

SEATTLE PORT INFRASTRUCTURE AND REQUIRED RENOVATIONS

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Abstract

This paper analyzes what Seattle can do to support the larger TEU vessels overwhelming aging port infrastructure in their container terminals. Larger container vessels are beginning to overwhelm port infrastructure in United States ports that are attempting to renovate to the larger ships. Seattle has terminal infrastructure with inadequate renovations to keep up with newer and larger ships bringing more containers.

The main goal for Seattle's future infrastructure is to improve infrastructure efficiencies through terminal development and automation implementation. The improvements will combat the port infrastructure problem against growing container vessels.

Two questions were asked. What are the challenges in renovating port infrastructure and what are other ports doing? The key challenges to automate Seattle includes security risks, financing investments to renovation projects, and automation concerns. Two case studies were done for Seattle and Long Beach ports and three Asian ports to compare the challenges and see the port success. Results found security in Seattle should be upgraded as more technology is added to port infrastructure. Current investments of Seattle could fully automate a terminal now if funds are allocated. Automated ships and terminals will be future of the maritime industry. The other ports compared have shown devotion to investing in their terminal infrastructure and being the ports of the future with automation implemented at every port.

The maritime industry and the ships show no signs of slowing down for terminals. Evidence found shows the Port of Seattle truly needs to automate infrastructure to meet demand of the maritime industry. Several solutions are available for Seattle's port to improve itself regarding efficiency. Main challenge impacts can be reduced with automation and good investments into terminal infrastructure.

Introduction

The problem

It is fascinating how one simple innovation can lead to immense growth in international business. Containerization changed everything for maritime shipping. Malcolm McLean is the man who revolutionized the industry (Vessel Tracking, 2018). He drove trucks up and down the east coast and was never satisfied with the time it took to unload cargo from truck and reload the cargo back onto ships. He invented a simple box that would hold cargo inside that could go straight from the truck chassis to the ships deck. The design would be known as the container. In 1950 he purchased two ships and containerized both for shipping (Vessel Tracking, 2018).

The International Maritime Organization reported that over ninety percent of all global trade is moved by ship (United Nations, 2018). Ninety percent of all non-bulk trade moves by container ships (Vessel Tracking, 2018). Shipping costs were exponentially cheaper after containers replaced break-bulk cargo (Vessel Tracking, 2018). Containers also reduced labor, increased efficiency, and allowed the port to handle more trade which brought in more revenue overall.

Two important factors are vital in the maritime shipping industry: Money and time. New obstacles begin to challenge ports as shippers seek for ways to stay on time and increase profit margins. Shipping lines analyze both factors to determine if the port is cost-effective and fast. A major part of having an efficient port is the maritime infrastructure supporting the port. Other public goods like rail, roads, and bridges factor in heavily as well, but the real issue begins at the ports and waterways.

The industry is beginning to run into problems with shortages and loss of profit partly due to the infrastructure currently in place. Starting in the 1960s, shipping companies began to

compete for who could create and manage the largest container ship (Vessel Tracking, 2018). Developments would improve the ships container capacity while decreasing the cost of operation. Larger ships decrease diesel emissions, bring in more profit per ship, and make ships more efficient per port call (R Wade, class lecture, 2018 August 27). Ships well over 10,000 Twenty-foot Equivalent Units (TEUs) have been making port calls across the west coast ports (Northwest Seaport Alliance, 2018). The early twenty-first century didn't have vessels of 8,000 TEUs; now there are ships over 18,000 TEUs making port across the world (Roy & Koster, 2018). The question lingers can current port infrastructure handle larger ships and growing demand?

To support these massive vessels deep channels and terminals must be ready with strong cranes tall and long enough to reach across the bigger ships (Port of Long Beach, 2012a). The Port of Seattle and the Port of Tacoma in the Puget Sound are falling behind in meeting the bigger ships demand. Compared to their competitors and ports in Asia, the infrastructure is becoming outdated requiring renovations and expansions to keep up with the increasing demand.

Thesis and Research Questions

I am working on the topic of the aging infrastructure in the Port of Seattle and the Port of Tacoma because I want to find out the best solution to renovate the infrastructure as policy experts need to understand the challenges behind renovating port and waterway infrastructure. If the infrastructure cannot support the larger vessels that keep coming, the ports will suffer from the changes in the industry. I'm interested in this topic because everyone needs to know what are the key challenges surrounding improving port infrastructure? Also, people need to know what works well in other ports and potentially what doesn't? Infrastructure is an interesting case

because finding the key issues surrounding improving port and waterways infrastructure will be vital to solving the infrastructure problem.

Doing a case study between the Port of Seattle and Tacoma with the Port of Long Beach will be important to find the problems with each port and the strengths that each port can consider. Analyzing both U.S. ports with a case study between three Asian ports will be essential to address U.S. port goals. The three Asian ports chosen are: The Port of Shanghai, the Port of Qingdao, and the Port of Singapore. Each Asian port is amongst the top eight ports, while Shanghai and Singapore are the top two ports ranked, globally based from TEU volume in 2016 (World Shipping Council, 2018). There are also three important challenges to focus on. Addressing automation, the security impact, and the finances will encompass some of the key issues presented to the aging infrastructure. All three areas must be addressed because each area are common barricades to infrastructure developments. If the technology is not protected, the innovations cost too much, and automation cannot be implemented to enhance efficiency, the Port of Seattle will have a difficult time having any viable infrastructure to be successful and grow the port in the future.

Investments to port infrastructure should be reducing emissions, making the port secure, and increasing efficiency. If done correctly, security will be enhanced, automation will be added to the port's infrastructure, and the finances will be simple with enough funds approved for projects to renovate. The port will prosper in the maritime industry. There is necessary background information to understand prior to approaching the infrastructure problem in Seattle.

Background

Defining key terms

Understanding terms used in the maritime industry will help others learn what are the options and how should aging infrastructure be addressed. TEU capacity, berthing capacity, and crane or ship sizes are common problems domestic terminals tend to have (Lawrence Livermore National Library, 2016). The capacities behind these terms are the issues that need to be addressed before renovations take place. As stated earlier, a TEU is the standard size of a container that shippers use. Ships are often described by how many TEUs the vessel can carry. The maritime industry uses containers to efficiently load and unload cargo from transportation systems. Containers will be the focal point for cargo discussed while container ships will be the main ship discussed.

A berth is at a wharf or dock, and it is the specific location a ship will be placed to be tied down and secured for port operations (“Berth”, 2018). Terminals have wharves and docks alongside their waterways. There are also crucial types of ships and cranes.

Different sizes of ships and cranes used have different names that can become confusing. Some sizes refer to different international canals. For example: container ships have the Panamax vessel that can carry up to 3,500 TEUs. These ships were able to go through the canal before expansion (Vessel Tracking, 2018). New Panamax ships launched in 2014 can travel through the new canal locks carrying 12,500 TEUs. Ultra Large Container Vessels (ULCV) have TEUs over 14,000 and need more than fifty feet clearance in the waterways (Vessel Tracking, 2018). ULCVs are too large for the new canal locks. Triple E ships are within the ULCV classification and carry 18,000 TEUs per ship. The E’s stand for economy, energy, and environment as this ship stands for all three E’s. Larger vessels mean decreased operating costs, fuel emissions per container, and increased efficiency per vessel (Vessel Tracking, 2018). Knowing the needed

terms helps cement an understanding of the infrastructure problems. Now it is time to look at some specific ports and what their current situation is with port infrastructure.

Required background about Seattle and Tacoma ports

The Port of Seattle will be analyzed closely to understand what both ports can do to improve their operations. Established in 1911, the Port of Seattle oversees the Seattle-Tacoma airport, maritime operations in the actual port, and services provided to both entities (Port of Seattle, 2017b). Seattle and Tacoma ports decided to merge cargo operations for both ports under the Northwest Seaport Alliance (NWSA) in 2015 (Port of Seattle, 2017a). The unification was completed to develop the Puget Sound's connections and engage more containers and jobs to the Puget Sound (Port of Seattle, 2017a). Therefore, the NWSA must increase ship activity in both ports and accommodate the larger ships.

Container forecasts for NWSA ports will increase total TEU volume at a substantial rate of one to three percent over the next five years (Soike, 2017). Despite competition and other factors limiting Seattle's container volumes per year, the container volumes in Seattle and Tacoma will still increase. 2016 port rankings put the NWSA ports combined at fourth largest maritime gateway in the nation with 3.61 million TEUs handled that year (Wolf, 2017).

The port is on the U.S. West Coast where major international and domestic trading partners from across the Pacific Ocean ship goods. Seattle-Tacoma waterways are naturally deep; about fifty feet at the shallowest in port (Soike, 2017). This gives Seattle and Tacoma a large advantage in global trade without worrying about immediate dredging. The Port of Seattle has 1,080 acres devoted just for containers (Wolf, 2017). However, the used acres have declined to 850 acres to develop about 300 acres of older container facilities (Wolf, 2017). Where does Seattle then fit into domestic port developments?

Figure 1 below shows ports across North America fighting for the U.S. heartland. The population is very dense there and large ships cannot reach the inland trade battleground efficiently. This leads ports across the continent to compete for business against one another as seen in Figure 1. Both major canal gateways to each coast in North America can support larger TEU vessels now (Vessel Tracking, 2018). Seattle and Tacoma are somewhat prepared for the larger vessels. They are currently expanding and developing terminals to keep up with demand (Seaport Alliance, 2015). Now that it is known the major Puget Sound ports have definite competition and are making developments, what are those developments exactly?

Figure 1. New & Intensified Competition. Port developments across North America. (Seaport Alliance, 2015)



Recent Renovations at Puget Sound ports

Figure 2. Current Container Cargo Facilities. All container terminals at NWSA Ports. (Seaport Alliance, 2015).

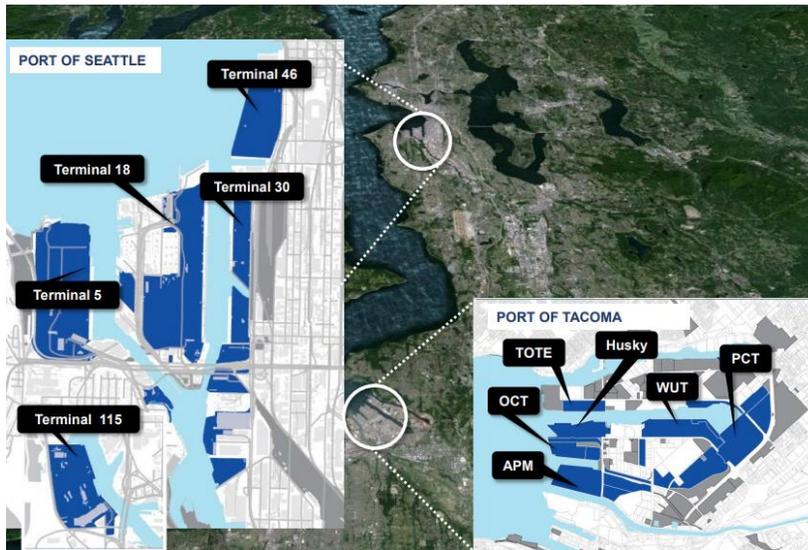


Figure 2 shows all container facilities at the Port of Seattle and the Port of Tacoma. Seattle has four major container terminals: Terminal 5, Terminal 18, Terminal 30, and Terminal 46 (Seaport Alliance, 2015). Recent maritime investments from Seattle plans include modernization of Terminal 5, purchasing eight container cranes for Husky Terminal, stormwater improvements for Terminal 18, Terminal 46 renovations for the dock, electric infrastructure, berth extension, crane rail, and standard maintenance for all terminals (Soike, 2017). Terminal 5 modernization in Seattle and Pier 4 investments in Tacoma will be discussed further. Terminal 5 is over 325 acres with six post-Panamax cranes and three berths (Seaport Alliance, 2015; World Port Source, 2012). The decrease in acres to develop infrastructure are from the Terminal 5 modernization project. The largest Seattle terminal will handle 1.2 million TEUs every year just in the container yard (Seaport Alliance, 2015). The terminal will meet ULCV standards to bring in larger vessels on a regular basis.

Renovations to Pier 4 at Husky Terminal in Tacoma are also ongoing. Larger cranes were ordered to accommodate bigger ships. Four cranes were at the terminal originally in 2005. In 2017, the number of cranes had doubled in just twelve years with four more cranes in 2018. Developments would cost about \$140 million (Northwest Seaport Alliance, 2018). The investments are there to keep increasing TEU volume and meet demand of larger ULCV vessels. For the future does Seattle have room for more terminals in the port?

Seattle Container Acreage

The case could be made Seattle doesn't have much space for port growth. The geography of Seattle itself makes Elliot Bay seem larger than it truly is. South Seattle and further south to Tacoma are the only container terminals between NWSA ports as seen in Figure 1 (Seaport Alliance, 2015). Seattle in the future might need more terminals if the port wants to continue to handle more containers each year.

One solution is to create a larger NWSA alliance with other ports within the Puget Sound. Together these ports will grow as one and operate smoother within the entire region. Containers could be distributed effectively to ports across the Puget Sound which will improve Puget Sound efficiencies and overall attract shipping liners and businesses to move their cargo in the Puget Sound more. Ports involved in the alliance will be pushed to improve when another port makes developments. Seattle and Tacoma would overall accommodate the largest vessels pushing 20,000 TEUs while the smaller ports handle smaller TEU ships. To accomplish this, some ports need to develop their infrastructure alongside Seattle.

There are numerous underdeveloped areas in the Puget Sound that could be made into active ports. Cargo is moved inefficiently from Seattle or Tacoma to other ports nearby who cannot handle the large TEU ships. Some of the smaller ports in the Puget Sound don't even

handle containers enough, they handle more bulk and breakbulk cargo depending on demand in the local area (“Port of Everett begins”, 2017). Even though the cargo is not containerized goods, the smaller ports could likely take some pressure off the Port of Seattle. Ships being distributed evenly across the Puget Sound makes way for smaller ports focusing on different types of cargo. Seattle then can focus on their container terminals. These ports should collaborate to ensure cargo is being moved as efficiently as possible. Costs and time of shipping will most likely decrease if smaller ports can handle some larger vessels instead of barging cargo to the port from Seattle or Tacoma.

The Port of Everett is a smaller port thirty minutes north from Seattle. Their port ranks second in the state for exports supporting \$30 billion worth of exports every year (“Port of Everett breaks”, 2018). The port is working on modernizing and expanding its terminal to handle larger ships and more weight on their docks (“Port of Everett breaks”, 2018). The Port is putting about \$60 million at least to accomplish their plan (“Port of Everett breaks”, 2018). Everett is just one good example of how Seattle can improve its port. There are also ports in Port Angeles inside the Strait of Juan de Fuca, Bellingham, Olympia, Ferndale, Vancouver, and elsewhere. Seattle needs to work together with other ports in the region, not just Tacoma.

Seattle could even offer some business to Everett which would spread out the ships and reduce traffic in Seattle overall. Containers are set up for success in Seattle, so Seattle should continue to develop its container facilities and improve their efficiency. A total Puget Sound alliance might be an option Seattle can accomplish in its current state. Outsourcing could potentially work as well, but both choices should be discussed and considered before deciding. As ports will continue to develop and innovate themselves, security risks will need to be addressed. The first question to ask is how safe are the Puget Sound ports?

Analysis

Security Impacts

Current port security risks

Security in ports and waterways is one of the major challenges to the Puget Sound. Security will be addressed and improved to complement future efficiency in the Puget Sound. It's up to ports operators to ensure terminals are ready if any threats are posed to new technology developments. Ports now function in a world associated with unpredictable risks (Notteboom & Lam, 2014). Global businesses grow changing the maritime industry at an increasing rate (Notteboom & Lam, 2014). Port infrastructure developments bring forward increased security problems in ports and waterways. Smuggling, trafficking, terrorist attacks, cyberspace hacking, and other illicit activity are the illegal acts found in maritime ports (Frantz, 2012). These crimes not only pose a threat to the Puget Sound, but to the nation as well. After terrorist attacks against the U.S. in 2001 shocked the world, fear came that terrorists would use containers to smuggle weapons, such as nuclear bombs, into the United States (Congressional Budget Office, 2016).

Port security in its current state is at high risk to attacks. Ports overall do not seem like a specific target for adversaries, but a fatal blow to any major U.S. port could cost ports millions if not trillions of dollars accompanied by extreme loss of life (Frantz, 2012). The problem starts with containers and what is hidden within them.

Container Security

One of the reasons why ports are so vulnerable is because of container screening. Containers are strong and sealed boxes which contents cannot be easily seen without opening the container. Twelve million containers are imported into United States ports every year. Only five percent of those containers are scanned by Customs and Border Protection (CBP) (Congressional

Budget Office, 2016). There is a large gap in screening which could be harmful to port infrastructure and the region around the ports.

Congress passed a law in 2007 requiring all cargo containers be screened at foreign ports before entering the United States by 2012 (Screening and Scanning of Cargo Containers, 2007; Congressional Budget Office, 2016). The Department of Homeland Security (DHS) is carrying out the plan, yet the deadline was never met. The deadline was extended three times to 2018 and it is unlikely the deadline was met in July of this year (Congressional Budget Office, 2016). It doesn't make sense to have a law if the own governing body cannot follow the law and carry out its total objective. The DHS needs to reconsider their options to screen all containers. The United States remains at risk with standard screening methods.

All containers are scanned for radiation in U.S. ports, but only containers deemed high-risk will be scanned to see the actual contents of the container (Congressional Budget Office, 2016). The reason why ninety-five percent of containers not being screened is due to the cost. The Secretary of the DHS estimated screening all containers at foreign ports will cost the U.S. \$16 billion at 700 ports (Frantz, 2012). Adding extra scanners at foreign ports will start massive negotiations. Foreign ports may also require the U.S. ports to screen cargo exporting to foreign nations costing the United States billions (Congressional Budget Office, 2016). The United States cannot afford to take on billions more in screening imagery that is meant for other states.

The situation pushed the CBP to use a passive system to not interfere with operations and still identify dangerous cargo. Under this system, the CBP has never found a nuclear weapon of mass destruction (WMD). Current scanning technology used is very expensive to operate (Congressional Budget Office, 2016). The DHS will continue to spend about \$1.5 billion by 2026 to continue to scan the five percent of containers at U.S. ports the DHS classifies as high-

risk cargo (Congressional Budget Office, 2016). More imaging requires more funds that the government could pay for through fees on shippers, importers, or moving federal funds to the DHS. However, experts have concluded the CBP and DHS strategies are too complex and expensive (Congressional Budget Office, 2016).

Some foreign ports screen containers while others refuse to (Congressional Budget Office, 2016). Some radioactive scanners used currently cannot detect all radioactive material in containers (Congressional Budget Office, 2016). The system needs to be simplified and more efficient. DHS costs and estimates could be decreased for scanning (Frantz, 2012). The screening process is too complex. The DHS needs to simplify with other methods used currently or even before 2012.

Waiting to scan radiation at U.S ports might be too late if a WMD is transferred to the U.S. by container and detonated (Congressional Budget Office, 2016). The Congressional Budget Office has shown new technology is cheaper overall than current equipment in use and the new will be more effective in scanning all containers (Congressional Budget Office, 2016; Frantz, 2012). Technology to automate ships are ready at minimal costs to implement. However, security of its servers and infrastructure must be up to speed (Lindsay, 2018). That means the Port of Seattle must be ready when automated ships overwhelm the industry just as ULCV vessels are overwhelming domestic port infrastructure. Any weakness in the ports infrastructure and security is a risk to shipping liners and their vessels. With containers being the problem, adding more containers will cause higher rate of risks. Screening and improving security will get more difficult as the industry advances if no developments are made in security.

Cybersecurity risks

Automated ships and automated port infrastructure make way for new security risks in the cyberspace. Connecting important physical infrastructure to information technology in the cybersphere comes with great risks (Department of Homeland Security, 2016). The connection from the cyber world to physical infrastructure has many vulnerabilities. Limiting the risk and impacts in cyber-attacks has its problems from tedious networks within the cyberspace.

Crimes in the past are transitioning to digital attacks. Hackers will use the cyberspace to steal information, money, and tamper with services by delaying or eliminating capabilities (Department of Homeland Security, 2016). Consequences for cyber-attacks vary between destroying or delaying operations which harm the economy (Department of Homeland Security, 2016). Cyber threats connecting infrastructure should become a focal point when referring to port security in 2018. The attacks will become inevitable for shipping liners and the ports unprotected which will disrupt operations.

Cyber-attacks have already happened in the maritime industry. The global shipping company known as A.P. Moller-Maersk was attacked in June 2017 (Wagner & Signe, 2017). A worm closed access to systems Maersk uses to operate terminals (Leovy, 2017). Maersk was forced to shut down multiple systems to contain the hack (Wagner & Signe, 2017). The attack pushed the Port of Los Angeles to close its largest terminal for six days while at least one ship waited to unload its cargo (Leovy, 2017). All other terminals Maersk ships were berthed couldn't move cargo for two days. For two weeks Maersk struggled to move cargo without their technology. Unprotected Microsoft operating systems were targeted which gave the bug an entry into Maersk systems (Leovy, 2017).

Ports, freight forwarders, and terminal management companies were impacted alongside the shipping liner from just one attack. (Leovy, 2017). In the shipping industry, six days of

nothing can equal substantial losses. Timing is so important for ships and ports. Maersk reported the cyber attack will cost the company up to \$300 million (Leovy, 2017). Maersk was hacked again in 2018 with personal data being stolen (Hedelund, 2018).

Vulnerabilities in ships and terminals will impact port infrastructure. The Maersk hackings have proved what the result could be from a hack to a shipping liner. The Port of Los Angeles' largest terminal shut down and the port lost millions from inactivity. Automation and the cyberspace pose weaknesses for all involved within the port (Leovy, 2017). Poor container screening promotes crime and puts the infrastructure at risk (Department of Homeland Security, 2016). Even in 2018, security in the maritime ports is never addressed to the level that it should be (Duzha, Gouvas, & Canepa 2017). It is crucial Seattle enhances security to be ready for anything. There are several challenges regarding infrastructure development and upgrading security. How can the changes be made without spending an extensive amount of time or money? Which vulnerabilities should be focused on if not all vulnerabilities can be achieved?

Enhancing Security

Developing Security alongside Infrastructure necessary?

U.S. ports are physically, financially, and operationally struggling with the increase in ship size. Many domestic ports must dredge, keep buying larger cranes, and redevelop internodal connections at the port (Lawrence Livermore National Library, 2016). Recent port investments totaling \$46 billion still wasn't enough for all U.S. ports as they struggle in being efficient and having the capacity of ports in Europe and Asia (Lawrence Livermore National Library, 2016). Most ports cannot handle the larger ships and take three times as long to offload vessels over 14,000 TEUs compared to some offshore ports being made handling 18,000 TEU ships

(Lawrence Livermore National Library, 2016). The government and the DHS may continue to ignore the container screening problem. Seattle must come forward to bring change.

Increasing security with technological advancements are needed. Ports can only do so much by themselves but to continue increasing business. Seattle should be looking to enhance security through improved systems. Behind infrastructure advancements should be concrete cybersecurity systems in place to prevent attacks against the infrastructure connected to the cyberspace. Seattle needs to keep up with shipping liners and their advancing vessels.

Automating equipment for efficiency and security will only help Seattle be a better port giving the terminals an ability to handle more containers faster while not polluting the environment.

Containerized Scanning

One of the biggest questions remains how to make container screening efficient and thorough without disrupting operations? Automating security systems would be the greatest solution. The DHS just needs to find reliable technology and implement it to port screening (Department of Homeland Security, 2016).

Seattle should consider offshore hubs like some ports in the world are beginning to create (Lawrence Livermore National Library, 2016). If Seattle can get the investment or the federal government takes over investments, Seattle will become a close rival to New York and Long Beach, keeping cargo on the West Coast. Or Seattle should do an equivalent move whether working with other ports in the region.

The Portunus platform, a large deep-water structure that will be a transshipment hub for international and domestic shipping, is the answer for Seattle and other domestic ports (Lawrence Livermore National Library, 2016). The idea enhances port security for infrastructure while upgrading shipping efficiency with automated equipment as well. Any past security threats

of WMDs are removed with offshore ports as dangerous weapons can be eliminated miles away from U.S. ports and coastlines without requiring other ports to screen containers coming to the U.S. The hub will move and screen containers during operations. Imaging and detection equipment will screen for criminal goods or activity (Lawrence Livermore National Library, 2016). The platforms can reach the 2007 law by scanning all containers before officially entering the U.S.

As ships continue to grow, maybe this is the rational solution to help ports catch up to the growing ships with TEU capacity and berthing space. Larger ships would remain doing transport between international ports and the domestic platforms. Smaller ships could go to other ports in the Puget Sound where all the ship's cargo moves a specific direction away from Seattle. Northbound cargo heads towards Canada. Some containers could be sent to ports in the upper Puget Sound region.

The platform will decrease unloading time and keep workers, the general public, and infrastructure safer. Since the law behind the Jones act requires U.S. ships and U.S. registered ships move cargo from two domestic points in U.S. territorial waters, creating these hubs will assist the U.S. maritime industry and make new jobs (Lawrence Livermore National Library, 2016). Implementing the platforms just on the Atlantic coast could reduce emissions by half, freight costs for international shipping by thirty percent, and freight costs for short domestic transport can be reduced up to forty percent (Lawrence Livermore National Library, 2016). Platforms on the Pacific coast could be even better if done correctly.

Overall, platforms are just one way to be able to meet the laws set forward for the DHS and enhancing security through container screening. Port security is better off with strong infrastructure to support security There are several methods security goals within infrastructure

can be achieved. Offshore hubs or contracting other Puget Sound ports could be the greatest solution for Seattle and the Pacific coast at large. A hub could be placed offshore Washington state nearby the strait entry. Screening could also happen at the Strait of Juan de Fuca entry, the entrance into the Puget Sound. The large peninsula west of Seattle provides a natural security barrier from natural disasters and funnel the ships into one point of entry; providing a simpler way to increase security. Container screening will not be the only improvement. Another positive outcome of implementing extra security is decrease of criminal activity within ports.

Anti-Crime

Enhancing security within ports will also eliminate crime across all U.S. ports. Unfortunately, ports across the U.S. have been the point of entry for smuggling narcotics, guns, and people. That means WMDs could also sneak their way in through containers (Lawrence Livermore National Library, 2016). The United States hasn't had too many problems with minimal screening regarding terrorism (Congressional Budget Office, 2016). However, if the U.S. screened every container, crime would decrease immensely. Ports would be catching illicit activity higher than before. Hundreds of crimes can be stopped just by screening more. It is up to the U.S. government and the ports together to find a solution.

The updated port infrastructure will make way for better methods of scanning containers and preventing cybersecurity breaches. As ports move towards automation, Seattle will be forced to invest into its cybersecurity systems. Seattle stated in their Long Range Plan the port should strengthen security through technology (Port of Seattle, 2017a). Seattle wants to develop and grow the port; port leaders need to take necessary action. Terrorism may not be a threat to the United States as it was in 2001, but there are still threats to be very cautious of. Ports are some of

the most vulnerable systems for enemies to target and breach (Congressional Budget Office, 2016).

Cybersecurity needs to be taken more seriously by domestic ports as the cyber world becomes the new location of crime leading to the crime found today. The cyber threat is real and is the gateway to more crime so cyber-crime should be considered the largest risk to ports. Seattle will need to implement advanced infrastructure to protect any technologically advanced systems and the ships which come to Seattle. Upgraded protection against malware will secure port servers and operations. As the hacks against Maersk shocked the industry, there is room to grow in protecting the cyberspace for technology within ports and the future infrastructure (Wagner & Signe, 2017). Security can be implemented effectively with investments from the government or the port itself.

Financial study

Renovation Costs

Types of renovations

Now that security issues have been discussed, the costs behind infrastructure improvements need to be evaluated. The overall need is a terminal efficient enough to handle all the cargo that comes in and out. Adding more terminals for containerization and renovating older terminals are the main two options. Renovations immediately needed include cranes able to handle the larger vessels and automated equipment to strengthen efficiencies. Ship cranes need to be taller, longer, and stronger to be able to accommodate larger ships. Seattle should set a goal to have one automated container terminal powered mostly by clean energy through electricity.

An automated container terminal at the bare minimum will include automated intermodal yard cranes, automated gantry cranes moving containers to and from the ship, and automated

ground vehicles moving cargo between both cranes (Luo, Wu, & Mendes, 2016). Each automated machine compliments the other and help the port run at higher efficiency rates. The automated cranes overall are faster, cheaper to use, safer, and more efficient from standard maritime cranes. Some automated cranes function three times faster than manual cranes (Cavotec Group, 2013). Automated terminals then can handle twice as many containers from standard operations (Port of Long Beach, n.d. c).

The 18,000 and 20,000 TEU ships will soon be the standard size for vessels. Seattle needs to be ready for that ship at every container terminal no matter the circumstances. Automation will handle these vessels with ease while most automated equipment can be powered by clean energy. The switch from diesel to clean energy will reduce pollution and operation costs overall. Due to environmental pressure and maritime demands, the ports should focus on lowering emissions through developments to show automation is worth the cost.

Automated mooring systems are another good system to consider. The berthing process in Seattle usually involves two or three tugs and a handful of longshoremen. The process securing the ship can take thirty minutes if nothing goes wrong. New automated systems can secure ships within thirty seconds (Container, n.d.). This advanced version of securing a ship at port will make vessels up to 19,000 TEUs more secure through port operations improving efficiency and drastically reducing emissions while mooring vessels. (Container, n.d.).

Some good developments are already in place at Seattle. There are shoreside power systems allowing vessels to turn off diesel engines and use electricity at port (Soike, 2017). The system reduces emissions even more in terminal while saving fuel and money for ships. More of these systems should be added as soon as possible. Actual costs should be discussed before adding the systems.

Renovation Costs for Terminal Infrastructure

Developing an automated port can be very expensive. The executive director of the Port of Los Angeles reported adding automation to terminals anywhere can cost over \$2 million per acre (Dillow & Rainwater, 2018). It may cost even more due to other developments necessary before automating. Automating the Port of Long Beach terminal cost \$1.5 billion for 300 acres (Port of Long Beach, n.d. c). Considering Long Beach was prepared to automate, the automation developments could have only cost \$600-\$650 million. However, the project to develop the terminal connected three piers into one terminal (Port of Long Beach, n.d. c). Seattle seems to be developing other infrastructure now to potentially automate in the future. Seattle is set up to automate with the modernization of Terminal 5 and other improvements to their container terminals.

Combining a modernization and automation project for Terminal 5 would cost around \$900-\$950 million. One-third of that investment has already been financed for modernization (Northwest Seaport Alliance, 2017). NWSA investments are half of what is necessary to fully automate Terminal 5 if designed. The other container terminals are much smaller, and some are already modernized or currently developing infrastructure weaknesses (Soike, 2017).

Automating the smaller terminals are feasible right now based off Seattle's current investments.

The automation projects should start as soon as possible. What other factors could impact automation changes to the port?

Development Components

Approval for Construction

Getting the approval to pass a large project could come with challenges. For the Seattle port, an executive director and five commissioners would pass container terminal developments.

They are the group that are the port governing body which create and implement port policy (Port of Seattle, 2017a). Federal funding will likely be reviewed by Congress before approval as well. Several stakeholders could influence development projects being passed if they financially support plans. Another major factor involved in approval is the time it will take to automate.

Estimated time to complete

Based from other automated terminals in California and Asia, renovating any terminal in Seattle could take anywhere from two to twelve years factoring in the size of each terminal. Long Beach was able to make a terminal fully automate systems in less than a decade (World Port Source, 2011). Construction for the Long Beach Middle Harbor terminal finishes in 2021, but automated operations began by 2016 (Guzman, 2017). The automated terminal in Long Beach is about the same size to the largest container terminal in Seattle. While Seattle's ports are partially developed and prepared for automation, the time to automate would take less time than Long Beach's project. Now understanding the timeframe and who will approve the projects where will the project be expensed within the port?

Where Investments Are Located

Determining where a large automated development project to the port will help the port move forward with the improvements. There is a Capital Improvement Plan (CIP) in place for both major Puget Sound ports. The CIP is a five-year plan which contains any maintenance and improvements within the port (Soike, 2017). Automation renovations should be enlisted within the NWSA CIP. Currently, most NWSA investments go towards improving container terminal infrastructure. Container terminal investments total \$508.3 million from 2018-2022 while most investments went to Seattle with a substantial amount still going to Tacoma's terminal developments (Soike, 2017). The airport between Seattle and Tacoma make up a large majority

of investments, two of the three billion dollars available, which limits what the actual port can develop. The major problem is some people don't want to invest into the infrastructure at all. The investments will be placed within the CIP. Where will the CIP get investments from to help the Port of Seattle further invest in their infrastructure?

Financial Sources for Capital Improvements

Discovering the source of investments for infrastructure development projects should help support the opportunity to invest more in infrastructure. Seattle currently has numerous sources to get investments for developing infrastructure. Revenue from the port for investments can come from property tax levies, bonds, grants, operations and service fees (All About Ports, 2018; Soike, 2017). The port alongside the NWSA will be paying for a majority of the innovations. There are financial returns for capital investments into all marine infrastructure and terminals for both Seattle and Tacoma (Wolf, 2017; Port of Seattle, 2017a). There are also outside sources and key stakeholders who can help Seattle raise money to develop infrastructure through other investments. Considering how expensive automation will cost and the current state of the port with operations and investments, Seattle may need to seek some assistance from the public and private sector to pay for innovations.

Federal Sources of Investments

Both Puget Sound ports bring \$380 million in state and local taxes annually (Northwest Seaport Alliance, 2014). Unfortunately, not much of those taxes get returned to support maritime infrastructure. The money goes to assist larger state funding's like education and law enforcement. The federal taxes are the same way with federal budget plans pouring into other necessities such as the military and healthcare for example. The return in investment in the maritime industry by the government is too small for the growth of the maritime industry,

therefore domestic ports have been struggling (Maritime transportation, 2017). The state and federal budgets should be adjusted to allow for future infrastructure developments in the domestic ports.

The property tax levy for Seattle could also be adjusted. 2018 tax levy funds go towards projects to maintain and advance the port while Seattle's port takes advantage of about eighty of the maximum \$100 million levy (Soike, 2017). It is possible to use more of the levy or simply transfer funds from other projects to fuel projects necessary for automated terminals through capital developments.

There should be no reason to raise taxes to the general public to support maritime infrastructure improvements at the state or federal level. Besides raising the port property tax levy to businesses, there are ways to get long-term investments without making taxes higher than necessary. The spending is a much larger issue at hand that governments should study and reassess. The importance of strong infrastructure is vital for nations and global trade. Money needs to be allocated effectively and spent on projects that have best chance for success and return of profit. Moving funds and investing more in port infrastructure in Seattle by the state and federal government will have long-term benefits and that will grow port productivity, therefore generating more taxes each year for the state and federal government.

Specific acts and grants passed by Congress invest in all maritime infrastructure within the United States (Maritime transportation, 2017). Two grants invested \$850 million in 2016 (Maritime transportation, 2017). The problems are investments are inconsistent, the investments are not distributed equally to ports, and the investments are not enough. Some ports invest over a billion dollars on their terminals currently. The Maritime Administration also can give grants to port infrastructure, but they didn't get any funding for grants towards domestic port projects this

year (Committee on Transportation and Infrastructure, 2018). With container volumes nearly doubling by the beginning of 2030, it's time to act and help develop maritime infrastructure in Seattle (Committee on Transportation and Infrastructure, 2018).

Private and Internal Investment Sources

Regarding the private sector, shipping lines and terminal operators that do business in Seattle are good applicants for grants directly to the Port of Seattle to improve the terminal infrastructure. These businesses are the first that benefit from the port and they may know what infrastructure is needed for each terminal. For the continuation and growth of their business, they could invest through grants. Specific groups such as environmental organizations would likely support clean energy plans so they would likely support any environmentally friendly grants. Projects such as a fully automated electrified terminal, plug-in stations for ships, and even berthing systems that reduce emissions could also be funded by regional or local businesses and organizations. Some of the funding that is missing between the NWSA for these programs could easily be filled by local or regional businesses or any businesses listed above.

Getting creative with other standardized arrangements and policy could help fund the improvements. The automated terminal in Southern California leased out its property for twice the standard lease period in the region: four decades (Mongelluzzo, 2017). Leasing out property in the Port of Seattle generated 41 percent of the port's overall revenue valued at about \$370 million (Soike, 2017). If Seattle automates a terminal and wants a large profit back guaranteed, leasing automated terminal property longer than usual will guarantee revenue will be made. Terminal operators may compete to operate an automated facility more and leasing value could rise since automated terminals are more profitable for everyone besides the labor.

The Port of Seattle budget for 2018, could also shift its budget around more NWSA capital improvements as demand will require more funding from the port. The total budget, valued at \$1.7 billion, has over \$3 million spent on developing customer service at the airport and \$12 million for environment investments (Soike, 2017). The investments might seem small compared to the total budget, but investments add up. After expenses, salaries, paying debts, and any other fees the budget should be managed very carefully for future investments. Money could be shifted towards the port more for a short period to automate the terminal infrastructure. Some current investments aren't as important as the port infrastructure. What could the process of automating terminal infrastructure do for the region?

Benefits of Investing

Construction Creates Jobs

Automating terminals in Seattle bring forward opportunities. Developments to port infrastructure requires contracting to outside businesses. A project to renovate an entire terminal will require a lot of manual labor. Ongoing construction to Long Beach's automated terminal created 1,000 jobs each year for ten years until 2020 (Port of Long Beach, n.d. b). After construction it is estimated that 14,000 more long-lasting jobs will be created in the region that supported more trade (Port of Long Beach, n.d. b). Automating terminals alone brings in thousands of jobs to make the terminal and tens of thousands of more jobs for supporting trade. More jobs from more trade in the region could prove to be more important than having standard terminals without any automation. The economy will only grow with capabilities to trade more and trade quicker. The investment to develop infrastructure will benefit the region and its trade.

Upgraded facility attracts shipping companies

Shipping liners, despite NWSA issues, enjoy doing business in the Puget Sound for various reasons. Due to its facilities, room for growth, deeper waters, great intermodal connections, and close location to markets Seattle has been an option for shipping liners for decades (Soike, 2017). Seattle is already a great option for shipping liners. When automated developments happen for the terminal, the terminal influences other intermodal transportation systems to develop and keep up with terminal production. Connecting infrastructure such as roads, rail, and shipping lanes will be improved to then meet terminal demands. Terminals would be, and currently are, improving for ship demand.

Shipping liners have also looked for the best port who can move their cargo cheaper and faster consistently. This is where regional ports come into play. Other ports in Canada are growing regional competition with Seattle and 10,000 jobs are at risk due to cargo moving to Canada instead of Seattle (Washington State Department of Transportation, 2017). Seattle should not settle to lose business to Canada. By renovating aging infrastructure with technology, shipping costs can decrease for Seattle and by supporting more cargo than other regional ports. The outcome will be Seattle being a more competitive port and not losing business to Canada. To be successful in global businesses is to have a profit from what you sell. So, if costs can be reduced as much as possible without losing quality, businesses increase their profit margin. Shipping liners have already attempted increasing profit. Automation will advance profit margins further and bring new technology that will become the future of the industry.

Automation

Automation is the Future of Success in the Industry

From determining the costs behind renovating infrastructure through automation, what will automation really bring to the Port of Seattle? To the finest level, automation is going to

increase efficiency and reduce costs for Seattle. Automating infrastructure will also remove people from cargo operations which improves safety, productivity, security, capacity, reliability, velocity, and decreases environmental impacts (Ward & Martin, 2008). Most infrastructure will replace diesel-powered units with electric powered automated cranes and vehicles which have no emissions (Mongelluzzo, 2017). An automated container terminal contains a storage area, berthing section, and further connections which automated equipment moves cargo from point to point (Ward & Martin, 2008). Using automated infrastructure in terminals will likely continue because internal transportation and terminals without automation have been both inefficient and expensive (Luo, Wu, & Mendes, 2016).

The magnitude of unloading a ship is getting too complex, too long, and too large for people to manually complete all the moves these ULCV vessels need (Tran, 2016). Seattle has efficiencies reaching 43 percent; their goal is to be closer to 70 percent (Seaport Alliance, 2015). To keep up with larger ships and more containers with the same amount of storage space Seattle needs to automate terminals. 43 percent is not efficient enough to keep up with today's ships without drastic consequences, delays, or additional expenses. Something will be sacrificed if Seattle tries to raise efficiency in the current state of the port. Container storage areas feel like they are shrinking every year due to the increase in containers (Luo, Wu, & Mendes, 2016). Something must be done to get ahead of shipping liners.

Staying competitive with regional ports comes down to which port is the most efficient? Who can move cargo the fastest at a sustainable rate? With Seattle being a gateway port for the remainder of the United States, the infrastructure in place must be efficient and dependable to be successful (Tongzon & Oum, 2018). Currently Seattle is falling behind. Part of the problem

behind automating is the longshoremen's union. In the past, the union has proven to be problematic for non-automated port operations across the West Coast.

The ILWU

Past issues

Relations between the port and the union haven't been optimal. The International Longshore and Warehouse Union (ILWU) is the labor that moves cargo for ports across the West Coast. Through the Pacific Maritime Association (PMA) they are contracted to work for the ports. The ILWU seemed to be the solution from past issues ports labor, but the longshoremen's union just brought extra problems.

The ILWU has proven to be troublesome in the past for the United States as a whole, not just Seattle. A more overlooked aspect is that unions are given certain workers' rights and compensation. Machines are not. Seattle terminals have over an hour break for longshoremen every day in the middle of the day (Port of Seattle Port Commerce, n.d.). From 11:45am-1pm operations freeze as all longshoremen take their lunch at the same time. Cargo cannot move at all. Add up each lunch break for the entire year and that is thirteen full days of productivity lost annually. Scheduling lunch breaks could fix this, but machines can also replace what the labor does. Automated terminals are far more efficient as they work nonstop twenty-four hours a day and seven days a week (Mongelluzzo, 2017). Longshoremen could never work that long. Yet the maritime industry doesn't stop. Growth is continuing, and Seattle needs new efficient infrastructure that can work more to accommodate for the growth.

Many ports perceive current labor to be unreliable, unpredictable, and inefficient (Lindsey, 2011). This may not be due to work ethic, but due to what the ILWU has done in the past regarding strikes and work slowdowns. The union has the power to strike which has

immense setbacks to Seattle, the local area, the state, the nation, and the economy at large. In 1971, the ILWU strike for over four months due to contract disputes with the PMA for more workers rights (Lindsey, 2011). Seattle and other ILWU ports on the West Coast were shut down while the strike caused Seattle to lose \$16 million in the first month alone with thousands of jobs at risk (Lindsey, 2011). When the workers that move international cargo from ship to shore refuse to work, the entire economy suffers. The nation and the ports cannot handle large work stoppages today. Another labor dispute in 2002 costs the economy \$1 billion each day the strike was active with six months dedicated to west coast ports attempting to catch up after the strike (Claire, 2015). Consequences for the labor not working at ports are too severe. The ILWU has a right to protest for certain worker rights, but the ILWU has pushed too far. The strikes didn't end in 2002, they continued.

The PMA reported from 2008-2014, dockworkers engaged in over 200 slowdowns or work stoppages (Mongelluzzo, 2015). One case in 2011 showed the ILWU in Southern Washington lash out at security guards, police officers, block a train, invade a terminal and damage operations immensely, and cause ILWU workers in Seattle and Tacoma to stop working (Horowitz, 2011). The unions decision impacts millions of others within the U.S. economy and it has gotten to a point where the president had to intervene to force the union back to work to keep trade moving. The labor has taken advantage of striking far too many times. The costs of striking impacts too many stakeholders who do not participate in strikes. Implementing automation in Seattle which automation will work more efficient than ILWU workers will create a more dependable infrastructure system.

These strikes have negatively impacted the longshoremen and their union through the years. Some jobs longshoremen do are very simple and repetitive. Machines could be

programmed to do the same job faster. Some jobs require little to no skill or experience, but the unions still fight to stop automation.

Union intervention with automated terminals

People still oppose automating terminals especially the labor working at the terminals. The ILWU has disagreed with the concept of automating terminals. Since the technology will be programmed to work on their own without human intervention, hundreds of labor jobs at the port will be lost eventually (Uranga, 2017). That is a sound and sensible argument. Nobody wants to take away jobs from people. Regarding industrialization, didn't containerization do the same to breakbulk shipping what automation is attempting to do for longshoremen jobs? The overall result is an efficiency upgrade while some manual jobs are lost. There is a reason for changes to the industry. The entire industry or sectors within the industry want to grow and improve efficiency. Automation is the next step to increase efficiency while also considering other important factors the world cares about today.

The public and governments have been pushing for reduced emissions worldwide. Do the ports want to trade off more emissions and reduced efficiency over a labor force that is rebellious and unreliable? Everything results to can the port keep up with the rest of the world in terms of shipping? Currently, Seattle cannot move cargo fast enough. Automation isn't just an option. Automation is a necessity to stay in business and remain competitive in the Pacific trade. It is in the Port of Seattle's best interest to invest into automation and to view automation as a successful and viable choice for the port.

Ports are organized to be a transportation system between land and sea. Efficiency Leaders at the Port of Los Angeles are concerned the port would fall behind and become less competitive if no automation was implemented (Uranga, 2017). The fear is from growing

volumes in trade and efficiency. If ports don't improve efficiency, there will be no room for containers and the port will suffer to keep up with demand. Shipping liners will then take their business elsewhere. Automation changes can't be avoided. If the port never automates, falls behind, and loses its importance in the industry all economic activity around the port will be lost completely (Uranga, 2017). If the port loses its value in the market, more than a few longshoremen jobs will be affected. The entire region will suffer the consequences. Automation must occur for Seattle. At current predictions, TEU volumes will increase and less yard space will be available than usual. Developments need to happen for Seattle to meet shipping liners needs, including larger ship sizes. The ILWU has no power to stop automation as well.

Past contracts between the ILWU and the PMA paved a way for terminal operators to implement technology and automation moving cargo with no restrictions due to past work stoppages of the union (Mongelluzzo, 2015). Negotiations for ILWU contracts can cause work stoppages or delays. The effect of the delays makes the labor obsolete at times. Trade cannot grow and succeed if a workforce won't show up to operate the port. Automation must take over and replace some longshoremen.

The Shift from Manual to Automated Labor

Not all jobs will be lost to automation. Instead, the port and the union need to work together from shifting jobs from labor into specialized roles. The longshoremen could be put into smarter jobs such as managing the technology that moves the cargo. Humans will monitor or operate equipment at specific periods to ensure operations run efficient and smooth. Employment will be created to manage the automated terminal equipment in a safer and more efficient method than done in the past.

Estimation timeframes for completion of construction will take about a decade to fully automate the top Southern Californian port, so jobs will still be around for years until there is enough capital to invest for automation (World Port Source, 2011). The automation might take even longer for Seattle to implement and get funds to invest. Even today, people work at the automated port in Los Angeles to monitor the automated infrastructure, program the equipment, and provide maintenance and repairs (Uranga, 2017). These jobs of higher importance should be what the ILWU and longshoremen should focus on training for as these jobs are the future for automated terminals. While some will still lose jobs, that money can be spent to develop the Port of Seattle further. Where will automation be in the maritime industry if Seattle changes or doesn't change its terminals?

Automation in Ports and International Business

The Future of shipping

No matter what Seattle does, the future of the industry will be automated ships sailing across the world for people. These ships will use clean energy and operate on their own or remotely (Lindsay, 2018). The first of its kind is beginning operations by 2020. Human error will be eliminated, and shipping will be safer and more efficient. The new ships are wider, longer, and have increased draft lengths as the ships need to operate in deeper waters. Longer cranes are needed, dredging needs to be done if waters are too shallow, and port efficiency needs to increase. That is just the minimum for port requirements; efficiency can be greatly improved through automation.

Seattle-Tacoma and Long Beach Case Study

Automation really opens various options for future efficiency and growth. How could Seattle and Tacoma become more like Long Beach? To find out more about the Puget Sound

ports and what the ports can do to improve themselves, a case study between NWSA ports and the Port of Long Beach will be done. Both ports will be compared based from security, costs of developing, and automating infrastructure. Seattle was discussed before, but Long Beach wasn't fully discussed. What is the Port of Long Beach doing?

Port of Long Beach Description

The Port of Long Beach is ranked as the 22nd busiest port in the world based from TEU volume (World Shipping Council, 2018). Created in 1911, the port became the first ranked gateway for trade between Asia and the United States. Even though Los Angeles terminals operate on their own alongside the Port of Long Beach, both ports together are the largest port in the United States handling over forty percent of all U.S. containers (Baumann, 2016). Long Beach is one of the few U.S. ports that can accommodate the larger vessels entering the industry (World Shipping Council, 2018). The port has six terminals supporting container ships (Port of Long Beach, n.d. a). The port is continuing to make one of the most innovated, efficient, and environmentally friendly harbors in the nation (Port of Long Beach, 2012b).

There are also current renovations within the port including the Middle Harbor project (Guzman, 2017). Long Beach's automated facility upon completion will have a capacity of 2.4 million TEUs, 40 percent, of what Long Beach terminals handle currently (Mongelluzzo, 2017). What makes these ports similar or different? How does the aging infrastructure limit each port? What are the ports doing to change the infrastructure?

Port Similarities and Differences

Both ports will be analyzed to see how the ports are the same or vary from each other. The Port of Seattle Commission has set forward goals to make Seattle the top global logistics hub, the most environmentally friendly, the most energy-efficient port in the continent (Port of

Seattle, 2017a). To accomplish these goals, Seattle wants to grow TEU capacity and make smart investments in port infrastructure (World Port Source, 2012). The port needs to be at least equal or close to what Long Beach is doing right now. The Port of Seattle is slowly making steps towards improvements through investing.

Investments between Seattle and Long Beach

Long Beach being ranked so high makes way for having some major investments and investors in the port's future. Long Beach is finishing up a decade-long capital investment program that is valued over \$4.5 billion (Baumann, 2016). The Middle Harbor Redevelopment program made up some of that capital investment. The port invested \$500 million just in 2017 for further development of the Port of Long Beach. Many renovation projects make up that infrastructure investment from automated terminals to deepening the port waterways (Guzman, 2017). Even CMA CGM, a major shipping line, invested into Pier J at Long Beach. The Pier will support an additional 2.6 million TEUs and an additional \$14 million in port every year (Port of Long Beach, 2012c).

The NWSA's strategic plan has set up goals that both ports invest in their port infrastructure at smaller levels compared to other major west coast ports (Seaport Alliance, 2015; Port of Long Beach, 2012a). The big question now is the NWSA investment plan enough for the Puget Sound ports? The investment seems straightforward and leads to steady growth, but the growth is too slow for the industry. NWSA ports are crawling to the future while the Port of Long Beach takes huge strides towards the future of the shipping industry.

The NWSA is also in place to develop current infrastructure and bring in more revenue (Port of Seattle, 2017a). Both ports are satisfied with the conclusion that creating the NWSA completed this objective (Port of Seattle, 2017a). The NWSA might have completed the

objective, but they did not catch up to what the Port of Long Beach is currently doing.

Infrastructure developments in Seattle are still slow, only improving one container terminal in Seattle currently. Most of their facilities are not equipped enough and large enough to welcome larger vessels (Seaport Alliance, 2015). Seattle is falling behind in an important race against U.S. ports. Current infrastructure will never be able to efficiently accommodate vessels over 20,000 TEUs. Perhaps automation in Long Beach should be analyzed as well.

Automation in Long Beach and Seattle's situation

Even though both ports are massive in size, the Port of Long Beach is larger and more developed than Seattle in terms of economic feasibility and automation. Long Beach seeks to upgrade container efficiency through advanced technology and infrastructure that can last (Guzman, 2017). Long Beach is advanced with innovation usage. All Long Beach should want to do in the future is automate more terminals. Seattle on the other hand has yet to implement automation. There are limits from not automating container terminals.

Statistics between Long Beach and Seattle are reasonably similar, yet production is very different between both ports. For example: both ports have about the same number of employees working at both ports (Seaport Alliance, 2015; Port of Long Beach, n.d. b). Then in 2011 Long Beach only had about 1100 acres dedicated to containers but handled over 6 million TEUs (World Port Source, 2011). Seattle currently has 800-1100 acres dedicated to containers but only handled over 3.6 million TEUs in 2017 (Wolf, 2017). Why is the margin so wide here? Why is the efficiency for Seattle so low compared to Long Beach? Seattle doesn't make use of their yard space as Long Beach does; the port is inefficient (Seaport Alliance, 2015). Seattle needs to start making some progress and begin their objective to improve infrastructure to make it safer for people. The method the port looks to use isn't the best technique to maximize efficiency. Part of

modernizing the port creating a more environmentally cleaner terminals involves implementing clean energy and working more or working harder. This is where automation comes into play. Automation is far too effective for Seattle to ignore. Automated terminals handle an immense amount of TEUs and make a safer port environment for people and machines (Mongelluzzo, 2017). If Seattle implemented automation, the port would receive an immense boost overall.

Another strategy in Seattle wanted to remove any workplace injuries (Port of Seattle, 2017a). The further people are from the machinery on the terminal, the less chance for injuries to happen. Automated ports just make sense for combating workplace injuries. Injuries will be removed completely in the yard around equipment. However, automation could be the cause to some security risks in Long Beach.

Security at the Ports

Automation could be vulnerable to breaches in the cyberspace. Yet due to the nature of the port, Long Beach has large challenges regarding security. The port is open and busy twenty-four hours a day; docking is given to nearly every type of ship with over 15,000 trucks and 100 trains moving around the port each day (Baumann, 2016). Long Beach needed several security layers, as most ports implement, to protect the port with radar, sonar, sensors, helicopters, and monitors with cameras (Baumann, 2016). Port security in Long Beach or Los Angeles' terminals are just as vulnerable as Tacoma and Seattle's terminals, if not more vulnerable since more containers move through the California ports (World Shipping Council, 2018). Any port in the United States is a vulnerability to the surrounding area and the rest of the country if security was breached (Hicks, 2017). Long Beach's port uses specific software, with all stakeholders in security or operations having access, to help connect all security systems (Baumann, 2016).

Security over Seattle's port is limited in terms of sources. There are systems in place at Seattle and some are likely effective as other domestic ports have the same systems. In Seattle's case, there isn't major security improvements for the port. The new executive director for the Port of Seattle discussed being ready for disasters; he looks to the maritime businesses and the properties along the waterfront to be a major player in preparing for the worst (Helm, 2018). Disasters can be anything from natural to terrorist strikes. The properties focused around the maritime will play a part in ensuring being prepared, but the industries cannot do that alone. The industries need a leader or an organization that will centralize preparations for the Puget Sound or give the industries and properties a baseline to start improving security and preparedness. Just like Long Beach's security systems improved incident response times and reduced the time ports are inactive from accidents, Seattle's security organization will do the same if all stakeholders are involved to complete the terms right (Baumann, 2018).

Below is Table 1 to summarize some key comparisons between both ports.

Table 1

	Seattle	Long Beach	Sources
Major investments	Terminal 5 modernization. Valued at \$600 million	10-year Capital Investment Program. Worth \$4.5 billion	(Northwest Seaport Alliance, 2017) (Baumann, 2016)
Types of Container Terminals	Four standard terminals	Five standard terminals with one automated terminal under operation and final construction	(Seaport Alliance, 2015) (Port of Long Beach, n.d. a; Guzman, 2017)
Security	Vulnerable, unprepared, and not centralized with stakeholders.	Vulnerable, but layers of security and software connects stakeholders	(Helm, 2018) (Baumann, 2016)

How could NWSA ports improve to Long Beach standards?

The NWSA managing both Puget Sound ports should look closely at what the Port of Long Beach is doing to increase efficiency, stay competitive, bring in more business, and add more revenue. The NWSA continues to plan short-term up to a decade or two away while Long Beach plans for decades ahead of the maritime industry. The NWSA ports are deep enough for the ULCV vessels partially, but they should prepare ahead for the future. The Port of Long Beach has five terminals at least fifty feet deep (Port of Long Beach, 2012b). Long Beach is not

only prepared for 20,000 TEU ships. Long Beach is prepared for incidents and vessels that may be over 20,000 TEUs in the future; Seattle is not.

Deep terminals are the first required infrastructure in ports and waterways. If ships cannot even traverse the channels ports offer, the ship will never reach the terminal. After comes the size of the berths, the number of berths available, cranes, yard space needed for containers, and rail connections. Ports must focus on having deeper terminals as larger ships need deeper waterways to travel. Width of the channel will also become a factor for narrow channels in Tacoma.

If Seattle and Tacoma got approval to dredge deeper terminals, the dredging would only continue to prepare the ports for the future of the shipping industry. It makes sense for Puget Sound ports to keep dredging deeper as ships grow. If Seattle does not stay ahead of the ships and how deep they can travel, Seattle could be at a loss of profit in the next decades and shipping liners could take their business elsewhere. The deeper waters could push Seattle to become more efficient with more containers to handle.

The NWSA reported that too much acreage is used for container cargo (Seaport Alliance, 2015). Furthermore, they stated most of their terminals are far too small for the larger vessels that plan on coming to port in Seattle and Tacoma (Seaport Alliance, 2015). The NWSA just stated the ships that plan on coming to port in the major Puget Sound ports are too big for the terminals. Changes need to be made immediately to accommodate such ships. It is extremely important that the port maximizes on its capabilities by investing enough funds to develop infrastructure and increase the overall efficiency.

Automation is the best possible way to accomplish the port goals and the Port of Long Beach have proved how efficient and effective automation can be. Even though Long Beach is a very successful seaport, both ports still have room to improve.

What can both ports do to improve?

The Californian port can also make some improvements to their entire facility while Seattle needs to begin more developments. The Port of Long Beach continues to make renovations to parts of the port that are lacking. The astonishing developments the Port of Long Beach has made comes at a cost. There is about \$900 million in debt that the port is attempting to repay from developments (Guzman, 2017). The port has a plan for that also, paying about \$90 million on time, but the large development program the port has will bring in an extra \$200 million in debt pushing the debt over a billion dollars (Guzman, 2017). The port is spending money they do not have while the NWSA ports lightly invest to avoid large debts. The Port of Seattle has a plan to manage their own debt while investing in infrastructure that will last (Thomas, 2014).

It seems the Port of Long Beach is willing to invest more in the beginning hoping for large payouts in the future (Guzman, 2017). The Port of Seattle looks to systematically invest discussed in the past section (Wolf, 2017). The Port of Seattle would not be making a poor decision to invest heavier in its port infrastructure. If other ports in the region, the United States, and even the continent can improve with large investments into their port infrastructure, then so can Seattle. The Port of Seattle is at high risk of getting left behind as other ports innovate. Seattle should be thinking about adding another terminal, automating older terminals, getting larger cranes, keep dredging shallow waters, and increase efficiency while developments are taking place. There will be a greater reward for the investment and Seattle has a real chance of

becoming the nations logistic hub. But the title of global logistics hub belongs to ports across East Asia.

U.S. and Asian Ports Case Study

Description of Each Asian Port

Comparing both the major Puget Sound ports and Long Beach to some Asian ports will put into perspective what the U.S. ports should be striving for. Being a deep-sea and a river port, the Port of Shanghai is the world's busiest port today (Ship Technology, 2010a). Shanghai's throughput in early 2018 reached 40 million TEUs, a world record (Safety4Sea, 2018a). The record was achieved through three main container terminals including an automated terminal (Ship Technology, 2010a). The port competing with Shanghai is the Port of Singapore.

The Port of Singapore (PSA) was first a British trading post in the early 1800s; in 1969 Singapore made the first container terminal in Southeast Asia. (Li, 2018). Now the PSA is known as the busiest transshipment port on the planet; handling about twenty percent of all international container transshipment. The port has six terminals that handled 24.54 million TEUs in 2017 (Ship Technology, 2010b; PSA Singapore, 2018b). The cranes at terminals allow operators to remotely operate six cranes at a time (PSA Singapore, 2018a; Ship Technology, 2010b). Yet the first fully automated terminal in China belongs to Qingdao.

The Port of Qingdao is important because Qingdao was the first Chinese port to fully automate a container terminal (New China TV, 2017). Qingdao is a smaller port compared to Shanghai or Singapore, but Qingdao was still the eighth ranked port in the world based from TEU volume in 2016 (World Shipping Council, 2018). Most information regarding Qingdao covers its automated terminal which will be discussed later. Now that the Asian ports have been

introduced with each using automation somehow, it will be important to see where the U.S. ports are not upgrading such as ports across East Asia.

Comparison between U.S. and Asian ports

Larger Investments Across the Pacific

Understanding Asian ports helps people know what the U.S. ports are doing. So how do these ports relate or differ overall? Asian ports studied have invested heavily in infrastructure projects. Long Beach has substantial investments compared to Asia. Seattle's investments compared to Asian ports are minuscule. Singapore invested in a terminal, Tuas, that will handle 65 million TEUs every year by 2040 and operations starting in 2021 (Li, 2018). The Tuas terminal is just one the terminals the industry can find in the future. The PSA saw the construction of the terminal as the next project to meet demand of the industry (Li, 2018). Long Beach and Seattle do have this idea in mind, however the domestic ports aren't investing to the level PSA did. Tuas terminal will be the largest container terminal in the world once finished (Li, 2018). Long Beach is attempting to mimic investments on a smaller scale. Seattle is roughly meeting Long Beach investments for one terminal.

Qingdao had limited information regarding investments, yet the numbers to automate terminals are present. Shanghai's automated offshore port, or terminal, initiated the phase four in construction of the port (Ren, 2017). The investment would create seven more berths costing 12.8 billion yuan (Ren, 2017). As of November 2018, the investment is worth 1.84 trillion U.S. dollars. Considering this is just another phase in development for Yangshan, the investment in the port is very high and exceeding expectations. This is just a fraction of investments as well. Most investments covered automation developments due to its extreme benefits at all ports.

Automation in Asia

All Asian ports covered are using automation to a degree. PSA has tested automating cranes and ground vehicles fully (Louppova, 2018). People are still needed for precise placements of containers on ships or vehicles (PSA Singapore, 2018b). Seattle could attempt to mirror this minimal automation at first. Long Beach has exceeded this level of automation. Some terminals have already fully automated some terminals. The Port of Qingdao is one of the few to complete full automation (New China TV, 2017).

Qingdao New Qianwan Container Terminal started operations in May 2017. Two berths were developed with seven remote-controlled container cranes, thirty-eight automated stacking cranes, and nearly forty automated grounded vehicles (Port Technology, 2017). The port being fully automated can work all day and all night nonstop without human intervention. In turn labor costs were reduced 70 percent and efficiency rose 30 percent (Port Technology, 2017). Ports using automation have shown numbers of being extremely efficient with infrastructure used. The port was able to unload about 1,800 TEUs in only nine hours. The cranes moved containers at forty moves per hour, which became a world record (New China TV, 2017). Shanghai has also made an enormous automated terminal known as Yangshan.

Yangshan is a deep-water terminal thirty kilometers from Shanghai with a bridge connecting the port to the mainland (Ship Technology, 2010a). The Yangshan Terminal alone is over ten square kilometers in size and is the largest automated terminal in the world (China [Shanghai] Pilot Free Trade Zone, 2017; Safety4Sea, 2018b). All vehicles and cranes are remote controlled with 120 cranes moving containers on and off vessels (Safety4Sea, 2018b).

Automating the terminal at Shanghai reduced labor expenses by 70 percent and increased efficiency to 50 percent while reducing emissions to about ten percent (Safety4Sea, 2018b).

Security Challenges Overseas

Shanghai has attacked security problems in their port dating back to 2005 at least. A terrorist drill was performed at the Yangshan terminal in 2005 with ten government organizations alongside the military (Shanghai Daily, 2005). With Yangshan being practically an island very far from shore having a drill like this when the terrorist attacks on the United States occurred a few years earlier is practicing good security measures to be more prepared for the future security issues. The director of the Port Administration Bureau stated the drill will be done annually to make sure the terminal is up to global security requirements (Shanghai Daily, 2005) Drills sometimes happen in west coast ports, but there isn't much news about drills happening. No information was found about Seattle doing any security drills independently or joint exercises.

Shanghai has other security systems and they transferred their surveillance onto a network system to connect security systems (Axis Communications, 2010). The result gave way for enhanced security within the port. The move also enhanced efficiency and output in the port from a simpler system with less complications (Axis Communications, 2010). Long Beach systems are like this as all ports look to connect security systems on one network.

Qingdao's port had no information about security. Singapore has multiple codes and partnerships to ensure security remains at the port. Part of the code entails rules of reporting incidents with security, piracy, and United Nations Security Council expectations (Maritime and Port Authority of Singapore, 2018). The United States Coast Guard worked with Singapore leaders to improve port security in 2016 (Defense Visual Information Distribution Service, 2016). Singapore signed the International Shipping and Port Security (ISPS) code back in 2004, and the ISPS program led by the Coast Guard hopes to combat security risks at sea while having safe maritime shipping (Defense Visual Information Distribution Service, 2016). The risks

involve from the time the ship leaves the port to the ship at port under terminal operations. It is likely China is also participating or participated in the program over the last decade. Partnerships between other federal organizations outside their borders is signs towards wanting to enhance security. Seattle should look to do the same and work closely with the military and law enforcement at ports.

What can West Coast Ports do

Long Beach may never be able to live up to everything Asian ports will do, but Long Beach can automate their terminals even more. Implementing more automation will help efficiency increase, labor costs decrease, and will bring in more profit for the port to continue investing more in its facilities (Port Technology, 2017).

The Puget Sound could study each port if they chose to, but the best port to align themselves with is the Port of Singapore. Both ports aspire to be a logistics hub, Singapore is just the largest transshipment hub in the world (Ship Technology, 2010b). Seattle is set up to be a large transshipment hub for the Northwest United States and beyond. Seattle supports shipping from the mainland to Alaska and Hawaii and international shipping with Asia as a whole (Seaport Alliance, 2015). Seattle should be automating like Singapore and creating more terminals that are clean, efficient, and safer. Offshore ports might be the answer for Seattle as most domestic ports suffer similar problems today (Lawrence Livermore National Library, 2016). Potentially buying out or subcontracting with smaller ports in the Puget Sound to expand and develop their facilities could be another option.

One idea Port of Seattle commissioners need to truly understand is Singapore's success is no accident or from their strategic location in the shipping industry (Li, 2018). Ports can be placed perfectly in the world but aren't used to their full potential from poor leadership. PSA's

leadership continue to seek the future and they have the courage to make bold decisions in the industry (Li, 2018). These actions gave Singapore ability to keep taking advantage of its developments in the industry. Being the trailblazer has its perks. Singapore set the standard for ports across the world while implementing new developments leading to success in the containerized shipping business (Li, 2018). Seattle's port leaders need to be bold and courageous to make an impact in the port industry. Automation is a key to create Seattle's port a leader in the maritime industry. Those changes start with bigger investments and enhanced security.

Conclusion

Current State of the Port

Global trade is much larger than just automated Asian ports and Seattle. The maritime industry continues to grow causing issues for Seattle to handle larger ships and more containers. Just as past developments changed the maritime industry a decade after world war II, the industry takes a shift again from manual labor to automated work (Vessel Tracking, 2018). Ship growth has been immense the past few decades (Vessel Tracking, 2018). Lacking infrastructure causes problems to the ports and the vessels being accommodated. Terminals will have to improve efficiency overall to keep up. Without strong infrastructure efficient enough to move the cargo Seattle will fall further behind in the booming port industry.

Port infrastructure in Seattle

Seattle's infrastructure amongst the rest of the nation's port infrastructure is beginning to age more without enough investments being made (Tran, 2016). The new ships require stronger accommodations which can service ships faster than before (Washington State Department of Transportation, 2017).

Long Beach, Qingdao, Shanghai, and Singapore ports were studied to show how these ports meet the bigger ship demand and move trade faster with their automated facilities (New China TV, 2017; Louppova, 2018; Safety4Sea, 2018b; World Port Source, 2012). To be as efficient as automated global ports, Seattle must automate their port facilities. Challenges facing the infrastructure improvements include adequate security, financing the project, and heavy union resistance. Yet adequate security systems, strong infrastructure funding, and automation are the future of the industry and the future of Seattle's port. Studying global ports has shown what some ports have automated and how these challenges are found in their own ports. Through new automated renovations important challenges are solved and turned into port strengths. Strong port infrastructure will support future growth of the region while reducing emissions (Ward & Martin, 2008). In a few decades, the automated ports will make manual ports obsolete.

Research Questions Answered

Sources were continuously drawn back to other ports and what changes they have been made to answer research questions. Challenges from renovations were analyzed and supported as well. The evidence helped prove how security, investments, and automation issues are challenges. The references then helped support solutions to the challenges and what international ports have done regarding the challenges. The issues at international ports are usually found to be port strengths. So, what should leaders expect for the future of the industry?

Lessons for the future

The Future of the Maritime industry

The industry has no signs of slowing down. If the renovations do not happen soon, there is a chance the port won't be able to keep up with increasing demand. Container ships are nowhere near expectations for their limits (Saxon & Stone, 2017). Over the next fifty years

containerized vessels could grow from 20,000 TEU to 50,000 TEUs (Saxon & Stone, 2017). While ships continue to grow, container growth in the industry will continue as well. By 2067, the low estimate for TEU container growth is 464 million TEUs in the maritime industry; the high estimate is 858 million TEUs (Saxon & Stone, 2017). While the industry will keep growing as expected, technology on ships will change to increase efficiency and reduce costs. Automation has been implemented already with high success and a reduction in overall costs (Luo, Wu, & Mendes, 2016). It is time to begin automation at Seattle's container terminals. Considering the challenges and changes to the industry, automating the terminals is the best option for the port alongside some other options.

Steps for the Future in Seattle

Determining what Seattle should do in the future will help plan for Seattle to automate easier and overcome their three major challenges. Seattle has much to consider with its infrastructure upgrades. First, Seattle should be looking to increase investments into maritime infrastructure to make an efficient and competitive automated terminal. Whether the port increases investments or moves its budget around, automation will require more funding than common investments at Seattle. Part of the problem is that the international airport in Seattle is also classified in the Port of Seattle with most investments going towards aviation and the SEATAC airport (Port of Seattle, 2017a). The Port of Seattle should attempt to isolate itself from the airport or improve container terminal investments within the current port budget.

After investments meet automation requirements, Seattle will be able to fully automate a terminal and that should be Seattle's goal. Automating a terminal in Seattle could shock the region and the maritime industry will highlight the renovations bringing more cargo to Seattle. During automation developments, the port should transition the longshoremen from their

standard jobs to more advanced roles which support automated terminals. Getting the labor on board to management and maintenance roles for automation will help transition the ILWU's role in automated terminals.

One rational idea for Seattle, Tacoma, and the remaining Puget Sound ports to consider is creating an alliance larger than just Seattle and Tacoma. All ports within the Puget Sound should align themselves and work together to create a larger alliance to benefit the region. The Puget Sound port alliance would help move cargo more efficiently and distribute cargo more throughout the Puget Sound. Some ports are much closer to the entrance to the Puget Sound where inland cargo could be offloaded and shipped faster to the inner United States. There are ports also closer than Seattle to ship highways that could help reduce traffic flows with trucks moving north, east, and south. If all Puget Sound ports connect and assist in allocating cargo across the Puget Sound, the entire region will grow and challenges automating Seattle's port could be eliminated. Straying from automation developments too long could backfire and make Seattle's port expendable to regional competition. With Seattle's port enhancing infrastructure through automation, Seattle will reposition itself as a leader of containerized trade in the United States doing more business with nations across the globe.

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