Revision of 24 December 2012

Next Generation Container Port Challenge

Registration Account NGCP– 6295

SPEEDPORT

Container Port for the 21st Century

A Proposal in response to the Republic of Singapore Maritime Institute's search for revolutionary new ideas in the planning, design and operation of the next generation of container ports that will achieve a quantum leap in handling efficiency and productivity to support future shipping in an economically and environmentally sustainable manner.

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SPEEDPORT Proposal

ACTA Maritime Development Corporation
Ablaze Development Corporation
Villanova University

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1.0 Executive Summary

A. Overview

1. Introduction

The tremendous impact of the improved supply chain has benefited the world economy and elevated the standard of living of almost everyone on our planet. Among the most significant changes in the marine transportation industry in the past one hundred years was the introduction of the modern intermodal container by Malcolm McLean in the late 1950's. The world-wide adoption of shipping container standards drove changes in ship and terminal designs, and influenced trade patterns around the globe.

Since the mid-1990's, maritime industry executives, Port Authority officials, legislators, and the public around the world have marveled at the positive impact of larger and larger capacity container vessels on their local economies. Government officials from competing regions vied for funding of mammoth dredging projects to ensure that their ports would accept the largest ships plying the seaways. Similarly, Port Authorities and terminal operators have sought to increase the capacities of their facilities to keep pace with the ever increasing volume of containers passing over their quays.

The first purpose built ship-to-shore (STS) gantry crane was constructed in Alameda, California in 1958. Containers from ships were loaded onto truck pulled chassis and stored in the container yard. In recent years, larger STS cranes, with higher speed lifts and trolleys were deployed in larger yards, with high density storage, supported by rail mounted gantrys (RMG), straddle carriers and purpose built lift trucks. Current terminal designs feature automated RMGs and automated ground vehicles (AGV) that move containers within the yard.

While all of these changes have resulted in improved efficiencies within the modern marine terminal, the basic model, the configuration of the physical plant and the methodology of crane to ground-based transport vehicle to storage has remained essentially the same for the past several decades. Process improvements and equipment upgrades to terminals now yield only fractional gains in efficiencies. However, 15,000 to 20,000 TEU vessels will soon call upon those ports. To accommodate the mega-vessels, a paradigm shift in terminal design is needed to keep pace with the increasing size of vessel designs. Incremental terminal improvements will no longer suffice. A design revolution is needed. The proposed SPEEDPORT is the revolutionary technology needed; capable, on the largest vessels, of moving nearly 1000 containers an hour, safely, efficiently and affordably.

2. Next Generation Container Port Challenge Proposal

The Republic of Singapore's Next Generation Container Port Challenge has provided innovators from around the world with a tremendous opportunity to propose new concepts and designs for terminals to achieve the needed exponential leap in performance, productivity and sustainability.

The operating specifications for the proposed port facility address the challenges currently faced by many established container ports around the world. These include a handling capacity of at least 20 million Twenty-foot equivalent units (TEUs), 24/7 operation and a 90 percent berth availability on arrival for ships. Designs must also be fully operational within the given land profile and be financially and environmentally sustainable.

3. Proposal Development Team

ACTA Maritime Development Corporation (ACTA) is pleased to team with **Ablaze Development Corporation** (Ablaze) and **Villanova University** to present our proposal to the Republic of Singapore's Next Generation Container Port Challenge.

ACTA Maritime Development Corporation (ACTA) is the owner of SPEEDPORT, a revolutionary, internationally patented, marine intermodal terminal design and operating system. Combining a unique terminal arrangement with use of proven materials, handling and robotics technologies, SPEEDPORT offers tremendous capacity and efficiency, beyond what is possible in a conventional terminal design.

In the late 1990's, ACTA's founders were inspired to look at the methodology used to load and unload container ships when the Port Authority of New York and New Jersey began to dredge the harbor to accommodate the largest ships in the world at that time. While the waterways could be enlarged for the big ships, there was, and still is, no additional waterfront property available in the Port of NY &NJ to expand the conventional marine terminals. A new means of loading and unloading ships was needed to accept the ever growing numbers of containers that would be coming to the port.

ACTA was founded in 1998 and from that time has worked to develop and refine the SPEEDPORT concept design, equipment and operating system. Although developed in response to the demand for the improved terminal productivity required by 15,000+ TEU mega ships of tomorrow, the SPEEDPORT design can be applied to meet the needs of any sized port.

Ablaze Development Corporation (ABLAZE) personnel have been developing leading edge technology for the international intermodal transportation industry since 1984. Past projects and products created by ABLAZE have combined robotics, artificial intelligence, and vision systems, with computer hardware and software systems for greatly improved efficiency in handling intermodal containers and cargo at ports, intermodal container terminals, depots, manufacturing plants, and warehouses.

ABLAZE personnel enjoy solving complex real-world problems in a straightforward, efficient manner. The key to providing such solutions is often combining traditional engineering techniques with artificial intelligence (AI). Problems with no suitable mathematical solutions can be solved using fuzzy logic, neural nets, heuristics, or rule-based expert systems. ABLAZE has designed and developed these intelligent systems for intermodal, marine, break bulk and transload terminals around the world. Such systems include optimizing the loading pattern and blocking of intermodal equipment for outbound consists of; intelligent inventory control at container terminals; optimizing cargo loading patterns for container shipments; compatibility verification of hazardous materials; and traffic management optimization at marine ports.

ABLAZE personnel invented a patented container cell elevator system that is particularly effective in reducing the time required to transfer containers between ship and shore and for use in the open seas. Past work has included the development of the GRAIL Automated Container Terminal, a robotic container handling facility, a Robotic Spreader that is able to be rigidly positioned in any combination of six degrees of freedom (roll, pitch, yaw, x, y, and z), under electronic control, and Spreader Telepresence and communications systems that dramatically improve the container transfer process.

Villanova University is committed to excellence and distinction in the discovery, dissemination and application of knowledge. The University's College of Engineering, ranked in the top ten in the United States by US News and World Reports, offers disciplines in the fields of Chemical, Mechanical, Electrical, Computer, Civil and Environmental Engineering. All undergraduate engineering programs at Villanova are accredited by the Accreditation Commission (EAC) of ABET (Accreditation Board for Engineering and Technology). The engineering faculty strives to develop a professional attitude in students; namely, the desire to grow intellectually through the continual search for and use of knowledge, and the motivation to become active, articulate and socially aware citizens. The College of Engineering is committed to its responsibility to develop, collect and disseminate new knowledge in the engineering field and related areas.

4. Challenge Proposal

This proposal is based on ACTA's internationally patented SPEEDPORT container transfer system and method and incorporates ABLAZE's patented Cell Elevator for even greater container transfer rates. Our team's proposed design and method will set the new standard for the international container transportation industry.

ACTA's fully automated, all weather SPEEDPORT, is a quantum leap beyond present day terminals, incorporating technological advances that dramatically reduce ship turnaround time, making it the fastest, most efficient and safest ship-to-shore container handling facility in the world. The SPEEDPORT terminal makes use of a simple structure to take advantage of natural time-motion relationships, and, when combined with the latest in information and control technology, results in a simple, efficient, low maintenance facility which permits all-weather, year-round operations.

At the heart of the SPEEDPORT system is a fleet of independent container handling vehicles, called "Spiders". The Spiders operate on an elevated grid of rails and beams to move containerized cargo directly between ships, trucks, rail and storage. There are no expensive, complex gantry cranes, buffers, straddle carriers, in-yard chassis, or associated multiple-vehicle transfers as found in a conventional container terminal. The Spider provides a single point of carriage for each container moved within the terminal. A single Spider vehicle can pick up, transport and discharge a 20, 40 or 45 foot container anywhere in the terminal under the guidance of a centralized control system. Container handling productivity is multiplied and operating costs are dramatically reduced as the precision of industrial robotics is applied to the intermodal container handling process.

ABLAZE's patented Cell Elevator system is particularly effective in reducing the time required to transfer containers between ship and shore. The purpose of the device is to raise the top container in each cell to deck level where the crane can easily access the container. Once the crane removes the container, the in-cell device retrieves the next container and raises it above deck. The system also works in reverse; that is, the crane operator places a container above deck and the in-cell mechanism stows the container below deck. The cell elevator will increase productivity significantly because it eases the task of picking and placing containers; and, since the device works in parallel with the Spider vehicles, eliminates the need for the Spider's spreader to enter the hatch, a major portion of the container transfer cycle.

B. Key Innovations

1. SPEEDPORT Configuration

ACTA's innovative new container terminal design and operating system, SPEEDPORT, is capable of moving high volumes of containers off of ships and directly onto feeder vessels, overland trucks and on-terminal railcars (where applicable) for rapid transport to and from any sized port.

The SPEEDPORT structure sits above the container storage stacks, gates, railhead, and quay areas. All container movements are accomplished by the unmanned Spider vehicles on the SPEEDPORT system of elevated rails and movable overhead beams. The fixed elevated rails are similar to those used in conventional railway operations, upon which the Spiders roll on wheels. Multiple moveable overhead beams precisely locate themselves above each row of shipboard containers and above each stack of containers in the storage area.

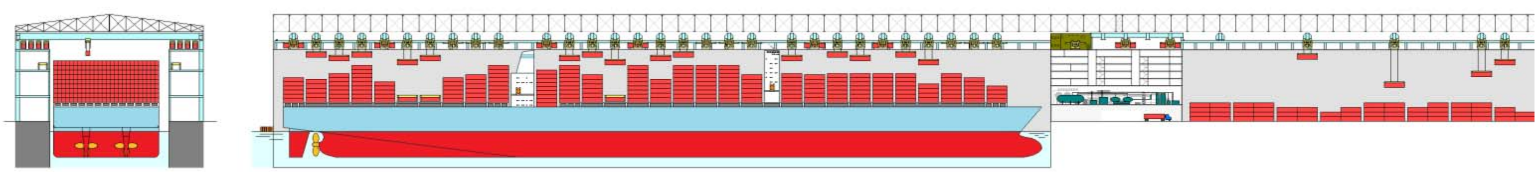

Figure 1-1 SPEEDPORT Elevation and Section

On the world's largest ships, container transfer rates of over 950 moves per hour will be attainable with the SPEEDPORT terminal. This high transfer rate of containers between ship and shore is possible as the SPEEDPORT Spiders are able to work every container hatch on the ship simultaneously. Each of the Spiders moves its container directly from the ship to its position in the storage area, or directly onto its next mode of transportation, without handing off to another vehicle or system.

The numbered captions in the illustration below describe each stage of the Spider container handling vehicle's movement through the terminal transporting a container from the ship to storage or onto its next mode of transportation.

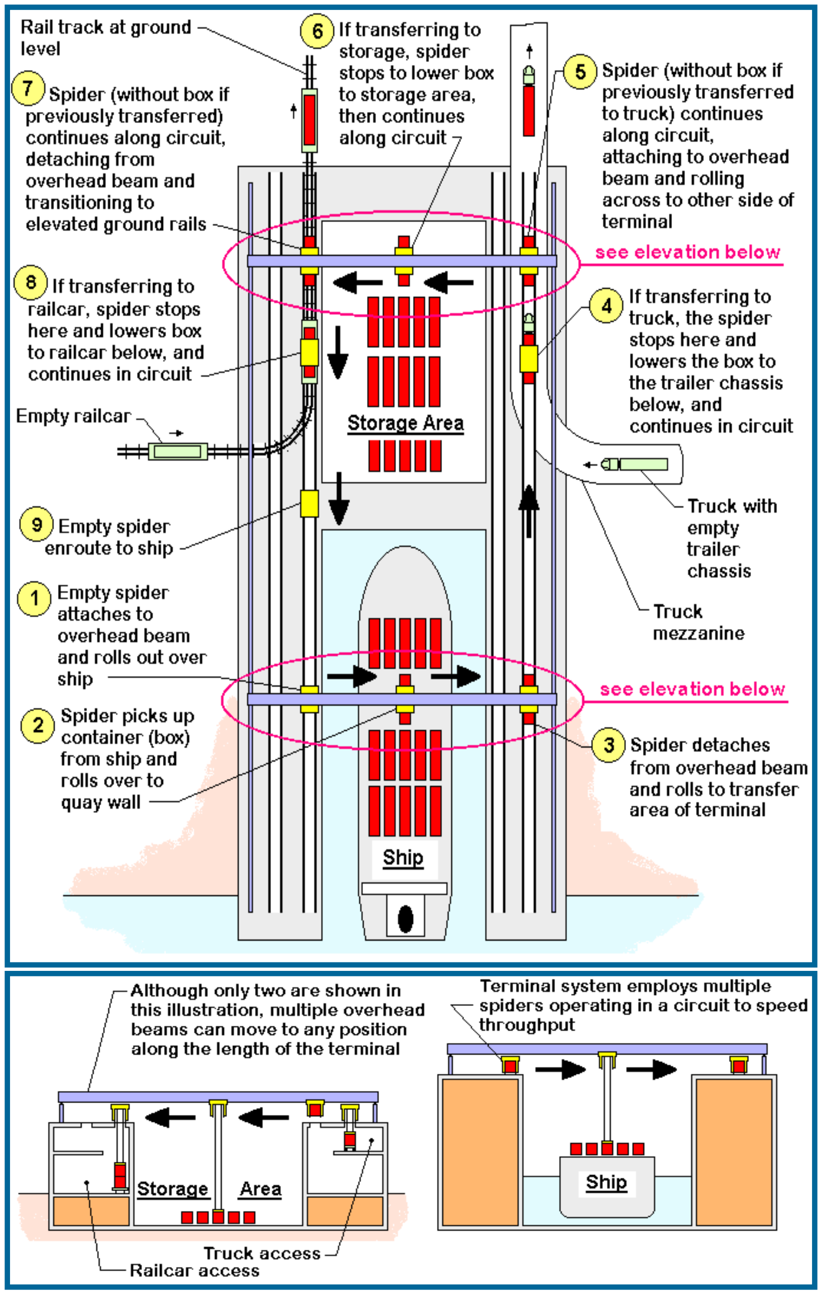

Figure 1-2 The SPIDER Movement Circuit

The patented SPEEDPORT design is capable of 24-hour operation, working all ships hatches simultaneously, with multiple simultaneous transfers of containers on and off of feeder vessels, trucks and railcars (where applicable), dramatically reducing the wait time presently experienced in conventional terminal systems.

The major benefits of the SPEEDPORT concept can be broken down into five essential elements:

SPEED: The use of multiple automated "Spider" vehicles within a new type of terminal structure dramatically increases the number of lifts per hour and provides direct transport to the next mode of transportation or interim storage. Each robotic Spider vehicle is capable of making the container lift, carrying the box to a location away from the quay, and placing it directly onto its next mode of transport.

SAFETY: Segregated avenues of transport for Spiders, on-dock rail, on-dock truck, and minimal personnel in the vicinity of cargo transfer make the SPEEDPORT design inherently safer than conventional terminals.

SECURITY: Use of a high-density storage area with limited access provides maximum protection for valuable cargo in the yard.

SPACE: Compact terminal design enables improved TEU throughput per acre, maximizing profitability for the available land.

COST: All of the above mentioned benefits are attained at a competitive cost to moving the same container through a conventional terminal of similar capacity.

2. SPIDER Container Handling Vehicle

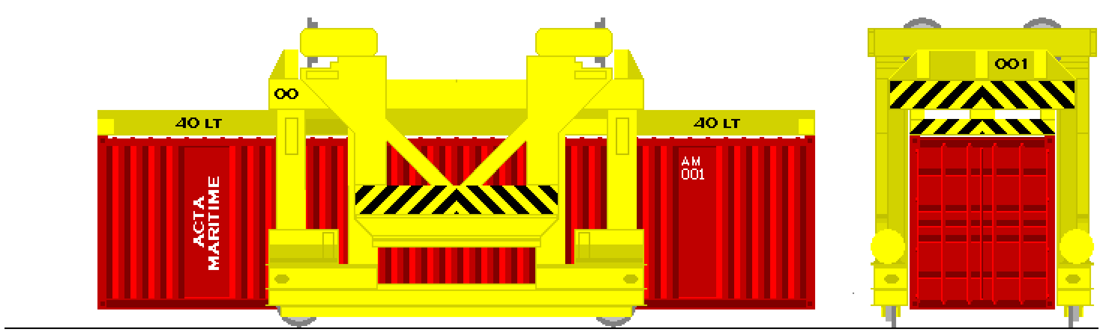

Figure 1-3 Spider, shown with 40-foot ISO Hi Cube Container

The Spider is a unique vehicle designed to hoist and transfer standard ISO containers anywhere within the SPEEDPORT terminal. Each Spider is self-propelled, and travels on a network of overhead beams and elevated ground rails. When loading or unloading containers to or from a ship or storage (athwartship direction), the Spider traverses select overhead beams via an overhead carriage. When travelling the length of the terminal (longitudinal direction), the Spider travels on ground wheels which guide the

Spider on elevated ground rails. The Spiders operate in a repetitive cyclic motion, rendering efficiency and speed in container handling operations.

One of ACTA's prime tenants in the SPEEDPORT development process has been reliance on existing technology and systems. All of the components that will be used within the SPEEDPORT terminal are presently successfully employed in functioning conventional marine terminals and/or industrial applications around the world. For this reason, we are supremely confident in the functionality of our patented SPEEDPORT terminal configuration, Spider container handling vehicle, and terminal operating systems. Future developments in terminal management and vehicle control systems, electric power systems, etc. are expected to further enhance the capabilities and efficiencies of the SPEEDPORT terminal and Spider vehicles in the next ten years.

The Spider is essentially a hybrid of the modern day straddle carrier, gantry crane trolley and hoist, and spreader. The Spider physically resembles a straddle carrier and is indeed built like a straddle carrier structurally and mechanically while incorporating a number of features of the automated stacking crane. The development and successful employment of automated guided vehicles (AGV) and automated stacking cranes (ASC) in conventional terminals around the world gives us great confidence in the viability of the mechanical and robotic system design of SPEEDPORT's Spider container handling vehicles.

Figure 1-4 Shuttlecarrier

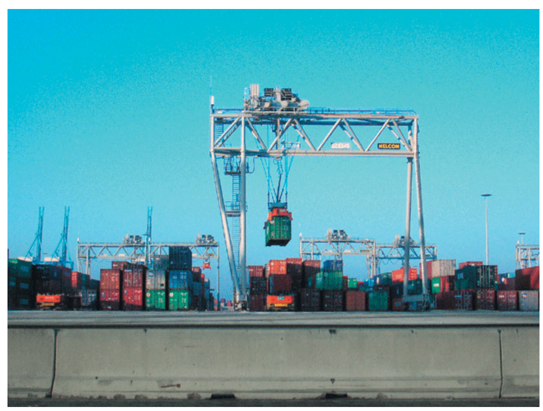

Figure 1-5   Automated Stacking Crane

In a conventional terminal, a crane trolley, which may or may not have an integral hoist, lifts containers from a ship or stack, then shifts them laterally along the crane boom to another location, where they are lowered to their next mode of transport, or simply placed on the ground to await pickup from their next mode of transport. Another vehicle, such as a yard tractor with chassis, reach stacker or straddle carrier, then transports the container to another location in the yard. This combination of movements demonstrates the inherent inefficiencies associated with the various transfers that occur, each time the container is transferred from one point to another in a conventional container terminal.

SPEEDPORT is a fully-automated system, although manual operation and control can be employed as a back-up. The Spider container handling vehicle is an unmanned robot that is controlled from a central terminal management system via wireless communications.

The Spider utilizes existing technology in all respects – no new technology is required for its design and construction. For the purpose of this proposal, we have used existing traction drive motor technology for Spider vehicle propulsion. Conventional motors provide the worst case scenario for the weight of the Spider and as a result, the cost of the structures required to support Spider Operation are also higher than will be possible in the future. As the technology used in Linear Induction Motors (LIM) and Linear Synchronous Motors (LSM) continues to advance, and those motor types are used in future Spiders, we believe that we will see substantial weight reduction of the Spider vehicles and a commensurate reduction in the capital and operating costs of the SPEEDPORT terminal.

The Spider is comprised of a steel structural frame that serves as the major strength component of the vehicle, as it carries the entire weight of all components. Like current straddle carrier design, the legs of the Spider are slim in profile, minimizing the required width of the lanes in which they operate.

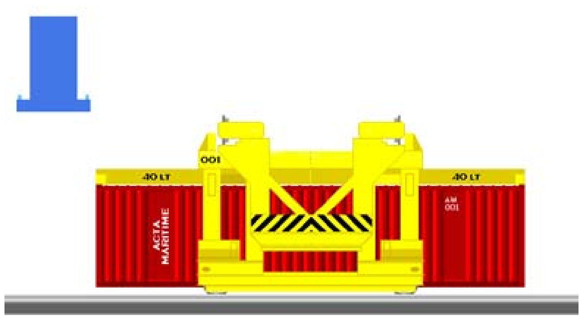

Figure 1-.6 Spider on Ground Wheels

When grounded on the elevated rails, the all-electric Spider vehicle runs on steel or composite flanged railroad styled wheels. It is propelled to a top shuttle speed of approximately 17 MPH using conventional traction drives. Slowing and stopping of the Spider is accomplished by electrical regenerative braking of the propulsion motors. Future versions of the Spider may use LIM or LSM for propulsion and braking.

The Spider engages the Overhead Beams via its Overhead Carriage which functions much like the trolley of an overhead bridge crane, and consists of beam wheels, electric brakes, carriage positioning actuators, wheel positioning actuators and a traction drive motor for propulsion.

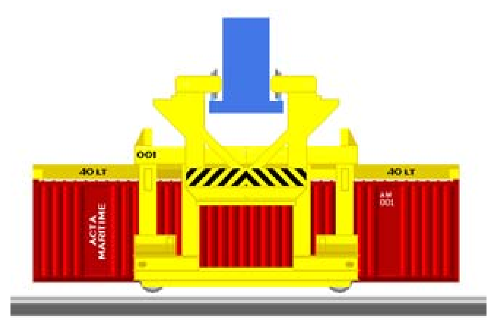

Figure 1-7 Spider with Overhead Carriage Engaged

The Spider container hoist system will employ four conventional motor or SEMA electric motors with planetary gearsets, wire rope drums and wire rope and sheaves. The Spider's hoist drums carry sufficient wire rope to enable its spreader to engage containers stowed above the level of the height of the terminal working level. A conventional all-electric spreader, with twistlocks and twistlock actuators, will be raised and lowered by the hoist machinery.

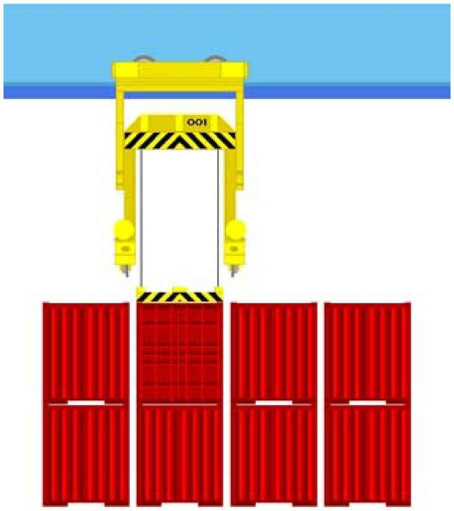

Figure 1-8 Spreader Engages Container

Spreader positioning is accomplished through the use of laser optic devices mounted on the corners of the spreader. Regenerative braking systems will be used to slow and stop the lowering of the container. In future versions of the Spider, the same set of motors may be used for hoist/lower operations and for propulsion, dramatically reducing the weight of the vehicle.

Animated depictions of SPEEDPORT, and its Spider container handling vehicles in action, can be viewed at the ACTA website: http://www.actamaritime.com.

3. Cell Elevator

The most time consuming portion of the STS crane cycle is loading and unloading containers below deck. In particular, the most critical element of this process is placing the spreader bar into the cell of a ship.

To address these problems and to greatly reduce the time needed to work any containership ABLAZE has developed the Cell Elevator. The Cell Elevator works with any containership. No modification of the ship or the container ship-to-shore transfer system is required.

The Cell Elevator raises and lowers containers in the cells of ships to greatly reduce the cycle time of container stow and retrieval. The device moves the containers between deck level and storage below deck, working automatically, in parallel with the Spider container handling vehicles.

The basic elements of the Cell Elevator are illustrated in Figure 1-9. The Cell Elevator elements consist of:

- Dual cell frame
- Lightweight ISO spreader bar with twist locks
- Lower corner post solenoids
- Overhead cell-to-cell trolley
- Electric winches to lift and lower the spreader bar

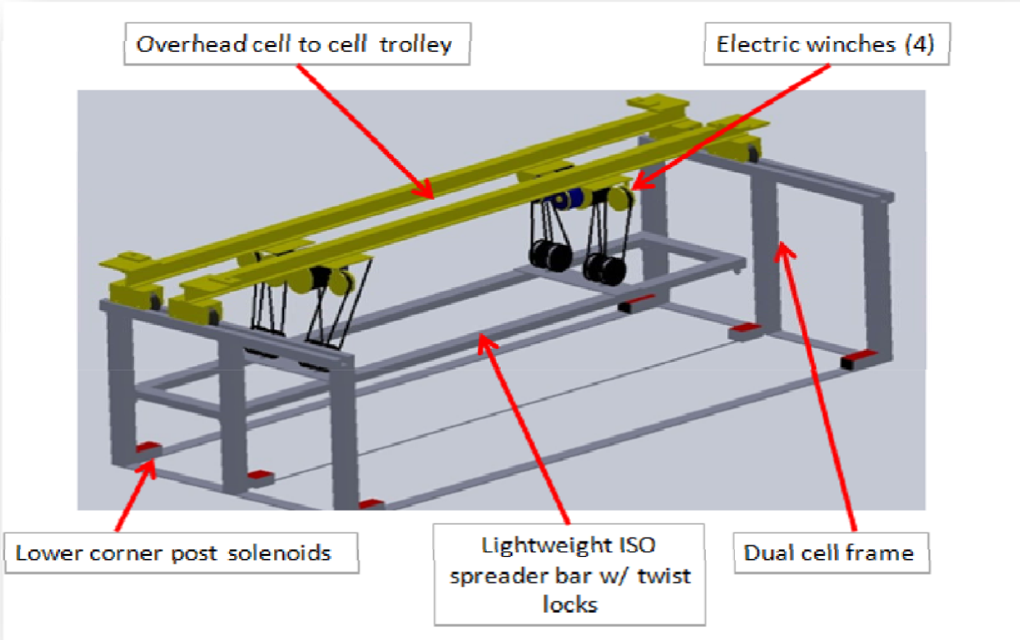

Figure 1-9 Cell Elevator with key elements indicated

Figure 1-10 illustrates how the crane's spreader bar interacts with the Cell Elevator.

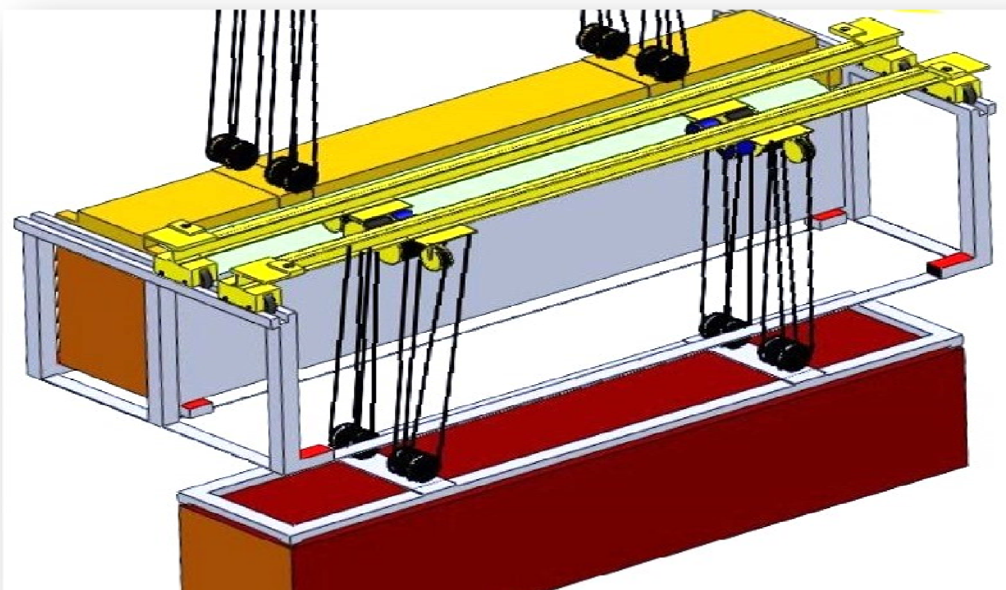

Figure 1-10 Crane removing container from the Cell Elevator in cell 2, while a container is being stowed by the Cell Elevator in cell 1

By reducing the time required to align the spreader and lower it into the cell, and for the vertical hoist required for all below deck containers, the Cell Elevator improves the productivity of the SPEEDPORT system by over 15%.

C. Assumptions

1. Ship Size Trend

Based on the recent and present trend of increasing ship size, this proposal assumes that ship sizes will continue to increase and that larger ships will continue to carry a larger percentage of the world's container cargo. Recently STX Shipyard in Korea announced the design of a 22,000 TEU container vessel. Although there are presently none on the order books, the SPEEDPORT facility in this proposal is designed to accommodate these 22,000 TEU Ultra Large Container Ships of the future. Should ships continue to grow beyond this design, the terminal's indented berths and structures can be modified to greater dimensions.

2. Ship Mix

The future mix of vessels used for this proposal is based on a maximum ship size of 22,000 TEU and extrapolation of current trends in ship sizes and industry consolidation. Please note however that the maximum size considered in this proposal is not a limitation of the SPEEDPORT design. The size of the berth(s) in a future terminal will be determined by the customer. Berths can be designed to any size without impact to the performance and reliability of the SPEEDPORT system.

Since the location of the proposed port is not defined, ACTA/ABLAZE conservatively projected the vessels calling at the proposed terminal to be a representative mix of the world fleet of 2022 rather than assume that mostly Ultra-Large Container Ships and large feeder ships would call at the SPEEDPORT terminal. By including the mix of smaller and larger ships, ACTA/ABLAZE has ensured that the Port is properly sized for many more arrivals and departures than will most likely take place in a Hub port application of the SPEEDPORT terminal.

The proposed SPEEDPORT, as presently configured, is built to accommodate the dimensions of the 22,000 TEU ship. However, if ships of the future exceed this size, the terminal design allows for modification to accept larger vessels by lengthening and widening the two outer most indented berths, and raising their Spider/Beam operating level. Also, there is sufficient area for an additional two full-sized indented berths, and their accompanying storage and transfer areas, within the allowable land allotted for this Challenge. These two additional berths could be built to any size to meet the requirements of the port.

3. Future Ship Designs

SPEEDPORT was designed with current ship designs as a baseline. As the terminal's overhead beams are moveable, our proposed design is capable of simultaneously working all of the container bays on any ship that is designed to have its container cargo accessed from above. For reasons of simplicity, the calculations presented in this proposal are based on future “hatchless” or “open top” ship designs that we believe will become more prevalent ten years from now.

Ships with hatch covers will be serviced by the SPEEDPORT terminal systems in the same manner as the hatchless ship. The time required to remove and replace hatch covers would have minimal impact on the speed and safety of the cargo transfer operation. The time required for a Spider to remove or replace a hatch cover in the SPEEDPORT is less than that of a conventional terminal.

Limitations of Present Analysis

Spider Operations: To insure that the costs and throughput predicted in this proposal can be achieved in the eventual implementation of the SPEEDPORT, all of the calculations performed in this proposal are based on an assumed most conservative standard work cycle of the Spider container handling vehicle. For the purpose of this proposal, during the off-loading of a ship, it is assumed that the Spider will make a pick of the container and transport it directly to its designated position in the storage area. Upon deposit of the container in the storage area, it is assumed that each Spider will return directly to the ship to pick its next container for offload. During one half of this circuit, the Spider will move without a container.

The most conservative standard Spider circuit described above is used as the basis for all of the calculations in this proposal. It is understood that the SPEEDPORT terminal management system will make much more effective use of the Spiders during actual operation such as working the ship in two-way mode where cells are loaded and unloaded simultaneously. ABLAZE personnel have designed several terminal management operating systems that employ expert systems and artificial intelligence to maximize the productivity of the container handling equipment; minimize distance traveled and minimize stack re-handling. Other commercial software programs such as NAVIS ASC Manager and NAVIS Prime Route, currently maximize the usage of Automated Stacking Cranes (ASC) and ground vehicles, respectively, within conventional terminals. This type of intelligent software will be used to make the most effective use of Spider vehicles moving cargo in the SPEEDPORT terminal. This will significantly reduce the total number of vehicles required to attain the performance levels calculated in this proposal. Accordingly, the capital costs of the terminal, as well as the costs associated with its operation and maintenance, will be substantially less than those described herein.

Ship Air Draft: The proposed terminal design shows a simple arrangement where the operating level of overhead beams is above the highest fixed structure of the 22,000 TEU ship. A lower beam operating level is possible, if there is a mechanism to raise a number the overhead beams above the ship to allow entrance to the indented berth. The beams could be lowered into place once the ship is moored. The height of the Spider/Beam working level is a critical driver of the cost of the steel terminal superstructure. Lowering this level will significantly reduce the capital cost of the facility, lowering the cost per box handled. Similarly, a reduction in facility height will reduce the hoist/lower times for all containers handled increasing the transfer rate and terminal throughput.

D. Key Performance Indicators

Using data from extensive research, ACTA/ABLAZE created detailed computational models for the design and terminal processes considering the assumptions indicated above. The ACTA/ABLAZE proposed container terminal meets or exceeds each of the requirements of the Next Generation Container Port Challenge:

Key Performance Area		Key Performance Indicator	Proposal
Performance	Container Throughput	TEU's per annum	20,012,640
	Berth on Arrival	%	90+%
Productivity	Labour Productivity	Number of port workers required	366
		Number of labour hours per year per TEU	0.038
	Land Productivity	Land Area required (hectare)	171.2
		TEU's per hectare per annum	116,801
Sustainability	Environmental Sustainability	Total energy consumption per year (kwh)	794,900,556
		Energy consumption per year per TEU	39.75
		Renewable energy generated on-site per year (kwh)	1,155,935,828
	Financial Sustainability	Total capital expenditure (US$)	$7,660,390,475
		Capital expenditure per TEU (US$/TEU)	$30.73
		Operating expenditure (US$/year)	$273,218,583
		Operating expenditure per TEU (US$/TEU)	$13.67

Table 1-1 SPEEDPORT Key Performance Indicators

1. Container Throughput

The SPEEDPORT terminal proposed for this Challenge is designed to handle 20,012,640 TEU per year. This figure was determined using computational models (spreadsheets and simulations) that considered numbers of boxes transshipped, those for import and export, berth size, moves per hour for each ship type, and ship calls per year based on a projected mix of ships of various sizes.

Berth Size: Each of the SPEEDPORT's six berths was designed to accept one 22,000 TEU ship and is 1,535 feet long and 235 feet wide. This maximum projected size of container ships in the year 2022 is based on a design by STX Shipyard, Republic of Korea.

Moves per Hour: The Spiders function much like the trolley on a gantry crane extending over the ship to access the cells. The Spiders attach themselves to overhead beams by means of a carriage assembly that reaches up to engage the beam and then hoists itself a short distance above the rails. In this way, the Spiders can access any cell on the ship. Similar beams also span the container stacks in the storage/transfer area enabling the Spiders to access all rows of containers. Working in concert with the Spiders are the Cell Elevators, which raise and lower containers in and out of the ship's container cells, such that the Spider cycle time is minimized and productivity is maximized. The amount of time that each Spider must spend on the overhead beam for each move determines the number of moves per hour that can be achieved by the system.

At any particular moment, the number of moves per hour in the entire SPEEDPORT terminal is dependent on the number and sizes of the ships in each of the berths. For each ship size, the number of container moves between ship and shore per hour is dependent on the number of bays of containers on each of the ships.
The time-on-beam for the Spiders is dependent on the size of the vessel in the berth. The Spider requires an average of 143 seconds on the beam to load or discharge a container to or from a 100 TEU ship. This equates to 25.2 moves per hour per bay or 100.9 moves per hour for the vessel, since there are four bays on this size ship. On a 22,000 TEU ship the Spider is on the beam for 111 seconds for each container, or 32.4 containers per hour per beam. As this size ship has 30 bays, this equates to a transfer rate of 974.8 moves per hour.

Vessel Size, TEU	No. Bays (40 ft)	No. Beams	Moves per hour per beam	Moves per hour
100	4	4	25.2	100.9
1,300	9	9	27.6	248.4
2,900	12	12	28.4	340.9
3,900	15	15	28.5	427.4
5,200	16	16	29.0	463.4
7,600	19	19	29.8	567.1
12,000	22	22	31.2	687.0
22,000	30	30	32.5	974.8

Table 1-2 Moves per Hour for Each Vessel Size

Ship Calls Per Year: To calculate the number of ship calls per year required to achieve a throughput of 20 million TEUs per year, ACTA/ABLAZE analyzed four different combinations of ship categories and TEUs/ship call. Each ship category has a minimum and a maximum vessel size, and a minimum and maximum percentage for transfer of TEUs/ship call. Four (4) separate arrival scenario analyses were run, the results of which determined various characteristics of the terminal and its performance.

Based on trending historical data, and extrapolation of near term trends in world fleet composition, it is estimated that approximately 7200 ships (of the mix of sizes predicted for the world container fleet) will call at the proposed SPEEDPORT terminal in the year 2022. This equates to an average of 19.7 ship calls per day.

2. Berth on Arrival

For each of the four arrival scenarios, the berth occupancy time per ship call was calculated for each ship size category. These values were then used to assess the total berth occupancy requirements per year for each ship size category. Berth occupancy time includes the time to enter the berth, moor, work cargo, unmoor and exit the berth.

Ship arrivals in each ship size category were then assigned to berths, making sure that the maximum berth availability hours per year are not exceeded. Where the maximum berth availability was exceeded, ship arrivals were split between more than one berth. Based on this analysis, six indented berths, each of sufficient size to handle a 22,000 TEU ship, are statistically shown to provide 100% berth on arrival. Assuming a very conservative margin of error of 10%, the SPEEDPORT terminal meets the 90% berth on arrival criteria.

3. Labor Productivity

While SPEEDPORT is highly automated, labor is still required to supervise the system, perform maintenance and repairs, update hardware and software, assist in ship berthing, loading and unloading, and provide human assistance where needed, such as with exceptions at the gate.

Excluding purely business operations such as accounting, personnel relations, customs, sales and marketing, SPEEDPORT Labor is divided into a number of departments: Port supervision, gate operations, equipment maintenance, Information Technology (IT) hardware and software, and quay / ship operations. Most of the departments work 24 x 7. A summary of full time equivalent (FTE) personnel requirements is shown in the below:

Category	FTE
Supervisory	15.0
Gate	30.0
Equipment Maintenance	28.0
IT Hardware Maintenance	8.5
IT Software Maintenance	11.0
Quay /Ship	274.0
Total (to cover 24x7, 365 day per year operation)	365.5

Table 1-3
Personnel Requirements

By far, the largest number of staff are assigned to quay operations. In spite of the automation improvements the SPEEDPORT offers in the terminal, this estimate assumes that the vessels and vessel container storage will not have advanced as far, and will require significant human labor for loading and unloading. As vessel technology improves, the labor numbers can be lowered.

It is estimated that the 365.5 FTEs, fully covered by fringe benefits and overhead costs will cost $48,700,000 per year. However, this amounts to only $2.44 per TEU and over 54700 TEU per FTE per year. Total labor hours per year is 760,240, based on 2080 hours per year per FTE. Labor hours per year per TEU is 0.038.

4. Land Productivity

The SPEEDPORT terminal structural configuration is modular in nature, consisting of paired berth and storage modules. Berth modules and storage modules are matched dimensionally in width and height to keep Spider lanes aligned and straight along the full length of the terminal, permitting optimum travel speed of the Spiders and therefore optimal terminal productivity.

Berth Module. As noted above, ACTA/ABLAZE has chosen to size all six berths such that they can accommodate the largest vessel size in the ship mix, which is 22,000 TEU, in order to provide maximum berthing flexibility. The table below illustrates the calculated berth module dimensions based on the 22,000 TEU ship.

Ship Dimensions			Berth clearances, ft			Berth Dimensions						Berth Module Dimensions			
Capacity, TEU	LOA, ft	Beam, ft	Head	End	Side	Length, ft	Width, ft	Ops Suite, ft	Spider Maint, ft	No. Spider Lanes	No. Interquay Transfer Lanes	Berth Module Length, ft	Berth Module Width, Ft	Berth Module Area, sq ft	Beam Width, ft
22,000	1495	195	20	20	20	1535	235	20	60	8	4	1795	371	665,945	371

Table 1-4 Berth Module Dimensions

Berth clearances (i.e., clearances between the ship and the quay structure) are similar to clearances in a navigation lock. Dimensional allowances within the berth area are also included for three other functional areas that are critical to terminal operations and maintenance: an Operations Suite, a Spider Maintenance Area, and Interquay Transfer Lanes.

Storage Module. Each storage module area includes clearance for access in and around the container stacks. Aisles are included to facilitate access to containers, and are spaced every other 40-foot container. Aisles are 6 feet wide, permitting the opening of container doors for inspection. Interquay transfer lanes are located at the end of the storage module to convey Spiders to other terminal modules. Each interquay transfer lane is approximately 45 feet wide.

Stacking heights can vary within the storage module. Shorter stacking heights minimize time to reshuffle containers, but require a larger area. Higher stacking heights increases the time required to reshuffle containers, but results in a smaller area. ACTA selected 4-high stacking as an optimum balance between storage density and access. As more sophisticated, terminal management and ship stowage software becomes available and more universally used, the stacking height of the terminal will be increased by one or two containers. This will result in far smaller Storage Modules, greatly reducing their size and the capital cost of the facility.

In order to ensure the terminal has container storage areas of sufficient size, based on the ship arrival projections, and duration of ship stays in berth, ACTA concluded that the required terminal storage capacity is the largest of the four ship arrival scenarios, 134,285 TEU. This requirement was driven by the scenario with the fewest ship calls (4252) of the maximum size for each ship category.

SPEEDPORT Structure. The proposed terminal structure, encompassing all berths and all storage/transfer areas, occupies a total of 1.345 km^2 (54%) of the 2.5 km^2 site.

Stacking Height	Berth Module Length		Storage Module Length		B/S Module Width		No. B/S Modules	Terminal Length		Terminal Width		Terminal Structure, KM^2	Maximum Land Profile, KM^2	Ratio Terminal Struct. to Max. Land Profile
	Feet	Meters	Feet	Meters	Feet	Meters		Feet	Meters	Feet	Meters			
4	1795	552	4586	1411	371	114	6	6381	1963	2226	685	1.345	2.500	0.54

Table 1-5 Terminal Structure Dimensions

Ancillary Space. The remaining portion of the site will accommodate the gates and truck lanes into and out of the terminal structure, as well as space for supporting services, such as administrative offices, customs inspection station, container and chassis service depot, and electrical generating plant and/or substations. All of these required supporting areas are easily accommodated on the site.

It is anticipated that an average of 251 trucks per hour will be processed at the terminal gate during a 16 hour workday, 365 days per year. A total of 8 lanes are required to handle the maximum anticipated traffic at the gate during a 16 hour workday. However, the gate is designed to accommodate the flow of traffic in the worst-case scenario where 502 trucks will pass through the gate per hour during an 8 hour workday, 365 days per year. A total of 20 lanes are required to handle the maximum anticipated traffic at the gate during an 8 hour workday.

The gate estimate assumes 2,933,334 gate transactions per year based on a total of 1,466,667 trucks entering and leaving the terminal each year. Each truck will incur one gate transaction when entering the terminal and one transaction when leaving the terminal. Further assumed is the estimate that the SPEEDPORT gate can process a gate transaction in 2 minutes, although ACTA/ABLAZE believes that this can be reduced to 1 minute in the future.

There is no requirement for rail in the design for this competition, however, the generic SPEEDPORT design does provide for containers brought to and from the terminal by rail.
Future expansion within the Challenge's maximum land allowance could accommodate two (2) additional modules sized to accommodate 22,000 TEU container ships. This expansion has the potential to grow terminal capacity by approximately 33%.

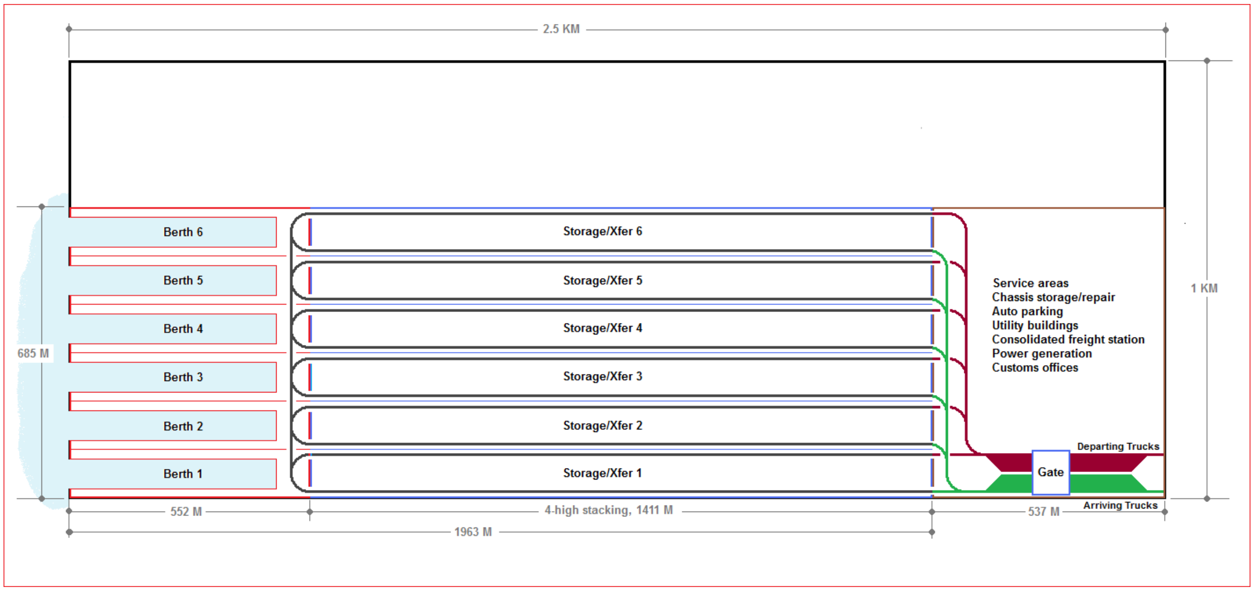

Figure 1-11 SPEEDPORT Configuration

There are three areas within the maximum land profile (black outline) comprising the SPEEDPORT terminal:

1. The ship berth area (red outline) – 37.8 hectares
2. The storage and transfer area (blue outline) – 96.6 hectares
3. The service and gate area (brown outline) – 36.8 hectares
4. Total area = 171.2 hectares or 68.5% of the total area allowed in the NGCP Challenge

Further land use efficiencies could be gained by building the berths on piles within the allotted sea area adjacent to the proposed terminal. This terminal design would provide the exact same performance at a different construction cost and occupy only 133.4 hectares or 53.4% of the allowed land area. This change would result in a land productivity rate of over 150,000 TEU per hectare per annum. However, ACTA/ ABLAZE has chosen to base its proposed design on indented berths with solid quay walls, so as to minimize the risk of oil or chemical spill propagation to the waters of the adjacent harbor.

In a port city with high demand for industrial or commercial space, land use efficiencies could also be gained, by modifying the storage area of the SPEEDPORT terminal to provide as much as 644,000m^2 of land for warehousing, offices, or industrial uses. This is based on a notional truck transfer area of approximately 1/3 of the length of the storage and transfer module. This design feature would raise the working level of 2/3 of the storage area approximately 60 feet above the ground. The space under the elevated container stacks (still stacked 4-high) would be capable of housing up to six stories of useful enterprises. This equates to over 3.8 million square meters of leasable industrial/commercial space. Also, increased container transfer rates would result from adding this feature, as the distance between the container stacks and the overhead beams would be reduced by 60 feet for 2/3 of the storage area module.

5. Environmental Sustainability

SPEEDPORT is the world's most environmentally friendly terminal. All container movements within the terminal are made by electric powered vehicles. The facility's 132 hectares of rooftops are covered by solar panels that generate, on average, more power than is consumed by the terminal and its vehicles. In a similar effort to reduce carbon emissions, the SPEEDPORT will have the capability to cold-iron all ships during cargo operations.

The three-sided, indented berths of the SPEEDPORT are closed in by a floating oil containment boom as a part of the terminal's standard operating procedures. Any risk of oil propagation beyond the slip is mitigated by the placement of the boom, protecting the environment of the local waterways.

Due to the enclosed design of the terminal, there is minimal impact to the local community from light and noise. There are no expansive parking areas or open areas of the terminal requiring high intensity lighting that disperses out beyond the fence line of a conventional terminal. The walls and roof of the structure also contain the noise that occurs during container placement onboard ships or in the storage areas.

6. Financial Sustainability

The financial sustainability was calculated by assessing the capital expenditures and annual operating and maintenance expenditures, and applying them over a project life of 20 years at a 5% interest rate. A project life of 20 years was chosen as this is the maximum life expectancy of the major terminal equipment, and at 20 years, will likely require additional capital investment to extend the operational life of the terminal.

All computational models in this proposal are based on conservative cost estimates and operating scenarios. Based on a total capital expenditure of US$7,660,390,475 and annual operating expenditures of US $273,218,583 over the life of the project, the total cost per TEU through the SPEEDPORT terminal is US$44.40

E. Conclusion

The unique arrangement of the SPEEDPORT terminal, the use of a fleet of independent Spider container handling vehicles, and employment of the Cell Elevator make this proposal the new paradigm for the Next Generation Container Port.

Our proposed terminal meets all of the criteria for success as outlined in the NGCP Challenge requirements while making the most conservative assumptions about all aspects of the design. The terminal is designed to handle an annual throughput of over 20 million TEU flowing through the six indented berths and their associated container storage and transfer modules. SPEEDPORT's high density storage allows room for future expansion of two additional berths which would enable the terminal to reach a capacity of 26.7 million TEU per year. In areas where land for commercial use is in high demand, the working level of the approximately 60 hectares of the storage and transfer areas of the SPEEDPORT terminal can be elevated to enable up to six stories of commercial office, warehouse, manufacturing space or other use.

Based on the trend of increasing size of the world container fleet, each of the terminal's berths is designed to accommodate one 22,000 TEU Ultra Large Container Ship (ULCS) or a mix or smaller capacity vessels. The berth's system of elevated rails and overhead beams provide the pathways for the terminal's fleet of independent Spider container handling vehicles to safely move containers between the ship and the storage area or directly onto its next mode of transportation. The fleet of Spiders is capable of attaining container transfer speeds of over 950 moves per hour to and from one ULCS due to the ability to work all bays of every ship simultaneously. Cell Elevators lift containers from within the ships hold to deck-top level on all vessels to improve the efficiency of the terminal operation.

90% berth availability on arrival is achieved through the ability of each of the terminal's indented berths to accept and work cargo on multiple smaller vessels without interruption as vessels come and go.

The fact that the movement of all cargo is conducted by automated robotic vehicles makes the employees in the SPEEDPORT terminal the most productive waterfront workers in the world, moving over 54,700 TEU per year per full-time employee.

The all-electric enclosed SPEEDPORT facility is environmentally sustainable. The expansive rooftop areas above each of the six berth/transfer and storage modules will house over 132 hectares of photovoltaic solar panels. This energy will be delivered continuously during daylight hours, providing over 100% of the energy requirements of the terminal. When solar generated electricity exceeds the demand of the terminal, the excess power will be sold back to the local grid.

As tidal power generation becomes more efficient, we will examine the possibility of harnessing this power source for our terminal.

Finally, the SPEEDPORT terminal is financially sustainable. This proposal is based on extremely conservative estimates of capital and operational costs. The SPEEDPORT structure is a simple all steel design that can certainly be improved upon once the design is taken past the conceptual state. Similarly the weights and costs of the materials and outfitting equipment of the Spider vehicles are based on basic structural elements and are estimated conservatively to ensure the realism of this proposal.

Enhanced by the addition of the Cell Elevator, which increases the transfer rate between vessels and the quay, the unique arrangement of the SPEEDPORT terminal and its fleet of Spider container handling vehicles provide a quantum leap in the design of intermodal container terminals. This system provides the speed, accuracy, safety, robustness and level of sustainability that is being demanded of terminals today.

Although the parameters of the Next Generation Container Port Challenge were defined by the needs of the year 2022, the terminal described in this proposal can be built today. Why wait any longer? The design and technology required to move forward are available today.

SPEEDPORT is the new paradigm for the intermodal transportation industry.