as a mean to compare both manned and automated operations. This section will include a basic and simplified design, terminal main figures such as Volume, equipment fleet, KPIs, etc.

- Capital Expenditures

For each of the proposed terminals, there will be an estimation of the CAPEX to implement the solution, focusing on the berth, yard, and horizontal transportation equipment.

- Operational Expenditures

Using a similar approach to what is already considered for both terminal design and CAPEX, an estimation of the operational costs will be carried out, including the main variables such as Personnel (labor), cargo handling, maintenance, fuel, and energy consumption, lease fees, and others.

- Profit & Loss and Cash Flow

Input all the outcome of the steps above into the regulatory format and design required by the Brazilian port Authority (CODESP) to reveal economic KPIs like gross revenue, EBITDA, net profit, cash flow, accumulated cash flow, Net Present Value, Internal Rate of Return, etc.

- Sensitivities

For a deeper understanding of the behavior of such an economic model, some sensitivities were applied to a few key parameters to be able to evaluate the impact of some changes on the financial results.

Due to the political instability of recent years, the Brazilian currency rate will be analyzed.

Motivated by recent fluctuations in volumes, new competitors on the container market and changes in the labor regulations, the cost & expenses are also part of a sensitivity analysis.

Moreover, the last variable to be considered is the controversial WACC (Weighted Average Cost of Capital), which is a specific discount rate that has to be considered for terminal leases according to the port authority.

Several other steps approach and variables could also be considered, but there is an infinite combination of possibilities for this study that at one point we need to limit the scope of the research to keep it concise, objective and functional, and this is where we draw the line for ours.

Chapter 4 Terminal Design and calculations

As stated by Velsink (1994) and Ligterigen (1999), port planning and design it is, by its nature a task that requires interdisciplinary skills and expertise from different fields and creativity. Embracing this idea and not being limited by this concept, since we will design a hypothetical terminal in Santos, it is only logical that we check the layout and overall main characteristics of the most important container terminals in the Port of Santos to identify possible trends, restrictions or any other specificity.

As a starting point, we look at the oldest and until recently, the biggest container terminal in the port, which is TECON Santos owned by the Santos Brasil group. (CODESP, 2018)

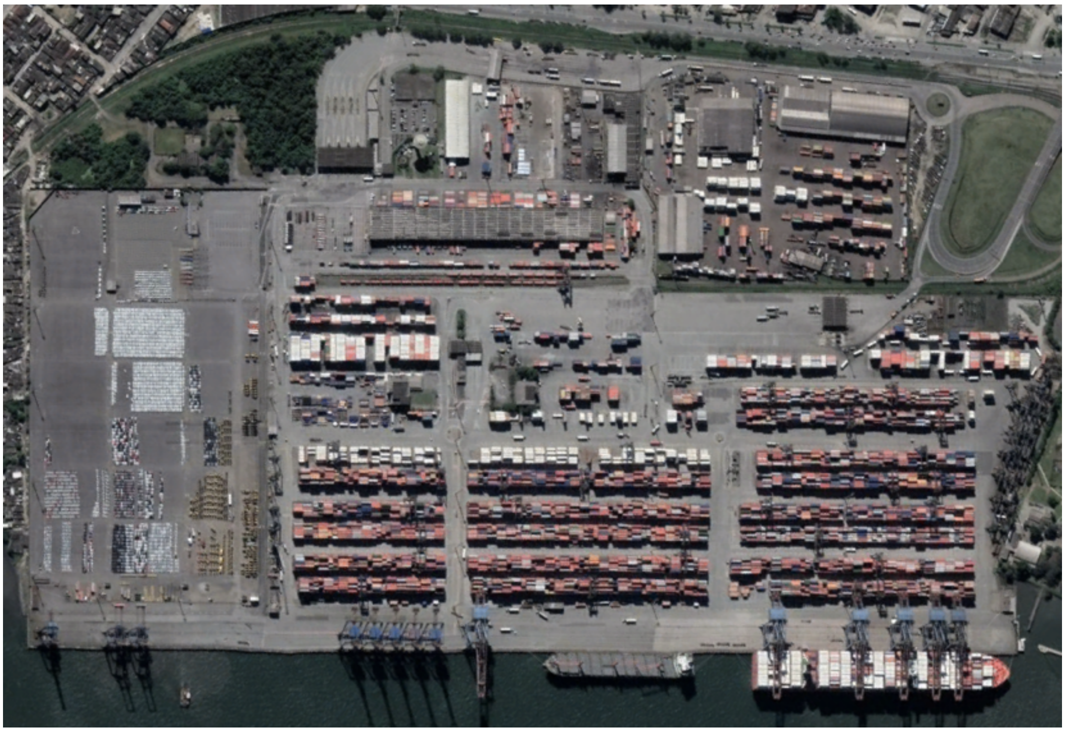


Figure 4-1 - TECON Santos (Source: Google Earth)

TECON Santos has the following characteristics[1]:

- Total Area: 600.000 m^2
- Quay Length: 980 m
- 2 million TEU of annual capacity
- 13 STS + 1 MHC
- 46 RTG
- 18 Reach Stackers

[1] Information extracted from the company's website (Santos Brasil, 2018a)

- 4 Rail tracks
- 2.000 Reefer plugs
- CFS Warehouse - 12.000 m^2

As it can be seeing in Figure 4-1, the terminal has a fairly standard shape with linear geometry on its quay wall and roughly a rectangle format at the storage area, with container blocks parallel to the berth, and the rail access also parallel but cutting the terminal at the back. A very straightforward and common design.

The second terminal we will look into is the Brasil Terminal Portuário – BTP. Starting its operations in 2013, this terminal ramped-up quickly to the top and currently occupies the status of the biggest container terminal in terms of volume handled (CODESP, 2018). BTP is the result of a joint venture of two well-known terminal operators, APM Terminals and Terminal Investment Limited (TIL).

Figure 4-2 - BTP (Source: Google Earth)

BTP has the following characteristics[2]:

- Total Area: 500.000 m^2
- Quay Length: 1.108 m
- 2.5 million TEU of annual capacity
- 8 STS
- 26 RTG
- 16 Gates (in & out)
- No rail tracks

[2] Information extracted from the company's website (BTP, 2018a)

- CFS Warehouse

As it can be seeing in Figure 4-2, the terminal has a slightly different shape compared with TECON, still with linear geometry on its quay wall but with a trapezoidal format at the storage area. It also can be noticed that the berth is not entirely contiguous with the yard, having a 250 meters extension. The container blocks are also parallel to the berth, and there's no rail access.

Lastly, we will have a brief look at the DP World Santos Terminal. Formerly known as EMBRAPORT, the terminal changed its name when the Dubai Ports World group, already one of the investors, fully bought the terminal in December of 2017. This terminal also started its operations in 2013 and currently holds the third position in terms of volume handled with approximately 20% of the port's market share.

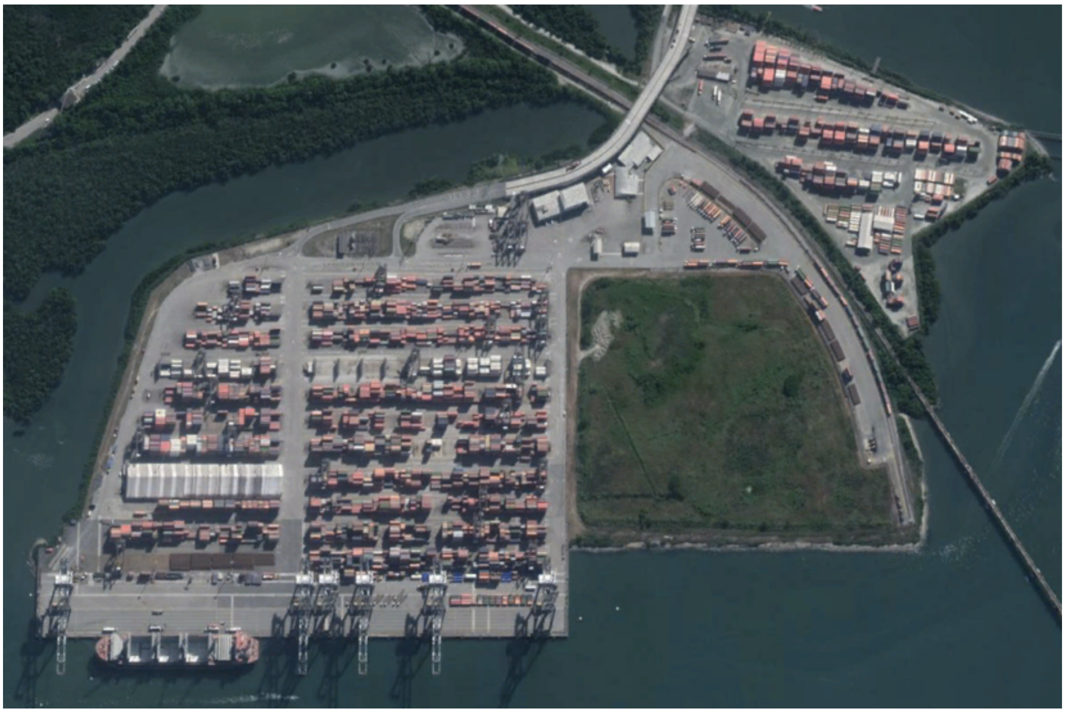


Figure 4-3 - DP World Santos (Source: Google Earth)

DP World Santos has the following characteristics[3]:

- Retro Area: 207.000 m^2 (+ 168.000 m^2 expansion)
- Quay Length: 656 m (+ 446 m expansion)
- 6 STS
- 22 RTG
- 18 Reach Stackers
- 20.000 m^2 of rail yard

[3] Information extracted from the company's website (DP World, 2018)

- 1.000 Reefer plugs
- CFS Warehouse

As it can be seeing in Figure 4-3, the terminal is the most ununiform shaped terminal among the three analyzed. Still, with linear geometry on its quay wall and a trapezoidal format at the adjacent storage area, this is another terminal with container blocks parallel to the berth, but now with rail access passing on its back with minimal interference due to an overpass that connects the terminal with the public road.

Just by looking at the three main terminals of the Port of Santos we can infer plenty of information for our design and also base our choices and layout on them, most specifically one of them: TECON Santos. This is a very standard terminal with a very straightforward and basic layout that adopts the most commonly used equipment design with RTG (Rubber Tyred Gantry cranes) as yard handling equipment and TT (Terminal Tractors) as the horizontal transport option.

In addition to that, TECON Santos also has a long track record of successful operations with plenty of KPIs available and published by the Port Authority, as well as public financial reports and plenty of data accessible due to the fact that the group *Santos Brasil* is listed in the Brazilian stock market.

Now that it is defined a proper reference to base the hypothetical terminal design, it is possible to use Santos Brasil's numbers as ballpark figures as a starting point to our calculations, that shall be common to both manned and automated options, allowing a proper and fair comparison of each solution.

The initial figures are:

- Terminal Annual Throughput: 2.000.000 TEU
- Terminal Quay Length: 1.000 m

As per the rest of the variables or figures, they will be either calculated using Santos Brasil's public data, Port of Santos overall data, or assumptions based on benchmarks found in relevant bibliography.

Santos Port Authority provides both monthly and yearly detailed and segmented information regarding all types of cargo handled in the port, and for the purpose of this study, we will use the most updated annual results found in CODESP (2018).

Table 4-1 - Port of Santos Annual Container Throughput – 2017 (CODESP, 2018)

			TEU	CNTR	TONS
IMPORT	Long Haul	20"	463.341	463.341	6.146.605
		40"	1.124.358	562.179	9.155.007
	Coastal	20"	107.903	107.903	1.954.521
		40"	251.480	125.740	1.895.334
	TOTAL		1.947.082	1.259.163	19.151.467
EXPORT	Long Haul	20"	461.759	461.759	10.031.766
		40"	1.056.664	528.332	11.177.376
	Coastal	20"	104.072	104.072	1.452.048
		40"	284.142	142.071	2.721.614
	TOTAL		1.906.637	1.236.234	25.382.804
TOTAL	Long Haul		3.106.122	2.015.611	36.510.754
	Coastal		747.597	479.786	8.023.517
	TOTAL		3.853.719	2.495.397	44.534.271

From the Table 4-1 is possible to derive one crucial variable: TEU Factor, which is the relation between the number of TEU moved per container.

$$TEU\ Factor = \frac{TEU}{Container} = \frac{3.853.719}{2.495.397} = 1.544$$

$$\boldsymbol{TEU\ Factor \cong 1.55}$$

Another key variable is the Transshipment Ratio, which according to Saanen & Rijsenbrij (2018) is the number of containers that arrive via the berth, visit the stack yard and is shipped again through the water side, never passing through the truck or rail gates, all through seagoing vessels, compared to the Total terminal Throughput.

$$Transshipment\ Ratio = \frac{Sea\ going\ moves\ IN + Sea\ going\ moves\ OUT}{Annual\ Throughput}$$

Transshipment Ratio: 19% (Sporl & Woelbeling, 2015)

$$Terminal\ Throughput = Sum\ of\ all\ Seagoing\ vessel\ STS\ moves$$

$$Terminal\ Throughput = \frac{2.000.000\ TEU}{1.544}$$

$$\boldsymbol{Terminal\ Throughput \cong 1.300.000\ containers}$$

Now, since the terminal capacity if by default determined by the capacity of its berth movements, and the berth usually holds the most expensive assets of a terminal (STS cranes and Quay wall), we need to make sure that the rest of the terminal can keep up with the berth to support the volumes expected on the waterside. For that, we will need to find a proper yard capacity and the waterside capacity that can be supported by the yard.

$$Yard\ Capacity = \frac{TGS \times Max\ Stack\ Ht. \times\ Stack\ Ht. Utilisation\ \times 365\ days}{Surge \times Peaking\ Factor \times Avg. Dwell\ Time}$$

$$Yard\ Storage\ Capacity = Throughput\ Capacity\ \times (1 - 0.5 \times T/S\ Ratio)$$

- TGS – TEU Ground slot – Will vary according to the design chosen and the volume required;
- Max Stack Height – Is the number of containers that can be stacked on top of another, and will depend on the type of yard equipment used;
- Max Stack Utilization – It is a variable that measures the maximum utilization of the yard remaining in a situation where the yard equipment can still perform at minimum design speed. This might also vary according to the equipment of choice;
- Peak Factor – It is a variable that considers the maximum TEU stored in a certain period, compared to the average TEU stored on the same period;
- Surge – Is a consideration on top of the peak factor that accounts for short periods of peaks, especially due to the increase on the average vessel sizes and consequently their average call size, and the shipping lines demand for similar service time;
- Dwell time – It is the average period of time that the container stays in the terminal.

From this point on it is necessary to separate the calculations of the manned design from the automated design since they will have different layout conceptions.

4.1. Manned Terminal Calculations

For the hypothetical manned terminal, we will consider the same systems used on all three terminals previously analyzed from Santos, which is the combination of regular quay cranes with RTGs operating in the yard and Terminal Tractors as the horizontal transportation solution.

With that we have the following design criteria:

- Dwell Time – 5 days

A simplified average estimation, since there might be several different dwell times for different types of containers such as import, export, reefer, empty, etc.)'

- Surge – 5%
- Peak – 20%
- Stacking Height: 6

  Since for the manned terminal it is considered RTGs that can usually stack up to 6 high and it is what TECON Santos has at this moment.

- Max. Stack Utilization: 85%

The stepwise approach and calculations methodology used in this study followed recommendations of Silveira & Sudjaka (2018) and Saanen (2018)

4.1.1. TEU Ground slots Calculation

Using the yard storage capacity and the yard capacity formulas already presented we have:

$$Yard\ Storage\ Capacity = 2.000.000\ \times \left(1 - (0.5 \times 0.19)\right)$$

$$\boldsymbol{Yard\ Storage\ Capacity \cong 1.800.000\ TEU}$$

$$1.800.000 = \frac{TGS \times 6 \times 0{,}85 \times 365\ days}{1{,}05 \times 1{,}2 \times 5}$$

$$\boldsymbol{TGS = 6.118\ TEU\ Ground\ Slots}$$

This is the minimum requirement of TEU ground slots necessary to handle the targeted volume and gives us enough information for a draft of such terminal, to later calculated the equipment fleet and validate it.

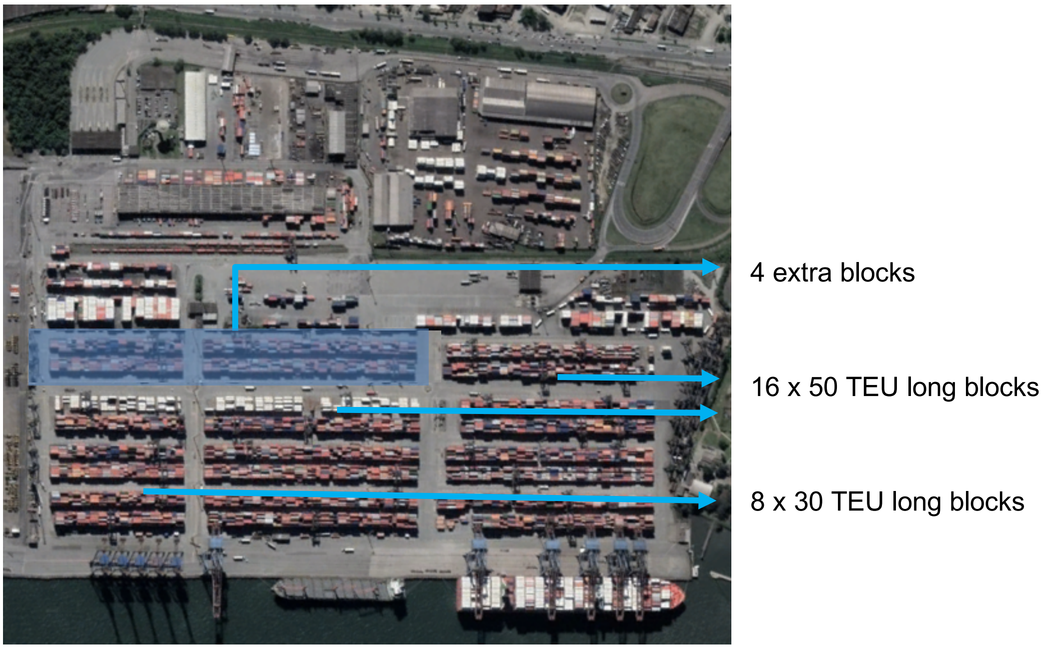


Figure 4-4 - TECON Santos "re-designed"

Just by keeping a similar format to what already exists at the real terminal and adding four extra blocks with the same measures of the existing ones do not cause any disturbance regarding truck flow we can reach the required number of TGS necessary and the yard would have the distribution presented in Table 4-2.

Table 4-2 - Manned terminal yard distribution

Long Blocks	16
Long blocks length	50 TEU
Short blocks	8
Short blocks length	30 TEU
Blocks Width	6
TEU Ground Slots	6.240 TGS

$$Number\ of\ TEUs\ Lengthwise\ per\ Block = 50 + 50 + 30 = 130\ TEU$$

Knowing that already with the gap necessary between 2 containers, each TEU occupies approximately 6,3 meters:

$$Container\ yard\ Stack\ Lenght = 130\ x\ 6{,}3 = 819\ Meters$$

$$Space\ for\ perpendicular\ internal\ truck\ road = 1.000 - 819 = 181\ Meters$$

$$Perpendicular\ truck\ roads = \frac{181}{4} = 45{,}25\ Meters\ per\ access$$

With two perpendicular roads on the edges of the terminal and two perpendicular roads between the container blocks, all of which would be able to have more than 45 meters width provides enough space for the truck operational traffic around the terminal.

4.1.2. Quay Crane Calculation

Input and Assumptions based on Benchmarks:

- Quay Crane Capacity = 2.000.000 TEU → 1.300.000 containers
- Quay Crane Max Running Hours = 5.200 hours (55% of the time)
- Average Gross Moves per Hour = 25 moves per hour

$$Quay\ Crane\ Capacity = \#QC\ \times Max\ Running\ Hours\ \times Avg.Gross\ Moves/hr$$

$$1.300.000 = \#\ QC\ \times 5.200\ \times 25$$

$$\#\ \boldsymbol{QC} = \mathbf{10}\ \boldsymbol{Quay\ Cranes}$$

4.1.3. Yard Handling Calculation

For the yard handling capacity, calculating the waterside peak demand and the landside peak demand will be necessary.

Assuming:

- Truck/Rail shake of 80/20'
- Weekly peak volume of 1,2 of the average week;
- Daily peak volume as 20% of the weekly volume;
- Hourly peak volume as 7% of the daily volume;

We have:

$$Landside\ Volume = Annual\ Throughput\ \times (1 - TS\ Ratio)$$

$$Landside\ Volume = 1.300.000\ \times (1 - 0{,}19)$$

$$Landside\ Volume \cong 1.050.000\ containers\ per\ year$$

$$Volume\ Through\ Gate = Landside\ Volume \times Truck\ Share$$

$$Volume\ Through\ Gate = 1.050.000 \times 0{,}80$$

$$Volume\ Through\ Gate = 840.000\ containers\ per\ year$$

$$Weekly\ Peak\ Volume = \frac{Volume\ Through\ Gate\ per\ Year}{52} \times Weekly\ Gate\ Peak$$

$$Weekly\ Peak\ Volume = \frac{840.000}{52} \times 1{,}2$$

$$Weekly\ Peak\ Volume \cong 19.350\ containers\ per\ week$$

$$Daily\ Peak\ Volume = Weekly\ Peak\ Volume \times Daily\ Gate\ Peak$$

$$Daily\ Peak\ Volume = 19.350 \times 0{,}2$$

$$Daily\ Peak\ Volume = 3.870\ containers\ per\ day$$

$$Hourly\ Peak\ Volume = Daily\ Peak\ Volume \times Hourly\ Gate\ Peak$$

$$Hourly\ Peak\ Volume = 3.870 \times 0.07$$

$$\boldsymbol{Landside\ \ Peak\ Volume \cong 271\ containers\ per\ hour}$$

$$Waterside\ Peak = (\#QC - 1)x\ Average\ QC\ gross\ moves\ per\ hour$$

$$Waterside\ Peak = (10 - 1)\ x\ 25$$

$$\boldsymbol{Waterside\ Peak\ Volume = 225\ containers\ per\ hour}$$

Considering that both waterside and landside peaks do not happen simultaneously, it is assumed that the joint peak would be approximately 85% of them combined.

$$Joint\ Peaks = (Landside\ Peak + Waterside\ Peak) \times 0{,}85$$

$$Joint\ Peaks = (271 + 225) \times 0{,}85$$

$$Joint\ Peaks = 422\ containers\ per\ hour$$

Also, to finalize, it is necessary to check if the yard equipment is able to handle the peak. As previously mentioned, the terminal has 24 container blocks. Considering 2 RTG per block, the yard fleet has 48 RTGs.

Due to operational conditions such as maintenance plans, the terminal rarely has all the equipment available at the same time, and for that reason, it is considered that only 90% of the fleet is available to handle the peak hour.

$$Available\ RTG = \#\ RTG\ \times 0{,}9$$

$$Available\ RTG = 48\ \times 0{,}9$$

$$Available\ RTG = 43$$

$$Yard\ Peak\ Handling\ Capacity = Available\ RTG\ \times RTG\ Peak\ Productivity$$

$$Yard\ Peak\ Handling\ Capacity = 43\ \times 10$$

$$Yard\ Peak\ Handling\ Capacity = 430\ containers\ per\ hour$$

$$Yard\ Handling\ Capacity = \frac{430}{422} \times 1.300.000$$

$$\boldsymbol{Yard\ Handling\ Capacity = 1.325.000\ containers\ per\ year}$$

Since the yard can handle more than the annual throughput of 1.300.000 container per year, this design is operationally feasible.

Now that the terminal peak is calculated, it is necessary to properly size the terminal tractor fleet using a similar methodology. The TTs will have to handle the waterside peak volume since the landside volume will be operated by external trucks that are delivering or picking up a container.

$$Available\ TT = \#\ TT\ \times 0{,}9$$

$$Waterside\ Peak\ volume = Available\ TT\ \times TT\ Peak\ Productivity$$

$$Waterside\ Peak\ volume = \#\,TT \times 0{,}9 \times TT\ Peak\ Productivity$$

$$225 = \#\,TT \times 0{,}9 \times 5$$

$$\#\,\boldsymbol{TT} = \mathbf{50}\ \boldsymbol{Terminal\ Tractors}$$

This fleet size matches the recommendation of 5 terminal tractors per quay crane (Patrício, 2014).

4.2. Automated Terminal Design

For the hypothetical automated terminal, we will consider some assumptions and benchmarks similar to the Manned terminal, making changes where the different equipment set up play a role.

Since container automation doesn't exist in Brazil yet, the arrangement chosen to proceed with the comparison will be the one that is perhaps the most commonly used automated setups used around the world according to (Rintanen & Recktenwald, 2018) and has been around since the first generation of container terminal automation, implemented at the ECT Delta Terminal in Rotterdam, which is the combination of Automated Stacking Cranes (ASC) and Automated Guided Vehicles (AGV) on container blocks perpendicular to the quay wall. (IAPH, 2015)

In this study there will be some slight differences since improvements have been made on the field over the last 25 years, so on top of that we will also consider the use of Automated STS cranes with double trolley with remote operations and 2 ASCs on each container block to be able to handle both waterside and landside operations simultaneously.

With that we have the following design criteria:

- Dwell Time – 5 days
- Surge – 5%
- Peak – 20%
- Stacking Height: 5

  Since for the automated terminal it is considered ASCs that can usually stack up to 5 high.

- Max. Stack Utilization: 85%

As done previously, the stepwise approach and calculations methodology used in this study followed the same recommendations of Silveira & Sudjaka (2018) and Saanen (2018)

4.2.1. TEU Ground slots Calculation

Using the yard storage capacity and the yard capacity formulas already presented we have:

$$Yard\ Storage\ Capacity = 2.000.000\ \times (1 - (0.5 \times 0.19))$$

$$\boldsymbol{Yard\ Storage\ Capacity \cong 1.800.000\ TEU}$$

$$1.800.000 = \frac{TGS \times 5 \times 0{,}85 \times 365\ days}{1{,}05 \times 1{,}2 \times 5}$$

$$\boldsymbol{TGS = 7.310\ TEU\ Ground\ Slots}$$

This is the minimum requirement of TEU ground slots necessary to handle the targeted volume and gives us enough information for a draft of such terminal, to later calculated the equipment fleet and validate it.

The Table 4-3 shows the initial arrangement to reach the number of TGS required.

Table 4-3 - Manned terminal yard distribution

Blocks	18
Blocks Length	46 TEU
Blocks Width	9 TEU
TEU Ground Slots	7.452 TGS

With that, it is possible to start calculating all the measures of the terminal to see how it would fit the area.

Knowing that already with the gap necessary between 2 containers, each TEU occupies approximately 6,3 meters long and 2,64 meters wide:

$$Container\ yard\ Stack\ Lenght = 46\ x\ 6{,}3\ \cong 290\ Meters$$

$$Container\ Block\ Width = 9\ x\ 2{,}64\ \cong 24\ Meters$$

$$Maintenance\ Lane\ (1\ on\ every\ 2\ blocks) = \left(\frac{18}{2}\right) - 1 = 8$$

$$Truck\ Lane\ Width = 4{,}5\ meters$$

$$ASC\ Leg\ widht\ Required\ = 2{,}2 + 2{,}2 = 4{,}4\ meters$$

$$ASC\ Leg\ widht\ Required\ = 2{,}2 + 2{,}2 = 4{,}4\ meters$$

$$Total\ Yard\ Width\ required = (cntr\ blocks\ width\ x\ \#\ blocks) + (maintenance\ lane\ width\ x\ \#\ lanes) + (ASC\ req.\ width\ x\ \#\ blocks)$$

$$Total\ Yard\ Width\ required\ = (24\ x\ 18) + (4{,}5\ x\ 8) + (4{,}4\ x\ 18)$$

$$\boldsymbol{Total\ Yard\ Width\ required\ \cong 547\ Meters}$$

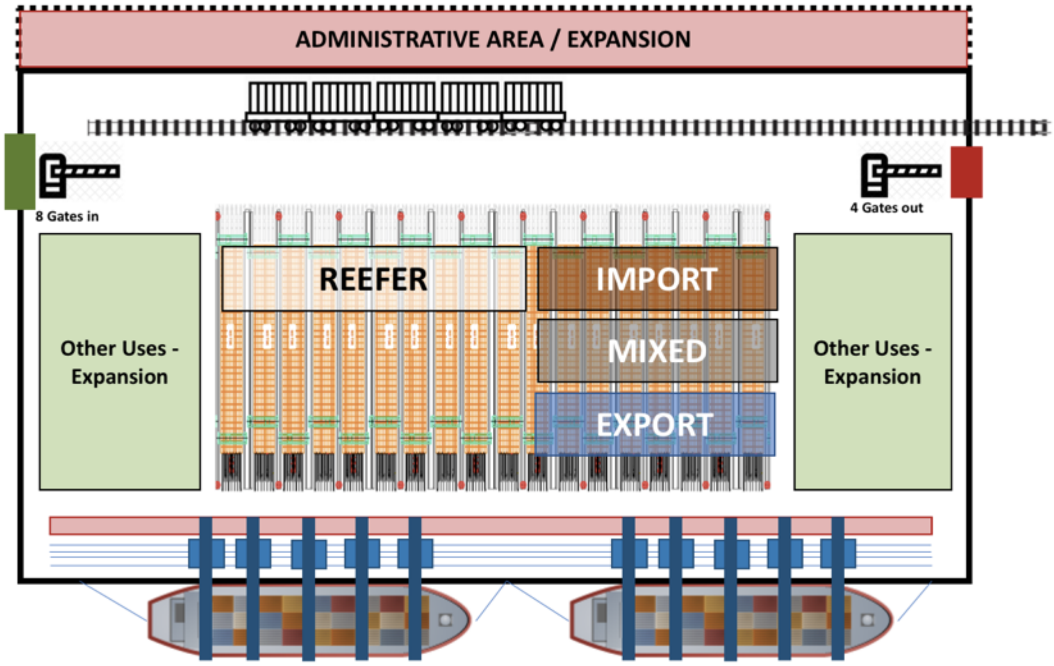


Figure 4-5 - Automated Terminal Draft

On the Depth, we would have some terminal values and some benchmarks measures.

Table 4-4 - Automated Terminal Dimensions (Depth)

Location	Measure
Clearance (behind QC)	5 m
Quay Crane Spam	30 m
Quay Crane Back Reach	25 m
Lanes Waterside	20 m
Waterside Transfer	30 m
Container Yard	290 m
Landside Transfer	30 m
Lanes	25 m
Rail Yard	20
Administrative Area / Expansion	125 m
TOTAL	600 m

This demonstrates that the proposed layout would fit the area available for the terminal (1.000 m x 600 m) with an excellent margin for expansion, especially in the yard, that still has more than 400 meters available for future new container blocks if demanded.

4.2.2. Quay Crane Calculation

It is worth mentioning that there are several authors, as presented in the literature review who argue in favor of the higher productivity in automated quay cranes. Meanwhile, others say that it might even drop a little bit, but the vast majority agrees that the main benefit would be the reliability and consistency of the operations, so here, as a conservative assumption, the productivity remained the same. A similar debate surrounds the running hours due to the facts that machines operate smoother than man, reducing the probability of mechanical breakdowns, not to mention the 24/7 operations without shift changes, meal breaks, etc. Again, as a conservative assumption, this was also kept similar to the manned scenario.

Input and Assumptions based on Benchmarks:

- Quay Crane Capacity = 2.000.000 TEU → 1.300.000 containers
- Quay Crane Max Running Hours = 5.200 hours (55% of the time)
- Average Gross Moves per Hour = 25 moves per hour

$$Quay\ Crane\ Capacity = \#QC\ \times Max\ Running\ Hours\ \times Avg.Gross\ Moves/hr$$

$$1.300.000 = \#\ QC\ \times 5.200\ \times 25$$

$$\#\ \boldsymbol{QC} = \mathbf{10}\ \boldsymbol{Quay\ Cranes}$$

4.2.3. Yard Handling Calculation

For the yard handling capacity, since most assumptions are similar, most of the calculations were already done in the previous scenario, and here only the results will be shown.

$$Landside\ Volume \cong 1.050.000\ containers\ per\ year$$

$$Volume\ Through\ Gate = 840.000\ containers\ per\ year$$

$$Weekly\ Peak\ Volume \cong 19.350\ containers\ per\ week$$

$$Daily\ Peak\ Volume = 3.870\ containers\ per\ day$$

$$Landside\ \ Peak\ Volume \cong 271\ containers\ per\ hour$$

$$Waterside\ Peak\ Volume = 225\ containers\ per\ hour$$

$$\boldsymbol{Joint\ Peaks = 422\ containers\ per\ hour}$$

Moreover, to finalize, it is necessary to check if the yard equipment is able to handle the peak. As previously mentioned, the terminal has 18 container blocks. Considering 2 ASCs per block, the yard fleet has 38 ASCs.

Using similar methodology, it is considered that only 90% of the equipment fleet is available to handle the peaks.

$$Available\ ASC = \#\ ASC\ \times 0{,}9$$

$$Available\ ASC = 36\ \times 0{,}9$$

$$Available\ ASC = 32$$

$$Yard\ Peak\ Handling\ Capacity = Available\ ASC\ \times ASC\ Peak\ Productivity$$

$$Yard\ Peak\ Handling\ Capacity = 32\ \times 14$$

$$Yard\ Peak\ Handling\ Capacity = 448\ containers\ per\ hour$$

$$Yard\ Handling\ Capacity = \frac{448}{422} \times 1.300.000$$

$$\boldsymbol{Yard\ Handling\ Capacity = 1.380.000\ containers\ per\ year}$$

Since the yard can handle more than the annual throughput of 1.300.000 container per year, this design is operationally feasible.

Now that the terminal peak is calculated, it is necessary to properly size the AGV fleet. For that, it is not going to be used a similar approach to what was done for the Terminal Tractor calculations. Saanen & Rijsenbrij (2018) presented in their simulation study an analysis of the ideal number of horizontal transportation equipment to be used. As it can be seen in Figure 4-6, for a quay crane productivity of 25 moves per hour, 3 AGVs are required hence it is necessary a total of 30 AGVS in the fleet to handle the waterside peak.

$$\# AGV = 30\ Automated\ Guided\ Vehicles$$

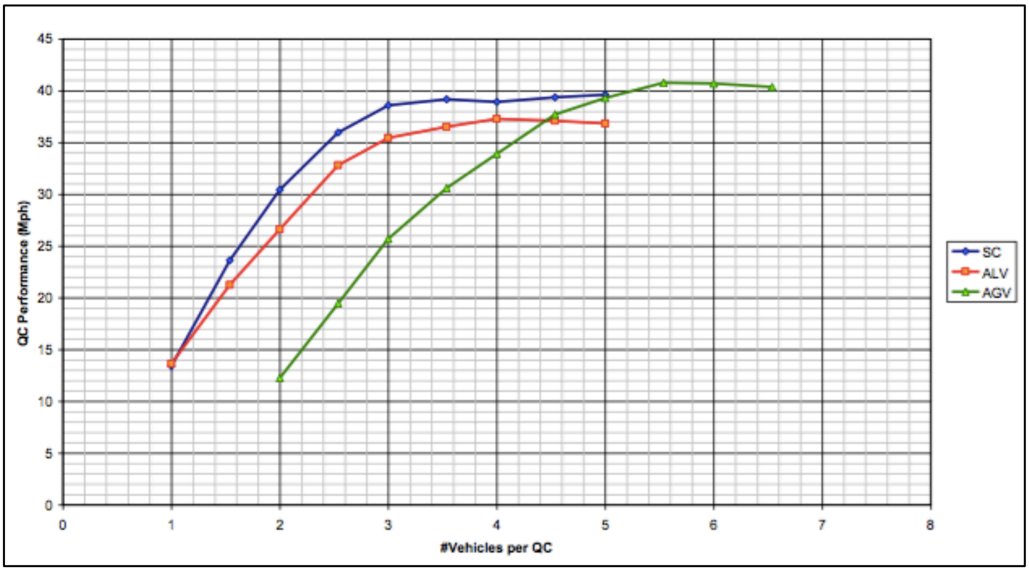


Figure 4-6 - Waterside productivity in peak scenario (Saanen & Rijsenbrij, 2018)

4.3. General Overview of the Terminal Design & Equipment Fleet

With the calculations and considerations presented in the previous segments, we can summarize the results regarding the main equipment fleet in the following table.

Table 4-5 - Terminal Overview - Main Specs

	Manned	Automated
Terminal Design	RTG + TT	ASC + AGV
Container Blocks	24	18
TEU Ground Slots	6.118	7.310
Yard Equipment	48 RTG	36 ASC
Horizontal Transportation	50 Terminal Tractors	30 AGV
Quay Cranes	10	10
Blocks Direction	Parallel to Berth	Perpendicular to Berth

Both terminal designs chosen and calculated are not only are the most commonly used solutions for manned and automated terminals respectively but also suitable for the operational requirements of such terminals, even the perpendicular blocks of the automated terminal can still handle the transshipment ratio (20%) without hampering the operations.

They have a similar land use (yard density), especially when compared to alternative solutions like Reach Stackers and Straddle Carriers.

The manned terminal design has a regular landside service level and a potential for high performances on the waterside, high OPEX and low CAPEX, poor safety and environmental performance.

Meanwhile, the automated terminal design has regular operations on both waterside and landside, low OPEX and high CAPEX with excellent safety and environmental performances.

The main benefits of the RTG + TT design is that the terminal can handle different container flows, including high transshipment ratio, it has flexibility on the terminal deployment and can handle high peaks. The main disadvantages of this design are the complexity of yard management, and the traffic issues due to mixing both internal and external truck on the same local.

While the advantages of the ASC + AGV design are the fully automated operations, the high-density capacity on the yard, and the segregation of internal and external horizontal transport equipment, improving the flow and safety. The main disadvantages of this design are the fact that the terminal loses flexibility due to the nature of the rail equipment, and also it makes it hard to cope with high peaks in short periods.

The details of the economic performance of both solutions will be discussed and calculated in the next chapter.

Chapter 5 Economic Model

The use of a cash flow analysis to make an economic viability study considering the total life cycle of an investment, including both capital expenditures and operational expenditures, as the primary methodology is a unique and simple way to approach investment options. In this case, we will dive into a more detailed level of the differences that exist on an automated container terminal versus a fully manned operated container terminal.

However, as mentioned before, the study is heavily based on the possible economic advantages of automation in a container terminal. Therefore, it is necessary to measure the size of the investment needed to implement both manned and automated terminals, as well as tracking the key productivity indicators like the number of moves per hour, dwell time, personnel headcount, and with that, monitor on a yearly basis the return on the investment of both cases, to check when (or if) the automation reaches the breakeven point compared to manual operations, and the difference of NPV from both solutions.

This Method seems appropriate because not only it can give a direct economic answer, which in the end is usually what drives the stakeholders' decisions towards an investment, but also allow to play with several scenarios once the economic model is built. The scenarios can be fine-tuned by tweaking a few things such as currency rates based on political and/or economic forecast, discount rate (WACC), chose the timing of the investments and reinvestments of the main equipment in a way that brings reasonable but realistic Net Present Values, depreciation the assets, etc.

As mentioned by Martín-Soberón (2014), automation is a process that usually requires a brutal investment, and for that reason, it is crucial to have an economic model analyzing the viability of such choice. But since every coin has two sides, the OPEX is also there to be studied, especially in this situation, where the reduction of personnel is the primary financial gain and can be intensified in a country where the labor laws are so protective like Brazil, hence has a high percentage of labor costs in the terminal's paycheck. Saanen (2017) said that for terminals of 1.000.000 TEU, the yearly cost reductions could be as high as half a million euros, enabling a fast return on the investment. Given this, it is expected to achieve similar or better results since the volume considered in this study is twice what Mr. Saanen evaluated.

To reach the goals of this study, it is necessary to structure an economic model able to analyze and compare all parts of the investments and outcomes that result from both manned and automated terminal operations structure. For that purpose, a cost model and a financial model was created.

The cost model used in this study captures a similar approach as the one made by Busk & Smyth (2013); however, a simplification was made, to fit the purposes of this study given the data available, maintaining the model ideal for either brownfield terminals, expansions, and terminal restructuring. This model can approach both of the chosen design solutions (RTG+TT & ASC+AGV) and would be able to tackle most of the technology's combinations used in container terminals.

This structure considers the outcome of the cost model as an input into the calculation as well as other parameters such as annual throughput, costs and, revenues over the project duration. In the end, a financial evaluation with the most common financial ratios and KPIs like IRR, NPV, EBITDA will be made.

This adaptation on the economic model was made considering the most recent Brazilian regulatory agency Manual of Procedures for Analysis of Technical, Economic Viability Study for Port Leases (ANTAQ, 2016) to make it applicable for the Port Authority requirements for container terminal leases.

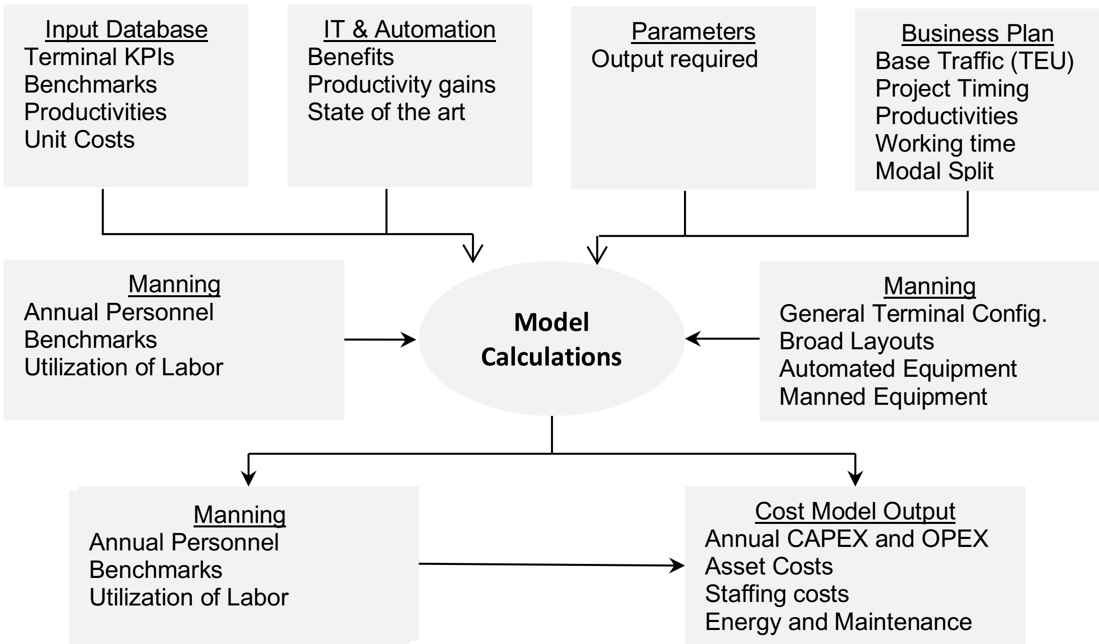


Figure 5-1 - Cost Model Arrangement - Based on Busk & Smyth (2013)

The Manual is a result of the systematization of the methods and techniques employed by ANTAQ, as well as other control and regulation bodies of the Brazilian Public Administration. For its preparation, the best practices developed internally by the Agency in previous Viability Studies analyzes were considered, including also the experiences of other regulated sectors and control bodies.

Among other items, the manual includes several steps that go from the Lease value, schematic drawings, and fleet calculations, to CAPEX, OPEX, revenues, providing detailed information on the desired structure and what to present in terms of investments, depreciation, amortization, discount rate, to build the contractual cash flow.

This entire chapter follows what is prescribed by the regulatory agency manual to comply with bid requirements.

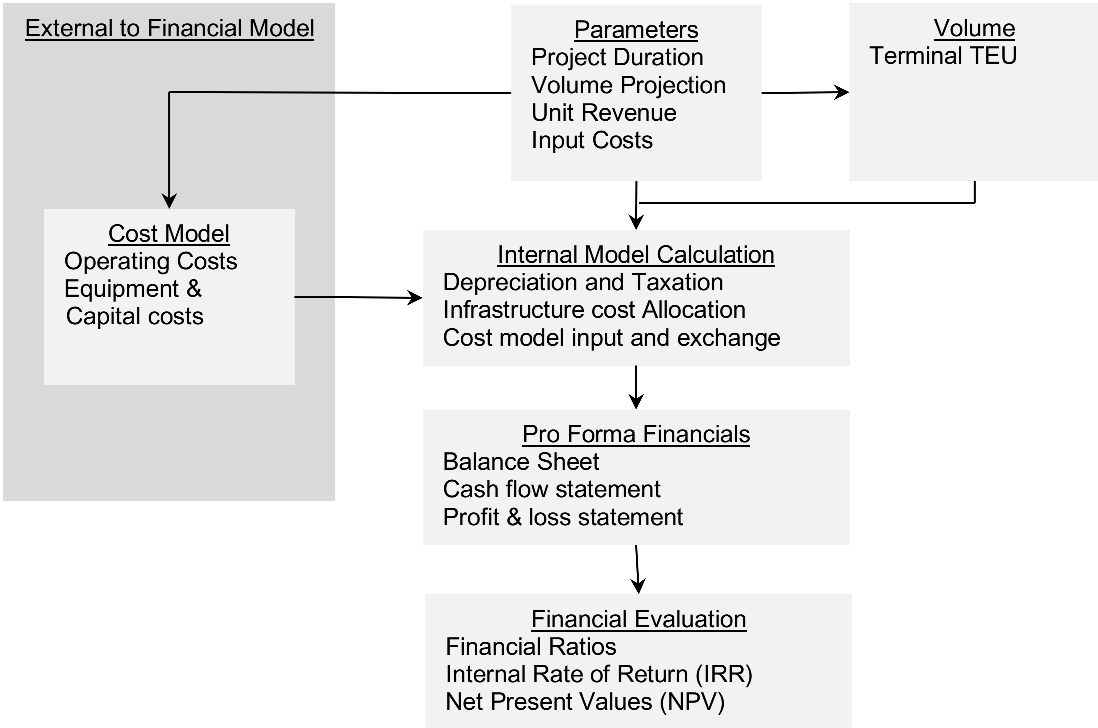


Figure 5-2 - Financial Model Arrangement - Based on Busk & Smyth (2013)

5.1. CAPEX

To comply with the Brazilian regulations when building the model, the CAPEX has to be done with certain reasoning behind it. As stated either in the government regulatory agency for Ports (ANTAQ) in their Model for Studies of Lease Viability Projects (ANTAQ, 2007) and in the Procedures Manual of Technical and Economic Feasibility Studies for Port Leases (ANTAQ, 2016), it should be calculated the investments necessary for handling the annual throughput expected for the project, involving the whole operational infrastructure.

The dimensioning of the required equipment fleet, meaning the terminal capacity, should be compatible with indexes and benchmarks of terminal performance. Besides that, the equipment should also have its life cycle specified, and all the investment should be associated exclusively with the project period (lease).

For the case being studied, an estimation was made in the Capital Expenditure for a manned and an automated terminal based on Table 4-5 that presents an overview of both terminal characteristics.

Mr. Peter McLean (2018) stated that by 2020, the worldwide trend of automation in ports is to convert brownfield into automated terminals. The brownfields will be responsible for the majority of projects, with approximately 35% of all automated projects, followed by automated terminal extensions with 30% and greenfield would be around 25% of the total projects developed in the world, leaving some 10% on unknown solutions.

With that being said and given the fact that this study is heavily based on the TECON Santos terminal characteristics, which has already a considerable infrastructure implemented, a simulation and estimation will be made, concerning the main items and assets that would be different in a manned and an automated solution, and this basically means the port equipment and the Terminal Operating System (TOS).

The Following tables presented below contain the estimated initial CAPEX[4] for both terminal solutions, which doesn't mean that this will be the only investment considered. Given the whole project period, the purchase of new equipment will be necessary, considering their individuals life cycles, and that is going to be detailed in the Depreciation and Amortization Section.

Table 5-1 - CAPEX - Manned Terminal

Equipment	Lifetime	Qt.	Cost	Investment (USD)	Investment (R$)
STS	20	10	€ 5.000.000	$ 60.937.500	R$ 195.000.000
STS - Spreader	5	2	€ 140.000	$ 341.250	R$ 1.092.000
RTG	20	48	$ 1.800.000	$ 86.400.000	R$ 276.480.000
RTG - Spreader	5	10	€ 140.000	$ 1.706.250	R$ 5.460.000
Terminal Tractor	10	50	$ 100.000	$ 5.000.000	R$ 16.000.000
Trailer	7	60	$ 35.000	$ 2.100.000	R$ 6.720.000
TOS	-	1	$ 2.000.000	$ 2.000.000	R$ 6.400.000
INITIAL INVESTIMENT				**$ 158.485.000**	**R$ 507.152.000**

Table 5-2 - CAPEX - Automated Terminal

Equipment	Lifetime	Qt.	Cost	Investment (USD)	Investment (R$)
STS	20	10	$ 12.000.000	$ 120.000.000	R$ 384.000.000
STS - Spreader	5	2	€ 140.000	$ 341.250	R$ 1.092.000
ASC	20	36	$ 3.000.000	$ 108.000.000	R$ 345.600.000
ASC - Spreader	5	8	€ 140.000	$ 1.365.000	R$ 4.368.000
AGV	10	30	€ 400.000	$ 14.625.000	R$ 46.800.000
TOS	-	1	$ 4.000.000	$ 4.000.000	R$ 12.800.000
Automated Gates	10	1	$ 1.000.000	$ 1.000.000	R$ 3.200.000
INITIAL INVESTIMENT				**$ 249.331.250**	**R$ 797.860.000**

[4] The investment estimation values is a compilation from several different authors and studies, among which are: (Kiani, et al., 2006) (Moghadam, 2006) (Moghadam & Noori, 2011), (Rademaker, 2007), (Saanen, 2018), (Saanen & Rijsenbrij, 2018), (Sauri, et al., 2014),

The investment of approximately a quarter billion dollars is within the range expected for this conversion of such an automated terminal. (Mongelluzzo, 2014)

The main values will be presented both in the Brazilian currency (R$ - Reais) and in American dollars (USD) and the exchange rate considered on this model is 1 USD = 3,20 R$, which refers to the quotation of the Brazilian central bank on January 20th of 2018, as shown in Figure 5-3 which was the initial period of this study. Although it is possible to see a deterioration of the Brazilian currency in recent months, this is highly related to speculations regarding the coming elections, so it is expected certain stability after this period, and therefore the used rate remains valid.

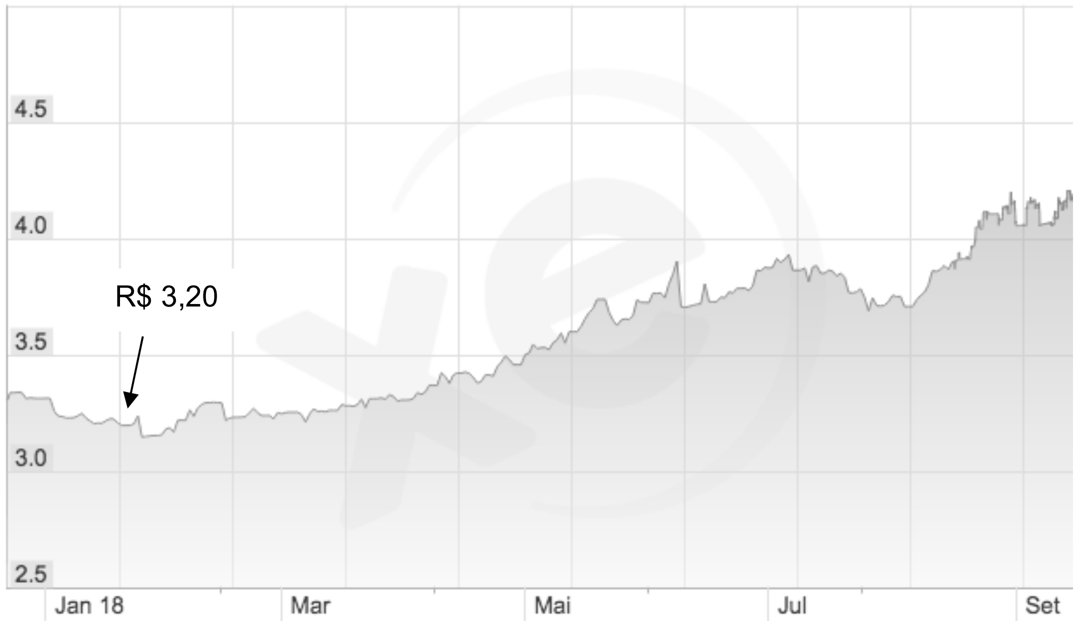


Figure 5-3 - Brazilian Real x 1 US Dollar exchange rate - Source: **(XE, 2018)**

5.2. Total Investment, Depreciation & Amortization

The CAPEX tables above show not only the value but also the estimated lifecycle[5] for each equipment and to follow the Brazilian port regulatory agency (ANTAQ), every investment should follow the estimated depreciation period compatible with the asset's life cycle, and it can be lower than the Brazilian tax law, therefore it must always be used the highest one. In this study's case, every equipment expected file cycle is higher than the minimum stipulated by the Brazilian tax law, so these will be the values used for this calculation. (ANTAQ, 2016)

The full amount invested must have its amortization within the contractual period of the project, meaning that every equipment, for the purposed of the cash flow analysis, will be amortized entirely within 35 years, and this included every re-

[5] The equipment life cycle estimation values are a compilation from several different authors and studies, among which are: (Merk, et al., 2015), (Saanen & Meel, 2003), (Sauri, et al., 2014),and (Rademaker, 2007).

purchase that have to be made due to the fact that all the equipment's lifecycle is smaller than the project duration of 35 years.

In other words, this causes a mismatch between the repurchase periods and the useful life of the equipment, and this difference must be corrected in the last cycle of each equipment purchased, being fully amortized in the remaining years that are still left in the contractual period.

The assets depreciation period, number of purchases over the project duration and the last depreciation period are summarized as follows:

Table 5-3 - Terminal Assets Depreciation

ASSET	Life Cycle	Regular Depreciation	# of Purchases	Last Depreciation Period
STS	20	20	2	15
RTG / ASC	20	20	2	15
AGV / TT	10	10	4	5
Spreaders	5	5	7	5
Trailers	7	7	5	7
Gates	10	10	4	5
TOS	35	35	1	35

Considering all the depreciation periods and number of purchases that have to be done throughout the entire period of the project, it is possible to calculate the total investment and the related depreciation as shown in Figure 5-4 and Figure 5-5.

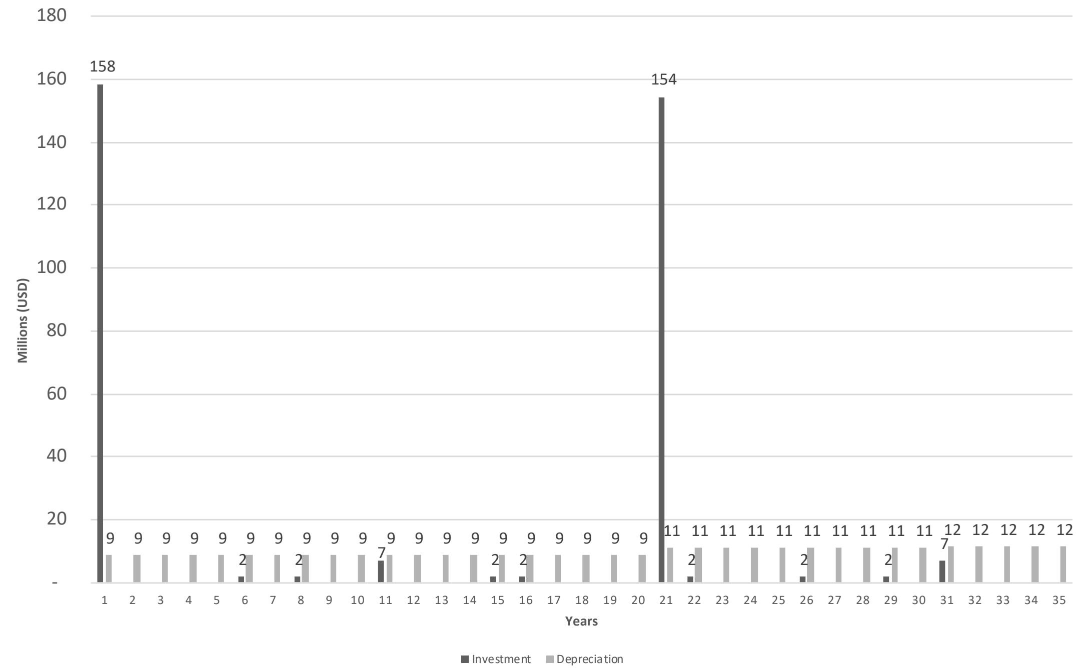


Figure 5-4 - Total Investment & Depreciation (manned terminal)

Looking at the overall project duration, the total investment necessary just for the manual assets aforementioned is **$ 341.507.500** (R$ 1.092.824.000) throughout the 35 years.

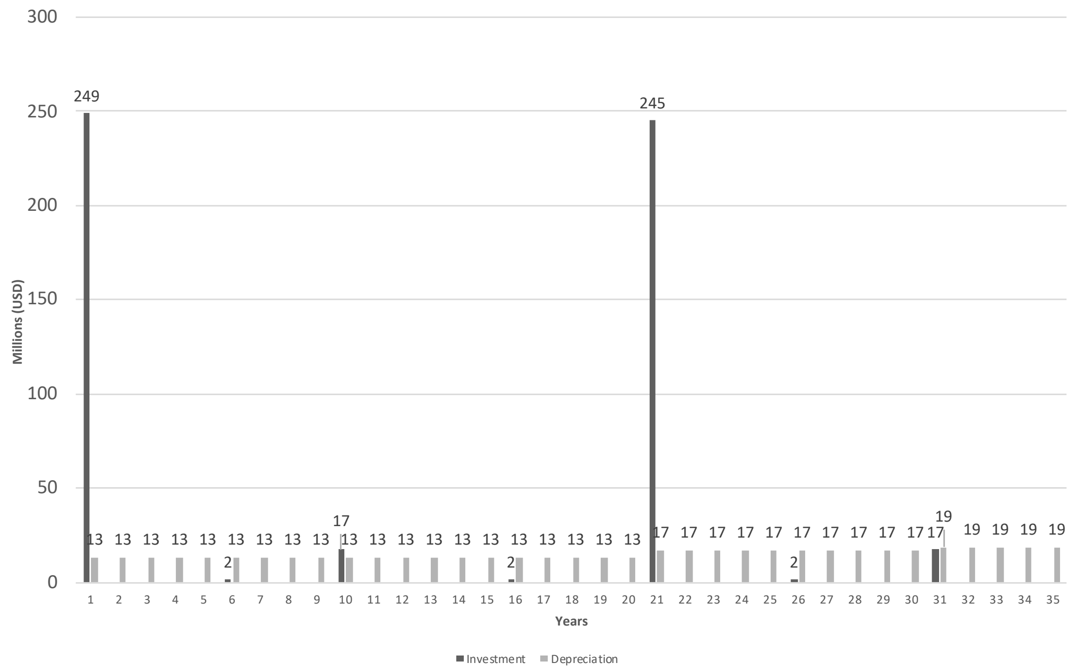


Figure 5-5 - Total Investment & Depreciation (Automated terminal)

Looking at the overall project duration, the total investment necessary just for the automated assets aforementioned is **$ 534.443.750** (R$ 1.710.220.000) throughout the 35 years, and this amount falls inside the range expected of total investment to fully automate such terminal. (Mongelluzzo, 2016)

The complete and detailed tables and information containing the investment and depreciation values over the years can be found in APPENDIX A.

5.3. Revenue & Volume Handled

According to Santos Port Authority, the volume projections over the total project duration must reflect the market expectations regarding the evolution of the production or consumption of the cargoes that are intended to be handled.

Those projections are required to be based on market analysis and public well known and reputable information (ANTAQ, 2007).

However, for the purposes of this study, the focus is merely to compare the performance of a manual and an automated container terminal, and not necessarily get the Port Authority approval for this report as a technical feasibility study. Therefore, it is assumed that the terminal will reach its full capacity (2.000.000 TEU), and it is also assumed a ramp-up on its volume over the first years due do Implementation, learning curve on its operations just to bring some reality into the study without considering a market study. On top of that, limitations on the volume handled will be considered on the years of the repurchase of STS and yard equipment because of the disturbance of such action on the operations.

The Table 5-4 shows the ramp-up over the first five years of operation, the remaining years of the terminal (under the variable N) and the volume drop on the 21st year due to the repurchase of berth and yard equipment.

Table 5-4 - Terminal Yearly Throughput

Year	1	2	3	4	5	N	21
Volume (TEU)	1.000.000	1.200.000	1.400.000	1.600.000	1.800.000	2.000.000	1.000.000

An analysis on the accessibility infrastructure that is undoubtedly an essential factor to be considered won't be observed, and it is assumed that the terminal will have full capability of receiving the vessels, not looking into the access channel possible restrictions, and the trucks and train the same.

To estimate the revenue, the BTP Public Table of Services (BTP, 2018b) was used, containing in detail all the general terms and conditions for each service they charge. The whole table includes nearly 300 different service charges that vary from reception and delivery of containers to delays, inspections, weighing, reefer plug, monitoring, etc. For the purposes of this study, the most common and basic service charge was considered, which is the reception or delivery of a container, full or empty, 20" or 40", to or from the deep-sea vessel or cabotage, and to or from rail or truck. Other services also inherent to the terminal activity like stuffing and striping, warehouse operations, direct delivery, etc. would have other revenues but also require different equipment and infrastructure to be invested and would add an extra complication to the analysis and divert the focus and purposes of this research scope.

The average revenue per box handled is **R$ 500,00**, already considering the TEU ratio of 1,55.

Table 5-5 - Terminal Revenue at Full Capacity

Container Volume	1.290.323	
TEU Volume	2.000.000	
TEU Ratio	1,55	
Exchange rate	R$ 3,20	USD 1,00
Average Price - per TEU	R$ 500	USD 156,25
(=) Gross Revenue (x 1.000)	R$ 1.000.000	USD 312.500
(-) Taxes	R$ 100.000	USD 31.250
Brazilian taxes (ISS + PIS + COFINS + Others)	10,0%	10,0%
(=) Net Operational Revenue (x 1.000)	R$ 900.000	USD 281.250

The terminal annual gross revenue is USD 312.500.000, and the yearly net operating revenue will be of **USD 281.250.000**.

5.4. OPEX

The calculations were done to define the cargo handling costs are reproducing the operational conditions of the volumes operated for each of the several phases. For that, it is detailed the costs with handling, personnel, lease fees, maintenance, electricity, depreciation, and others that include all the operational costs. The expenses related to general port fees like the usage of maritime and terrestrial infrastructure a cannot be included in the cash flow as payment to the port authority related to the lease fees.

To determine the detailed variable and fixed costs and expenses of a terminal is highly complex with several different variables that are intrinsically connected to how the terminal is managed and operated and may vary from operator to operator.

In this research, since the TECON Santos is being used as a start base case scenario, it is assumed that the manned terminal will have similar financial performance and based on that assumption. Therefore, it is possible to use the public financial statements that the *Santos Brasil Participações S.A* (Group that owns the terminal) published every year complying to the CVM (*Comissão de Valores Imobiliários*, which is the Brazilian regulator of listed companies and the equivalent to the US SEC).

5.4.1. Cost and Expenses – Manned Terminal

From the Santos Brasil Financial Statement of 2017 and 2016 (Santos Brasil, 2018b), as well as statements of previous years[6] it is possible to see the ration and relation between gross revenue, net revenue and the cost of services & expenses. The net revenue income is approximately 90% of the gross income, which it corroborates with what was calculated and presented at 5.3, and the Costs & expenses of the terminal on the last 4 years are on average approximately 70% of the gross income, which leads to a R$ 700 million of yearly expenses, the equivalent to **USD 218 million**.

It is necessary to break down those expenses and still using the financial statements. It is used the current ration of the TECON Santos to base the costs as given the known revenue, the costs are presented as follows:

Table 5-6 - Cost and Expenses of the Manned Terminal - based on (Santos Brasil, 2018b)

Revenue (x 1.000)	R$ 1.000.000	USD 312.500	
Costs and Expenses	R$ 700.000	USD 218.750	100%
Cargo Handling	R$ 140.000	USD 43.750	20%
Personnel Expenses	R$ 266.000	USD 83.125	38%
Lease	R$ 84.000	USD 26.250	12%
Maintenance	R$ 56.000	USD 17.500	8%
Fuel & Lubs	R$ 28.000	USD 8.750	4%
Electricity	R$ 14.000	USD 4.375	2%
Others	R$ 112.000	USD 35.000	16%

According to Rademaker (2007), personnel expenses account for nearly 50% of the operational costs, and in this case, it is approximately 40%, which is reasonable given the fact that the Brazilian labor is somewhat cheaper than Western European labor.

5.4.2. Cost and Expenses – Automated Terminal

The automated terminal operational costs will use a similar rationale behind its calculation. However, there will be some changes to be considered due to the robotized nature of the operation, meaning that the core structure of the expenses is held the same, however, on top of the Labor personnel costs, maintenance, fuel and electricity, reductions will be applied based on benchmarks.

The following tables below present the differences between personnel structure for the manned and the automated terminals and therefore their respective cost reductions separated per area (Yard, Berth, and Horizontal Transport), based on benchmarks and assumptions.

[6] Analyzed from all the annual financial statements published from 2010 to 2017.

Table 5-7 - Labor Reduction of Automation on the Yard Equipment

Yard Equipment	**Manned**	**Automated**	**Difference**	
	RTG	**ASC**		
# Equipment	48	36	12	
# Personnel	192[7]	29[8]	163	
Salary	R$ 5.500[9]	R$ 5.500	-	-
Yearly cost per person	R$ 129.855[10]	R$ 129.855	-	-
Yard Handling Labor Cost	R$ 24.932.160	R$ 3.765.795	R$ 21.166.365	$ 6.614.489

The shift from fossil-fueled RTGs to ASCs provides a yearly cost reduction of **$6.614.489** exclusively related to wages.

Table 5-8 - Labor Reduction of Automation on the Berth Equipment

Berth Equipment	**Manned**	**Automated**	**Difference**	
	STS	**STS (Remote)**		
# Equipment	10	10	0	
# Personnel	50	20[11]	30	
Salary	R$ 7.150[12]	R$ 8.223[13]	R$ 1.073	$ 335
Yearly cost per person	R$ 168.812	R$ 194.133	R$ 25.322	$ 7.913
Yard Handling Labor Cost	R$ 8.440.575	R$ 3.882.665	R$ 4.557.911	$ 1.424.347

The shift from manual STS to automated double trolley STS[14] provides a yearly cost reduction of **$1.424.347** exclusively related to wages.

[7] Estimation of the personnel based on the number of men to operate each equipment 24/7 divided in 3 shifts according to Brazilian labor regulations.
[8] Assuming 85% reduction on the number of workers per transtainer (Mongelluzzo, 2014)
[9] Salary estimation based on data gathered from (Glassdoor, 2018).
[10] Using 96,75% regarding Brazilian labor taxes and benefits that the company has to bear (Guia Trabalhista, 2018).
[11] Assuming that 1 STS operator can assist the operation of 2 STS simultaneously.
[12] Salary estimation based on data gathered from (Glassdoor, 2018).
[13] Assuming a salary 15% higher than the regular STS due to higher technical skills.
[14] Quay Cranes that are operated remotely specifically for the last part of the movement to position on the AGVs.

Table 5-9 - Labor Reduction of Automation on the Horizontal Transportation Equipment

Horizontal Transport	Manned	Automated	Difference	
	TT	AGV		
# Equipment	50	30	20	
# Personnel	180	0	180	
Salary	R$ 4.800[15]	R$ -	-	-
Yearly cost per person	R$ 113.328	R$ -	R$ 113.328	$ 35.415
Horizontal Handling Labor Cost	R$ 20.399.040	R$ -	R$ 20.399.040	$ 6.374.700

The shift from Terminal Tractors to AGVs provides a yearly cost reduction of **$6.374.700** exclusively related to wages.

Table 5-10 - Labor Costs Reduction

Labor Costs	Manned	Automated	Dif. R$	Dif. USD
Yard Equipment	R$ 24.932.160	R$ 3.765.795	R$ 21.166.365	**$ 6.614.489**
Berth Equipment	R$ 8.440.575	R$ 3.882.665	R$ 4.557.911	**$ 1.424.347**
Horizontal Transport	R$ 20.399.040	R$ -	R$ 20.399.040	**$ 6.374.700**
Total Labor Cost Difference	R$ 53.771.775	R$ 7.648.460	R$ 46.123.316	**$ 14.413.536**

By robotizing the operations, it is achieved a considerable reduction of more than 14 million dollars per year as presented in Table 5-10 just because of the cutback on the overhead count of the terminal.

The remaining main cost reductions were assumed and based on benchmarks, and the summarized version of those reductions on the automated terminal can be seen in Table 5-11.

Table 5-11 - Overall Costs Reduction

Other Costs	Manned	Automated	Dif. R$	Dif. USD
Maintenance	R$ 56.000.000	R$ 44.800.000[16]	R$ 11.200.000	**$ 3.500.000**
Fuel	R$ 28.000.000	R$ 5.600.000[17]	R$ 22.400.000	**$ 7.000.000**
Electricity	R$ 14.000.000	R$ 13.300.000	R$ 700.000	**$ 218.750**
Total Cost Difference	R$ 98.000.000	R$ 7.648.460	R$ 34.300.000	**$ 10.718.750**

[15] Salary estimation based on data gathered from (Glassdoor, 2018).
[16] Estimated reduction of 20% based on Rademaker, (2007).
[17] Estimated reduction on Fuel of 80% based on Saanen, (2018).

The total cost reduction on the OPEX of the automated terminal compared to the manual option is **$ 25.132.286** per year.

5.5. Cash Flow

To verify if the container terminal is lucrative as a business unit, it is necessary to check the total operational costs and the investments made, because the profitability is extremely reliant on that relationship throughout the entire life of the project. And to enable the comparison of the results between the manned and automated terminal options, a discounted cash flow (DCF) was made and based on that, the financial KPIs will be extracted to evaluate the performance and demonstrate if they reach a breakeven point within the 35 years of the projects lifespan.

The financial and economic analysis of a port business, according to the Brazilian regulatory agency, ANTAQ (2014a), should be made based on revenues and expenditures related to the operation of the services to be carried out, in order to attest to the viability of the enterprise.

The cash flows, therefore, consolidate the information presented in the viability study and determine the Net Present Value - NPV resulting from the project. In other words, the cash flow can be understood as the mathematical formula that demonstrates the outcome of the project.

In practice, the cash flow compiles all elements evaluated throughout the project, ordering them in an equation that also includes conditions of accounting, tax and business legislation. It is therefore clear that the input data for the preparation of the cash flow should reflect the positive and negative financial impacts generated by the enterprise during the whole contractual period.

Regarding the presentation of the financial information, this study will follow ANTAQ (2014b) that defines how to present the basic format of the Profit & Loss statement, which should be structured as follows:

$$Gross\ Revenue - Taxes\ (ISS, PIS, COFINS) = Net\ Revenue$$

$$Net\ Revenue - Costs\ \&\ Expenses = EBITDA$$

$$EBITDA - Depreciation/Amortization = EBIT\ (Operational\ Profit)$$

$$EBIT - Income\ Taxes = Net\ Profit$$

The cash flow, which also must follow ANTAQ (2014b) it is structured as follows:

EBIT (Operational Profit) + Depreciation/Amortization = EBITDA

EBITDA – Income Taxes +/- Working Capital Variation – Investments = ***Cash Flow***

It also must be considered the appropriate discount rate (WACC) to be applied on the Cash Flow. Usually, the discount rates are set by the regulatory agencies, but on cases where this is not specified, the use of the WACC is dispensed, and the application of only Internal Rate of Return (IRR) is accepted.

5.5.1. WACC

The WACC, as stated before, stands for Weighted Average Cost Capital, and it is the cost of capital commonly used on a payback analysis. This rate indicates the minimum level of attractiveness of the invest, in other words, it is the return that a stakeholder would expect by investing in other safer investments (Borges, 2013).

It is essential that the project discount rate is set at an appropriate level. An adequate discount rate should ensure a fair return to investors. A return below the opportunity cost of the market may make investments in new ventures financially unviable for investors in the regulated sector.

On the other hand, if the discount rate is estimated considering a higher risk than what is actually verified, the project will appropriate a rate higher than the appropriate cost of capital. This would lead to a distortion of price signals for both consumers and investors, resulting in poor management of resources and levels of productive efficiency below optimal levels.

According to ANTAQ (2016), this WACC technique is a tool used on both sides of the Atlantic to estimate the cost of capital from regulated and non-regulated companies. Therefore, this standard has been vastly used by the majority of Brazilian regulatory agencies.

The average cost of Capital is a weighted average of the cost of equity and the cost of debt, and this can be calculated by (Investopedia, 2018):

$$WACC = \frac{E}{V} \times Re + \frac{D}{V} \times Rd \times (1 - Tc)$$

Where:

$Re = \textit{cost of equity}$

$Rd = \textit{cost of debt}$

$E = \textit{market value of the firm's equity}$

$D = \textit{market value of the firm's debt}$

$V = E + D = \textit{total market value of the firm's financing (equity and debt)}$

$E/V = \textit{percentage of financing that is equity}$

$D/V = \textit{percentage of financing that is debt}$

$Tc = \textit{corporate tax rate}$

Despite this being a necessary tool for the investors to analyze their risks and assess an investment choice, for the government perspective; this is partly skewed towards more control over the assets and the companies that plan to bid for a port lease.

As already explained and presented in Chapter 2 , the government tends to control the discount rate to be used on the contracts, regardless of what type of business they are leasing (containers, agro-bulk, cellulose, general cargo, roro, etc.) without taking into account the particularities of each activity and also the difference in terms of the cost that the companies might manage their debts and equities.

The government claims that the WACC calculations involve difficult choices between simplicity and rigor; and subjectivity and transparency. Also saying that it is not uncommon for methodologies and data used by different agents to differ to some extent. Therefore, estimates of WACCs calculated by different agents will hardly be precisely the same, which is yet another factor of diversity in auction bids, so the Ministry chose to fix the preferred rate.

In 2015 the Ministry of Finance updated once more the discount rate for the next port leases bids, and based on their internal evaluation, the standard for the **WACC is 10,0%** (Ministry of Finance, 2015), which is the number that shall be considered for the purposes of this study on the cash flow analysis, more specifically for the discounted cash flow calculations, and the same as used in Busk & Smyth (2013).

5.5.2. Profit & Loss Statement – Manned Terminal

The Profit and Loss Statement is an accounting tool which the primary goal is to present the results calculated in a summarized way of a set of operations carried out within a year. With the use of this tool, it is possible to analyze if the business is being profitable or making losses.

The Table 5-12 was extracted from the full profit and loss of the manned terminal on the APPENDIX B where it can be seen in details, and shows the results of the first years with the ramp-up in the yearly throughput as well as in the costs and expenses that have a share of fixed and variable costs.

Table 5-12 - Profit & Loss Statement of the Manned Terminal[18]

Year	**1[19]**	**2**	**3**	**4**	**5**	**6**
Container Volume	**645.161**	**774.194**	**903.226**	**1.032.258**	**1.161.290**	**1.290.323**
TEU Volume	1.000.000	1.200.000	1.400.000	1.600.000	1.800.000	2.000.000
TEU Ratio	1,55	1,55	1,55	1,55	1,55	1,55
Average Price - R$ per TEU	500	500	500	500	500	500
(=) Gross Revenue (x 1.000)	**500.000**	**600.000**	**700.000**	**800.000**	**900.000**	**1.000.000**
(-) Taxes	50.000	60.000	70.000	80.000	90.000	100.000
ISS + PIS + COFINS + Others	10,0%	10,0%	10,0%	10,0%	10,0%	10,0%
(=) Net Operational Revenue	450.000	540.000	630.000	720.000	810.000	900.000
(-) Costs & Expenses	525.000	560.000	595.000	630.000	665.000	700.000
Cargo Handling	105.000	112.000	119.000	126.000	133.000	140.000
Personnel Expenses	199.500	212.800	226.100	239.400	252.700	266.000
Lease	63.000	67.200	71.400	75.600	79.800	84.000
Maintenance	42.000	44.800	47.600	50.400	53.200	56.000
Fuel	21.000	22.400	23.800	25.200	26.600	28.000
Electricity	10.500	11.200	11.900	12.600	13.300	14.000
Others	84.000	89.600	95.200	100.800	106.400	112.000
(=) EBITDA (x 1.000)	(75.000)	(20.000)	35.000	90.000	145.000	200.000
(-) Depreciation + Amortization	27.627	27.627	27.627	27.627	27.627	27.627
(=) EBIT:	(102.627)	(47.627)	7.373	62.373	117.373	172.373
Profit Before Income Tax	(102.627)	(47.627)	7.373	62.373	117.373	172.373
(-) Income Tax:	0	0	(2.507)	(21.207)	(39.907)	(58.607)
(=) Net Profit: (x 1.000)	(102.627)	(47.627)	9.879	83.579	157.279	230.979
(=) Net Profit: (x 1.000 USD)	**(32.071)**	**(14.884)**	**3.087**	**26.119**	**49.150**	**72.181**

[18] All financial values are in Brazilian Reais (R$) unless explicit otherwise.
[19] This column also represents the same values of the 21st year due to the repurchase of berth and yard equipment.

5.5.3. Profit & Loss Statement – Automated Terminal

The Table 5-13 was extracted from the full profit and loss of the automated terminal on the APPENDIX B where it can be seen in details, and shows the results of the first years with the ramp-up in the yearly throughput as well as in the costs and expenses that have a share of fixed and variable costs.

Table 5-13 - Profit & Loss Statement of the Automated Terminal[20]

Year	1[21]	2	3	4	5	6
Container Volume	**645.161**	**774.194**	**903.226**	**1.032.258**	**1.161.290**	**1.290.323**
TEU Volume	1.000.000	1.200.000	1.400.000	1.600.000	1.800.000	2.000.000
TEU Ratio	1,55	1,55	1,55	1,55	1,55	1,55
Average Price - R$ per TEU	500	500	500	500	500	500
(=) Gross Revenue (x 1.000)	**500.000**	**600.000**	**700.000**	**800.000**	**900.000**	**1.000.000**
(-) Taxes	50.000	60.000	70.000	80.000	90.000	100.000
ISS + PIS + COFINS + Others	10,0%	10,0%	10,0%	10,0%	10,0%	10,0%
(=) Net Operational Revenue	450.000	540.000	630.000	720.000	810.000	900.000
(-) Costs & Expenses	422.565	464.346	501.665	535.265	568.865	619.577
Cargo Handling	105.000	112.000	119.000	126.000	133.000	140.000
Personnel Expenses	130.315	143.615	156.915	170.215	183.515	219.877
Lease	63.000	67.200	71.400	75.600	79.800	84.000
Maintenance	25.200	35.700	42.000	44.800	47.600	44.800
Fuel	5.600	5.600	5.600	5.600	5.600	5.600
Electricity	9.450	10.631	11.550	12.250	12.950	13.300
Others	84.000	89.600	95.200	100.800	106.400	112.000
(=) EBITDA (x 1.000)	27.435	75.654	128.335	184.735	241.135	280.423
(-) Depreciation + Amortization	42.938	42.938	42.938	42.938	42.938	42.938
(=) EBIT:	(15.503)	32.716	85.397	141.797	198.197	237.486
Profit Before Income Tax	(15.503)	32.716	85.397	141.797	198.197	237.486
(-) Income Tax:	0	(11.123)	(29.035)	(48.211)	(67.387)	(80.745)
(=) Net Profit: (x 1.000)	(15.503)	43.839	114.432	190.008	265.584	318.231
(=) Net Profit (USD):	**(4.845)**	**13.700**	**35.760**	**59.378**	**82.995**	**99.447**

It is possible to see that the automated terminal already shows a slightly better performance in economic terms if compared to the manned terminal making approximately USD 27 million more per year after stabilizing the 2.000.000 TEU annual throughput.

[20] All financial values are in Brazilian Reais (R$) unless explicit otherwise.
[21] This column also represents the same values of the 21st year due to the repurchase of berth and yard equipment.

5.5.4. Cash Flow – Manned Terminal

Table 5-14 - Cash Flow of the Manned Terminal

Year	1	2	3	4	5	35
Operational Profit (EBIT):	**(102.627)**	**(47.627)**	**7.373**	**62.373**	**117.373**	**162.915**
(+) Depreciation + Amortization:	27.627	27.627	27.627	27.627	27.627	37.085
(=) EBITDA	**(75.000)**	**(20.000)**	**35.000**	**90.000**	**145.000**	**200.000**
(-) Income Tax	0	0	(2.507)	(21.207)	(39.907)	(55.391)
(+/-) Variations in working capital	0	0	0	0	0	0
(=) Operational Cash Flow	(75.000)	(20.000)	37.507	111.207	184.907	255.391
(-) Investments	507.152	0	0	0	0	0
(=) TOTAL Cash Flow	(582.152)	(20.000)	37.507	111.207	184.907	255.391
(=) Accumulated Cash Flow	(582.152)	(602.152)	(564.645)	(453.439)	(268.532)	6.530.267
(=) Discounted Accumulated Cash Flow	(582.152)	(600.334)	(569.337)	(485.785)	(359.491)	1.156.703
(=) Accumulated Cash Flow (USD)	**(181.923)**	**(188.173)**	**(176.452)**	**(141.700)**	**(83.916)**	**2.040.709**
(=) Discounted Accumulated Cash Flow (USD)	**(181.923)**	**(187.604)**	**(177.918)**	**(151.808)**	**(112.341)**	**361.470**

The Table 5-14 shows an extraction of the cash flow and the full detailed tables can be seen in APPENDIX C.

5.5.5. Cash Flow – Automated Terminal

Table 5-15 - Cash Flow of the Automated Terminal

Year	1	2	3	4	5	35
Operational Profit (EBIT):	**(102.627)**	**(47.627)**	**7.373**	**62.373**	**117.373**	**220.326**
(+) Depreciation + Amortization:	27.627	27.627	27.627	27.627	27.627	60.098
(=) EBITDA	**(75.000)**	**(20.000)**	**35.000**	**90.000**	**145.000**	**280.423**
(-) Income Tax	0	0	(2.507)	(21.207)	(39.907)	(74.911)
(+/-) Variations in working capital	0	0	0	0	0	0
(=) Operational Cash Flow	(75.000)	(20.000)	37.507	111.207	184.907	355.334
(-) Investments	507.152	0	0	0	0	0
(=) TOTAL Cash Flow	(582.152)	(20.000)	37.507	111.207	184.907	355.334
(=) Accumulated Cash Flow	(582.152)	(602.152)	(564.645)	(453.439)	(268.532)	9.537.768
(=) Discounted Accumulated Cash Flow	(582.152)	(600.334)	(569.337)	(485.785)	(359.491)	1.946.585
(=) Accumulated Cash Flow (USD)	**(181.923)**	**(188.173)**	**(176.452)**	**(141.700)**	**(83.916)**	**2.980.552**
(=) Discounted Accumulated Cash Flow (USD)	**(181.923)**	**(187.604)**	**(177.918)**	**(151.808)**	**(112.341)**	**608.308**

The Table 5-15 shows an extraction of the cash flow and the full detailed tables can be seen in APPENDIX C.

5.5.6. Net Present Value & Internal Rate of Return

Evaluation of investment projects commonly involves a set of techniques that seek to determine their economic and financial viability, considering a specific Minimum Attraction Rate. Thus, these parameters are typically measured by the Payback, the Internal Rate of Return (IRR) and/or the NPV (Net Present Value) (Leonardo & Morasco, 2018).

This section will focus on the last two methodologies and the analysis of the conflict generated when comparing them.

Net Present Value is the most used tool by large companies in the analysis of investments (Copeland, et al., 2005), being defined as the sum of the present value of the cash inflows and the present value of the cash outflows. That is, this method discounts the cash flows of the project being evaluated at a certain rate, stipulated by the shareholders. This rate, usually called the discount rate, is the minimum return that must be expected for the project to be accepted (Brealey & Myres, 1992).

If the cash flow of the project, after being discounted to the discount rate value, is greater than or equal to zero means that executing the project is feasible since it pays the capital invested at a rate equal to or greater than the minimum rate of return. When the NPV is less than zero, the project is rejected (Costa & Attie, 1987).

The Internal Rate of Return is defined as the discount rate that equals the net present value of the cash flows of a project to zero. In other words, the IRR is the discount rate that cancels the NPV. For decision purposes, projects that have the IRR greater than or equal to the minimum rate of return defined by the shareholders must be executed. Projects that have IRR less than the required minimum rate of return should be rejected (Filho & Kopittke, 2000).

The Table 5-16 summarizes the final results of the IRR and NPV Values of both manned and automated terminals. In Chapter 6 the results obtained in this section will be further analyzed and discussed in detail, bringing more light to all these numbers presented.

Table 5-16 - Final NPV &IRR

Manned - NPV	361.470
Manned - IRR	23,98%
Automated - NPV	608.308
Automated - IRR	30,37%

Chapter 6 Analysis and Results

After an extensive, thorough and necessary path taken on the previous section to cover if not all but at least the most important aspects involving a container terminal, its operational nuances, along with clear differences of the operational choice (Manned vs. Automated), finalizing with the economic performance of the solutions in accordance with the current Brazilian framework in terms of revenue, costs and regulation.

This section will be dedicated to present the findings investigated in this research in an organized manner, analyze and discuss the results and their meaning.

The structure will be similar to the methodology, and the findings will be breakdown into Profit & Loss, Cash Flow and Economic KPIs (NPV and IRR), sensitivity analysis and finalizing with an overview of the results.

6.1. Profit & Loss

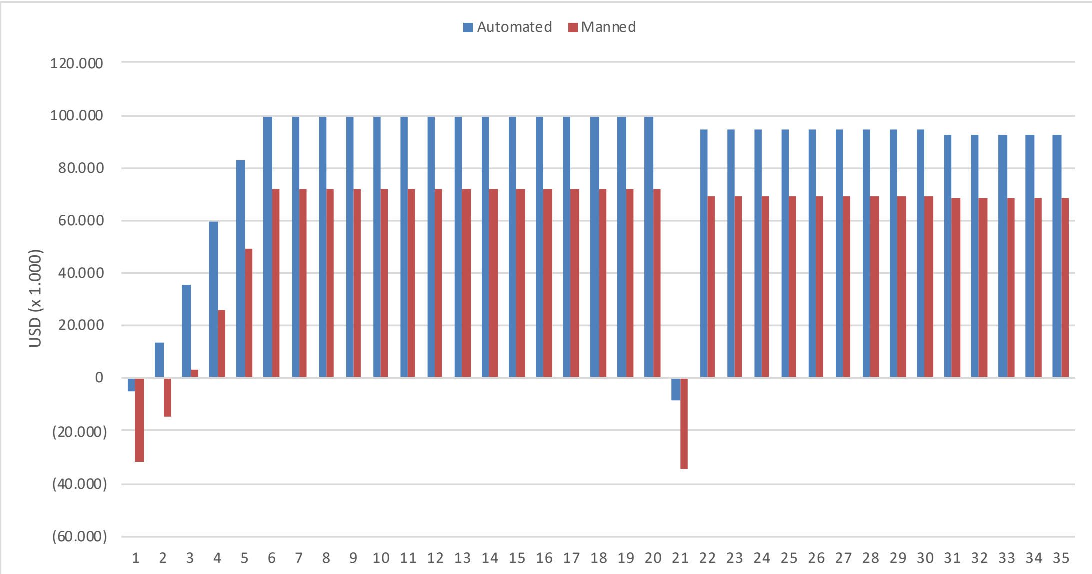


Figure 6-1 - Profit & Loss Comparison

It is possible to see from the P/L results that the automated terminal performs better throughout the entirety of the project. Even with a considerable higher initial investment (57% more than the manned terminal), with the similar volume and growth rate, the automated terminal starts to get profitable already in the second year, whereas the manned is still making losses whilst handling 1.2 million TEU and barely reaches the equilibrium with 1,4 million TEU on the 3rd year. This is a consequence of the constant yearly savings of USD 25 million on OPEX.

However, it is fair to say that with these volumes and the structure considered, both terminals have the ability to generate profits for the stakeholders.

6.2. Cash Flow &Payback

The cash flow of the terminals shows a healthy financial result over the years, with approximately USD 80 million per year on the manned terminal against USD 110 million per year on the automated terminal. This will culminate on an accumulated cash flow in the last 35th year of USD 2 Billion (manned) versus USD 3 Billion (automated). However, this is not enough to fully understand the results from the investors perspective, and the Figure 6-2 plays an exciting role in that interpretation.

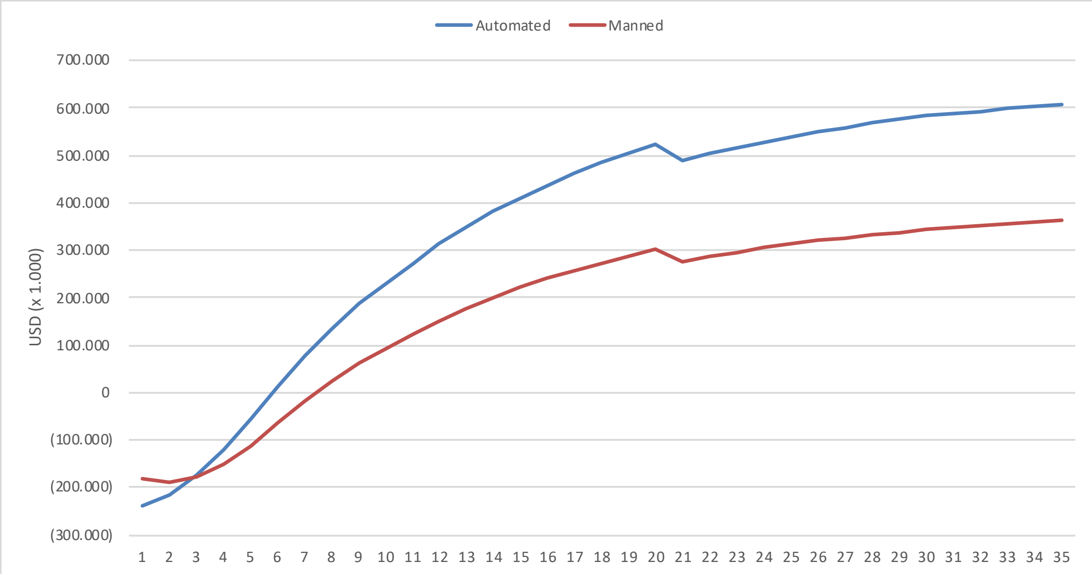
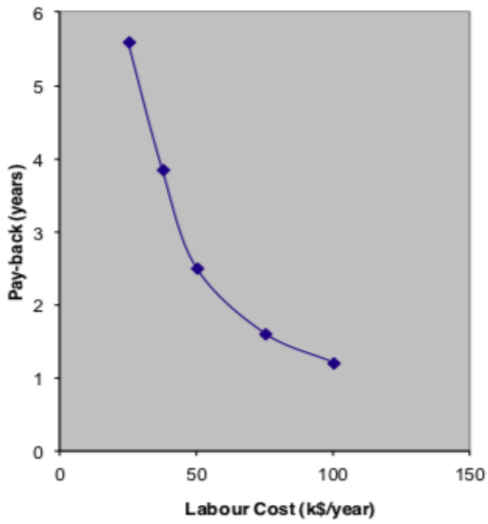


Figure 6-2 - Discounted Cash Flow Comparison

The discounted cash flow shows the automated terminal at a slow start due to its higher initial CAPEX but rapidly catching up with the manned terminal. After 3 to 4 years, the automated terminal becomes more attractive in providing a higher return with the given discount rate (WACC = 10%). Because of its lean OPEX, it shows a steeper growth especially in the early years if compared to the manned terminal, and after approximately 20 years, they run almost in parallel, maintaining the gap between them until the end of the period. This parallelism is due to the cost of capital over the years showing that the most important and impacting moment is at the beginning of the project.

More than seeing when automation surpasses the manned terminal, this also shows that the automated terminal reaches the breakeven point in the 6th year, proving that this investment pays back. Moreover, it is interesting to see this result when looking to what ABB and TBA showed at Cederqvist (2012), when it is possible to see the payback when switching from RTGs to ASC on an environment with a labor cost bellow USD 40.000, which is the case of Brazil, per year takes approximately 6 years to pay back.

Table 6-1 - Labor cost vs. Payback time (Cederqvist, 2012)



6.3. NPV, IRR

Both methodologies might be used to decide which investment is more interesting, but the IRR is commonly used for straightforward investments, where the expenditure is concentrated at the beginning and the revenues on the following years. Meanwhile, the NPV can be used for more complex situation with investments and revenue varying throughout the years, and which fits this case better.

In cases of conflict between those KPIs, it is suggested the NPV method to choose which project should be executed since this indicates the project that generated greater wealth to the shareholders (Leonardo & Morasco, 2018).

The Table 5-16 presented at the end of 0 shows that both terminal options are quite attractive with manned and automated terminal reaching **24%** and **30%** of Internal Rate of Return respectively, while the Net present values were **USD 360 million** and **USD 600 million**. Rademaker (2007) said that usually container terminals stakeholders demand between 10% to 15% of return, which is within the WACC considered, and looking at the numbers, it is possible to see that any of those options would be attractive enough for investors, with the automated option once more being more interesting, generating 65% more revenue to the investor.

6.4. Sensitivities

Attempting to see how sensible the model is to some variables that might as well change over the years due to instabilities, this study sought to analyze possible significant input and find out the outcome of such sensitivities.

6.4.1. Exchange Rate (USD x R$)

As explained on 5.1, the exchange rate used on this project is 1 USD – R$ 3,20, based on data from January 2018. Due to the Brazilian recent political scandals and instabilities (e.g., the impeachment of the former President Dilma Rousseff in 2016), the Brazilian currency (Real) is losing its strength and it is speculated that might stabilize after the elections on a higher rate than the used on this study, therefore the motivation to see the behavior of the model regarding this.

Table 6-2 - Exchange Rate Variation

	1 USD - 4 RS		1 USD - 3,20 R$	
	Manned	Automated	Manned	Automated
Initial Investment	R$ 583.552.000	R$ 984.260.000	R$ 507.152.000	R$ 797.860.000
Overall Investment	R$ 1.257.064.000	R$ 2.081.420.000	R$ 1.092.824.000	R$ 1.710.220.000
IRR	21,82%	25,25%	23,98%	30,37%
NPV	R$ 1.053.512	R$ 1.700.640	R$ 1.156.703	R$ 1.946.585
NPV – USD	$ 263.378	$ 425.160	$ 361.470	$ 608.308
Difference	73%	70%	-	-

The Table 6-2 shows that there is some room for variations in the model. With an increase of 25% on the exchange rate, there was a drop of 30% in the NPV, meaning that the economic model is slightly more responsive to the exchange variation. This happens because the only input considering the USD is the CAPEX, while all the other values are dependent on Brazilian Reais (local cost & expenses, and revenue).

The model is incapable of indicating the outcome of such variation in terms of business attractiveness and practical consequences. With a weaker currency, it is possible that the terminal might increase its fees and still charge the shipping companies the same value in dollars but compensating the higher CAPEX without a more profound impact on clients, but in order to reach that conclusion it would be necessary, or more recommended, to make use of a business and market analysis.

Regardless of that, the terminals still maintain a healthy economic performance under this specific situation.

6.4.2. Operational Costs

On the original scenario of the manned terminal, the costs and expenses considered and shown on 5.4.1, accounted for 70% of the gross revenue based on the latest financial statements from Santos Brasil. However, looking at older financial statements when the terminal was handling a higher volume and reaching records of throughput and revenue, the costs would account for as low as 50% of the gross revenue, and for that reason, since this terminal in handling a considerable volume, it is fair to assume that they might improve their cost efficiency and reduce their expenses again. The effect of that sensitivity is shown on the

Table 6-3 - Cost vs Gross Revenue Ratio

Cost	70%	60%	50%
Manned - NPV	361.470	762.544	1.173.877
Manned - IRR	23,98%	42,14%	69,25%
Automated - NPV	608.308	1.022.228	1.438.233
Automated - IRR	30,37%	47,68%	71,14%

As expected, the results are remarkably impacting. By reducing 20% of the cost ratio, the automated terminal would more than double their revenue, and this should not be seen as a distant possibility since the terminal operated below 50% (costs x gross revenue) from 2010 to 2012.

Moreover, it is worth mentioning that with automation, there is much room for cost reductions with most focused actions, since the headcount is smaller, the processes are mostly digital and operational improvements should be possible with IT and TOS evolution. Whereas in a manual operation would require actions on a larger scale to reach similar results due to the bigger staff to train, bigger risk exposure due to human errors and etc.

6.4.3. WACC and Lease Fees

Similar to the Cost analysis, the WACC is another variable that over the last years suffered some changes and the majority of the time as an imposition of the regulatory agencies. In recent years, as presented on 5.5.1, the government is taking a more “pro-business” approach with several items and requirements for the lease bids, and WACC is one of them, however the instability and changes are already a common thing within the Brazilian port regulations and therefore the discount rate is a valid point be analyzed.

Table 6-4- WACC Variation

WACC	10%	9%	8%	7%
Manned - NPV	$ 361.470	$ 422.846	$ 495.181	$ 581.126
Automated - NPV	$ 608.308	$ 696.062	$ 799.240	$ 921.559

In terms of returns, while reducing the discount rate, obviously shows better results because in simple words it means that compared to a lower IRR, would be easier for the investor to have more revenue if compared to investing on other business with that specific IRR.

This, however, is a very controversial point on every bid and contract renewal because the lease fees can be strongly related to the discount rate. In ANTAQ (2007), the government set a minimum lease value as a result based on the estimated cash flow, being split into the area (fix cost) and the volume handled (variable cost) charged throughout the contract but based on the results of the situation upon which the IRR equals the WACC. This means that any amount that surpasses the WACC should be reverted to the Port Authority.

However, while this was applied for many years and was in force over some contracts, ANTAQ (2016) leaves this issue open just by mentioning an article of ANTAQ (2014a) which says that the lease value is “the amount owed by the lessee to the Port authority, under the terms established in the contract”.

So, in that sense the terminal operators prefer either to have autonomy to define their own discount rates, that let’s face it, it is something completely related to the company and its structure; or they would like to have a higher WACC set by the government assuring that they would make more money leaving a smaller share in fees for the port authority.

Also exercising this possibility because of the recent changes in the regulation, we tested the lease fees so that the IRR would practically balance with the WACC and see the impact of both manned and automated options.

So, in order to simulate the previous regulation (ANTAQ, 2007), an increase on the lease values of both terminal options was applied, attempting to make the IRR reach closer to the WACC (10%).

Increasing the lease values from USD 26 million per year of both options to USD 72 million and USD 88 million per year on the manual and automated terminal options respectively, it is obtained the following results:

Table 6-5 - Lease Value Under Previous Regulation

	IRR	NPV	Lease Fee	Overall Lease Value (35 yrs.)
Manned	11,91 %	$ 19 Million	$ 72 Million	$ 2.5 Billion
Automated	11,85 %	$ 29 Million	$ 88 Million	$ 3 Billion

The results show that even with a 22% increase in the lease fee by the automated terminal, they would have a similar IRR and NPV at the end of 35 years while the port authority would make either USD 2.5 billion (manned) or USD 3 billion (automated) in comparison with the USD 900 million overall lease value over the 35 years of contract. So, this regulation, which is still in force for some contracts, makes it counter-intuitive to the investor’s perspective. It reduces the incentive of the operator to improve their performance and/or cut down their costs to make more profits since the Port Authority, by that definition, would just take a bigger chunk without any effort, limiting the IRR of the terminal to the WACC defined.

Another important consequence of that can be seen in Figure 6-3, is that the payback of the investment is delayed in 10 years, only being achieved after 16 years on investment. The same moment where the automation starts to be more attractive than the manual terminal. This delay reduces the attractiveness of the business because even on a 35 years contract,16 years is too far ahead to predict safely, increasing the risks.

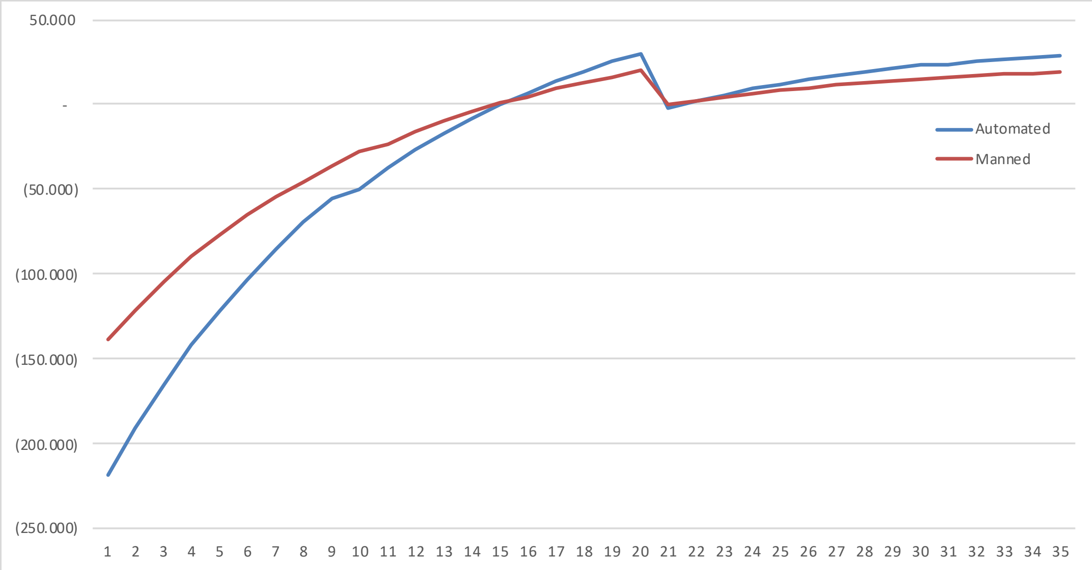


Figure 6-3 - NPV with higher lease values

6.5. Overall Findings

Getting back to basics and summarizing all the results, the economic model built indicated that there is a considerable financial benefit of implementing such an automated terminal on those conditions, especially if compared to the manual option. Although both performed well on all analysis, the model demonstrated that automation indeed makes the lower OPEX compensate for a higher CAPEX in the long run.

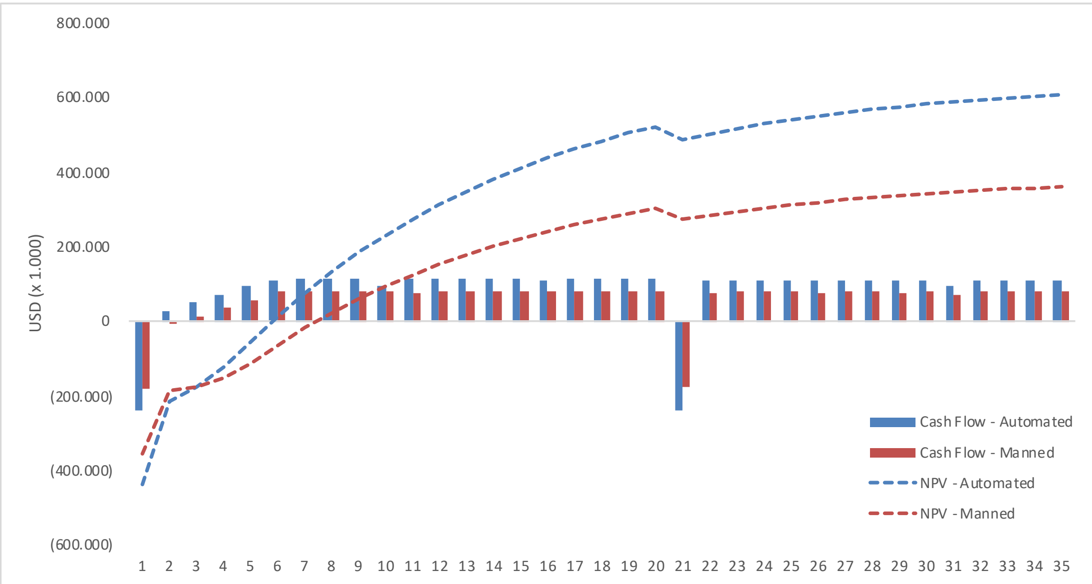


Figure 6-4 - NPV and Cash Flow Overview

Chapter 7 Conclusions

After a thorough and detailed analysis of all aspects investigated throughout this research, it is possible to look back into the methodology used and the results obtained and verify that all grounds regarding the research question and sub questions we're covered.

With regards to the question of whether or not the economic feasibility of container automation in Brazil can be studied by the combination of terminal design and cost benefit analysis technique, this research showed by means of a vast literature and methodology background, that this approach is extensively used as the main decision making tool for terminals throughout the world.

Many other studies adopt similar steps because by integrating the terminal design with the economic model, it is encompassed the whole lifecycle of a terminal project from an investor's perspective, all the way from conception up to the end of the contract. Moreover, this method fits perfectly the Brazilian port regulatory authorities' requirements for approval of a terminal investment based on the final feasibility result.

Prior to that, a background study was performed to determine what design should be considered for the analysis. Therefore, based on the most common and tested terminal design setups around the world, combined with the local characteristics of the Port of Santos the ideal solution of RTG / TT and ASC / AGV for the manned and automated terminal respectively were chosen. In addition to that, the main elements such as Annual Throughput, benchmark equipment performances and terminal main specs (Terminal Area, Quay wall length) respected the current situation of terminals in Santos.

Lastly, to determine which elements go into the cost benefit analysis, once again the study relied on comparable researches and heavily used the requirements contained in the Brazilian port legislation and regulations, complying with all local stipulations.

The main elements used into the cost benefit analysis were the Capex of the terminals, OPEX – including fixed and variable costs based on the terminal size and characteristics, wages, maintenance, lease fees, fuel, handling costs and others. On top of that the cost analyses also considered the revenues, depreciation & amortization, local taxes, stipulated WACC and contract duration.

Therefore, following the detailed analysis of the local characteristics, capacity and operational aspects, we can refer back to the main question of this research, which is whether or not is economically feasible to develop an automated container terminal in Brazil.

Considering the Capital Expenditures required for the implementation of such terminal, as well as cost estimation for running the operations, this study showed that the economic feasibility of implementing an automated terminal in the Port of Santos – Brazil was proven.

Moreover, the research also presented, that similarly to what has already been showed in other countries, the container automation investment in Brazil takes approximately 6 to 7 years to break even, and this is a remarkable outcome considering the most recent regulation update that allows terminal leases to have 35 years with extensions up to 70 years, allowing some room for harvesting the benefits of the lower operational costs for more extended periods.

On top of that, perhaps the noteworthy finding of analyzing automation in Brazil, always in comparison with the manual terminal operations, is to demonstrate that not only automation has a bright prospect, but it also pays off when put together with manned operations.

It is essential to differentiate the fact that automation per se reaches the breakeven point, bringing value to the investors, from the impressive conclusion that under certain conditions, automation can also surpass manual operations economically speaking, making this a definitive attractive solution to consider from now on when planning a large-scale container terminal in Brazil with similar environment.

However, to know if all the elements considered sufficiently cover the Brazilian situation that goes beyond local terminal sizes, volumes and main operational aspects which are in accordance with what is currently practiced in Brazil, the research had to go through some political, labor and regulatory issues.

So, as shown in the course of the research, not everything is a bed of roses. Brazil still has some, although very interesting, also very recent and still untested regulation updates. History tells that the port regulation and its conditions in the country can be rather volatile and might as well change again on the basis of the specific government that takes over the power in the next coming years and their agenda.

Not to mention the “battle” between the companies and the unions, although judicially settled in favor of terminals, in practice can still damage and hamper any disruptive move that leaves the dockers and stevedore workers aside. These two factors bring some complication into the equation that is hard to monetize in the economic model.

Does the bigger returns over the investment pays enough for the political variations and unions possible frictions? It is hard to monetize these issues, but that can be minimized with a stepwise approach towards the investment, that not necessarily need to be done all at once, as well as the high margins of the discount rate, allowing some room to play with the port authority lease fees, or even the labor costs.

Such long terms give the opportunity of, similarly to the USA, keep some unnecessary dockers for the sake of getting flexibility regarding deals with the union force, and slowly move towards the full automation possibility.

Legally it is already possible to do this in Santos, and it might just be a matter of having the negotiation skills to tackle this the right way and harvest the fruits of being the pathfinder.

Others common variations on the inputs of a Brazilian “volatile economy” such as exchange currency rate, operational costs and even regulatory variations like the WACC established by the governments were tested. On all these non-extreme scenarios, considerable fluctuations were made independently, and all the outcomes were positive. Some with better results than others, but more importantly, the model also proven that this is not only working on an ideal scenario, but it supports some minor mishaps along the way, which again brings confidence for the investors.

It should be noted that this scenario of automation will contribute to the improvement of the regional environmental quality, to the energy transition and to the competitiveness the terminals, as well as the prestige of port operations branding the country as one of the few to reach this automated status.

Finally, it should also be highlighted that in addition to the benefits aforementioned, there will be a modernization and valorization of the public asset, which will return to the port authority at the end of the contract, as well as the improvement of the level of service provided to all clients involved in the logistic chain, bringing the port operations to a whole new level, setting some new benchmarks for those to come.

So once again: Is it worthwhile to implement container automation in Brazil? With the support of all sub questions responses, the straightforward economic answer is yes. The results show that the extra investment of the automated equipment not only pays off but are also 7% higher than the manual terminal with the discounted cash flow calculations, under the same discount rate.

The political and strategic answer could be a bit more subjective. The development around the globe should be of service and a lesson for Brazil in the next coming years to see what the best practices are, what is working and what is not working in similar nations. Analyze the union deals and frictions and try to slowly replicate some in the country to not cause any big shock and incentivize even more the unions to rebel against it or go on strikes creating bigger barriers such as those recently happening in the east coast of North America.

If one wonders what would be the ideal place to automate a terminal, that would probably be in a place with very high wage costs and/or very low union control, neither of which is the case of Brazil, however, as shown on the study, the economic model says to move on and the country is on the frontier of both aspects. So, this can be a matter of who will be audacious enough and make the first move because the status quo is not going to lead us there.

7.1. Recommendations

Analyzing the results and conclusions, an interesting recommendation that can be made is that by looking at the volume of investment into terminal areas and comparing with the cost savings of automation for each of those areas (berth, yard and horizontal transport), it is noteworthy that the lowest reduction is on the berth, with the STS (see again Table 7-1) while the same equipment are responsible for the most significant investment.

It is possible to think and consider an operation less automatized, with AGVs and STS just being remotely operated, but not robotized, lowering the investment on the most expensive assets (QCs) and maintaining the cost savings on the remaining (AGV + ASC).

This is because the number of STS is considerably small (10), compared to yard equipment, while the operators have quite similar wages.

Table 7-1 - Labor Costs Reduction

Labor Costs	Manned	Automated	Dif. R$	Dif. USD
Yard Equipment	R$ 24.932.160	R$ 3.765.795	R$ 21.166.365	**$ 6.614.489**
Berth Equipment	R$ 8.440.575	R$ 3.882.665	R$ 4.557.911	**$ 1.424.347**
Horizontal Transport	R$ 20.399.040	R$ -	R$ 20.399.040	**$ 6.374.700**
Total Labor Cost Difference	R$ 53.771.775	R$ 7.648.460	R$ 46.123.316	**$ 14.413.536**

Perhaps this can be an appealing solution for automation, and labor union meet halfway. The remotely manly operated quay cranes would provide some flexibility to work on peaks, and also as a bargaining chip to negotiate with the union the automation on other areas, guarantying the jobs partially, while still reducing capex and moving forward with automation on other areas.

Chapter 8 Next Steps & Future Researches

The possibilities of next steps in the same direction of this research are numerous. Due to the limited time and necessity of limiting the scope, many opportunities were left behind and surely would bring great value to this topic.

A deeper analysis into the automation options could lead to a concrete and detailed oriented result especially if segregated into smaller pieces, making an economic viability study of individual projects of automation inside a terminal like gate automation, other options of yard equipment setup, different levels of IT and big data used for reducing the man participation on the decision processes among others. The important thing would be to analyze the NPV of each project separately to see the investment and return of each part of the process.

In this study, the model does not provide such possibility because the investments are all integrated. This break down approach could be used to convince investors of smaller investments, check the outcome and increase their trust in the automation in general, generating enthusiasm toward the technology.

Another interesting development that could be done is the use of a proper market analysis inputting the model with more realistic data. This study used a very optimistic and stable environment of volumes handled. By using more detailed market analysis, the variation nor only on the annual throughput but also on the ideal periods of investment with a growth rate and a phased investment will surely provide a more accurate result of the reality, making it somewhat more reliable on the perspective of terminal operators.

These suggestions would be greatly benefited by the participation of a terminal operator interested in see if and how they should move towards automation. This is because doing such study and analysis in partnership with a real terminal, could allow the use of better data in terms of profit and loss detailed statement, based on real fixed and variable costs, as well as the terminal's idea of return on investment, ideal discount rate, and limits of their possibilities.

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APPENDIX A Total Investment and Depreciation

Manned Terminal Investment and Depreciation

MANNED TERMINAL	1	2	3	4	5	6	7	8	9	10
Thourghput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Investment	507.152.000					6.552.000		6.720.000		
Expected Troughput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Depreciation - STS (20 years)	9.750.000	9.750.000	9.750.000	9.750.000	9.750.000	9.750.000	9.750.000	9.750.000	9.750.000	9.750.000
Depreciation - STS Spreader (5 Years)	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400
Depreciation - RTG (20 years)	13.824.000	13.824.000	13.824.000	13.824.000	13.824.000	13.824.000	13.824.000	13.824.000	13.824.000	13.824.000
Depreciation - RTG Spreader (5 years)	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000
Depreciation - TT (10 Years)	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000
Depreciation - Trailler (7 Years)	960.000	960.000	960.000	960.000	960.000	960.000	960.000	960.000	960.000	960.000
Depreciation - TOS (35 years)	182.857	182.857	182.857	182.857	182.857	182.857	182.857	182.857	182.857	182.857
Total Depreciation	27.627.257	27.627.257	27.627.257	27.627.257	27.627.257	27.627.257	27.627.257	27.627.257	27.627.257	27.627.257

MANNED TERMINAL	11	12	13	14	15	16	17	18	19	20
Thourghput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Investment	22.552.000				6.720.000	6.552.000				
Expected Troughput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Depreciation - STS (20 years)	9.750.000	9.750.000	9.750.000	9.750.000	9.750.000	9.750.000	9.750.000	9.750.000	9.750.000	9.750.000
Depreciation - STS Spreader (5 Years)	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400
Depreciation - RTG (20 years)	13.824.000	13.824.000	13.824.000	13.824.000	13.824.000	13.824.000	13.824.000	13.824.000	13.824.000	13.824.000
Depreciation - RTG Spreader (5 years)	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000
Depreciation - TT (10 Years)	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000
Depreciation - Trailler (7 Years)	960.000	960.000	960.000	960.000	960.000	960.000	960.000	960.000	960.000	960.000
Depreciation - TOS (35 years)	182.857	182.857	182.857	182.857	182.857	182.857	182.857	182.857	182.857	182.857
Total Depreciation	27.627.257	27.627.257	27.627.257	27.627.257	27.627.257	27.627.257	27.627.257	27.627.257	27.627.257	27.627.257

MANNED TERMINAL	21	22	23	24	25	26	27	28	29	30
Thourghput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Investment	494.032.000	6.720.000				6.552.000			6.720.000	
Expected Troughput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Depreciation - STS (20 years)	13.000.000	13.000.000	13.000.000	13.000.000	13.000.000	13.000.000	13.000.000	13.000.000	13.000.000	13.000.000
Depreciation - STS Spreader (5 Years)	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400
Depreciation - RTG (20 years)	18.432.000	18.432.000	18.432.000	18.432.000	18.432.000	18.432.000	18.432.000	18.432.000	18.432.000	18.432.000
Depreciation - RTG Spreader (5 years)	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000
Depreciation - TT (10 Years)	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000	1.600.000
Depreciation - Trailler (7 Years)	960.000	960.000	960.000	960.000	960.000	960.000	960.000	960.000	960.000	960.000
Depreciation - TOS (35 years)	182.857	182.857	182.857	182.857	182.857	182.857	182.857	182.857	182.857	182.857
Total Depreciation	35.485.257	35.485.257	35.485.257	35.485.257	35.485.257	35.485.257	35.485.257	35.485.257	35.485.257	35.485.257

MANNED TERMINAL	31	32	33	34	35
Thourghput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Investment	22.552.000				
Expected Troughput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Depreciation - STS (20 years)	13.000.000	13.000.000	13.000.000	13.000.000	13.000.000
Depreciation - STS Spreader (5 Years)	218.400	218.400	218.400	218.400	218.400
Depreciation - RTG (20 years)	18.432.000	18.432.000	18.432.000	18.432.000	18.432.000
Depreciation - RTG Spreader (5 years)	1.092.000	1.092.000	1.092.000	1.092.000	1.092.000
Depreciation - TT (10 Years)	3.200.000	3.200.000	3.200.000	3.200.000	3.200.000
Depreciation - Trailler (7 Years)	960.000	960.000	960.000	960.000	960.000
Depreciation - TOS (35 years)	182.857	182.857	182.857	182.857	182.857
Total Depreciation	37.085.257	37.085.257	37.085.257	37.085.257	37.085.257

Automated Terminal Investment and Depreciation

MANNED TERMINAL	1	2	3	4	5	6	7	8	9	10
Throughput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Investment	797.860.000					5.460.000				55.460.000
Expected Throughput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Depreciation - STS (20 years)	19.200.000	19.200.000	19.200.000	19.200.000	19.200.000	19.200.000	19.200.000	19.200.000	19.200.000	19.200.000
Depreciation - STS Spreader (5 Years)	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400
Depreciation - ASC (20 years)	17.280.000	17.280.000	17.280.000	17.280.000	17.280.000	17.280.000	17.280.000	17.280.000	17.280.000	17.280.000
Depreciation - ASC Spreader (5 years)	873.600	873.600	873.600	873.600	873.600	873.600	873.600	873.600	873.600	873.600
Depreciation - AGV (10 Years)	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000
Depreciation - TOS (35 years)	365.714	365.714	365.714	365.714	365.714	365.714	365.714	365.714	365.714	365.714
Depreciation - Gates Automation (10 yea	320.000	320.000	320.000	320.000	320.000	320.000	320.000	320.000	320.000	320.000
Total Depreciation	42.937.714	42.937.714	42.937.714	42.937.714	42.937.714	42.937.714	42.937.714	42.937.714	42.937.714	42.937.714

MANNED TERMINAL	11	12	13	14	15	16	17	18	19	20
Throughput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Investment						5.460.000				
Expected Throughput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Depreciation - STS (20 years)	19.200.000	19.200.000	19.200.000	19.200.000	19.200.000	19.200.000	19.200.000	19.200.000	19.200.000	19.200.000
Depreciation - STS Spreader (5 Years)	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400
Depreciation - ASC (20 years)	17.280.000	17.280.000	17.280.000	17.280.000	17.280.000	17.280.000	17.280.000	17.280.000	17.280.000	17.280.000
Depreciation - ASC Spreader (5 years)	873.600	873.600	873.600	873.600	873.600	873.600	873.600	873.600	873.600	873.600
Depreciation - AGV (10 Years)	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000
Depreciation - TOS (35 years)	365.714	365.714	365.714	365.714	365.714	365.714	365.714	365.714	365.714	365.714
Depreciation - Gates Automation (10 yea	320.000	320.000	320.000	320.000	320.000	320.000	320.000	320.000	320.000	320.000
Total Depreciation	42.937.714	42.937.714	42.937.714	42.937.714	42.937.714	42.937.714	42.937.714	42.937.714	42.937.714	42.937.714

MANNED TERMINAL	21	22	23	24	25	26	27	28	29	30
Throughput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Investment	785.060.000					5.460.000				
Expected Throughput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Depreciation - STS (20 years)	25.600.000	25.600.000	25.600.000	25.600.000	25.600.000	25.600.000	25.600.000	25.600.000	25.600.000	25.600.000
Depreciation - STS Spreader (5 Years)	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400	218.400
Depreciation - ASC (20 years)	23.040.000	23.040.000	23.040.000	23.040.000	23.040.000	23.040.000	23.040.000	23.040.000	23.040.000	23.040.000
Depreciation - ASC Spreader (5 years)	873.600	873.600	873.600	873.600	873.600	873.600	873.600	873.600	873.600	873.600
Depreciation - AGV (10 Years)	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000	4.680.000
Depreciation - TOS (35 years)	365.714	365.714	365.714	365.714	365.714	365.714	365.714	365.714	365.714	365.714
Depreciation - Gates Automation (10 yea	320.000	320.000	320.000	320.000	320.000	320.000	320.000	320.000	320.000	320.000
Total Depreciation	55.097.714	55.097.714	55.097.714	55.097.714	55.097.714	55.097.714	55.097.714	55.097.714	55.097.714	55.097.714

MANNED TERMINAL	31	32	33	34	35
Throughput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Investment	55.460.000				
Expected Throughput	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
Depreciation - STS (20 years)	25.600.000	25.600.000	25.600.000	25.600.000	25.600.000
Depreciation - STS Spreader (5 Years)	218.400	218.400	218.400	218.400	218.400
Depreciation - ASC (20 years)	23.040.000	23.040.000	23.040.000	23.040.000	23.040.000
Depreciation - ASC Spreader (5 years)	873.600	873.600	873.600	873.600	873.600
Depreciation - AGV (10 Years)	9.360.000	9.360.000	9.360.000	9.360.000	9.360.000
Depreciation - TOS (35 years)	365.714	365.714	365.714	365.714	365.714
Depreciation - Gates Automation (10 yea	640.000	640.000	640.000	640.000	640.000
Total Depreciation	60.097.714	60.097.714	60.097.714	60.097.714	60.097.714

APPENDIX B Profit and Loss Statement

Manned Terminal Profit & Loss Statement

PROFIT & LOSS										
Year	1	2	3	4	5	6	7	8	9	10
Container Volume	**645.161**	**774.194**	**903.226**	**1.032.258**	**1.161.290**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**
TEU Volume	1.000.000	1.200.000	1.400.000	1.600.000	1.800.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
TEU Ratio	2	2	2	2	2	2	2	2	2	2
Average Price - R$ per TEU	500	500	500	500	500	500	500	500	500	500
Average Price - R$ per TEU (Port Operation)	325	325	325	325	325	325	325	325	325	325
Average Price - R$ per TEU (Bonded Storage)	175	175	175	175	175	175	175	175	175	175
(=) Gross Revenue (x 1.000)	**500.000**	**600.000**	**700.000**	**800.000**	**900.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**
(-) Taxes	50.000	60.000	70.000	80.000	90.000	100.000	100.000	100.000	100.000	100.000
ISS + PIS + COFINS + Others	0	0	0	0	0	0	0	0	0	0
(=) Net Operational Revenue	**450.000**	**540.000**	**630.000**	**720.000**	**810.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**
(-) Costs & Expenses	525.000	560.000	595.000	630.000	665.000	700.000	700.000	700.000	700.000	700.000
Cargo Handling	105.000	112.000	119.000	126.000	133.000	140.000	140.000	140.000	140.000	140.000
Personnel Expenses (labor with taxes, benefits, etc.)	199.500	212.800	226.100	239.400	252.700	266.000	266.000	266.000	266.000	266.000
Lease	63.000	67.200	71.400	75.600	79.800	84.000	84.000	84.000	84.000	84.000
Maintenance	42.000	44.800	47.600	50.400	53.200	56.000	56.000	56.000	56.000	56.000
Fuel	21.000	22.400	23.800	25.200	26.600	28.000	28.000	28.000	28.000	28.000
Electricity	10.500	11.200	11.900	12.600	13.300	14.000	14.000	14.000	14.000	14.000
Others	84.000	89.600	95.200	100.800	106.400	112.000	112.000	112.000	112.000	112.000
(=) EBITDA	**(75.000)**	**(20.000)**	**35.000**	**90.000**	**145.000**	**200.000**	**200.000**	**200.000**	**200.000**	**200.000**
(-) Depreciation + Amortization	27.627	27.627	27.627	27.627	27.627	27.627	27.627	27.627	27.627	27.627
(=) EBIT:	**(102.627)**	**(47.627)**	**7.373**	**62.373**	**117.373**	**172.373**	**172.373**	**172.373**	**172.373**	**172.373**
Profit Before Income Tax	**(102.627)**	**(47.627)**	**7.373**	**62.373**	**117.373**	**172.373**	**172.373**	**172.373**	**172.373**	**172.373**
(-) Income Tax:	0	0	(2.507)	(21.207)	(39.907)	(58.607)	(58.607)	(58.607)	(58.607)	(58.607)
(=) Net Profit:	**(102.627)**	**(47.627)**	**9.879**	**83.579**	**157.279**	**230.979**	**230.979**	**230.979**	**230.979**	**230.979**
(=) Net Profit (USD):	**(32.071)**	**(14.884)**	**3.087**	**26.119**	**49.150**	**72.181**	**72.181**	**72.181**	**72.181**	**72.181**

PROFIT & LOSS										
Year	11	12	13	14	15	16	17	18	19	20
Container Volume	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**
TEU Volume	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
TEU Ratio	2	2	2	2	2	2	2	2	2	2
Average Price - R$ per TEU	500	500	500	500	500	500	500	500	500	500
Average Price - R$ per TEU (Port Operation)	325	325	325	325	325	325	325	325	325	325
Average Price - R$ per TEU (Bonded Storage)	175	175	175	175	175	175	175	175	175	175
(=) Gross Revenue (x 1.000)	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**
(-) Taxes	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
ISS + PIS + COFINS + Others	0	0	0	0	0	0	0	0	0	0
(=) Net Operational Revenue	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**
(-) Costs & Expenses	700.000	700.000	700.000	700.000	700.000	700.000	700.000	700.000	700.000	700.000
Cargo Handling	140.000	140.000	140.000	140.000	140.000	140.000	140.000	140.000	140.000	140.000
Personnel Expenses (labor with taxes, benefits, etc.)	266.000	266.000	266.000	266.000	266.000	266.000	266.000	266.000	266.000	266.000
Lease	84.000	84.000	84.000	84.000	84.000	84.000	84.000	84.000	84.000	84.000
Maintenance	56.000	56.000	56.000	56.000	56.000	56.000	56.000	56.000	56.000	56.000
Fuel	28.000	28.000	28.000	28.000	28.000	28.000	28.000	28.000	28.000	28.000
Electricity	14.000	14.000	14.000	14.000	14.000	14.000	14.000	14.000	14.000	14.000
Others	112.000	112.000	112.000	112.000	112.000	112.000	112.000	112.000	112.000	112.000
(=) EBITDA	**200.000**	**200.000**	**200.000**	**200.000**	**200.000**	**200.000**	**200.000**	**200.000**	**200.000**	**200.000**
(-) Depreciation + Amortization	27.627	27.627	27.627	27.627	27.627	27.627	27.627	27.627	27.627	27.627
(=) EBIT:	**172.373**	**172.373**	**172.373**	**172.373**	**172.373**	**172.373**	**172.373**	**172.373**	**172.373**	**172.373**
Profit Before Income Tax	**172.373**	**172.373**	**172.373**	**172.373**	**172.373**	**172.373**	**172.373**	**172.373**	**172.373**	**172.373**
(-) Income Tax:	(58.607)	(58.607)	(58.607)	(58.607)	(58.607)	(58.607)	(58.607)	(58.607)	(58.607)	(58.607)
(=) Net Profit:	**230.979**	**230.979**	**230.979**	**230.979**	**230.979**	**230.979**	**230.979**	**230.979**	**230.979**	**230.979**
(=) Net Profit (USD):	**72.181**	**72.181**	**72.181**	**72.181**	**72.181**	**72.181**	**72.181**	**72.181**	**72.181**	**72.181**

PROFIT & LOSS										
Year	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Container Volume	**645.161**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**
TEU Volume	1.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
TEU Ratio	2	2	2	2	2	2	2	2	2	2
Average Price - R$ per TEU	500	500	500	500	500	500	500	500	500	500
Average Price - R$ per TEU (Port Operation)	325	325	325	325	325	325	325	325	325	325
Average Price - R$ per TEU (Bonded Storage)	175	175	175	175	175	175	175	175	175	175
(=) Gross Revenue (x 1.000)	**500.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**
(-) Taxes	50.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
ISS + PIS + COFINS + Others	0	0	0	0	0	0	0	0	0	0
(=) Net Operational Revenue	**450.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**
(-) Costs & Expenses	525.000	700.000	700.000	700.000	700.000	700.000	700.000	700.000	700.000	700.000
Cargo Handling	105.000	140.000	140.000	140.000	140.000	140.000	140.000	140.000	140.000	140.000
Personnel Expenses (labor with taxes, benefits, etc.)	199.500	266.000	266.000	266.000	266.000	266.000	266.000	266.000	266.000	266.000
Lease	63.000	84.000	84.000	84.000	84.000	84.000	84.000	84.000	84.000	84.000
Maintenance	42.000	56.000	56.000	56.000	56.000	56.000	56.000	56.000	56.000	56.000
Fuel	21.000	28.000	28.000	28.000	28.000	28.000	28.000	28.000	28.000	28.000
Electricity	10.500	14.000	14.000	14.000	14.000	14.000	14.000	14.000	14.000	14.000
Others	84.000	112.000	112.000	112.000	112.000	112.000	112.000	112.000	112.000	112.000
(=) EBITDA	**(75.000)**	**200.000**	**200.000**	**200.000**	**200.000**	**200.000**	**200.000**	**200.000**	**200.000**	**200.000**
(-) Depreciation + Amortization	35.485	35.485	35.485	35.485	35.485	35.485	35.485	35.485	35.485	35.485
(=) EBIT:	**(110.485)**	**164.515**	**164.515**	**164.515**	**164.515**	**164.515**	**164.515**	**164.515**	**164.515**	**164.515**
Profit Before Income Tax	**(110.485)**	**164.515**	**164.515**	**164.515**	**164.515**	**164.515**	**164.515**	**164.515**	**164.515**	**164.515**
(-) Income Tax:	0	(55.935)	(55.935)	(55.935)	(55.935)	(55.935)	(55.935)	(55.935)	(55.935)	(55.935)
(=) Net Profit:	**(110.485)**	**220.450**	**220.450**	**220.450**	**220.450**	**220.450**	**220.450**	**220.450**	**220.450**	**220.450**
(=) Net Profit (USD):	**(34.527)**	**68.891**	**68.891**	**68.891**	**68.891**	**68.891**	**68.891**	**68.891**	**68.891**	**68.891**

PROFIT & LOSS					
Year	**31**	**32**	**33**	**34**	**35**
Container Volume	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**
TEU Volume	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
TEU Ratio	2	2	2	2	2
Average Price - R$ per TEU	500	500	500	500	500
Average Price - R$ per TEU (Port Operation)	325	325	325	325	325
Average Price - R$ per TEU (Bonded Storage)	175	175	175	175	175
(=) Gross Revenue (x 1.000)	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**
(-) Taxes	100.000	100.000	100.000	100.000	100.000
ISS + PIS + COFINS + Others	0	0	0	0	0
(=) Net Operational Revenue	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**
(-) Costs & Expenses	700.000	700.000	700.000	700.000	700.000
Cargo Handling	140.000	140.000	140.000	140.000	140.000
Personnel Expenses (labor with taxes, benefits, etc.)	266.000	266.000	266.000	266.000	266.000
Lease	84.000	84.000	84.000	84.000	84.000
Maintenance	56.000	56.000	56.000	56.000	56.000
Fuel	28.000	28.000	28.000	28.000	28.000
Electricity	14.000	14.000	14.000	14.000	14.000
Others	112.000	112.000	112.000	112.000	112.000
(=) EBITDA	**200.000**	**200.000**	**200.000**	**200.000**	**200.000**
(-) Depreciation + Amortization	37.085	37.085	37.085	37.085	37.085
(=) EBIT:	**162.915**	**162.915**	**162.915**	**162.915**	**162.915**
Profit Before Income Tax	**162.915**	**162.915**	**162.915**	**162.915**	**162.915**
(-) Income Tax:	(55.391)	(55.391)	(55.391)	(55.391)	(55.391)
(=) Net Profit:	**218.306**	**218.306**	**218.306**	**218.306**	**218.306**
(=) Net Profit (USD):	**68.221**	**68.221**	**68.221**	**68.221**	**68.221**

Automated Terminal Profit & Loss Statement

PROFIT & LOSS										
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Container Volume	**645.161**	**774.194**	**903.226**	**1.032.258**	**1.161.290**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**
TEU Volume	1.000.000	1.200.000	1.400.000	1.600.000	1.800.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
TEU Ratio	2	2	2	2	2	2	2	2	2	2
Average Price - R$ per TEU	500	500	500	500	500	500	500	500	500	500
Average Price - R$ per TEU (Port Operation)	325	325	325	325	325	325	325	325	325	325
Average Price - R$ per TEU (Bonded Storage)	175	175	175	175	175	175	175	175	175	175
(=) Gross Revenue (x 1.000)	**500.000**	**600.000**	**700.000**	**800.000**	**900.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**
(-) Taxes	50.000	60.000	70.000	80.000	90.000	100.000	100.000	100.000	100.000	100.000
ISS + PIS + COFINS + Others	0	0	0	0	0	0	0	0	0	0
(=) Net Operational Revenue	**450.000**	**540.000**	**630.000**	**720.000**	**810.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**
(-) Costs & Expenses	422.565	464.346	501.665	535.265	568.865	619.577	619.577	619.577	619.577	619.577
Cargo Handling	105.000	112.000	119.000	126.000	133.000	140.000	140.000	140.000	140.000	140.000
Personnel Expenses (labor with taxes, benefits, etc.)	130.315	143.615	156.915	170.215	183.515	219.877	219.877	219.877	219.877	219.877
Lease	63.000	67.200	71.400	75.600	79.800	84.000	84.000	84.000	84.000	84.000
Maintenance	25.200	35.700	42.000	44.800	47.600	44.800	44.800	44.800	44.800	44.800
Fuel	5.600	5.600	5.600	5.600	5.600	5.600	5.600	5.600	5.600	5.600
Electricity	9.450	10.631	11.550	12.250	12.950	13.300	13.300	13.300	13.300	13.300
Others	84.000	89.600	95.200	100.800	106.400	112.000	112.000	112.000	112.000	112.000
(=) EBITDA	**27.435**	**75.654**	**128.335**	**184.735**	**241.135**	**280.423**	**280.423**	**280.423**	**280.423**	**280.423**
(-) Depreciation + Amortization	42.938	42.938	42.938	42.938	42.938	42.938	42.938	42.938	42.938	42.938
(=) EBIT:	**(15.503)**	**32.716**	**85.397**	**141.797**	**198.197**	**237.486**	**237.486**	**237.486**	**237.486**	**237.486**
Profit Before Income Tax	**(15.503)**	**32.716**	**85.397**	**141.797**	**198.197**	**237.486**	**237.486**	**237.486**	**237.486**	**237.486**
(-) Income Tax:	0	(11.123)	(29.035)	(48.211)	(67.387)	(80.745)	(80.745)	(80.745)	(80.745)	(80.745)
(=) Net Profit:	**(15.503)**	**43.839**	**114.432**	**190.008**	**265.584**	**318.231**	**318.231**	**318.231**	**318.231**	**318.231**
(=) Net Profit (USD):	**(4.845)**	**13.700**	**35.760**	**59.378**	**82.995**	**99.447**	**99.447**	**99.447**	**99.447**	**99.447**

PROFIT & LOSS										
Year	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Container Volume	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**
TEU Volume	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
TEU Ratio	2	2	2	2	2	2	2	2	2	2
Average Price - R$ per TEU	500	500	500	500	500	500	500	500	500	500
Average Price - R$ per TEU (Port Operation)	325	325	325	325	325	325	325	325	325	325
Average Price - R$ per TEU (Bonded Storage)	175	175	175	175	175	175	175	175	175	175
(=) Gross Revenue (x 1.000)	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**
(-) Taxes	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
ISS + PIS + COFINS + Others	0	0	0	0	0	0	0	0	0	0
(=) Net Operational Revenue	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**
(-) Costs & Expenses	619.577	619.577	619.577	619.577	619.577	619.577	619.577	619.577	619.577	619.577
Cargo Handling	140.000	140.000	140.000	140.000	140.000	140.000	140.000	140.000	140.000	140.000
Personnel Expenses (labor with taxes, benefits, etc.)	219.877	219.877	219.877	219.877	219.877	219.877	219.877	219.877	219.877	219.877
Lease	84.000	84.000	84.000	84.000	84.000	84.000	84.000	84.000	84.000	84.000
Maintenance	44.800	44.800	44.800	44.800	44.800	44.800	44.800	44.800	44.800	44.800
Fuel	5.600	5.600	5.600	5.600	5.600	5.600	5.600	5.600	5.600	5.600
Electricity	13.300	13.300	13.300	13.300	13.300	13.300	13.300	13.300	13.300	13.300
Others	112.000	112.000	112.000	112.000	112.000	112.000	112.000	112.000	112.000	112.000
(=) EBITDA	**280.423**	**280.423**	**280.423**	**280.423**	**280.423**	**280.423**	**280.423**	**280.423**	**280.423**	**280.423**
(-) Depreciation + Amortization	42.938	42.938	42.938	42.938	42.938	42.938	42.938	42.938	42.938	42.938
(=) EBIT:	**237.486**	**237.486**	**237.486**	**237.486**	**237.486**	**237.486**	**237.486**	**237.486**	**237.486**	**237.486**
Profit Before Income Tax	**237.486**	**237.486**	**237.486**	**237.486**	**237.486**	**237.486**	**237.486**	**237.486**	**237.486**	**237.486**
(-) Income Tax:	(80.745)	(80.745)	(80.745)	(80.745)	(80.745)	(80.745)	(80.745)	(80.745)	(80.745)	(80.745)
(=) Net Profit:	**318.231**	**318.231**	**318.231**	**318.231**	**318.231**	**318.231**	**318.231**	**318.231**	**318.231**	**318.231**
(=) Net Profit (USD):	**99.447**	**99.447**	**99.447**	**99.447**	**99.447**	**99.447**	**99.447**	**99.447**	**99.447**	**99.447**

PROFIT & LOSS										
Year	21	22	23	24	25	26	27	28	29	30
Container Volume	**645.161**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**
TEU Volume	1.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
TEU Ratio	2	2	2	2	2	2	2	2	2	2
Average Price - R$ per TEU	500	500	500	500	500	500	500	500	500	500
Average Price - R$ per TEU (Port Operation)	325	325	325	325	325	325	325	325	325	325
Average Price - R$ per TEU (Bonded Storage)	175	175	175	175	175	175	175	175	175	175
(=) Gross Revenue (x 1.000)	**500.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**
(-) Taxes	50.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
ISS + PIS + COFINS + Others	0	0	0	0	0	0	0	0	0	0
(=) Net Operational Revenue	**450.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**
(-) Costs & Expenses	422.565	619.577	619.577	619.577	619.577	619.577	619.577	619.577	619.577	619.577
Cargo Handling	105.000	140.000	140.000	140.000	140.000	140.000	140.000	140.000	140.000	140.000
Personnel Expenses (labor with taxes, benefits, etc.)	130.315	219.877	219.877	219.877	219.877	219.877	219.877	219.877	219.877	219.877
Lease	63.000	84.000	84.000	84.000	84.000	84.000	84.000	84.000	84.000	84.000
Maintenance	25.200	44.800	44.800	44.800	44.800	44.800	44.800	44.800	44.800	44.800
Fuel	5.600	5.600	5.600	5.600	5.600	5.600	5.600	5.600	5.600	5.600
Electricity	9.450	13.300	13.300	13.300	13.300	13.300	13.300	13.300	13.300	13.300
Others	84.000	112.000	112.000	112.000	112.000	112.000	112.000	112.000	112.000	112.000
(=) EBITDA	**27.435**	**280.423**	**280.423**	**280.423**	**280.423**	**280.423**	**280.423**	**280.423**	**280.423**	**280.423**
(-) Depreciation + Amortization	55.098	55.098	55.098	55.098	55.098	55.098	55.098	55.098	55.098	55.098
(=) EBIT:	**(27.663)**	**225.326**	**225.326**	**225.326**	**225.326**	**225.326**	**225.326**	**225.326**	**225.326**	**225.326**
Profit Before Income Tax	**(27.663)**	**225.326**	**225.326**	**225.326**	**225.326**	**225.326**	**225.326**	**225.326**	**225.326**	**225.326**
(-) Income Tax:	0	(76.611)	(76.611)	(76.611)	(76.611)	(76.611)	(76.611)	(76.611)	(76.611)	(76.611)
(=) Net Profit:	**(27.663)**	**301.936**	**301.936**	**301.936**	**301.936**	**301.936**	**301.936**	**301.936**	**301.936**	**301.936**
(=) Net Profit (USD):	**(8.645)**	**94.355**	**94.355**	**94.355**	**94.355**	**94.355**	**94.355**	**94.355**	**94.355**	**94.355**

PROFIT & LOSS					
Year	31	32	33	34	35
Container Volume	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**	**1.290.323**
TEU Volume	2.000.000	2.000.000	2.000.000	2.000.000	2.000.000
TEU Ratio	2	2	2	2	2
Average Price - R$ per TEU	500	500	500	500	500
Average Price - R$ per TEU (Port Operation)	325	325	325	325	325
Average Price - R$ per TEU (Bonded Storage)	175	175	175	175	175
(=) Gross Revenue (x 1.000)	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**	**1.000.000**
(-) Taxes	100.000	100.000	100.000	100.000	100.000
ISS + PIS + COFINS + Others	0	0	0	0	0
(=) Net Operational Revenue	**900.000**	**900.000**	**900.000**	**900.000**	**900.000**
(-) Costs & Expenses	619.577	619.577	619.577	619.577	619.577
Cargo Handling	140.000	140.000	140.000	140.000	140.000
Personnel Expenses (labor with taxes, benefits, etc.)	219.877	219.877	219.877	219.877	219.877
Lease	84.000	84.000	84.000	84.000	84.000
Maintenance	44.800	44.800	44.800	44.800	44.800
Fuel	5.600	5.600	5.600	5.600	5.600
Electricity	13.300	13.300	13.300	13.300	13.300
Others	112.000	112.000	112.000	112.000	112.000
(=) EBITDA	**280.423**	**280.423**	**280.423**	**280.423**	**280.423**
(-) Depreciation + Amortization	60.098	60.098	60.098	60.098	60.098
(=) EBIT:	**220.326**	**220.326**	**220.326**	**220.326**	**220.326**
Profit Before Income Tax	**220.326**	**220.326**	**220.326**	**220.326**	**220.326**
(-) Income Tax:	(74.911)	(74.911)	(74.911)	(74.911)	(74.911)
(=) Net Profit:	**295.236**	**295.236**	**295.236**	**295.236**	**295.236**
(=) Net Profit (USD):	**92.261**	**92.261**	**92.261**	**92.261**	**92.261**

APPENDIX C Cash flow

Manned Terminal Cash Flow

CASH FLOW										
Year	1	2	3	4	5	6	7	8	9	10
Operational Profit (EBIT):	(102.627)	(47.627)	7.373	62.373	117.373	172.373	172.373	172.373	172.373	172.373
(+) Depreciation + Amortization:	27.627	27.627	27.627	27.627	27.627	27.627	27.627	27.627	27.627	27.627
(=) EBITDA	(75.000)	(20.000)	35.000	90.000	145.000	200.000	200.000	200.000	200.000	200.000
(-) Income Tax	0	0	(2.507)	(21.207)	(39.907)	(58.607)	(58.607)	(58.607)	(58.607)	(58.607)
(+/-) Variations in working capital	0	0	0	0	0	0	0	0	0	0
(=) Operational Cash Flow	(75.000)	(20.000)	37.507	111.207	184.907	258.607	258.607	258.607	258.607	258.607
(-) Investments	507.152	0	0	0	0	6.552	0	6.720	0	0
(=) TOTAL Cash Flow	(582.152)	(20.000)	37.507	111.207	184.907	252.055	258.607	251.887	258.607	258.607
(=) Accumulated Cash Flow	(582.152)	(602.152)	(564.645)	(453.439)	(268.532)	(16.477)	242.130	494.016	752.623	1.011.230
(=) Discounted Accumulated Cash Flow	(582.152)	(600.334)	(569.337)	(485.785)	(359.491)	(202.985)	(57.009)	72.249	192.891	302.566
TOTAL Cash Flow	(181.923)	(6.250)	11.721	34.752	57.783	78.767	80.815	78.715	80.815	80.815
(=) Accumulated Cash flow (USD)	(181.923)	(188.173)	(176.452)	(141.700)	(83.916)	(5.149)	75.666	154.380	235.195	316.009
(=) Discounted Accumulated Cash Flow (USD)	(181.923)	(187.604)	(177.918)	(151.808)	(112.341)	(63.433)	(17.815)	22.578	60.278	94.552
NPV (x USD 1.000)	(352.472)	(187.604)	(177.918)	(151.808)	(112.341)	(63.433)	(17.815)	22.578	60.278	94.552

CASH FLOW										
Year	11	12	13	14	15	16	17	18	19	20
Operational Profit (EBIT):	172.373	172.373	172.373	172.373	172.373	172.373	172.373	172.373	172.373	172.373
(+) Depreciation + Amortization:	27.627	27.627	27.627	27.627	27.627	27.627	27.627	27.627	27.627	27.627
(=) EBITDA	200.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000
(-) Income Tax	(58.607)	(58.607)	(58.607)	(58.607)	(58.607)	(58.607)	(58.607)	(58.607)	(58.607)	(58.607)
(+/-) Variations in working capital	0	0	0	0	0	0	0	0	0	0
(=) Operational Cash Flow	258.607	258.607	258.607	258.607	258.607	258.607	258.607	258.607	258.607	258.607
(-) Investments	22.552	0	0	0	6.720	6.552	0	0	0	0
(=) TOTAL Cash Flow	236.055	258.607	258.607	258.607	251.887	252.055	258.607	258.607	258.607	258.607
(=) Accumulated Cash Flow	1.247.285	1.505.891	1.764.498	2.023.105	2.274.992	2.527.046	2.785.653	3.044.260	3.302.866	3.561.473
(=) Discounted Accumulated Cash Flow	393.575	484.215	566.615	641.524	707.854	768.194	824.474	875.638	922.151	964.435
TOTAL Cash Flow	73.767	80.815	80.815	80.815	78.715	78.767	80.815	80.815	80.815	80.815
(=) Accumulated Cash flow (USD)	389.776	470.591	551.406	632.220	710.935	789.702	870.517	951.331	1.032.146	1.112.960
(=) Discounted Accumulated Cash Flow (USD)	122.992	151.317	177.067	200.476	221.204	240.061	257.648	273.637	288.172	301.386
NPV (x USD 1.000)	122.992	151.317	177.067	200.476	221.204	240.061	257.648	273.637	288.172	301.386

CASH FLOW										
Year	21	22	23	24	25	26	27	28	29	30
Operational Profit (EBIT):	(110.485)	164.515	164.515	164.515	164.515	164.515	164.515	164.515	164.515	164.515
(+) Depreciation + Amortization:	35.485	35.485	35.485	35.485	35.485	35.485	35.485	35.485	35.485	35.485
(=) EBITDA	(75.000)	200.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000	200.000
(-) Income Tax	0	(55.935)	(55.935)	(55.935)	(55.935)	(55.935)	(55.935)	(55.935)	(55.935)	(55.935)
(+/-) Variations in working capital	0	0	0	0	0	0	0	0	0	0
(=) Operational Cash Flow	(75.000)	255.935	255.935	255.935	255.935	255.935	255.935	255.935	255.935	255.935
(-) Investments	494.032	6.720	0	0	0	6.552	0	0	6.720	0
(=) TOTAL Cash Flow	(569.032)	249.215	255.935	255.935	255.935	249.383	255.935	255.935	249.215	255.935
(=) Accumulated Cash Flow	2.992.441	3.241.656	3.497.591	3.753.526	4.009.461	4.258.844	4.514.779	4.770.714	5.019.929	5.275.864
(=) Discounted Accumulated Cash Flow	879.852	913.529	944.969	973.552	999.536	1.022.553	1.044.027	1.063.549	1.080.830	1.096.964
TOTAL Cash Flow	(177.823)	77.880	79.980	79.980	79.980	77.932	79.980	79.980	77.880	79.980
(=) Accumulated Cash flow (USD)	935.138	1.013.018	1.092.997	1.172.977	1.252.957	1.330.889	1.410.869	1.490.848	1.568.728	1.648.708
(=) Discounted Accumulated Cash Flow (USD)	274.954	285.478	295.303	304.235	312.355	319.548	326.258	332.359	337.760	342.801
NPV (x USD 1.000)	274.954	285.478	295.303	304.235	312.355	319.548	326.258	332.359	337.760	342.801

CASH FLOW					
Year	31	32	33	34	35
Operational Profit (EBIT):	162.915	162.915	162.915	162.915	162.915
(+) Depreciation + Amortization:	37.085	37.085	37.085	37.085	37.085
(=) EBITDA	200.000	200.000	200.000	200.000	200.000
(-) Income Tax	(55.391)	(55.391)	(55.391)	(55.391)	(55.391)
(+/-) Variations in working capital	0	0	0	0	0
(=) Operational Cash Flow	255.391	255.391	255.391	255.391	255.391
(-) Investments	22.552	0	0	0	0
(=) TOTAL Cash Flow	232.839	255.391	255.391	255.391	255.391
(=) Accumulated Cash Flow	5.508.703	5.764.094	6.019.485	6.274.876	6.530.267
(=) Discounted Accumulated Cash Flow	1.110.308	1.123.614	1.135.710	1.146.706	1.156.703
TOTAL Cash Flow	72.762	79.810	79.810	79.810	79.810
(=) Accumulated Cash flow (USD)	1.721.470	1.801.279	1.881.089	1.960.899	2.040.709
(=) Discounted Accumulated Cash Flow (USD)	346.971	351.129	354.909	358.346	361.470
NPV (x USD 1.000)	346.971	351.129	354.909	358.346	361.470

Automated Terminal Cash Flow

CASH FLOW										
Year	1	2	3	4	5	6	7	8	9	10
Operational Profit (EBIT):	(15.503)	32.716	85.397	141.797	198.197	237.486	237.486	237.486	237.486	237.486
(+) Depreciation + Amortization:	42.938	42.938	42.938	42.938	42.938	42.938	42.938	42.938	42.938	42.938
(=) EBITDA	27.435	75.654	128.335	184.735	241.135	280.423	280.423	280.423	280.423	280.423
(-) Income Tax	0	(11.123)	(29.035)	(48.211)	(67.387)	(80.745)	(80.745)	(80.745)	(80.745)	(80.745)
(+/-) Variations in working capital	0	0	0	0	0	0	0	0	0	0
(=) Operational Cash Flow	27.435	86.777	157.370	232.946	308.522	361.168	361.168	361.168	361.168	361.168
(-) Investments	797.860	0	0	0	0	5.460	0	0	0	55.460
(=) TOTAL Cash Flow	(770.425)	86.777	157.370	232.946	308.522	355.708	361.168	361.168	361.168	305.708
(=) Accumulated Cash flow	(770.425)	(683.648)	(526.278)	(293.332)	15.190	370.899	732.067	1.093.236	1.454.404	1.760.112
(=) Discounted Accumulated Cash Flow	(770.425)	(691.537)	(561.479)	(386.463)	(175.738)	45.129	248.999	434.335	602.823	732.473
TOTAL Cash Flow	(240.758)	27.118	49.178	72.796	96.413	111.159	112.865	112.865	112.865	95.534
(=) Accumulated Cash flow (USD)	(240.758)	(213.640)	(164.462)	(91.666)	4.747	115.906	228.771	341.636	454.501	550.035
(=) Discounted Accumulated Cash Flow (USD)	(240.758)	(216.105)	(175.462)	(120.770)	(54.918)	14.103	77.812	135.730	188.382	228.898
NPV (x USD 1.000)	(437.217)	(216.105)	(175.462)	(120.770)	(54.918)	14.103	77.812	135.730	188.382	228.898

CASH FLOW										
Year	11	12	13	14	15	16	17	18	19	20
Operational Profit (EBIT):	237.486	237.486	237.486	237.486	237.486	237.486	237.486	237.486	237.486	237.486
(+) Depreciation + Amortization:	42.938	42.938	42.938	42.938	42.938	42.938	42.938	42.938	42.938	42.938
(=) EBITDA	280.423	280.423	280.423	280.423	280.423	280.423	280.423	280.423	280.423	280.423
(-) Income Tax	(80.745)	(80.745)	(80.745)	(80.745)	(80.745)	(80.745)	(80.745)	(80.745)	(80.745)	(80.745)
(+/-) Variations in working capital	0	0	0	0	0	0	0	0	0	0
(=) Operational Cash Flow	361.168	361.168	361.168	361.168	361.168	361.168	361.168	361.168	361.168	361.168
(-) Investments	0	0	0	0	0	5.460	0	0	0	0
(=) TOTAL Cash Flow	361.168	361.168	361.168	361.168	361.168	355.708	361.168	361.168	361.168	361.168
(=) Accumulated Cash flow	2.121.281	2.482.449	2.843.618	3.204.786	3.565.954	3.921.663	4.282.831	4.644.000	5.005.168	5.366.337
(=) Discounted Accumulated Cash Flow	871.719	998.307	1.113.386	1.218.004	1.313.111	1.398.264	1.476.865	1.548.320	1.613.280	1.672.334
TOTAL Cash Flow	112.865	112.865	112.865	112.865	112.865	111.159	112.865	112.865	112.865	112.865
(=) Accumulated Cash flow (USD)	662.900	775.765	888.631	1.001.496	1.114.361	1.225.520	1.338.385	1.451.250	1.564.115	1.676.980
(=) Discounted Accumulated Cash Flow (USD)	272.412	311.971	347.933	380.626	410.347	436.958	461.520	483.850	504.150	522.604
NPV (x USD 1.000)	272.412	311.971	347.933	380.626	410.347	436.958	461.520	483.850	504.150	522.604

CASH FLOW										
Year	21	22	23	24	25	26	27	28	29	30
Operational Profit (EBIT):	(27.663)	225.326	225.326	225.326	225.326	225.326	225.326	225.326	225.326	225.326
(+) Depreciation + Amortization:	55.098	55.098	55.098	55.098	55.098	55.098	55.098	55.098	55.098	55.098
(=) EBITDA	27.435	280.423	280.423	280.423	280.423	280.423	280.423	280.423	280.423	280.423
(-) Income Tax	0	(76.611)	(76.611)	(76.611)	(76.611)	(76.611)	(76.611)	(76.611)	(76.611)	(76.611)
(+/-) Variations in working capital	0	0	0	0	0	0	0	0	0	0
(=) Operational Cash Flow	27.435	357.034	357.034	357.034	357.034	357.034	357.034	357.034	357.034	357.034
(-) Investments	785.060	0	0	0	0	5.460	0	0	0	0
(=) TOTAL Cash Flow	(757.625)	357.034	357.034	357.034	357.034	351.574	357.034	357.034	357.034	357.034
(=) Accumulated Cash flow	4.608.712	4.965.746	5.322.780	5.679.814	6.036.848	6.388.422	6.745.456	7.102.490	7.459.524	7.816.558
(=) Discounted Accumulated Cash Flow	1.559.717	1.607.964	1.651.824	1.691.697	1.727.945	1.760.394	1.790.351	1.817.585	1.842.343	1.864.850
TOTAL Cash Flow	(236.758)	111.573	111.573	111.573	111.573	109.867	111.573	111.573	111.573	111.573
(=) Accumulated Cash flow (USD)	1.440.222	1.551.795	1.663.369	1.774.942	1.886.515	1.996.382	2.107.955	2.219.528	2.331.101	2.442.674
(=) Discounted Accumulated Cash Flow (USD)	487.412	502.489	516.195	528.655	539.983	550.123	559.485	567.995	575.732	582.766
NPV (x USD 1.000)	487.412	502.489	516.195	528.655	539.983	550.123	559.485	567.995	575.732	582.766

CASH FLOW					
Year	31	32	33	34	35
Operational Profit (EBIT):	220.326	220.326	220.326	220.326	220.326
(+) Depreciation + Amortization:	60.098	60.098	60.098	60.098	60.098
(=) EBITDA	280.423	280.423	280.423	280.423	280.423
(-) Income Tax	(74.911)	(74.911)	(74.911)	(74.911)	(74.911)
(+/-) Variations in working capital	0	0	0	0	0
(=) Operational Cash Flow	355.334	355.334	355.334	355.334	355.334
(-) Investments	55.460	0	0	0	0
(=) TOTAL Cash Flow	299.874	355.334	355.334	355.334	355.334
(=) Accumulated Cash flow	8.116.432	8.471.766	8.827.100	9.182.434	9.537.768
(=) Discounted Accumulated Cash Flow	1.882.035	1.900.548	1.917.377	1.932.677	1.946.585
TOTAL Cash Flow	93.711	111.042	111.042	111.042	111.042
(=) Accumulated Cash flow (USD)	2.536.385	2.647.427	2.758.469	2.869.511	2.980.552
(=) Discounted Accumulated Cash Flow (USD)	588.136	593.921	599.180	603.961	608.308
NPV (x USD 1.000)	588.136	593.921	599.180	603.961	608.308