Port Innovation Workshop Final Report

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1 Executive Summary

In order to explore opportunities for improving the sustainability and energy efficiency of their cargo container operations, the Ports of Seattle and Tacoma convened a two-day Innovation Workshop in collaboration with Puget Sound Clean Air Agency (PSCAA) and Rocky Mountain Institute. The event included representatives from both ports, NGOs (non-governmental organizations), government, shipping lines, terminal operators, rail, trucking, local utilities, and labor.

Questions for the workshop included, but were not limited to:

- How can ports simultaneously grow business *and* reduce environmental impact?
- How can we make cargo moving seamless?
- Can we move cargo around the world using significantly less energy?
- What would a zero-emissions terminal look like?

Over the course of the Workshop, participants identified forty-four ideas for increasing efficiency and improving air quality in cargo container marine ports. These opportunities fell into the following three categories:

Port leadership opportunities – achievable short- to medium-term ideas for the Ports of Tacoma and Seattle.

Partnership opportunities – medium-term ideas that will require the cooperation of other groups or networks to execute.

Blue Sky opportunities – long-term, innovative ideas that may require the development of new intellectual capital or large-scale paradigm shifts.

Ideas of note included:

Developing a pilot project for the electrification of yard hostlers (Leadership Opportunity)
Shifting from diesel to electric yard hostler would eliminate on-port hostler emissions and draw power from low or zero-emission electricity from Seattle City Light or Tacoma Power. Initial life cycle calculations suggest that electrification could save $95,000 over the lifetime of each vehicle.

Building an "Information Guru" system to better integrate and coordinate information regarding container transportation (Partnership Opportunity)
A central barrier to increased efficiency and reduced bottlenecks in intermodal cargo shipping is the smooth exchange of information along the supply chain. The Information Guru system would be a consolidated, comprehensive data-sharing system to better coordinate transportation information, yielding saved time and money, reduced idling, and lower emissions.

Creating a lease or lease-to-own financing structure that provides drayage truckers access to cleaner vehicles (Partnership Opportunity)
Most drayage truck drivers lack the financial means or the financial incentives to acquire low-emission technology for their trucks. A loan fund offering a ten-year lease to truckers (and possibly an additional rebate for trading in their old, high-emission truck) could stimulate use of green vehicle technology and reduce emission impacts from the 1200 to 1500 drayage trucks servicing the Puget Sound region.

A suite of recommendations around voluntary clean technology practices and performance standards for ocean-going vessels (Partnership Opportunities)
Ideas included a "feebate" system to encourage vessel use of cleaner fuels while at dock; global standards for vessel emissions and shore power plug-in technologies; encouraging pilot testing of emissions-reduction technologies by vessel operations; and sharing of best practices and successes via collaboration between Ports of Tacoma, Seattle, and Puget Sound Clean Air Agency.

Multiple innovative design ideas intended to challenge and inspire (Blue Sky Opportunities)
These "NuPort" ideas included lightweighting Super Post Panamax cranes for energy savings and reduced infrastructure cost; small, wind powered container vessels; moving containers via inflatable air mats; and alternative techniques for designing and unloading container ships.

The Ports of Seattle and Tacoma, in partnership with PSCAA and other regional entities, are already engaged in an impressive list of activities to improve regional air quality and stimulate clean technology for their industry. In a period of unprecedented growth and public concern for the environment, there are opportunities to go even further. In the long term, leadership in the arena of ports efficiency and improved air quality may prove the competitive advantage that ensures their existence and success well into the next century.

2 Introduction

The projected future growth in global maritime activity presents tremendous opportunities and challenges for Northwest ports. Imports from Asia into the Puget Sound region are expected to increase significantly in the coming years. The growth goals of both ports are ambitious, and increasing globalization will likely result in a doubling or tripling of international cargo during the next few decades. In this context, reducing or eliminating air pollution from port operations is a challenge that will require considerable energy and creativity across the international intermodal goods movement industry.

The continued success of both ports is important to the economic health of the region. More than 113,000 jobs in Washington State are connected to the Port of Tacoma,[1] and more than 150,000 jobs to the Port of Seattle's seaport operations. One in three jobs in the state of Washington depends on international trade.[2]

In addition to managing growth, both ports face growing challenges related to the environment. The Puget Sound region, where the ports are located, is currently in compliance with all National Ambient Air Quality Standards. A major goal of both ports' air quality programs has been to reduce emissions from their operations.[3] Both ports are working aggressively to reduce greenhouse-gas emissions rather than waiting for regulations. At the same time, growing concerns over diesel particulate matter and health as well as climate-change issues are encouraging both ports to further reduce emissions from maritime-related activities, thus building upon their existing award-winning air quality programs.

Containerization dramatically changed the shipping industry forty-plus years ago, increasing the loading and unloading efficiency of dockworkers six thousand times in terms of tons moved per man-hour, cutting vessel docking time from three weeks to eighteen hours, and radically improving the deployment opportunities and carrying capacity of cargo vessels.[4] Ensuring a sustainable and prosperous future may stimulate innovation of a similar magnitude within the next decade.

The Innovation Workshop focused almost exclusively upon issues surrounding containerized cargo. Participants did not examine in any detail other port operations such as aviation, bulk cargo, marinas, etc. Similar workshops for other elements of port operations may prove useful for identifying additional opportunities in the future.

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[1] www.portoftacoma.com/aboutus.cfm?sub=26.
[2] Trade Development Alliance of Greater Seattle www.seattle.gov/tda/trade_info/stats_info.htm.
[3] There are many sources of air emissions in the area unrelated to ports activities. For example, in the case of the "$PM_{2.5}$" (particulate matter small than 2.5 microns) standard, the major threat to regional compliance at this time is home heating with wood.
[4] From "A sea change in shipping: 50 years ago, container ships altered the world." George Raine, *Chronicle Sunday*, February 5, 2006.

2.1 Current State of the Ports

Port of Seattle

The Port of Seattle handled 2 million twenty-foot-equivalent units (TEUs) in 2006, and expects to double its throughput to 4 million TEUs at its major container terminals in the next 10 to 15 years. About 35 percent of the movement of goods out of the port is by truck; the remaining 65 percent is by rail. Most rail capacity is near-dock rather than on-dock, thus requiring a short drayage trip (often less than a mile) to transfer containers to rail. The availability of very near-dock rail allows Seattle to maximize cargo operations without losing space to rail operations on the terminal. A recent expansion study indicates that harbor area rail yards' volume is the primary constraint to growth, with mainline rail capacity and off-dock support capacity secondary constraints.

At the Port of Seattle Terminal 30 Cruise Facility, cruise ships can plug in to the electrical grid at two berths, a process known as shore power or "cold ironing." This process eliminates the need to run ships' engines while in port, reducing local air pollution emissions and shifting the energy demand to Seattle City Light, a utility with one of the cleanest electricity supplies in the United States.

Port of Tacoma

The Port of Tacoma moved almost 2.1 million TEUs of cargo in 2006 and expects to quintuple that number to 10 million TEUs annually in the next 20 years, with an annual projected growth rate of 8.6 percent, resulting in ~3.1 million TEUs a year by 2011. The port handles containers as well as bulk cargo, break bulk (non-containerized cargo), and project/heavy lift cargos in addition to automobiles and medium-duty trucks.

Tacoma installed on-dock rail in the 1980s and now has four rail yards served by Burlington Northern Santa Fe (BNSF) and Union Pacific (UP). Four of the port's six terminals have on-dock rail and one has near-dock (across the street). There are three facilities for break bulk, one for automobiles, and four intermodal facilities. About 70 percent of the international cargo is shipped out by rail, and 30 percent via drayage or short haul trucks. The port expects this ratio to stay about the same with growth.

2.2 Port Challenges and Opportunities

Air Quality

The Seattle–Tacoma area was out of compliance with federal air quality standards for ozone and carbon monoxide until 1996 due primarily to motor vehicle emissions. It reached attainment for particulate matter in 2001. Currently, the greater Puget Sound region is in compliance with federal air quality standards with the exception of the EPA's new fine particle standard. Monitoring data indicate that areas in Pierce (Tacoma) and Snohomish (north of Seattle) Counties will violate that new standard. A voluntary Maritime Emissions Inventory of the two ports is expected in April 2007; the results will help identify areas of greatest opportunity and urgency for the two ports with regard to air quality improvements.

Both the Puget Sound Clean Air Agency (PSCAA) and the Washington State Department of Ecology ("Ecology") state that of the various outdoor airborne pollutants, diesel particulate matter poses the greatest cancer risk. In 2001, the Clean Air Agency implemented the Diesel Solutions program to bring clean fuels and clean engines to the region well in advance of EPA's national standards. The Clean Air Agency also led a 2003 effort to secure funding from the Washington State Legislature for clean diesel projects. Although this funding has focused on school buses, projects involving marine emissions have also received state funding. Most recently, Ecology has developed a Diesel Particulate Emission Reduction Strategy for Washington State (report released December 2006) to address concerns prompted by diesel emissions, particularly fine diesel particulate matter ($PM_{2.5}$) which represents 94 percent of diesel particulate emissions.[5] In 2006, the federal EPA adopted a newer, stricter policy for $PM_{2.5}$. There is concern that while all of Washington State met the old standard, many areas may not meet the new standard.[6]

Emissions from Vessels

Emissions from ships include particulate matter (PM), nitrogen oxides (NOx), sulfur oxides (SOx), carbon dioxide (CO_2), and volatile organic compounds (VOCs). Currently, the International Maritime Organization's (IMO) MARPOL Annex VI convention sets standards, with respect to air quality, for ocean-going vessels. MARPOL Annex VI sets limits on NOx emissions for new engines and has established a global cap for marine fuel sulfur content at 4.5%; additionally a country can apply to be designated as a Sulfur Emissions Control Area (SECA), which reduces the marine fuel sulfur content to 1.5%.[7]

Emissions from Drayage Trucks

Drayage trucking involves the movement of containers from the terminals at the ports to local distribution centers and warehouses or to near-dock rail. Each run is generally short (estimates are 10-30 miles for the Port of Seattle and 15-25 miles for the Port of Tacoma), and drayage trucks are controlled by independent owner-operators rather than a single corporation.

Drayage trucking offers an area for substantial improvement, as the trucks used are often very old long-haul trucks that were not intended for short-hauling. They emit considerable pollution, and pre-1988 trucks may emit 60 times more diesel particulate matter (DPM) than new trucks sold today under 2007 EPA heavy truck standards.[8] Current rate structures for freight do not incorporate energy usage and emissions, so they do not provide a method for distributing these costs along the supply chain. Trucks are

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[5] "Ports in a Storm," Dinesh, C. Sharma, Environmental Health Perspectives. 2006 April; 114(4): A222–A231.

[6] "Diesel Particulate Emission Reduction Strategy for Washington State," Washington State Department of Ecology Air Quality Program, December 2006.

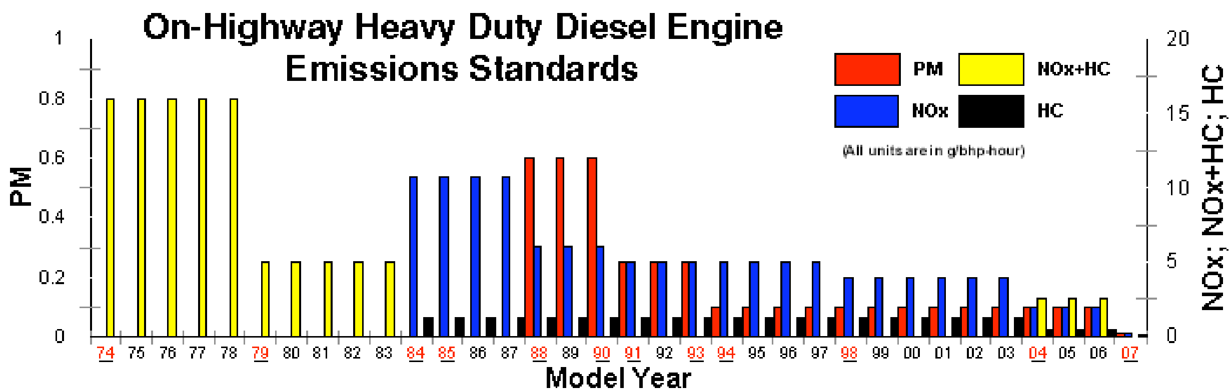
[7] "In-Use Marine Diesel Fuel." EPA. 1999. www.epa.gov/otaq/regs/nonroad/marine/ci/fr/dfuelrpt.pdf.

[8] Calculation done comparing old EPA emissions standards to new ones, see Figure 1

often single-cycled or make bobtail trips without chassis, which results in a suboptimal utilization of the fleet.

Details regarding net emissions from sources other than vessels and trucks (cargo-handling equipment, rail, tugs) are described in greater detail in the forthcoming Puget Sound Emission Inventory.

Figure 1: EPA Emissions Standards Timeline[9]



Surge and Bottlenecks

Due to shipping schedules in Asia, a surge of vessels often arrives at the West Coast ports that receive most of their vessels directly from Asia over the weekend, including the Ports of Los Angeles and Long Beach. This results in hectic two- or three-day "work weeks" for the terminals as they rush to offload the ships as fast as possible, as well as a productivity pulse that goes through the rest of the system. One source referenced a very rough cost for a ~6000 TEU vessel as $50,000 per day (capital cost, operations, etc.), regardless of what the vessel is doing. This high daily cost provides an incentive for the operators to pay the increased costs associated with 24-hour operation at the terminals; the much smaller daily costs of train operation do not usually justify 24-hour operation.[10] Surge is less of an issue for Port of Tacoma and other Pacific Northwest ports since many of their vessels stop in other West Coast ports first. Nonetheless, initiatives that reduce surge will likely yield other benefits along the supply chain.

Collaboration and Environmental Leadership

Although competitors, the Ports of Tacoma and Seattle cooperate over things of mutual interest such as freight mobility (setting up roads so that drayage trucking can move freely), grade separation (separating rail and drayage trucks from roadways via overpasses, underpasses, bridges, etc.), and mainline rail improvements. The Puget Sound Maritime Air Emissions Inventory will be the first detailed regional emissions inventory in the United States to include a comprehensive greenhouse-gas emissions inventory

[9] http://www.epa.gov/otaq/retrofit/overoh-all.htm
[10] Personal communication, Port of Seattle employee, January 30, 2007.

from maritime-related sources. The Ports of Tacoma, Seattle, and Everett are working with the Washington State Department of Transportation on the FAST (Freight Action Strategy) Corridor Project to streamline the movement of freight through the Puget Sound Region by building numerous grade separations over rail tracks. This leads to a reduction in emissions because vehicles are not delayed by train traffic.

In February 2005, the Port of Seattle Commission adopted a resolution expressing its commitment to maritime air quality and to helping maintain the region's compliance status, as well as urging the governments of the United States and Canada to seek designation of the U.S. and Canada as a SECA under IMO MARPOL Annex VI. In February 2006, the Port of Seattle and multiple stakeholders[11] created a memorandum of understanding (MOU) for emissions reductions. They agreed to work collaboratively on issues such as gate technologies and electronic truck tags at terminals that would help alleviate truck congestion, seaport-related emissions, and share information via meetings and electronic "clearinghouse" forums.[12] Both ports have led the industry in the use of cleaner equipment, retrofits, and a widespread switch to ultra-low-sulfur diesel and biodiesel blends in cargo terminal operations in the region. The U.S. EPA recognized the leadership of the Port of Seattle with the first ever award to a seaport for the implementation of emissions reduction strategies and leadership within the industry.[13]

In addition, both ports have a strong desire to act as good neighbors to surrounding constituencies and to partner with local governments around issues of greenhouse-gas emissions. Tacoma has signed the U.S. Mayors Climate Protection Agreement initiated by Seattle and nine other cities, in which participating cities have agreed to meet or exceed Kyoto's 2012 reduction targets. The Mayor of Seattle has announced his desire to meet or exceed the reductions mandated by the Kyoto Protocol for 2012 (7 percent below 1990 emissions), and the Port of Seattle has joined the City of Seattle's Seattle Climate Partnership.

An additional collaboration effort is the Puget Sound Maritime Air Forum. The Forum is a voluntary, broad-based regional association of maritime organizations, air agencies, and other parties with operational or regulatory responsibilities related to maritime industry air quality impacts. Begun in 2004, the Forum is led by the Port of Seattle and includes members from throughout the greater Puget Sound region and Western Washington. Forum members have a shared interest in enjoying the benefits of cleaner air, protecting the region's ambient air quality attainment status, participating in policy decision making regarding maritime operations, ensuring that policies are based on the best available information, minimizing regulatory mandates, enhancing the region's economic competitive advantages, and preserving positive relationships with communities. By improving understanding of maritime-related emissions sources, the maritime community

[11] Port of Seattle, West Coast Trucking, BNSF, Union Pacific Railroad, SSA Terminals, APL, TTI, Expeditors International, MacMillan-Piper, and NYK line.
[12] Draft Memorandum of Understanding, Seattle Seaport Industry Resolution on Traffic Congestion and Air Pollution Prevention, Feb 10, 2006.
[13] Further detail is available at http://www.portseattle.org/news/press/2006/04_05_2006_70.shtml

will be better able to design and implement cost-effective, fact-based air pollution control strategies. These strategies, in turn, will help ensure the long-term success of maritime commerce in our region with its positive impact on the region's economic vitality. Forum members have agreed to provide funding, data, in-kind assistance, technical expertise or a combination thereof and have agreed to work together to develop the 2005 baseline Puget Sound Maritime Air Emissions Inventory.[14]

Beyond the significant current initiatives, future opportunities for collaboration and leadership abound. For example, the Port of Seattle's upcoming 100th anniversary offers an additional opportunity to showcase the entire Puget Sound region as a leader in innovative, cost-effective operations and design for sustainable ports.

3 Innovation Workshop Summary

In preparation for the Workshop, a team from RMI conducted a site visit in the fall of 2006 in order to gain a first-hand understanding of the size and complexity of port operations, energy usage and emissions concerns, and the differences in operations between the two ports. They met with representatives from both ports and the Puget Sound Clean Air Agency.

The Innovation Workshop was held January 8–9, 2007 at the Hilton Seattle Airport and Conference Center. It brought together more than fifty Port of Seattle and Port of Tacoma stakeholders, including port employees, terminal operators, labor representatives, consultants, utility personnel, and regulators.[15] The Workshop was part of a larger effort to generate near-term and long-term action plans to improve the environmental and economic performance of both ports while simultaneously respecting and challenging the perspectives of all stakeholders.

All of the participants were chosen for specific technical expertise in air, energy, operational, or business expertise. Furthermore, each participant was jointly agreed upon by the sponsors and RMI to ensure a well-rounded group with the overall expertise needed for success.

Day One

Day One of the Workshop began with introductions from the Managing Director of Seattle Seaport Charlie Sheldon and Port of Tacoma Executive Director Tim Farrell. Following the introductions, Stephanie Jones (Senior Manager of Seaport Environmental Program for the Port of Seattle) and Lou Paulsen (Senior Director of Facilities Development for the Port of Tacoma) made presentations summarizing current challenges, opportunities, and each port's goals.

The Port of Seattle's presentation, "Progress and Challenges in Air Quality and Energy Efficiency," began with cargo growth projections and existing constraints or concerns. A major concern is the pollution emissions related to port activities. Areas of current work

[14] For further information and a list of members, go to http://maritimeairforum.org/
[15] See Appendix A for a full list of participants.

include electrification (shore power); road, rail and terminal efficiencies; and emissions reduction projects. Current challenges include trucks, terminal operations, ocean-going vessels, and the complexities of the overall system.

The Port of Tacoma presentation provided an overview of container growth projections and air quality, specifically diesel particulate emissions related to different pieces of port equipment. Current efforts to address these concerns include the use of ultra-low-sulfur diesel usage and emissions reduction retrofits. The port is looking for innovative ways to take advantage of the opportunities available in efficiencies, asset utilization, and emissions reduction to meet the challenges of future port growth.

Amory Lovins, CEO of Rocky Mountain Institute, closed the morning with a presentation on efficient engineering design and its applications to port operations. Lovins offered examples from the building, manufacturing, and transportation sectors that illustrated how better design can lead to significant savings of both natural and economic capital. Lovins also explained the concept of "muda," a Japanese word that means waste or opportunity, and a well-known concept in the field of lean manufacturing.

In the afternoon, Workshop attendees participated in one of four breakout groups:

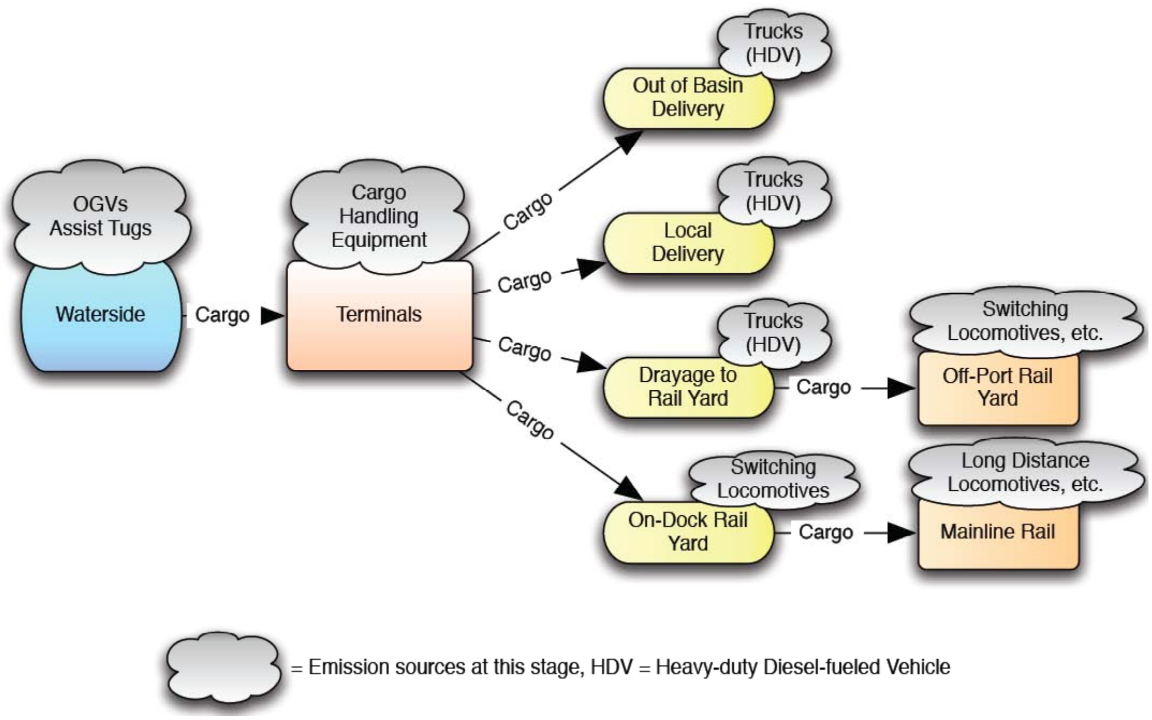
Goods Arrival, which refers to activities related to vessels coming in from the sea and the unloading process to the point where the container is offloaded onto the terminal.

Goods in Port, which refers to all terminal activities, including cargo handling, container movement, and container storage. The *Goods-in-Port* period includes all activities until the container leaves the port for an inland destination.

Goods Leaving, which refers to activities around truck or rail transportation of the containers from the ports to an inland destination.

Business Opportunities, which refers to the overall strategic and financial operations of the ports.

Figure 2: Imported Cargo Flow Diagram



The breakout groups were asked to identify opportunities for improvement—with a focus on ideas that improve air quality *and* increase efficiency of operations—at the ports. Each participant was provided with a "muda" worksheet and asked to identify an initial list of sources of muda within the area of focus for the breakout group. Following the articulation of opportunities, each group generated potential solutions to a subset of those opportunities. These were reported to all Workshop attendees at the end of the day.

At the conclusion of day one, the day-two breakout groups were reconfigured to reflect the highest-priority issues that were identified on day one. Several solution sets were put aside on day two, either because they were established projects with known champions, or because their scale and political nature exceeded the scope and reach of the Workshop. Examples of ongoing work in the transportation infrastructure area were the FAST Corridor project and the Container Ports Initiative Policy Brief, which was issued by the Washington Governor's office on January 18, 2007; it calls for improvements in transportation infrastructure.[16]

Box 1: Day One Solution Sets

Efforts already underway with leadership in place:

1. Emissions from ships/harbor crafts
2. Vehicle/engine efficiency (non-electric)
3. Off-dock infrastructure (road and rail)
4. Street Traffic/truck congestion in Seattle

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[16] Washington State Governor Chris Gregoire, Container Ports Initiative www.governor.wa.gov/priorities/economy/ports.pdf.

Solutions outside the scope of the workshop as a large-scale political issue:

5. Emissions-trading structure

Solutions ideas for second day:

6. Container imbalance and storage (tabled based on participant feedback)
7. Logistics and Information flow (e.g., surge, container tracking, chassis pooling)
8. Truck-ownership business model/screening/access
9. Port electrification (hybrids, plug-in hybrid electric vehicles (PHEVs), electric vehicles (EVs), etc.)

Initiatives from the floor:

10. Next-generation supply chain — The NuPort
11. Vessels

The initial day-two breakout groups were organized around the following topics:

Logistics:
How do port operators reduce the unnecessary movement of chassis, boxes, and trucks?
Container Imbalance: What can be done to reduce the massive numbers of empty containers in North America caused by the trade imbalance with Asia, which generate large storage costs and deadhead runs back to Asia by container ships?

Trucking: What business models or initiatives can help reduce emissions and improve the efficiency of local drayage trucks in a manner that creates "win-win" opportunities for the ports and the trucking companies?

Port Electrification: What opportunities are there to move from diesel power to electric power within a port? Such a switch could improve efficiency, reduce emissions from the port, and encourage the port's electric utility to leverage clean energy sources.

NuPort: What would a totally redesigned port—free of the constraints of modern port infrastructure and design—look like?

After feedback from participants in the morning, container imbalance was considered to be too large an issue and of lower priority than the topic of vessels. It was replaced with: How to reduce current and future vessel emissions in a cost-effective manner via seawater scrubbing, cold ironing, clean fuels, or other means?

Day Two

Dennis McLerran, Executive Director of the Puget Sound Clean Air Agency, introduced the second day of the Workshop. McLerran stressed the importance of collaboration in the Puget Sound area and the opportunity to learn from the experience of the Ports of Los Angeles and Long Beach in managing their pollution emissions problems.

Amory Lovins reflected on the discussions of day one. Lovins questioned the concept of container "dwell time" and suggested a goal of "zero dwell"—in other words, that containers be in constant motion in the port once transferred from vessel to shore. He also remarked on how pricing could be a function of cargo arrival time and potentially contributes to alleviating vessel surge.

Participants spent the remainder of the morning and the early afternoon in the day-two breakout groups. At the conclusion of the Workshop, each group reported back its findings, which included new ideas, action plans,[17] potential barriers, and next steps.

4 Summary of Ideas

The forty-four ideas generated at the Workshop are listed below according to the breakout group that discussed and developed them. Two ideas, lightweighting cranes and lighting improvement, were formulated on day one but not pursued in detail in the day-two breakout groups.

4.1 Classification of Ideas

RMI further classified the ideas generated into three categories described in **Box 2** below. All the ideas from the workshop are collected in Tables 1-5 based on the breakout group that generated them.

Box 2: Idea Classification

Port leadership opportunities – achievable short- to medium-term ideas for the Ports of Tacoma and Seattle.

Partnership opportunities – medium-term ideas that will require the cooperation of other groups or networks to execute.

Blue Sky opportunities – long-term, innovative ideas that may require the development of new intellectual capital or large-scale paradigm shifts.

[17] The roadmap worksheet supplied to each group is provided in Appendix F.

Table 1: Day One & Ports Electrification Ideas

Idea #	Solution	Breakout Group	Idea Classification
1.1	Lightweighting Cranes	Day One Groups	Blue Sky
1.2	Lighting Improvement	Day One Groups	Port Leadership
2.1	Harborcraft Electrification	Ports Electrification	Port Leadership
2.2	Harborcraft Charging from Clean-Energy Vessels	Ports Electrification	Blue Sky
2.3	Rubber Tired Gantry Crane Hybrid Retrofit	Ports Electrification	Port Leadership
2.4	Auxiliary Power Unit Retrofits for Trucks	Ports Electrification	Partnership
2.5	Rail Locomotive Hybrid Retrofit	Ports Electrification	Partnership
2.6	Yard Hostler Electrification	Ports Electrification	Port Leadership

Table 2: Vessels Ideas

Idea #	Solution	Breakout Group	Idea Classification
3.1	Encourage use of cleaner fuel in auxiliary engines while at dock	Vessels	Partnership
3.2	Develop global vessel-emissions standards through the IMO	Vessels	Partnership
3.3	Strengthen IMO MARPOL Annex VI through cooperation with international stakeholders	Vessels	Partnership
3.4	Develop international standards for shore-power plug-in technologies in order to prevent the proliferation of incompatible technologies.	Vessels	Partnership
3.5	Develop incentives to encourage vessel owners to demonstrate and test various emission-reduction technologies and find the most efficacious solutions.	Vessels	Partnership
3.6	Develop collaborative conversation among steamship companies in which they share their experiences trying new solutions.	Vessels	Partnership
3.7	Develop positive PR for green ports, in part, using progress in vessel emissions.	Vessels	Partnership
3.8	Convene stakeholders to develop a best path to use of cleaner fuels in main engines.	Vessels	Partnership
3.9	Work with Pacific Ports Clean Air Collaborative to achieve related ideas on list	Vessels	Partnership

Table 3: Logistics & Trucking Ideas

Idea #	Solution	Breakout Group	Idea Classification
4.1	Transportation Information Guru System	Logistics	Partnership
4.2	Chassis Pooling	Logistics	Partnership
5.1	Leasing or Lease-to-Own for Cleaner Trucks	Trucking	Partnership
5.2	Feebate Program for Cleaner Trucks That Pays Higher Container Rates	Trucking	Partnership
5.3	Express Lane for Cleaner Trucks	Trucking	Partnership
5.4	Clean Truck Design Competition	Trucking	Partnership

Table 4: NuPort Ideas (Container)

Idea #	Solution	Breakout Group	Idea Classification
6.1	Decouple Power from Cargo	NuPort - Container	Blue Sky
6.2	Move containers with airmat technology	NuPort - Container	Blue Sky
6.3	Fast Ship	NuPort - Container	Blue Sky
6.4	Longitudinal Cassette Discharge	NuPort - Container	Blue Sky
6.5	Intelligent Cargo	NuPort - Container	Blue Sky
6.6	Third Party Service Providers	NuPort - Container	Blue Sky
6.7	Automated Crewless Ships	NuPort - Container	Blue Sky
6.8	Transverse Block Discharge	NuPort - Container	Blue Sky
6.9	Move vessels up and down via locks	NuPort - Container	Blue Sky
6.10	Water Wheel	NuPort - Container	Blue Sky

Table 5: NuPort (Non-Container) and Non-Group Ideas

Idea #	Solution	Breakout Group	Idea Classification
7.1	Non-Scale-Based way of Reducing Tare	NuPort - Non Container	Blue Sky
7.2	Rubik's Cube In-Transit Sorting	NuPort - Non Container	Blue Sky
7.3	Sea Snake	NuPort - Non Container	Blue Sky
7.4	Breakbulk Cargo Holds with Sorting Technology	NuPort - Non Container	Blue Sky
7.5	Automated Sorting to Destination Bins	NuPort - Non Container	Blue Sky
8.1	1000-TEU Wind-Powered Container Vessels	Non-Group	Blue Sky
8.2	Port Research Center	Non-Group	Partnership
8.3	Drift Packages using currents	Non-Group	Blue Sky
8.4	Ocean Pipeline Batches	Non-Group	Blue Sky
8.5	Galvanic Vessel	Non-Group	Blue Sky

4.2 Linkages

The following section addresses some recurring themes that emerged across the different breakout groups.

Electric Load, Renewables, and Efficiency

When possible, replacing internal combustion engines with electric or hybrid electric vehicles could mitigate some aspects of air pollution. Unlike mobile sources of emissions (vehicles), power plants are stationary sources of pollution and are therefore generally easier to control. For carbon dioxide, each kilowatt-hour that replaces diesel saves 2–4 pounds of carbon dioxide (depending upon whether the electricity replacing it is from zero-emission renewable energy, or from fossil fuel).[18] Electrification of vehicles that traditionally run on diesel could help to mitigate local levels of diesel particulate matter.

All electricity-related discussions during the Workshop were based on the premise (supported by existing data) that the greater use of electricity reduces overall emissions (including source emissions for the grid). [19] In particular, Seattle City Light, power

[18] Joel Swisher, RMI, personal communication 1/9/07. The Electric Power Research Institute (EPRI) reported that the use of electricity instead of fossil fuels to power vehicles results in a significant reduction in overall emissions considering the national electric grid, which was 56% powered by coal in 2000.
[19] In 1995 the Los Angeles Department of Water and Power (the Port of Los Angeles utility) and Southern California Edison (the Port of Long Beach's utility) had a carbon intensity of 8.44 lbs carbon/$ revenue, and 4.81 lbs carbon/$ revenue, respectively.

provider for the Port of Seattle, is carbon neutral. Tacoma Power has a strong mix of zero-emission renewable energy capacity and plans on further reducing their carbon footprint in the future.

If the ports increased the electrification of their operations, they could potentially expand the use of low-emission/carbon-neutral electricity in coordination with Seattle City Light and Tacoma Power. This would help reduce emissions beyond the scope of the ports and improve the long-term sustainability of the Puget Sound region. In addition, the Pacific Northwest could drive energy and air quality technology research and development as a result of the ports' quest for distributed generation, energy storage, and renewable energy devices and systems.

Emissions, Waste, and Worker Safety

Opportunities for improving energy efficiency and reducing waste often also yield benefits in the form of improved workplace conditions. A study done by the California Air Resources Board estimates that for every dollar spent on reducing diesel particulate emissions, health care costs are reduced by $3–8,[20] and the Union of Concerned Scientists estimates that every dollar spent on diesel emissions exhaust retrofits returns $9–16 to society. While the costs of emissions reduction are high, it is a small percentage of the total operating and maintenance costs for the existing diesel fleet over 10 years.[21]

Local air quality is a topic of concern for labor. In spring 2006, the local International Longshore and Warehouse Union (ILWU) chapter and the Apollo Alliance and the Sierra Club sent a letter to the Port of Seattle expressing concern over diesel emissions and continued dependence upon foreign oil. The letter specifically called for reduction targets for SOx, NOx, PM, and CO_2 emissions; provisions in tenant leases for monitoring air quality; and measures in the leases requiring practices to improve air quality.[22] Similar calls to action are occurring in unions around the country. The coast-wide presence of the ILWU puts them in a good position to advocate changes up and down the West Coast.

There are other overlaps between worker safety and improved efficiency. For example, driver jostling due to the setting and resetting of a container on a chassis can result in injury, wasted time, and damaged equipment. Wasted time can easily increase bottlenecks in the system, which in turn increases idling time and emissions. Reduction of waste in the system, if done properly, can yield multiple benefits for all involved.

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[20] Recommendations: California EPA, Air Resources Board, March 21, 2006; "Sick of Soot: Reducing the Health Impacts of Diesel Pollution in California," Union of Concerned Scientists, Cambridge, MA, 2004.
[21] "Recommendations for Reducing Emissions from the Legacy Diesel Fleet—Report from the Clean Air Act Advisory Committee," April 10, 2006).
[22] Letter to Port Commissioners, April 10, 2006; WA State Apollo Alliance website www.apolloalliance.org/state_and_local/Washington/index.cfm.

West Coast Collaboration

Record container volumes and concern about air quality has led the Ports of Seattle and Tacoma to engage in regional, national, and international collaboration efforts as a part of their voluntary, proactive approaches to addressing maritime air quality issues. These collaborative partnerships include the Puget Sound Maritime Air Forum (described on page 9 of this document), the West Coast Diesel Collaborative (WCDC), the American Association of Port Authorities (AAPA) Air Committee, and the Pacific Ports Air Quality Collaborative.

The West Coast Diesel Collaborative is a public-private partnership that is part of the National Clean Diesel Campaign, and its objectives include a reduction in diesel emissions from trucking, rail, marine vessels, ports, and other sources along the West Coast. The AAPA Air Committee is comprised of port environmental staff from across the United States and is a forum to provide a common voice on recommendations from the group on port air quality issues. The Port of Los Angeles, with support from the Maritime Administration (MARAD) and U.S. EPA, initiated the Pacific Ports Air Quality Collaborative to encourage communication and collaboration on air quality issues between ports around the Pacific Rim.

Engagement in these collaborative efforts allows for the creation of voluntary solutions that do not affect port competitiveness, yet do positively address the different needs of the ports, both in terms of operations and air quality. The collaboration model has strong potential, then, for replication in other issue areas. Initiatives that can build on the support of the ILWU will additionally benefit from the union's coast-wide presence. In 2005, total Pacific Coast shipping traffic for the United States and Canada was 23.5 million TEUs: Long Beach, Los Angeles, Tacoma, and Seattle together comprised 78 percent of this traffic. Adding Vancouver would bring this group's share of the market up to 85 percent. Collectively, this makes the region's current and future influence on the evolution of sustainable shipping practices considerable.

5 Day One Breakout Groups

Below is a summary of the opportunities and solutions considered by the breakout groups on day one of the workshop.

5.1 Goods Arrival

This group addressed the sphere of operations that occur when a ship comes into port and unloads cargo. The pollution emissions problems associated with ships are detailed above in Section 2.2: Emissions from Vessels (page 8). The group discussed options for mitigating air pollution, including seawater scrubbing aboard the ship, cold ironing/shore power, the use of alternative fuels, feebate programs to promote cleaner vessels/emissions technology, efforts with naval architects to improve ship design, and the formation of a West Coast/North American SO_x Emissions Control Area (SECA) to influence the supply and promote the usage of lower-sulfur fuels.

Cold ironing is a complex issue that merits examination for individual cargo shipping lines. In general, it is considered a viable option for cruise ships that make frequent calls to the same ports. For cargo ships, the viability of cold ironing depends upon type of cargo and the frequency of vessel calls to cold iron-equipped ports. While equipment and connections standards for cold ironing are quickly being developed, potential variations in quality and consistency of supply could pose ongoing compatibility challenges for vessels. On the other hand, on-shore scrubbers can be used for any ship, but offer no potential cost savings and no reduction of greenhouse-gas emissions. Ship-side scrubbers, currently in development, may also prove to be an attractive option as they can reduce emissions at any port, regardless of facilities.

As ships near port, they are met by assist tugs that bring them into berth. Mostly fueled by diesel, these harbor craft increase the emissions associated with ships in port. In theory, tugs could be retrofitted with add-on control systems, or redesigned with hybrid-electric systems, potentially even plugging in to the ships' electric generation. Tugs could also use alternative fuels, like biodiesel or ultra-low-sulfur diesel, and the balance between ship and tug propulsion can be optimized to minimize emissions from both.

The group also addressed the problem of surge and bottlenecks with regards to vessels. Evenly spreading the arrival of ships throughout the week has the potential to smooth port operations and improve the utilization of equipment and land—especially when combined with measures to improve the efficiency of container movement through the terminal—and decrease dwell time. This could be achieved through collaboration with the shipping lines to pace arrivals, as well as incentives like lower berthing fees on less-congested days and real-time pricing. Increasing the speed at which containers move through the terminal (i.e., reducing dwell time), can be achieved through enhanced rail capacity, more use of on-dock and near-dock rail, extending gate hours, reducing "free time," increasing demurrage fees for containers that exceed "free time," and increasing the collection and management of information.

Solutions

The solutions discussion focused on 6 main areas:

- Reduce emissions from ships in Puget Sound by using scrubbers on board and on shore and cold ironing.
- Cleaner fuels for harbor craft
- Minimize surge loads.
- Use receipt/timing information for train/ship/truck arrival and departure, in order to make the system more efficient.
- Minimize moving empty containers.
- Propulsion of ships by harbor craft

The surplus of empty containers is a general result of a greater than two-to-one[23] imbalance between imports and exports. In order to deal with this, the containers could be made smaller or collapsible, or they could be scheduled to maximize the opportunities for shipping freight back to Asia. Also, excess containers could be scrapped and used in manufacturing, especially if they are made out of recyclable materials that are needed in the United States.

Improving the flow of information regarding the arrivals and departures of ships, trains, and trucks could reduce dwell time, smooth operations, and mitigate the problem of surge. Creation of such a system is discussed below in the Logistics group work plan.

An additional idea generated by the Goods Arrival group is the lightweighting of cranes, which offers multiple possible savings. This concept is described in Box 3 below.

Box 3: Idea 1.1 Lightweighting Cranes

Current super-post-Panamax cranes weigh around 1,400 metric tons. The containers they lift weigh up to 65 long tons, less than one twentieth of the crane weight. Typical 40-foot containers weigh closer to 30 to 33 long tons (personal communication, Port of Tacoma employee). As a result, a crane weighs 46 times more than the average container that it lifts. Since wharf structures were not designed to support the weight of super-post-Panamax cranes, two options exist to serve super-post-Panamax vessels: making cranes lighter, or reinforcing wharf structures. Carbon composites are five times stronger than steel by weight and could be used to make cranes lighter. Based on strength comparison alone, a carbon composite crane could weigh as little as 280 metric tons.

In addition, much of the structure (and weight) of the crane is not there to support the weight of the containers but rather the weight of the crane itself. Saving a ton of weight in the structure at the top of the crane could allow the structure at the bottom of the crane to be smaller, lighter, and cheaper; saving a ton of weight on top might actually save 1.5 tons in the entire crane. Much smaller motors would be needed to raise and lower a lighter boom—another savings in weight in the upper portion of the crane as well as lower cost for equipment. Such mass-decompounding design advantages will result in far lighter and simpler crane structures. A crane made entirely of carbon composites might be prohibitively expensive, but lightweighting certain components with carbon composites could allow other steel structures to be smaller and lighter so that the total crane weight can be supported without reinforcing the wharf.

A rough estimate of the cost of rebuilding/building berths at terminals is $30,000 per linear foot. Since the average berth is around 1,200 feet long, the ballpark estimate for

[23] Figures on the imbalance vary. "It is expected that in 2015 the container volume of westbound trade on the trans-Pacific route will be around 10.2 million TEU, which is less than half of the eastbound trade, 23.3 million TEU." From "Regional Shipping and Port Development Strategies," United Nations Economic and Social Commission for Asia and the Pacific, p.33. www.unescap.org/ttdw/Publications/TFS_pubs/pub_2398/pub_2398_fulltext.pdf, accessed 1/29/07.

rebuilding a single berth is $36 million.[24] Carbon fiber reinforcement panels have also been considered in wharf reinforcement of existing waterside crane beams at the Port Newark Container Terminal.

Fiber reinforced plastics, including carbon fiber, have been used in a variety of structures around the world—including pre-fabricated curtain-wall panels for a skyscraper in Japan, bridge reinforcements, and marine structures like the wharf at Hall's Harbour, Nova Scotia, which used carbon fiber reinforcement bars rather than steel. The high strength, low weight, low fatigue and high resistance to corrosion make fiber-reinforced plastics ideal for these applications.[25] Other strong-yet-lightweight materials can also be investigated for this application.

Beyond lightweighting the crane structure, it could also be cost-effective to seek the lightest spreaders available. Since spreaders are lifted with every container movement, making the spreader as light as possible could save a significant amount of energy and crane weight. Assuming that 90 percent of the lowering energy is regenerated, the average container weighs 33LT, the average crane lifetime is 2 million moves, energy costs 7 cents/kWh, and the average lift takes 1 minute using 1MW, then making the spreader 1LT lighter would save ~$7000 over the life of the crane. Other energy savings can be captured through lighter-weight structures—a lighter crane will require less energy to move along the terminal, and a lighter boom will require less energy to raise and lower.

Recaptured Energy

Virtually all ship-to-shore cranes are equipped with regenerative braking, which captures about 90 percent of the lowering energy. This energy must be used at the terminal, since currently the port's utilities do not allow net metering. If other loads exist (auxiliary/hotel loads, other cranes that are lifting) when containers are lowered, this energy is recaptured at the terminal. One way to guarantee that the energy is recaptured is to couple lifting and lowering movements between cranes. A simple control system could signal to operators when another crane in the network is ready to lift or lower so that the signaled crane could perform the opposite operation. Other alternatives to recapture the lowering energy are super capacitors, flywheels, or batteries to store the regenerated energy locally.[26]

5.2 Goods in Port

The Goods-in-Port group considered the activities that take place at the terminal, from the point when a container comes off a ship to when it leaves the terminal via truck or rail. Solutions fit into the following five categories, ranked by group in terms of priority:

[24] Personal communication, Port of Tacoma employee, January 31, 2007.

[25] Emerging Construction Technologies, Division of Construction Engineering and Management, Purdue University, website accessed January 30, 2007.

[26] Personal communication, 19 September 2006, Tom Sholes, ABB Crane Systems.

- Engine/Vehicle Efficiency and Electrification
- Equipment and Terminal Utilization
- Truck Gate Access
- Data Collection for Planning, Logistics, Coordination, and Analysis
- Lighting Controls/Type/Layout

The first solution category, Engine/Vehicle Efficiency and Electrification, included opportunities related to electric and hybrid vehicles, alternative fuels, and idling reduction. It is discussed more fully in the Ports Electrification summary (page 28).

One early action identified is the implementation of idle-time reduction technologies on the existing equipment, particularly yard hostlers. At the very least, all equipment could be turned off during breaks, lunches, and shift changes.

Equipment and Terminal Utilization included a discussion of chassis usage and pooling, truck gate access protocols, right-sizing of equipment for specific needs, incentives/feebates, trucking and vessel scheduling, continuous operations, idling-time reduction, densification with improved land usage, logistics, and electrified fixed rail equipment, such as rail-mounted gantry cranes (RMGs). Truck gate access protocols included testing truck emissions as criteria for access to the terminal, feebates to encourage cleaning up trucks, and appointment systems. The group discussed the important of more thorough data collection to increased security, better coordination with rail and distribution centers, and increased efficiency of terminal operations and logistics.

Box 4: ***Lighting Improvement (Idea 1.2)***

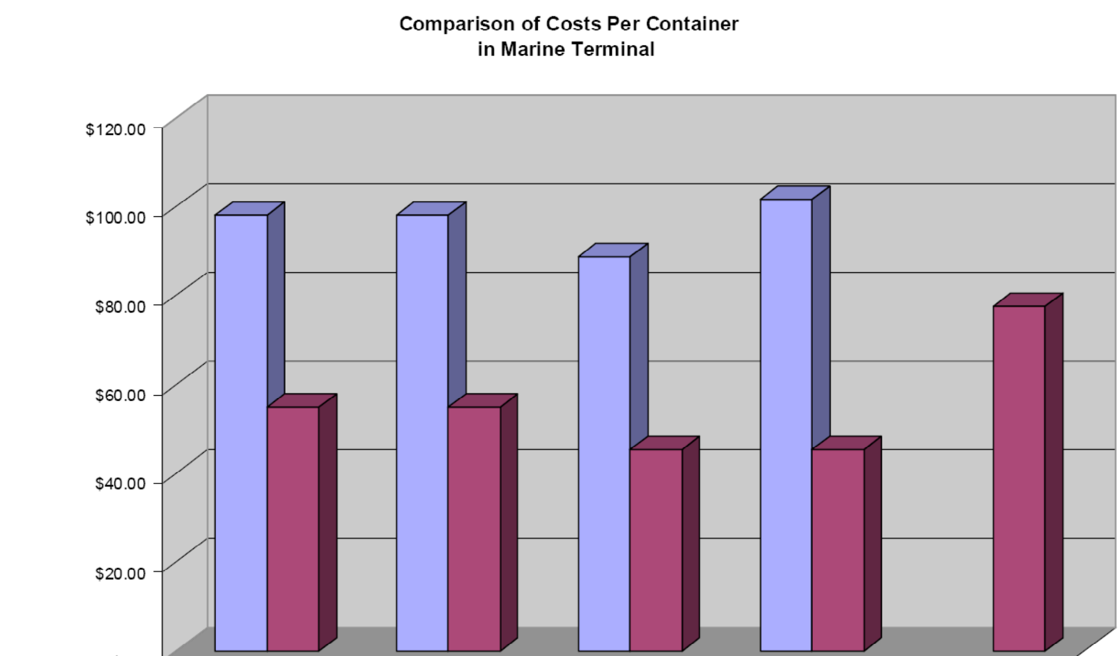
Lighting is generally a simple, cost-effective opportunity to save energy and emissions—lighting retrofits are often referred to as "low-hanging fruit." Lighting may only account for a small percentage of total operating costs, energy usage, and emissions, but any cost-effective opportunities should be taken advantage of, particularly if they enhance other operations, such as safety. Switching from floodlights to more efficient, shielded-light towers may increase efficiency five-fold under some circumstances. Perhaps more importantly, reducing glare from floodlights via shielded lights and task lighting can improve productivity and safety.[27]

The Port of Seattle already emphasizes the use of minimum glare, fully enclosed light fixtures. One specific example is Terminal 5, which was redeveloped and now illuminates 180 acres using half as much energy as before. Additional improvements for consideration include: use of lighting only when there is ongoing work, controlling lighting from a central location to allow for day-to-day lighting specificity, proper arrangement of perimeter and security lighting, and ensuring that all dock areas, cranes, and adjacent work areas are designed and measured for the proper lighting levels with the ability to adjust as needed for different activities.[28]

[27] Nancy Clanton, Clanton & Associates, Lighting Design and Engineering, personal communication, January 30, 2007.
[28] Commentary from George Blomberg, Port of Seattle Senior Environmental Program Manager, 2/22/2007

Box 5: Agile Ports Demonstration Project[29]

The Washington United Terminal (WUT) at the Port of Tacoma demonstrated the Efficient Marine Terminal (EMT) concept, which is one component of the Efficient Marine/Rail Intermodal Interface. The purpose of the short-term demonstration was to quantify dwell time, throughput capacity, and the cost of container handling in order to compare the EMT and a typical U.S. operation. Containers on the vessel are simultaneously loaded onto and unloaded from an intermodal train (double-cycled), which results in reduced container dwell time at the terminal. The intermodal shuttle train travels inland to an Intermodal Interface Center (IIC) where containers are transferred to/from continental trains and over-the-road trucks. The average dwell time of the EMT was reduced from 3.6 days to 1.5 days in the WUT benchmark study. The average dwell time in U.S. marine terminals is 7 days. The per-acre throughput capacity increased 140 percent while the total container-handling cost could be reduced by as much as 40 percent by using the EMT as a part of the Efficient Marine/Rail Intermodal Interface system. The demonstration concluded with a report summarizing results and recommendations for terminal operators. See chart below for comparison of cost per container from the demonstration.



	Truck Import	Truck Export	Rail Import	Rail Export	ITZ Export
Benchmark	$98.11	$98.11	$88.70	$101.54	
EMT Operations	$54.84	$54.84	$45.43	$45.43	$77.53

29 For more information, see www.ccdott.org/content/search_fr.html.

5.3 Goods Leaving

The Goods Leaving group focused on the movement of goods out of the ports via drayage trucking and rail. Drayage operations are plagued with numerous problems, including traffic congestion, a considerable amount of idle time waiting in line, a limited amount of information shared between parties, and an inconsistent supply of drivers (some say there are too many, some say there aren't enough). One participant noted that poor data flow may result in a dispatcher waiting until fifty drayage trucks were needed and then sending them all at once, creating bottlenecks, increased idling and wasted time (not to mention opportunity cost for the drivers). It has been reported that there is a very high turnover rate for the drayage drivers. There is also a very high turnover rate for the drayage drivers. The system as it currently stands creates very little incentive for capital investment in the vehicles, and even fewer resources for owner-operators to upgrade. Challenges in terms of rail emissions and energy consumption include aging equipment and a lack of information with regard to containers. Opportunities for improvement include the right-sizing of equipment and the increased utilization of on-dock and near-dock rail.

Logistical complexity can also lead to waste. From origin to destination, thirty-five companies may touch the cargo. Inadequate information regarding timing and cargo leads to massive inefficiencies in the system. At the same time, since the incremental effect of the inefficiency is minimal for most of the companies involved, there is little incentive for a single player to invest effort into increasing efficiency throughout the entire system.

Suggestions for addressing the problem of aging rail and trucking equipment included emissions standards or an industry-created replacement age for equipment. Options for financing the improvement of drayage trucks included creative loan programs, improved wages for drivers, and improved operations efficiency so that a driver can make more trips in a day and thus make more money.

Participants generally agreed that new business models are needed in order to improve efficiency and reduce emissions for drayage trucks. Current non-fleet arrangements, in which brokers compete over price for the amount of freight moved, have driven drayage rates down to the point where independent drivers working with a broker may not make competitive wages. These arrangements contribute to frequent driver turnover.

Solutions discussed included:

- New rate structures that value clean trucks over dirty trucks;
- Age-of-equipment rules that "raise the bar" for entry into the ports;
- Incentives or mandates that establish engine and/or emissions standards for trucks at port gates; and
- Altering the current broker-independent driver arrangement so the driver earns more and can purchase or lease newer trucks.

One existing example of an already existing mandate program is the Vancouver Port Authority (VPA) Truck License System (TLS). The VPA requires all trucks accessing port facilities to have a valid port truck license. There is an application and an on-road safety test, as well as a simple opacity emissions test. The VPA is also considering emissions tests that go beyond the current requirements of British Columbia, as well as the possibility of a trucking appointment system and limiting access based on truck age[30].

The importance of the entrepreneurial "American dream" was voiced by some members of the break-out group. This argument runs counter to the idea of creating a centralized fleet with hired truckers driving port- or company-owned clean trucks. Alternative business models included truck leasing on a pay-per-mile basis for truckers who would prefer to not own their trucks. This would accommodate, but not fix, the current problems of frequent driver turnover.

In terms of gate hours and congestion, dedicated road infrastructure could help with congestion near the ports, but it is not always feasible. Another solution is to extend gate hours, which would need to occur in conjunction with altering the hours the distribution centers operate. Implementing a real-time data system and appointment program can also help with congestion by allowing drivers to deliver cargo during the night. "Night gate hours" have been successful at reducing congestion. A revenue-neutral feebate program could be implemented, in which a driver or the distribution center pays a higher fee for a daytime trip, and gets a correspondingly lower fee or a rebate for a night trip.

Business models for trucking are discussed in more detail below, in the trucking breakout group section.

5.4 Business Opportunities

The fourth breakout group looked at a variety of business opportunities related to emissions and energy efficiency and overall operations, as well as business-related issues that came to light in other groups' discussions. They discussed opportunities around the existing cargo surge, port expansions and infrastructure, idling and unnecessary fuel usage, container dwell time, and information flow. They also suggested rewarding velocity—things that would increase the rate at which containers move through the port—and the market value of energy use and emissions measurements. Many of these ideas qualify as partnership opportunities.

The solutions that received the greatest participant support were:

- Rail and trucking corridor improvements – transportation infrastructure;
- Emissions trading structure – valuing offsets; and
- Optimized scheduling – differential fee structure

Transportation infrastructure improvements could include dedicated roadways and overpasses to decrease the mixture of drayage and rail traffic with local non-port-related traffic. Participating in emissions trading schemes places a monetary value on emissions

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[30] www.portvancouver.com and Christine Rigby, Vancouver Port Authority, personal communication, 3/12/2007; Bob Hayter, VPA, personal communication 3/15/2007

and offsets, thus creating incentives to reduce emissions and increase efficiency. Clearly, an emissions trading system would need to be created.

Other solutions discussed included the possibility of coordinating expansion plans between the three largest ports in the Puget Sound (Seattle, Tacoma and Everett) to make the most of transportation infrastructure improvements and mainline rail opportunities. Container and chassis pooling were also discussed, as were ship emissions reductions and the possibility of distributed generation and energy storage.

6 Day Two Breakout Groups and Roadmaps

Summaries of Day Two breakout group discussions, ideas and action plans are provided below.

6.1 Port Electrification Breakout Group

The Port Electrification Group tried to determine where emissions could be most effectively reduced via electrification of equipment related to port operations. This group's effort included analysis of the cargo ships, harbor craft, the STS (ship-to-shore) cranes, cargo-handling equipment, and drayage and rail equipment. The group identified optimal technologies for eliminating emissions at each stage of port operations (see Table 6) and discussed the need for the right-sizing of all equipment (e.g., many terminals already use different equipment to lift full containers than to lift empty containers since power needs are different for these two operations). Once various options were identified, the group selected the best opportunities for focus and implementation.

The table below shows electrification options for each stage of cargo flow through the port. Some options, like shore power, require difficult trade-offs. Other options have interesting synergies that should be investigated further, like the replacement of straddle carriers with rail-mounted gantries. This would reduce diesel emissions and improve the overall efficiency of operations. Eliminating the straddle carriers could also enable double cycling of drayage vehicles—an improvement, provided that the drayage vehicles are also electric or hybrid.

Table 6: Preferred Electrification Technologies

Equipment Class	Marine Vessels	Harbor Craft	Cargo-handling Equipment	Heavy Trucks	Rail	Passenger Vehicles
Preferred Technology	Shore-power for cruise ships	Electric Tug	Electric Hostlers & RMG	Hybrids, Short distance Evs, Retrofit APUs	Hybrid Locomotives	PHEVs or Evs

Equipment Evaluations
A wide variety of equipment is used in the terminals to move containers; all of them were listed and compared in terms of estimated energy usage (Table 7).

Table 7: Summary of Equipment and Average Energy Usage

Equipment	Energy Demand	
Ship (Hotelling)	1-2 MW (avg)	1-2 MW (avg)
Tug	<2 MW	<2 MW
Crane	2 MW (peak) 1 MW (avg)	2 MW (peak) 1 MW (avg)
Hostlers	177-217 hp	132-164 kW
Top Picks	330 hp	246 kW
Reach Stackers	300 hp	223 kW
Strads	250-300 hp	186-223 kW
RTGs	1000 hp	746 kW
RMGs	300 kW	300 kW
Trucking/Drayage	??	??
Rail	2000 hp	1492 kW

Ocean-Going Vessels and Harbor Craft (Ideas 2.1 and 2.2)

As ocean-going cargo ships near the ports, they are met by various harbor craft, usually tugboats, which bring them into berth. While these tugs generally produce fewer emissions than ocean-going vessels, their emissions can still be reduced. Reducing tug emissions through electrification was discussed briefly. Electrified tugs could plug in to clean energy at the port and use stored electric energy to meet the ship in the harbor. One interesting "blue sky" idea was the possibility of the ship using clean electricity generated while at sea to hydrolyze water and store hydrogen onboard. This hydrogen could then be used in port via reversible fuel cells, in the tugboat, and on the ship itself. At the very least, tug boat engine replacements have produced substantial emissions reductions.[31]

Terminal Operations

Once in port, ship-to-shore gantry cranes (STS cranes) unload the containers from the ship. At both the Ports of Seattle and Tacoma, these cranes are rail mounted and completely electrified. Thus these pieces of equipment received no further electric-power consideration, although opportunities for design optimization and efficiency likely exist.

After assessing all equipment options, the group determined the approximate total electrical demand for a terminal to be approximately 8 MW (for the container-moving equipment). This is calculated assuming use of the most energy-intensive piece of equipment for each task: STS cranes, yard hostlers, and straddle carriers or RTGs. This calculation assumes a terminal with 4 STS gantry cranes, 80 yard hostlers, and 50 straddle carriers (corresponding to 25 RTGs) (Table 8). This calculation does not include the existing electric need for reefer systems.

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[31] Bailey et al. "Harboring Pollution: The Dirty Truth about U.S. Ports." National Resources Defense Council/Coalition for Clean Air. March 2004.

The electrical capacity for the STS cranes (3 MW) is already in place, meaning an additional 5 MW would be needed in order to electrify all of the cargo-handling equipment at the terminal**.**

Table 8: Most Energy Intensive Equipment per Stage of Operations

Equipment	Hostlers	Strads or RTGs	STS Gantry Cranes
Number	80	50 or 25	4
HP	177-220	300	~1200
Average	2 MW	3 MW	3 MW
Total	**8 MW**		

Daily terminal operations also involve a number of passenger vehicles: cars, light trucks, and SUVs. Many of these vehicles could be hybrid-electric vehicles (HEVs), plug-in HEVs (PHEVs), or pure electric vehicles (EVs) and still perform their tasks.

RTG Hybrid Retrofit (Idea 2.3)
It is worth noting that RailPower Technologies, Inc. has a new retrofit hybrid system for rubber-tired gantries (RTGs) that reduces fuel usage up to 70 percent along with the associated greenhouse-gas (GHG) emissions. The retrofit system also reduced NO_x and particulate emissions at levels similar to the reductions achieved with their rail locomotive hybrids (see rail discussion below).[32]

Drayage and Rail (Ideas 2.4 and 2.5)
The next stage of operations considered was the container conveyance out of the terminal, generally done with drayage trucks or rail. The group agreed quickly that any sort of hybrid technology applied to drayage trucking or longer-haul heavy trucking would be very useful, and, at the least, auxiliary power unit (APU) retrofits to reduce idling and emissions should be seriously considered. The Trucking breakout group also discussed both suggestions.

Rail operations use different locomotives for different purposes—such as switching locomotives for the intermodal rail yards and long distance locomotives for crossing the country. At least one retrofit hybrid locomotive exists for switching operations—the Green Goat produced by RailPower Technologies, Inc. The Green Goat advertises a 40–60 percent fuel savings in addition to an 80–90 percent reduction in NO_x and particulate emissions for the 2,000 horsepower retrofit. A smaller version (1,000 hp) is also available, as well as a Road Switcher retrofit available in two configurations: an EPA-approved three-engine genset and a two-engine battery hybrid. These Road Switchers boast a 20–35 percent fuel savings and 80–90 percent reductions in NO_x and particulate emissions.[33]

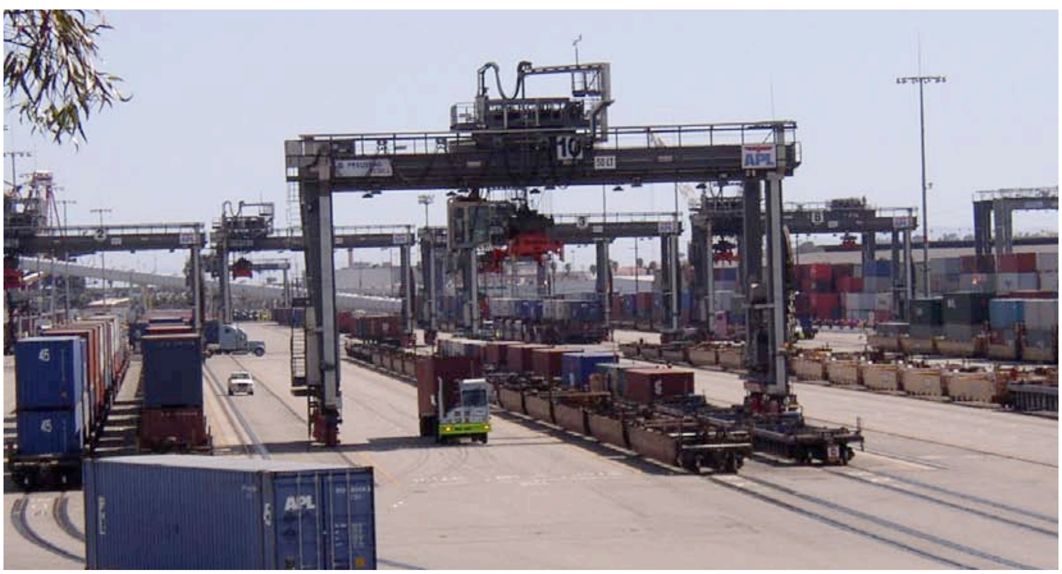
[32] www.railpower.com
[33] www.railpower.com

Electric Yard Hostlers (Idea 2.6)
After going through the equipment inventory, the group decided to focus on cargo-handling equipment as a strategic entry point for electrification. Cargo-handling equipment offers a significant opportunity to evaluate and implement various technologies, due in part to a faster replacement rate than that of rail and OGV replacement rates.

The group decided that electric yard hostlers working with electric rail-mounted gantry cranes (RMG) are the preferred technology options (Image 1) for cargo-handling equipment. Pure electric yard hostlers represent an ideal opportunity for electrification due to the following:

- Yard hostlers do less work per vehicle than tugs, cranes, or top picks;
- Yard hostlers spend approximately half their time idling;
- When yard hostlers are being used more than half of their operations include hauling only a chassis or bom-cart;[34] thus half of the time they are moving they are hauling a minimal load rather than a full container; and
- Studies of emissions completed at other ports have shown that yard hostlers are usually the largest source of emissions for cargo-handling equipment emissions.

Image 1: Rail-mounted gantry (RMG) crane transferring container from yard hostler onto rail



[34] Bom-cart: on-terminal-only cart hauled by yard hostler for moving containers; consists of a flat bed with sloped sides to hold container, allows for faster transfer of containers compared to pin chassis where container has to be set down precisely aligned with the four corner pins.

Image 2: Yard hostler minus chassis, Port of Seattle

General Equipment Needs

A pure electric yard hostler requires the capability to:

- Haul fully loaded containers short distances;
- Recharge quickly to fit into the workflow of terminal operations; and
- Have simple maintenance routines due to the reduction of working parts—there is no longer a need to change fuel filters, check/replace spark plugs, fuel lines, etc.

Several options were discussed for battery technology and fast charging-capabilities. John Waters (RMI) presented several available battery technologies, the most notable being Altairnano's NanoSafe™ batteries. Current battery-life test results shows the NanoSafe™ can handle more than 5,000 full charge/discharge cycles (100 percent depth-of-discharge), after which the batteries still retain more than 80 percent of the original capacity. In addition to the high-cycle life, the alternative chemistry used in the NanoSafe™ battery results in a battery that is inherently safe—a large advantage over other battery chemistries.[35] Although initial costs may be more expensive than other energy storage options, the total cost of operating of high cycle-life batteries is potentially one of the least expensive options.

Terminal operations require equipment to be in use continuously during standard 8-hour shifts and up to 24 hours a day. Charging batteries with modern fast-charging systems would take only minutes compared to older charging systems, which take hours. This technology works with lead-acid batteries and would be compatible with lithium battery products as well.

[35] Altairnano Technologies, http://www.altairnano.com/markets_amps.html

Box 6: Fast Charging Systems

Fast-charging systems (such as PosiCharge®, a product of AeroVironment) have been installed for pure electric fleets in factory environments, as well as for airport cargo-handling systems with outdoor, all-weather, and all-season charging stations. Several systems were installed to mitigate emissions concerns; however, the systems also offer safety benefits and savings in life-cycle costs.

More than 15,000 industrial vehicles in North America use fast-charging, including vehicles used by auto manufacturers, airlines, and major air cargo carriers. Dozens of installations have demonstrated more than three years of successful operation, and some sites exceed six years. Replacing a standard diesel forklift with an electric forklift results in a 40 percent savings in maintenance costs, an up to 80 percent savings in fuel costs, an up to 30 percent longer equipment life, as well as improved comfort for the operators and personnel due to decreased noise and vibration.

Some airports use fast charge technology for their all-electric tugs and ground service equipment (GSE). The systems are able to fast charge electric tugs that can pull a Boeing 777 airliner, which weighs 650,000 lbs fully loaded. That is equal to 290 long tons—the equivalent of ~4.5 40 foot containers loaded to their maximum of 65 long tons, or ~8.8 40 foot containers loaded to 33 long tons each, an average scenario.[36]

Electric Infrastructure

Infrastructure for electrification of the ports is already strong. Both Seattle City Light and Tacoma Public Utility currently have excess capacity. Any additional capacity from either utility has the potential to be renewable and thus decrease the emissions related to electricity generated for port needs. Seattle City Light is currently carbon neutral and plans to remain carbon neutral even with future load growth. Tacoma Power also intends to meet any incremental load increases through renewable energy sources, thus decreasing the carbon intensity of their energy portfolio over time. The majority of existing terminals have electrical infrastructure in place for plugging in reefer containers (480 volts at 32 amps). Further evaluation is needed to determine if this existing infrastructure can meet the needs of fast charging and/or opportunity charging for a yard hostler.

Electric Yard Hostlers Roadmap

After addressing concerns about key electrification technologies, the group focused on a roadmap for evaluating and developing electric yard hostlers at both the Port of Tacoma and the Port of Seattle. The project team will include both ports, terminal operators, the ILWU, and the Puget Sound Maritime Air Forum steering committee.

Technical partnership possibilities for the project include relationships with current manufacturers of yard hostlers, advanced battery-makers, electric power train-makers,

[36] www.posicharge.com and personal communication with Blake Dickinson and Charlie Botsford at AV, Inc.

and manufacturers of fast-charging infrastructure. Both ports can also begin partnerships with the electric utilities, Seattle City Light and Tacoma Power, to evaluate the electrification of yard hostlers and other equipment.

Funding possibilities for the program were considered and included the following institutions: EPA West Coast Collaborative, DOE/PNNL, the Ports and Cities of Seattle and Tacoma, the State of Washington, PSCAA, EPRI, BC Hydro/Vancouver/Port of Vancouver, Google.org, American Lung Association, Clean Cities, MARAD, and the Health and Welfare department of the ILWU.

Phase 1: Business Plan and Prototypes
The overall business plan assessment includes the following:

- A life-cycle cost analysis of standard diesel yard hostlers and the electric equivalent
- An analysis of the benefits, risks, and value proposition of a development program.
- Cost of producing demonstration vehicles (possibly retrofits for the initial proof-of-concept vehicle as well as new vehicles)
- Cost of resources
- Intellectual property investigation,
- Development and implementation timeline.

The more obvious benefits associated with an electric yard hostler are operating cost savings and emissions reductions. Further analysis will bring to light other benefits (e.g., ergonomic design for operators).

The initial operation and maintenance cost estimate generated by the group at the Workshop for a standard diesel yard hostler is ~$16 per operating hour (this figure includes all operating and maintenance expenses, from fuel to insurance to tires, wiper blades, fuel filters, etc.). At 2000 operating hours a year, that translates to ~$32,000 in operating costs per year per unit, and each unit has a life of 7–8 years before it is completely replaced. Since the current upfront cost of a new yard hostler is ~$64,000, a 15 percent premium was added for the all-electric hostler for the life-cycle costs.

A back-of-the-envelope calculation for undiscounted life-cycle costs of a single diesel yard hostler is between $288,000 and $320,000 for a 7 to 8 year life, respectively. Each unit uses an average of 2.8 gallons of diesel per operating hour, resulting in a more than $92,000 savings for ULSD/B20 diesel alone over the life of the hostler.[37]

Comparatively, an all-electric hostler offers:

- Reduced maintenance (no fuel filters, oil changes, etc.);
- A lower energy use per hour due to lack of idling (further reductions possible with regenerative braking);

[37] All data for diesel hostlers was provided by terminal operators present at the workshop.

- A more than 50 percent reduction in fuel cost for an equivalent conventional unit;
- A longer equipment life; and
- A 100 percent reduction of on-site emissions (well-to-wheel emissions should be calculated using the data from the Emissions Inventory after it is released and other sources for the upstream emissions).

The calculations here result in a savings of more than $95,000 per hostler—a 32 percent savings in undiscounted life-cycle cost, which does not take into account the extended life of the electric hostler. The life-cycle costs and savings presented in Table 9are conservative—larger savings have been shown for electric forklifts. This estimate also does not take into account the advantages of regenerative braking; an optimized, lightweight platform design, or any other compounding benefits that can result from a whole-system design approach.

Once the initial economics are demonstrated, at least two prototypes (one for each port) should be built and tested alongside the standard cargo equipment. Demonstration vehicles performing the same duty cycle as diesel equipment will provide information regarding durability and other data so that the vehicle's performance, life-cycle costs, and expansion potential can be seen.

Phase 2: Larger Demonstration

After the initial prototypes are built, tested, evaluated, and proven worthy, the next step is to implement a larger-scale demonstration—ideally, an entire terminal running with only electric hostlers. This would show the scalability of the technology and verify the emissions reductions and life-cycle cost savings that are possible by electrifying only the yard hostlers. Such a demonstration may also involve an OEM that produces yard hostlers. The group identified Terminal 30 at the Port of Seattle as a possible location for a larger, near-term demonstration since it will soon be retrofit for cargo-handling operations.

Table 9: Life Cycle Costs

Yard Hostler Life Cycle Costs			
Diesel Yard Hostler[a]		Estimated for All-Electric Yard Hostler	
$16.00	avg. maintenance & operating cost per operating hour including diesel fuel[b]	$8.97	operating & maintenance costs per hour including electric fuel[c]
2000	operating hours/year	2000	operating hours/year
$32,000	annual maintenance and operating costs, incl. fuel	$17,934	annual maintenance and operating costs, incl. fuel
2.8	gallons diesel / operating hour	2.1	equivalent electricity unit / operating hour[d]
$2.20	$/gallon B20 diesel	$0.99	cost of electricity per B20 equivalent "gallon" if electricity is $0.08/kWh[e]
$6.16	cost of fuel / operating hour	$2.08	cost of fuel / operating hour
5600	gallons diesel / year	4200	equivalent electricity unit / year
$12,320	annual fuel cost for single diesel hostler	$4,158	annual fuel cost for single electric hostler
7.5	avg. hostler lifetime	9	20% longer life[f]
$92,400	**Lifetime B20 fuel costs**	**$31,185**	**Lifetime electric fuel costs** (for the 7.5 years comparable to the diesel hostler)

$240,000	**7.5 year Lifetime maintenance and operating costs (including fuel)**	**$134,505**	**7.5 year Lifetime maintenance and operating costs (including fuel)**
$64,000	avg. cost of new hostler	$73,600	avg. cost of new hostler[g]
$304,000	**Estimated Total Life-Cycle Cost of Diesel Hostler**	**$208,105**	**Estimated Life-Cycle Costs for Electric Hostler** (for the 7.5 years comparable to the diesel hostler)

Total Life-Cycle Cost Savings	**$95,895**
Percentage Savings	**32%**

CO_2 Emissions

9.32	kgs / CO_2 per gallon B20 burned[h]	0	kgs / CO_2 per kWh electricity provided by Seattle City Light
		100%	**CO_2 emissions reduction**

[a] All calculations based on average data provided by a Seattle terminal operator present at the Workshop.
[b] Operating and maintenance costs include fuel, insurance, filters, oil changes, wiper blades, tires, etc.
[c] After 30% reduction in non-fuel related costs; electric forklifts have demonstrated up to 40% reduction in maintenance costs
[d] 25% reduction to account for time spent idling by diesel, does not account for regen braking energy which will reduce this figure further. Also, the 25% reduction for idling is a conservative estimate which may prove to be low after the duty-cycle is released in the Emissions Inventory.
[e] Average cost for industrial electricity in 2006 for the State of Washington was $0.0436/kWh, $0.08/kWh conservatively assumes some additional service charges.
[f] Electric forklifts have demonstrated up to 30% longer equipment life; this value not used for the comparative life-cycle cost.
[g] Assumes 15% cost premium for the all-electric hostler.
[h] Solely based on emissions from the fuel, does not take into account duty cycle; full emissions reductions for CO2, NOx, SOx, and PM can be calculated after the Emissions Inventory is released.

Phase 3: Commercialization
Once electric yard hostlers have been proven successful at an operating marine terminal, the technology can be expanded and commercialized. If the ports and other partners develop intellectual property as a result of this project, it can potentially be commercialized for controlled influence or revenue generation. In addition, the partners in the program have the opportunity to capitalize on their new expertise in port electrification by electrifying other equipment or assisting other ports with electrification programs.

Initial Electric Yard Hostler Support Team
Multiple representatives at the Innovation Workshop expressed support for evaluating the potential of an all-electric yard hostler:

Galen Hon – Port of Tacoma
Peter Ressler – Port of Seattle
Barbara Cole – Port of Seattle
Darrell Stephens – SSA Terminals, Seattle
Lynn Best – Seattle City Light
Andy Evancho – Tacoma Power
Richard Feldman – Apollo Alliance
Mike Jagielski – ILWU

The group discussed the possibility of kicking-off this project to coincide with the release of the Maritime Emissions Inventory.

Recent Equipment Electrification at Other Ports

In September 2006, the Port of Long Beach announced an initiative, partly funded by the EPA West Coast Collaborative and in partnership with the Port of Los Angeles, to develop hybrid yard hostlers.[38] As discussed above, the duty cycle and the terminal-only usage of yard hostlers make them ideal candidates for electrification. An all-electric system would reduce emissions, energy usage, and maintenance/operating costs even more effectively than a hybrid system.

On January 16, 2007, after the Innovation Workshop for the Ports of Seattle and Tacoma, the Port of Los Angeles announced an initiative aimed at developing an electric tractor to haul containers from the port to local warehouses and rail yards,[39] the main work currently done by drayage trucking in Seattle. Since this program in Los Angeles is for local short-haul container drayage, the truck and chassis must meet on-road equipment safety specifications; basic in-terminal yard hostlers have different requirements to meet.

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[38] Port of Long Beach Press Release, September 6, 2006, www.polb.com/news/displaynews.asp?NewsID=90.
[39] Port of Los Angeles Press Release, January 16, 2007, www.portoflosangeles.org/Press/REL_Electric_Tow_Tractor_Demonstration_Project.pdf.

The technology demonstrated in the Los Angeles program will support the demonstration of all-electric trucking technology and the development of all-electric yard equipment technology. The development of an electric yard hostler for terminal-only use is a complementary opportunity for the Ports of Seattle and Tacoma. It may offer an opportunity to collaborate with other ports to address additional aspects of the emissions produced by port equipment.

6.2 Vessels

The vessels group focused most of its attention on policy initiatives and partnership opportunities. Several important and instructive points were repeated often during the conversation:

- To reduce emissions in ways feasible for the industry, shippers would benefit from global standards. Developing separate on-board technologies for each port or region is not a viable strategy. The group agreed that the various stakeholders should be coordinated to influence:
    - U.S. agency-driven and Congress-driven actions to implement Annex VI and North American SECA;
    - IMO action on cleaner standards for green ships; and
    - Pacific Ports Clean Air Collaborative (PPCAC) mitigation measures.
- All standards should be performance-based not technology-based. The former encourages innovation and uses the market; the latter discourages innovation and quickly becomes obsolete.
- Industry competitors should begin sharing information on successful efforts to reduce emissions. One industry representative said that the benefits were so important that he would do so regardless of whether his competitors also shared their successes.
- A collaborative initiative should be led by POT, POS, and PSCAA and a few industry representatives to test emissions-reduction technologies. However, industry representatives are concerned that if their experiments include clean technologies that are found to be financially infeasible, standards requiring those technologies may be imposed upon them. They feel that they must be protected from such risk.
- Celebrate successes to encourage future collaboration and to inform the public about positive change.

The group identified the following ideas as important and promising for further development:

3.1 Encourage use of cleaner fuel in auxiliary engines while at dock—for example by creating incentives such as “feebates,” which would provide rebates to cleaner burning vessels paid for by charging more polluting vessels fees.

3.3 Develop global vessel-emissions standards: To avoid the proliferation of conflicting local standards, develop global standards for vessel emissions through the

IMO. In particular, pressure Congress and federal agencies to ratify MARPOL Annex VI before establishing a North America SECA.

3.4 Strengthen IMO MARPOL Annex VI through cooperation with international stakeholders (e.g., Europe and Canada).

3.5 Develop international standards for shore power plug-in technologies in order to prevent the proliferation of incompatible technologies. The aim is to avoid technical solutions in one port that require on-board equipment that is incompatible with another port. Consider San Pedro's solution as one option.

3.6 Develop incentives to encourage vessel owners to demonstrate and test various emissions-reduction technologies and find the most efficacious solutions.

3.7 Develop a collaborative conversation among steamship companies in which they share their experiences trying new solutions. One group member, a steamship company, committed to doing this unilaterally and posting what the company learns on a website. Cleaner fuels and treatment technologies are in use by some companies.

3.8 Develop positive PR for green ports using, in part, progress in vessel emissions.

3.9 Convene stakeholders to develop the best path to use of cleaner fuels in main engines.

3.10 Work with Pacific Ports Clean Air Collaborative to achieve many of the above ideas, and celebrate existing successes.

There are many reports that document the opportunities for efficiency improvements and emissions reductions—through alternative fuel usage as well as technological solutions. For example, the use of a single clean fuel for all vessel operations would address emissions from sulfur oxides (SO_x) and particulate matter (PM), and could achieve a reduction of about 5 percent of carbon dioxide emissions as well.[40] A 44 percent reduction in SO_x emissions *and* a corresponding 18 percent reduction in PM emissions can be achieved using lower-sulfur fuel (1.5 percent).[41]

For additional references and a discussion regarding emissions-reduction technologies, see Appendix H.

[40] "Study of Greenhouse Gas Emissions from Ships", Final Report to the International Maritime Organization, Issue no. 2-31, March 2000
[41] Bailey et al. "Harboring Pollution: The Dirty Truth about U.S. Ports." National Resources Defense Council/Coalition for Clean Air. March 2004.

6.3 Logistics Breakout Group

The logistics group focused on issues related to information flow and operations, such as cargo surge and bottlenecks, container dwell time, and chassis pooling. Beginning with intermodal capability, the group discussed the use of on-dock rail, the possibility of an off-dock surge yard to accommodate peak activity periods, and the need for the right combination of infrastructure to fully utilize intermodal capabilities.

The group also discussed the consolidation of data and virtual container yards, and agreed that establishing a centralized information center was an achievable goal that both ports could collaborate on. Creating a centralized information center with appropriate, transparent data-sharing improves understanding of the supply chain and can help to improve the efficiency of transportation and operations. A better flow of information could help shippers improve the efficiency of container movement, decrease idle time and wasted trips, and improve the utilization of existing rail capacity.

The group decided that collecting and sharing operations data would be a good starting point; later, the system could be expanded to include data with marketing value. Potential resources for information sharing systems include Starbucks, IKEA, and Wal-Mart. The system should focus on the local market and be a neutral entity that everyone is comfortable with. The Puget Sound Marine Exchange, for example, collects data on vessel movements that could be quite useful if it were easily available. The consolidation of the data into a single, transparent portal is crucial.

Transportation Information Guru System (Idea 4.1)
After identifying a broad problem that both ports could address jointly, the group developed a roadmap for a centralized, consolidated transportation information system that would lead to better logistics and reduced emissions in Puget Sound. This would be a comprehensive database. Virtual trucking systems (such as Montreal's system, which matches imports and exports) exist, and a virtual system could be considered for improving efficiency.

The desired outcomes of the project are increased efficiencies resulting in reduced costs, increased service reliability and quality, elimination of bottlenecks, and enhanced freight mobility. Such a data-sharing system could also foster reduced energy usage, decreased emissions, reduced health problems, community support, and a continued collaborative relationship with regulatory agencies. The biggest challenge is likely to be stakeholder buy-in. Thus, there is a need to demonstrate the benefits to potential participants. There are also concerns over confidentiality and prioritization.

In order to develop a consolidated transportation information system, the following steps need to be completed:

Next Steps

- Identify participants and stakeholders;
- Identify what kind of information each participant needs: influence database

design and agree on the scope of the database;
- Identify what must be common (not proprietary) information;
- Business process mapping;
- Define deliverables, benefits and cost;
- Decide who should manage/administer this system and how it should be managed;
- Identify funding resources;
- Inventory benchmark systems that are out there: eModal, Cargosmart, GT Nexus, Inttra, Marine Exchange, Port of Tacoma Business Exchange System, etc.;
- Provide scalability by starting with a focus on operations, expanding later to address broader marketing issues;
- Tie use of data to environmental issues; and
- Look to industrial leaders for best practices in reducing environmental impacts that are related to supply chains.

Timeline for Deliverables
- Form team: Ports of Seattle and Tacoma lead effort: one month (by March 1).
- Request for proposals around June 1.
- Publish request for proposals for vendor September 1.
- Deliverable in summer '08.

Project Leads:

Mike Zachary Port of Tacoma
Linda Styrk, Port of Seattle

Box 7: Chassis Pooling (Idea 4.2)

Typically chassis are owned and maintained by individual terminal operators or steamship lines and are not permitted for use with containers from another carrier. For a driver to serve multiple carriers, the chassis must be switched, which can add up to an hour per trip, substantially reducing income for drayage truck drivers. Trucking companies and truckers are typically paid by the trip, so reducing gate turn-time is crucial for maintaining pay level and driver retention.

A common chassis pool can reduce fuel consumption, delivery time, emissions, port congestion, and idling time because it eliminates the need to switch chassis between trips. Any driver can therefore serve any shipping line without switching the chassis. This eliminates bobtailing, increases the number of containers one truck can move in a day, and decreases idling time waiting for switches to happen. It also eliminates a number of lift operations at the terminal, such as "flip lines" (where a container is lifted off a chassis to be put on a different one). The equipment and terminal space used for those operations can then be better utilized. A common pool also prevents the chassis from leaving the port operations when a driver leaves the business.

The current business model of each steamship line or distributor owning their own chassis would need to be addressed, and there is the possibility of establishing new rate structures for truck trips. A common chassis pool can be organized in such a way that participating shipping lines provide their own chassis for use by the pool, which is then managed and maintained by a subsidiary of the participating terminals or a third party.

An example of a successful common chassis pool is the Hampton Roads Chassis Pool II (HRCPII) at the Port of Virginia. Beginning in October 2004, the Port of Virginia became the first U.S. port to require all chassis onsite to be part of the pool, which consists of over 15,000 chassis. This reduced the number of chassis stored onsite by 5000–6000, a 20 percent reduction of the original fleet, and allowed 40–60 acres of land to be recaptured for use by terminals. Local drivers who would previously only be able to complete two to three container moves per shift are now able to move up to ten containers daily. This has resulted in more reliable service, higher revenues, and higher driver income.

Common concerns voiced with regard to chassis pooling are liability and maintenance—who will be responsible for chassis if the companies using them do not own them? The Port of Virginia currently operates their chassis pooling program and is in search of a third party to manage it in the future.

Steamship lines participating in the Port of Virginia chassis pool are:[42]

ACL
APL
China Shipping
CMA/CGM
CSAV
COSCo
CP Ships
Evergreen
K-Line
Hamburg Sud
Hanjin
Hapag Lloyd
Hyundai
Marfret
Maersk
MSC
MOL
NSCSA
NYK
OOCL
SCI
Turkon
United Arab Shipping
Yang Ming
Zim

6.4 Trucking

The biggest challenge for drayage trucking identified on the first day was the existing owner-operator business model, which does not provide incentives or funding for truck improvements. Thus, the Trucking breakout group set a goal of creating a business model that values cleaner, more efficient trucks and moves containers in the most efficient manner. Different opportunities and ideas were discussed, from scrap-and-replace to lease-to-own programs to using incentives, like feebates, instead of mandates, to encourage change. The existing fleet consists of Class 8 trucks, which are not designed for hauling containers short distances, so there is a tremendous potential to improve the fleet by designing a truck specifically for short-hauling and right-sizing all the equipment.

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42 Virginia Port Authority, Hampton Roads Chassis Pool II, www.vaports.com/Media_Room/2006/IANA.pdf.

Improvements in logistics and information flow could also be used to match the movement of trucks to the movement of containers and to address idling and congestion issues. For instance, marginally profitable trucking operations could be improved if trucks had no in-port waits, zero gate queuing, and were dispatched efficiently to minimize wait times at destination and return-cargo pickup locations.

The group also discussed whether trucks were the most efficient means of transferring containers. Some terminals have on-dock rail that could be utilized more fully, and in some situations a conveyor system (or other more efficient means) could be used to move the containers the short distance to near-dock rail.

Box 8: Cascade Sierra Solutions Loan Fund (Idea 5.1)[43]

An innovative model for financing truck replacement

Cascade Sierra Solutions (CSS) operates a loan fund to upgrade trucks in Oregon, Washington, and California and processes SBA loans for truckers nationwide.

Drayage trucks are typically at the end of their mechanical life and any efficiency upgrade that could be implemented is worth more than the truck. Simply put, these trucks need to be replaced. Replacing the 1,200 or so trucks that serve the Ports of Seattle and Tacoma would require an approximately $90 million investment. This money could come from a loan fund. The beauty of a loan fund over a grant is that at the end of a project, the money is paid back—so it is the most cost-effective way to accomplish the goal.

There are currently opportunities to access the money required for a revolving loan fund using the Federal Highway Administration's (FHA) allocation of private activity bonds.

How it could work:

1. Identify an issuer with the authority to issue bonds (state, municipality, or port).
2. The bond allocation would not count against the allocation of the issuer to issue bonds, but would come from the FHA's allocation to issue Private Activity Bonds.
3. CSS is qualified as a surface transportation project for FHA funding (Title 23).
4. The issuer would simply issue the bonds in the name of Cascade Sierra Solutions (CSS). CSS would have the liability to repay the bonds in ten years.
5. CSS would work with stakeholders and truck OEMs to develop a practical, fuel-efficient, no-frills day cab complete with a diesel particulate filter.
6. CSS would buy trucks with the money as truckers who want to upgrade order them. The balance of the funds would be drawn down as the trucks are leased.
7. There would be multiple truck OEM choices that met the criteria, giving options of colors, makes, etc.
8. CSS would provide a low-cost ten-year lease that comes with a maintenance contract. At the end of the lease, the operator would own the truck. Since this truck has been well maintained, there should be ten additional years of life left at the end of the

[43] For further information, contact Sharon Banks, CEO Cascade Sierra Solutions: sharon@cascadesierrasolutions.org.

lease.
9. The cost of the truck as paid by the driver over time would be less than the cost of the old dirty truck because old trucks are typically financed at 25 percent interest rates and have huge costs for maintenance and repairs.
10. The ports could use a number of incentive programs to encourage the use of these trucks over dirty trucks. (Fee-bate, express lane, increased pay rates for clean trucks etc.
11. A great idea would be to pay drivers $5k–10k when the old truck is traded in. CSS would contract with a truck recycler to make sure the old truck was forever taken out of service and the grant would make a down-payment on the new truck, giving the operator instant equity.
12. Any defaults would be recovered by CSS and re-leased.

The group suggested pilot programs to test various solutions, including:

5.1 **A straight leasing or a lease-to-own program for cleaner trucks.** It would get drivers into cleaner trucks faster and provide upfront monthly savings to the drivers through reduced operating and fuel costs. See **Box 8** for a proposed approach).

5.2 **A feebate program, potentially revenue-neutral, that would pay higher per-container rates to operators with cleaner trucks.** This program would require collaboration between shippers, steamship lines, terminal operators, and trucking brokers, as well as the truck drivers as they would need education about the program. The Washington Trucking Association could possibly provide this education.

5.3 **An express lane for clean trucks at the terminal gates,** allowing for faster turn-around times and more container moves per truck per day. This program needs to be evaluated in conjunction with anti-idling policies so that dirtier trucks aren't waiting—and idling—for longer periods.

5.4 **A competition between truck manufacturers to create a clean truck designed specifically for drayage.** The winning design models would be showcased in a lease-to-own program targeted at replacing the existing dirty fleet.

The trucking group also recommended that each port and terminal be evaluated in a holistic way to determine the most efficient method of moving containers off the terminal.

Box 9: Truck Anti-Idling Options[44]

Anti-idling devices for trucks came up several times during the Workshop. Although idling for over an hour and overnight truck idling are not likely to be port-specific issues, it could potentially contribute to regional air pollution. Below are four technology options for addressing the problem.

[44] Data provided by Michael Ogburn, Rocky Mountain Institute, 3/10/07.

- Assuming that trucks are stopped there are several ways to provide comfort and electricity. The most obvious is a $5000-8000 *Auxiliary Power Unit* (APU), which generates power, heat, and cooling. Wal-Mart installed APUs in their long-haul trucks and achieved a fairly rapid payback time, since their truckers tend to sleep in their cabs and idle their truck engines for temperature control. Two APU systems currently on the market are the ComfortPro by TruckTrailer[45] and the TriPac by ThermoKing[46].

- If only heat is needed, and only for an hour or two, an *electric water pump and electric fan* to "harvest heat" from the stopped engine would work well even in cold climates.[47]

- For cooling only, either a direct evaporative cooler or an indirect evaporative cooler, which does not add water content to the air. Units of this variety have an 8-10 gallon water tank, an evaporative element and an electric blower. They can also provide cooling while the truck is underway, saving additional fuel[48].

- A fourth alternative is an *"electric APU"* with 2 deep cycle batteries that run a diesel fired heater, and an electric air conditioner installed in the cab. An inverter can be added to provide 110V power. This type of unit recharges when the truck is turned on and costs approximately $4000[49].

6.5 NuPort Breakout Group

What is the most energy-efficient way to transport five million widgets from Shanghai to multiple U.S. destinations? The "NuPort" or Next Generation Port group tasked themselves with answering this question, removing existing infrastructure and assumptions to allow "blue sky" ideas to emerge.

Early on in the discussion, it was recognized that two major variables influence energy consumption, namely the *size of the package* being shipped and *the type (or types) of conveyance* used. Given this framework, the group organized its discussion around container- and non-container-based conveyance models (where conveyance may include any form of transportation along the supply chain). However, many of the strategies may apply to containers or smaller (or larger) packages. Prior to the development of specific conveyance models, the group discussed general goals and opportunities to achieve greater energy efficiency within the existing "goods transportation" industry.

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45 http://www.trucktrailer.carrier.com/Files/TruckTrailer/Local/US-en/trucktrailer/comfortpro.pdf
46 http://www.thermoking.com/products/product/tripac.asp?mn=tripac&pg=image&mainURL=&cat=
47 http://www.autothermusa.com/
48 http://www.saferco.com/viesa.asp
49 http://www.nitesystem.com/

Goal: Minimize Energy Expenditures

The NuPort group worked with one goal in mind—minimize energy expenditure during goods transportation from origin to destination. For the ports, Amory Lovins suggested that the minimum energy expenditure goal may include pursuing zero dwell, a "steady pulse" of package movement, only moving items once, providing transparent information to all participants, generating zero emissions, moving goods not air, "simplicating" and adding lightness to packages and movements, and rewarding the behavior ports would like to see. These goals could be aligned both with those of customers (low-cost, reliable, and flexible) and the local community (economy and environment).

Opportunities for Greater Energy Efficiency

Sprint and Wait: The existing shipping industry supports a "sprint and wait" mentality via the continuous increase in ship size, the availability of "free storage" at U.S. ports (this is not true of Asian ports), and the ability (and precedence) of repeatedly moving containers once in port. Analogous to a relay runner sprinting 99 meters, crawling one, and then not relinquishing the baton to the next runner for two minutes, ships cruise across the Pacific only to sit in port for 2–3 days, while the actual cargo may linger in port for upwards of a week.

Vessel Design: Vessels are optimized for one principal function: to rapidly traverse harsh ocean conditions. Accommodating port operations is of secondary importance. Redesigning ships while correspondingly redesigning ports presents potentially ideal whole-system opportunities. Ship redesign should not involve the "unoptimization" of ships, but rather the optimization of the entire system—port and local transport included. Compromise or "unoptimization" is not necessary. The argument against ship designs that better coordinate with ports and local transport is the fact that ships call at multiple ports—especially when considering the 30-plus-year life of ships. If a ship is optimally designed for a particular port, it loses flexibility. The rise of containerization represents an opportunity to balance flexibility and optimization via the use of a globally-standardized modular interface: the container itself.

Door-to-Door Service: Southwest Airlines has achieved great success in the airline industry with its point-to-point service—is the shipping industry moving in the same direction? While the number of ever-larger ships increases, Workshop discussion implied that there is also potential for the industry to accommodate the increasingly large volume of Asian cargo with smaller ships reaching more ports more frequently. These smaller ships, carrying fewer TEUs, would run slower to save fuel, yet experience increases in labor costs. The advantage of smaller ships is their ability to unload faster, thereby decreasing the mismatch between ocean cargo speed and port cargo speed (note: large ships moving slow are more efficient than small ships moving slow). A continuous flow of smaller ships may also be preferable to suppliers who could more accurately specify the delivery date or unloading procedures for high-value products. Smaller ships may also allow ports to provide better service and greater flexibility to terminal operators.

Trade Imbalance: The majority of cargo travels eastbound from Asia to the United States with mostly empty containers filling westbound ships. Opportunities may exist to reuse containers in the United States or create foldable containers to reduce space consumed by empty ships on the return trip. However, regardless of whether or not empty containers make the journey, the ships must still return to Asia.

Are Containers the Enemy? Containerization has brought incredible efficiencies to the shipping industry, yet only to the sea-leg portion of the goods transportation industry. Furthermore, cargo contents are becoming more varied and fragile, raising the question of whether containers are still the ideal devices to transport cargo in.

Twenty-foot Equivalent Unit: TEUs are currently the smallest unit transported on standard container ships. Inside TEUs are multiple layers of packaging protecting a range of products. Resizing containers to better align with product requirements (refrigeration or high-tech) or loading and unloading procedures may reduce overall energy consumption, or it may further complicate an already complex process. New containers may also serve as part of a ship's structure in the future (empty steel containers contain as much steel as built into the entire ship), and steel is an imported, therefore expensive, commodity.

Rail Capacity: Rail capacity has been identified as a severe long-term constraint at both ports. Pulling longer trains with lighter containers can increase capacity (as weight along with safety and congestion limits length). Similarly, adding more locomotives to the train or using a European light rail model could potentially increase rail capacity. One advantage to large ships is that they result in full trains. Occasionally, however, there is not enough cargo for one destination and cargo is stored in port until more cargo going to the same destination arrives. This suggests that smaller, lighter trains may help reduce cargo dwell time (if more trains were going to more destinations), although this may not help reduce emissions.

Customer Coordination: Another complication is the quantity of customers using the port with rail needs. FedEx, UPS, and DHL are the primary package delivery services available, thus coordination with ancillary service providers in the package delivery industry is less complex than in the shipping industry. It was noted that at one terminal, twelve different shipping lines are active. The sheer number of shipping lines using the Ports of Seattle and Tacoma makes terminal and rail upgrades more controversial and complex.

Following a discussion of goals and opportunities (some expressed as existing barriers), the group began brainstorming conveyance strategies. Several assumptions emerged during the conveyance strategies discussion:

- Reducing energy use will require de-surging the sea leg so fewer containers are received more often (e.g., 1,000 containers per day rather than 8,000 containers one day per week);
- The initial sea-leg is point to point;
- Data on package RFID tags is re-addressable in real-time; and

- Any new conveyance strategy must reduce energy consumption below existing levels (see table below) without increasing transit time.

Table 10: Energy Expenditures Along Shipping Container Journey

Per TEU	Factory Origin	Asian Port	Ocean Voyage	U.S. Port	N. American Dest.	Totals
Miles	50	0.1	6500	0.1	1500	8050
Dwell (hrs)	2	0.03	312	0.03	2	316
Hp	100	750	10	750	50	-
Hp-hrs	200	21	3120	21	100	3462
Hp-hrs/mile	4	208	0.5	208	0.07	421
% Energy of Total	6%	1%	90%	1%	3%	100%
Fuel Type	Diesel	Elect/Regen	Marine Diesel	Elect/Regen	Diesel	-
CO2 Emissions (kg)	34	4	530	4	17	588

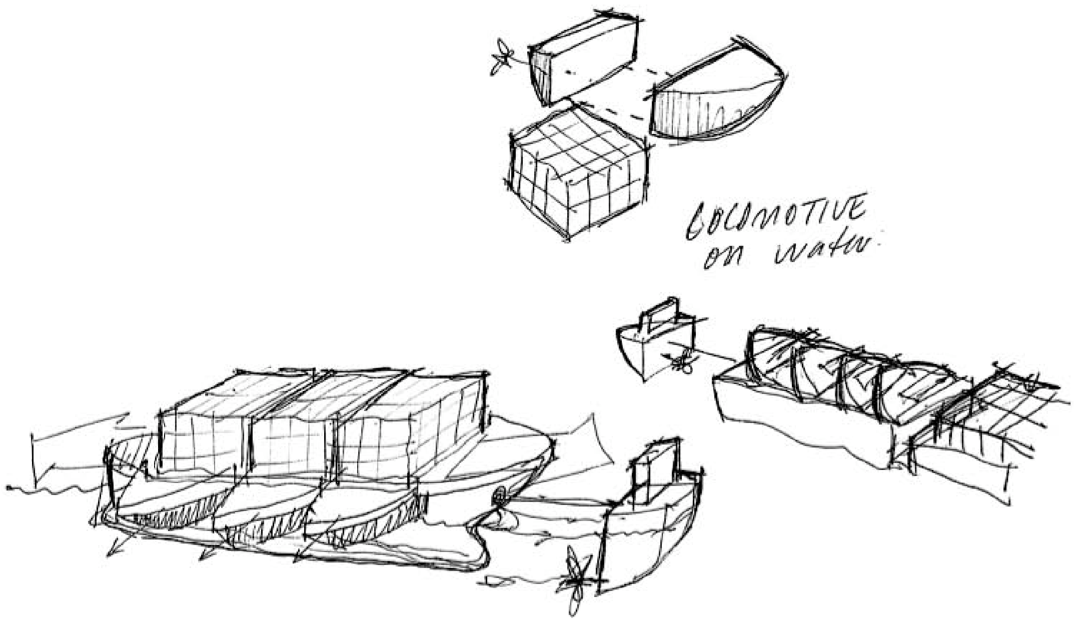
Assumptions:
Marine Diesel: 269 kg CO_2 per MWh (based on higher heating values)
Truck/Rail Diesel: 250 kg CO_2 per MWh (based on higher heating values)
Elect/Regen: 227 kg CO_2 per MWh (calculated from: 2006 WA fuel mix)

2006 Washington State CO_2 per MWh: http://www.cted.wa.gov/site/539/default.aspx

Total CO2 =	21,060,856	tons
Total MWh =	83,918,557	MWh
CO2 emissions =	227.63	kg/MWh

NuPort Ideas: Container-Based

6.1 Decouple Power from Cargo Due to the trade imbalance, many ships carry only empty containers back to Asia. Assuming a use for empty containers was found, it may prove efficient to detach power units from cargo holds and tow multiple power units back to Asia with only one operating power unit. This "ocean locomotive" separates the propulsion function from the container function and would significantly reduce the number of empty ships traveling westbound (note: the propulsion system is at least 50 percent of a ship's $100 million capital cost). Different assets of the shipping infrastructure (propulsion, containers, and crew) return to Asia in different manners. This solution becomes even more attractive if ships are unmanned, as you don't have to address the problem of "what do you do with the crew?"



Drawing Courtesy of: Brian Mannelly, Port of Tacoma.

6.2 Air-hockey Deck/Airmats
The entire deck of a ship could be layered with pressurized air to allow containers to slide with a minimal amount of force. Alternatively, containers could be retrofitted with individual airmats to create the same effect. Airmats operate by balancing air with weight (in pounds per square inch or psi). It was noted that one psi would support one container while 8 psi would work for a stack of eight containers since the average container has a distributed load of 1 psi. For an example of airmat technology, watch a video at www.hoverbench.com.

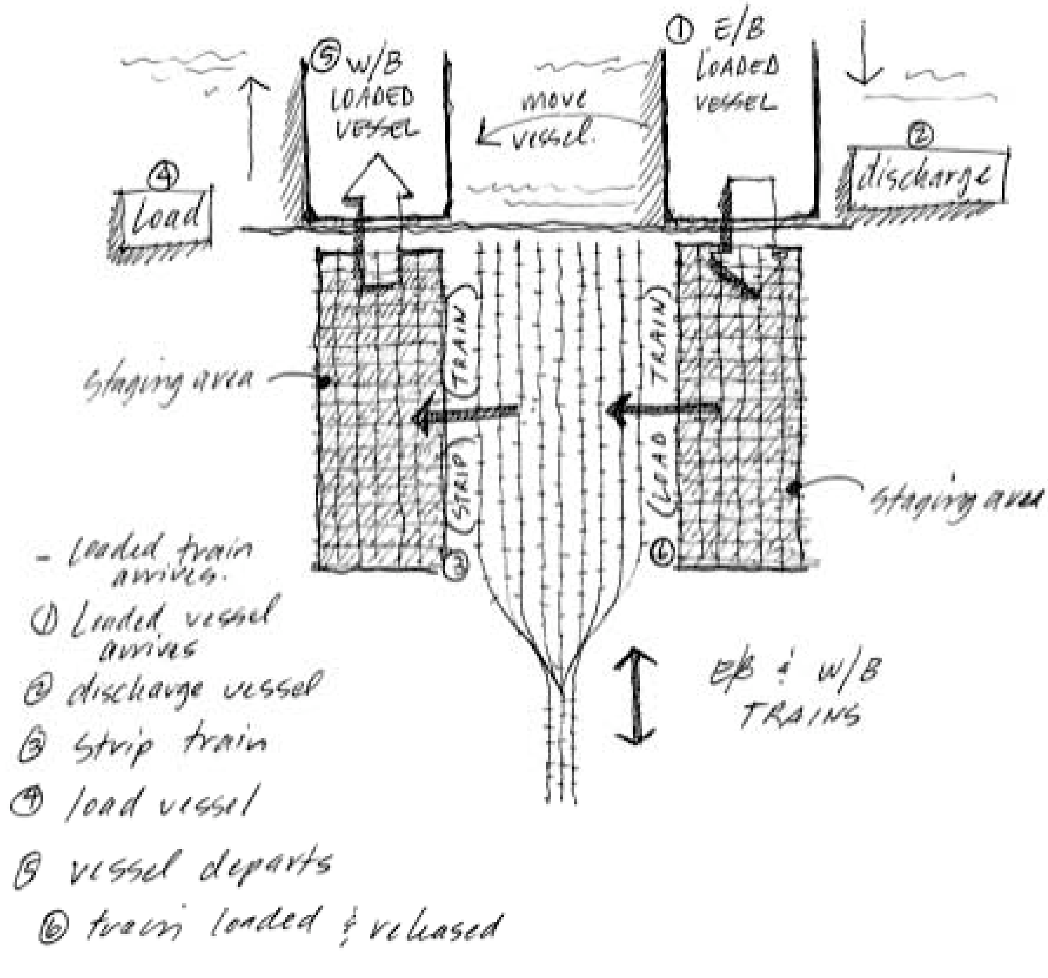
6.3 Fast Ship
Fast Ship Atlantic™ is a very high-speed container ship (~40 knots) carrying only high-value time-sensitive cargo. The baseline Fast Ship has a capacity of about 1430 TEU and is fitted with engines that boast 250,000 horsepower, thus using about six times the energy of conventional 8000 TEU/25-knot ship. In order to preserve the time gains made on the sea leg, the Fast Ship concept includes a concept for unloading the containers using a rail "cassette" that is as long as the ship. This concept is described below.[50]

6.4 Longitudinal Cassette Discharge To quickly unload and load the ship while *also* quickly loading and unloading on-dock rail, strings of containers can be pulled, rolled, or "airmatted" off the ship's stern onto waiting trains. This concept was first explored with both the train and the ship arriving full (except for one empty train cell). A "string" (defined as 40 containers long by two containers high) of containers was then pulled off the ship onto the empty train cell, while a string of containers from the train was pulled into the now empty cell on the ship. This concept requires the capability for containers to

[50] Christopher McKesson, email correspondence, January 20, 2007; see also www.fastshipatlantic.com/aboutfastship.html.

move on and off the ship in both directions from the same set of rail tracks. It also requires careful consideration of weighting and ship balance as well as speed of discharge.

A second longitudinal cassette discharge idea (shown in the figure below) is much quicker and potentially more energy efficient than moving single rows of cassettes as described above. In this case, the train arrives full and horizontally "slides" all cargo to the staging area on the left. This could be accomplished by having a stepped staging area (whereby the train unload area is at a lower elevation than the train arrival area). The vessel also arrives full and discharges all its cargo in one transition onto the dock (using airmat or tether technology). The cargo is then horizontally loaded onto the now-empty train (again using gravity and rollers or airmats to move the containers). The horizontal movements of containers from staging areas on and off rail may be assisted by the proper design (elevation and materials) of the staging areas. The goal is to eliminate all lifting functions. The ship then moves laterally and is loaded with the cargo originally offloaded from the train (locks could be used to move the ship to an elevation below that of the cargo). Other considerations include ship redesign (the size of the ship discussed was 1,000 feet long by six containers wide and two high), ways to secure containers onto vessels and rail, and coordination or redesign of the wells and sills on railcars.



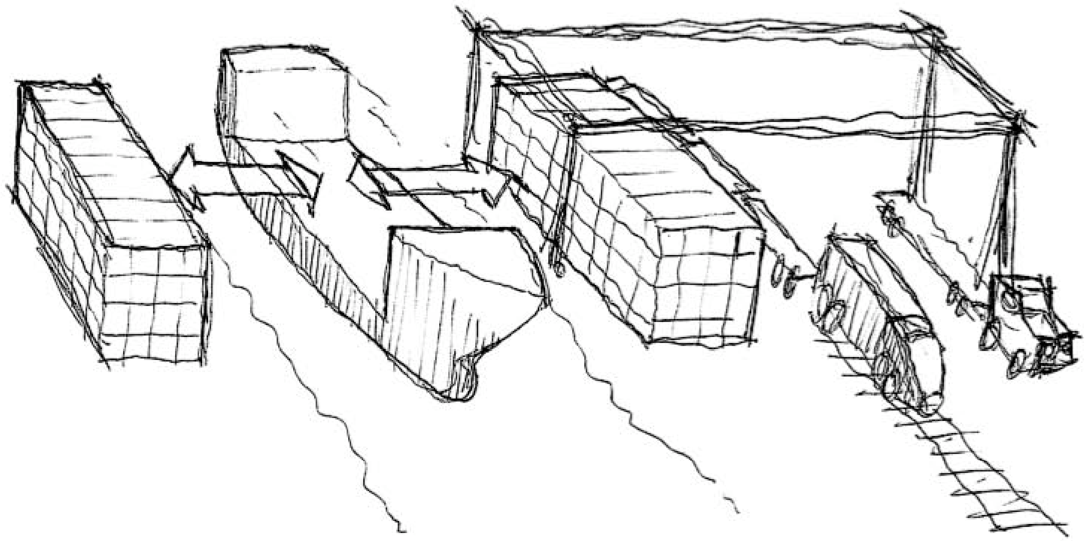
Drawing Courtesy of Brian Mannelly, Port of Tacoma.

6.5 Intelligent Cargo: Just as airline passengers act as self-sorting cargo, containers and other packages could self-sort if given the proper technology and infrastructure. Information about each container would be stored on the package or on a mainframe computer system. The cargo would know what it is, where it's going, and be able to make decisions regarding its most efficient, safest, or reliable route.

6.6 Third-Party Service Providers: Because there are so many players in the shipping industry, retrieving information and coordinating activities is challenging. Most activities have been optimized for their particular purpose (e.g., vessels are optimized for ocean-travel and cranes are optimized for unloading containers), not for their integration with other activities. Third-party service providers may be able to technologically link all industry players to improve information-sharing and overall management.

6.7 Automated Crewless Ships A pilot crew would guide the ship from its origin to a point of departure at which point a course would be set for the ship. The crew would disembark while the ship continued unmanned across the ocean. These ships could be more barge-like in nature, yet must withstand bad weather. Such a ship could be remotely controlled and under human control at all times—the captain is simply not on board. Satellite data links combined with global positioning systems (GPS) make this feasible. The ship could be programmed so that if the data link is lost it goes into a "hold station" mode. A common criticism of the unmanned ship is that it is less safe, as there is no active lookout. However, it was noted that a man who is warm, dry, and got a good night's sleep in his own bed at home is a *better* lookout than a man at sea, even if the "looking out" is being done by television camera. Additionally, the man on the bridge of today's 1000-foot container ship, looking through rain-shrouded windows into the dark of night, is not as good a lookout as a digitally-enhanced video camera. Furthermore, without an on-board crew, the ship need not be fitted with human-support systems such as cabins, toilets, food storage systems, fresh water making devices, heating, cooling, and air conditioning systems, sewage treatment facilities, and other human necessities.

6.8 Transverse Block Discharge: By moving containers off the ship in blocks, loading and unloading time can be reduced from days to hours. Elevation of the ship and dock must coordinate with that of the rail (note: currently, for ships with stacks of 18 boxes, the ships center of gravity is above the dock), as might the length of the container mass and the length of the rail. By moving the containers off the ship quickly, the ship can disembark much more quickly. However, containers will still sit on the dock until loaded onto local transportation. Given that lifting is the most energy-intensive process of loading and unloading, this concept could be combined with airmat technology to eliminate lifting altogether.



Drawing Courtesy of Brian Mannelly, Port of Tacoma.

6.9 Move Vessels Up and Down via Locks

An alternative means of moving goods could be to place the ship in a lock, which would allow containers to always be moved down onto rail or down from rail onto the ship.

6.10 Water Wheel: A Ferris wheel could be used to unload and load containers from the ship to and from various elevations on dock. An example of this technology is in place in the village of Tamfourhill, Scotland. Called the Falkirk Wheel, the device allows shippers to transfer boats and cargo between two canals at different elevations.

Image 3: Water wheel in Scotland, Image from: www.scotland-flavour.co.uk/falkirk.html.

NuPort Ideas: Non-Container-Based

7.1 Non-Scale-Based Way of Reducing Tare: All ocean transportation includes the notion of tare weight: in addition to cargo, there are engines, fuel, hulls, men, etc., that are shipped across the sea with each delivery. These necessary components are not part of the five million widgets needed from Shanghai. They are "tare weight" to that shipment. The same is true of trains, where the empty cars and the locomotives represent tare weight, and trucks, where the cab, tractor, chassis, and driver all constitute "tare." Designers are aware of the "overhead" nature of tare weight, and they actively seek ways to reduce it. The easiest such way is to simply make the vehicle larger. A triple-trailer truck doesn't have any more engines or drivers than a single-trailer truck.

In the case of ships this "economy of scale" has lead to the 8000- and 10,000-TEU mega ship. However, while this improvement has led to greater efficiency of one transportation leg (reducing the tare weight fraction of the sea leg), it has lead to a worsening of another (cargo surge). What is needed is to eschew the "low-hanging fruit" of reducing tare fraction by making the ship bigger (economy of scale) and instead pursue those tare-reductions that do *not* lead to a bigger ship. Examples include:

- The use of lighter structural materials such as composites;
- Eliminating all the tare weight associated with the human operation by using unmanned/remotely-manned ships;
- Using steel in containers to reduce the (tare) weight of the steel in the ship; and
- Slowing the ship down to reduce the amount of the power required, thus reducing the tare weight associated with engines, fuel, etc.

7.2 Rubik's Cube In-Transit Sorting: Instead of wasting time sorting cargo during either the loading or unloading process, cargo could be sorted, tagged, and inspected while the ship is in-transit. Essentially, the cargo remains untouched for seven days before requiring a plethora of attention once at its destination. If some of the requisite port tasks could be accomplished while in-transit, time could be saved on both ends of the sea journey. This concept would likely apply better to break bulk as opposed to containerized cargo.

7.3 Sea-snake: Watertight containers are dragged across the ocean on an electric marine conveyor belt, which could hook directly into a system of port conveyor belts that sort and load cargo onto appropriate trucks and trains (or land-based conveyor belts). This sea-snake could build upon the Coreolis effect and follow natural currents to increase its efficiency.

7. 4 Break bulk Cargo Holds with Sorting Technology: With break bulk cargo, smaller-scale intelligent sorting technology can quickly read cargo information (via RFID tags) and move cargo to the appropriate land transportation. Break bulk cargo eliminates the need for chassis pooling and the problem of container imbalance and would likely require less expensive new infrastructure than would any new container-based infrastructure.

7.5 ***Automated Sorting to Destination Bins:*** An entirely automated port with conveyor belts and spinning sorting zones would bring packages to rail cars without human oversight.

Additional, Non-Group Concepts

Box 10: 1000-TEU Wind-Powered Container Vessels (Idea 8.1)

Naval architect Christopher McKesson noted that a 1,000-TEU container ship could, if designed properly, travel from Asia to the West Coast entirely by wind power (although prevailing winds would require the use of an engine for the return trip).

"Conventional wisdom is that wind isn't reliable enough to eliminate the engine, and that the cost of the gear and sails (and men?) is higher than the cost of fuel," he wrote. "Is it still true at today's fuel prices? Particularly if one places a value on the environmental impact of the fuel? …. Further, it's true that sail would not buy you much on a 25-knot ship. But how about on a 15-knot ship? Now we are talking about power levels that are attainable with sails. Further, while we might have no wind for a seven-day trip, if the trip is now a 15-day trip we will see statistically more variation in the weather. That means that we can rely more on 'averages,' and we *could* actually use a smaller engine because we can count on some average contribution due to wind." [51]

8.2 Port Research Center: Many groups discussed the need for improved information about existing projects in a variety of arenas as well as a need for more demonstration projects. Building on those discussions, a Port Research Center could act as an aggregator of information about existing projects, a network center for different parties to discuss concepts, and an incubator and testing facility for new projects, particularly highly innovative ideas.

[51] Christopher McKesson, email correspondence, 1/27/07.

8.3 Drift Packages: It would take approximately three years for a package to drift from Shanghai to Seattle during July, but only one year to drift the same distance during January (note: the explicitly absurd notion of a July that is three years long). Items could be wrapped in waterproof, reusable materials and smart-tagged with pertinent information. A modicum of sail area would provide the control necessary to avoid getting caught in gyres.

8.4 Ocean Pipeline Batches: A transcontinental underwater pneumatic tube could batch products from continent to continent. Signal items (such as beach balls) could indicate the beginning or end of a new batch of products.

8.5 Galvanic Vessel: By coating the fore and aft halves of a ship (or port and starboard halves) with two different metals, an electric potential is created between the halves of the ship. With seawater acting as an electrolyte, the entire vessel becomes a giant battery—or galvanic cell—and generates electricity to power the vessel across the ocean. In the process, one of the metals (the anode of the battery) corrodes, and the electrochemical reaction stops when that metal has corroded completely. This would require a protective layer between the hull and the metal coatings to prevent the ship from corroding completely as it crosses the ocean.

7 Conclusion

Convening a diverse group of individual to rethink how ports can improve their competitive advantage *and* their sustainability is an audacious and daunting activity. The ideas generated at the Innovation Workshop varied widely. Some stimulated action plans and partnerships, others promising ideas for individual port pilot projects. Some are design notions whose time may come a decade from now. Hopefully this is the beginning of an ongoing dialogue for the participants who gave generously of their time and creativity in this effort.

Appendices

Appendix A: Workshop Participant List

Innovation Workshop for Business and Sustainability

Participant Listing

Anderson, Bruce.....................Starcrest Consulting..................Principal, Air Quality Director
Banks, Sharon.........................Cascade Sierra Solutions..................Chief Executive Officer
Beckett, Jeannie.....................Port of Tacoma..................Senior Director, Inland Transportation
Best, Lynn.............................Seattle City Light..................Manager, Science Policy Unit
Boerner, Bryon..
Botsford, Charlie.....................AV, Inc...................Business Development, Energy Systems Dev. Center
Bors, Doug..
Brady, Mark...........................Puget Sound Clean Cities Coalition..................Program Manager
Burke, Mike...........................Port of Seattle..................Director, Cargo & Cruise Services
Catalani, Rick.........................Expeditor's International..................Import Manager
Cole, Barbara.........................Port of Seattle..................Senior Environmental Program Manager
Dugan, Brendan......................Port of Tacoma..................Senior Director, Container Terminal Businesses
Evancho, Andy..
Farrell, Tim.............................Port of Tacoma..................Executive Director
Feldman, Rich.........................King County Labor Council..................Executive Director of Economic Workforce Division
Flagg, Sarah...........................Port of Seattle..................Environmental Management Specialist
Flanagan, Jim..........................APM / Maersk..................Regulatory Affairs Director
Fluhrer, Caroline......................Rocky Mountain Institute..................Research Fellow, Built Environment Team
Grotheer, Wayne.....................Port of Seattle..................Director, Seaport Finance & Asset Management
Hanson, Eric...........................Port of Seattle..................Senior Planner
Hessenauer, Ginny.................APL..................Director of Environmental Affairs
Hogman, Phil..........................Tacoma Rail..................Mechanical Officer
Holde, David van.....................Seattle City Light..................Acting Manager, Account Executive Officer
Hon, Galen.............................Port of Tacoma..................Environmental Engineer
Ison, Tom...............................BNSF Railroad Company..................General Director, Hub & Facility Operations West
Jagielski, Mike........................ILWU Local #23..................Member
Jefferson, Matoya..
Johns, Stephanie....................Rocky Mountain Institute..................Research Fellow, Breakthrough Design Team
Jones, Stephanie....................Port of Seattle..................Senior Manager, Seaport Environmental Programs
Kannewurff, Chris von............K-Line..................Group Vice-President, Marine Technical Division
Kim, G. S................................HASA..................Vice-President
Kimbrough, Eric......................ILWU Local #23..................Member
Kindberg, B. Lee.....................Maersk..................Director, Environment
Kinsley, Michael......................Rocky Mountain Institute..................Senior Consultant, Breakthrough Design Team
Kircher, Dave..........................Puget Sound Clean Air Agency..................Manager, Air Resources Department
Lee, J. H.................................HMM - America..................Chief Executive Officer

Leng, Capt. C. M.	Evergreen America	Vice-President, Marine Operations
Lin, Cindy	Port of Tacoma	Environmental Compliance Manager
Lingerfelt, Mike	WUT - Tacoma	President
Long, Colleen	Rocky Mountain Institute	Events Coordinator, Breakthrough Design Team
Lovins, Amory	Rocky Mountain Institute	Chief Executive Officer
Mannelly, Brian	Port of Tacoma	Manager, Terminal Planning & CADD Services
Mauermann, Sue	Port of Tacoma	Director, Environmental Programs
McKesson, Christopher	Alion Science & Technology, Inc.	Sr. Engineering Science Advisor-Unconventional Naval Architecture
McLerran, Dennis	Puget Sound Clean Air Agency	Executive Director
Meister, Diana	Port of Tacoma	Administrative Assistant, Facilities Operations
Moore, Mike	PMSA	Vice-President
Most, Bryan	Wal-Mart	Vice-President, Logistics
Murchie, Peter	U.S. EPA	Coordinator, West Coast Collaborative
Nye, Larry	Moffat Nichol	Vice-President
Ogburn, Michael	Rocky Mountain Institute	Consultant, Breakthrough Design Team
Page, Chris	Rocky Mountain Institute	Integrated System Design
Pahk, K. S.	WUT - Tacoma	Chief Executive Officer
Park, Y. K.	HMM - Seoul	Vice-President
Paulsen, Lou	Port of Tacoma	Senior Director, Facilities Development
Peeler, Rod	ILWU Local #52	President, Washington Area Marine Clerks
Reichman, Jim	Paccar	Director, Powertrain Technology
Ressler, Peter	Port of Seattle	Manager, Environmental Compliance & Program Dev.
Sasala, Steve		
Seum, Stefan	ENVIRON International Corporation	Consultant
Shaw, Michael	Port of Tacoma	Environmental Program Manager
Sheldon, Charlie	Port of Seattle	Managing Director, Seaport
Shing, Y. C.	OOCL	Director, Marine & Consortium, NAT Security Officer
Southards, Mike		
Stephens, Darrell	SSA	Maintenance Manager
Stuhr, Greg	ITS / Husky	Director, Corporate Planning
Styrk, Linda	Port of Seattle	General Manager Container Services
Swisher, Joel	Rocky Mountain Institute	Managing Director
Thomas, Jeff	Husky Terminals	Director
Ugles, Herald	ILWU Local #19	President
Waters, John	Rocky Mountain Institute	Team Leader, Breakthrough Design Team
Zachary, Mike	Port of Tacoma	Director, Planning & Logistics
Zent, A. J.	TOTE	Terminal Supervisor

Appendix B: Glossary of Acronyms and Terms

Glossary of Acronyms

APU – auxiliary power unit
BNSF – Burlington Northern Santa Fe Railway
CARB – California Air Resources Board
CO_2 – carbon dioxide
CSS – Cascade Sierra Solutions, non-profit organization operating in Washington, Oregon, and California with initiatives focused on saving fuel and reducing emissions from heavy-duty diesel engines
DOE – federal Department of Energy
DPM or PM – diesel particulate matter, $PM_{2.5}$ is all particulate matter smaller than 2.5 microns in size, represents ~94% of particulate emissions
EMT – Efficient Marine Terminal, demonstration of Efficient Marine/Rail Intermodal Interface at the Washington United Terminal in Tacoma
EPA – federal Environmental Protection Agency
EPRI – Electric Power Research Institute
EV – electric vehicle
FAST Corridor – Freight Action Strategy for the Everett-Seattle-Tacoma Corridor
GHG – greenhouse gas
GPS – global positioning system
HEV – hybrid-electric vehicle
HFO – heavy fuel oil
Hp - horsepower
HRCPII – Hampton Roads Chassis Pool II, neutral chassis pool started in October of 2004 at the Port of Virginia, required all steamship lines and terminals to use chassis pool
IIC – Intermodal Interface Center, part of EMT demonstration where containers were transferred to/from trains and trucks
ILWU – International Longshore and Warehouse Union
IMO – International Maritime Organization
MDO – marine diesel oil, a blend of gas oil and heavy oil
MGO – marine gas oil, clear oil not blended with heavy fuel
MOU – memorandum of understanding
Muda – Japanese term for waste, purposeless, or opportunity for improvement, well-known concept in field of lean manufacturing
MW - megawatt
NO_x – nitrous oxide emissions, one type of criteria pollutant
OEM – original equipment manufacturer
PHEV – plug-in hybrid-electric vehicle
PNNL – Pacific Northwest National Laboratory
PPCAC – Pacific Ports Clean Air Collaborative
PSCAA – Puget Sound Clean Air Agency, sponsored part of Innovation Workshop
Psi – pound per square inch, unit of pressure
RFID – Radio Frequency Identification
RMG – rail mounted gantry crane

RMI – Rocky Mountain Institute
RTG – rubber tire gantry crane
SEAaT – Sulfur Emission Abatement and Trading
SECA – SO_x Emission Control Area, term used by IMO
SO_x – sulfur oxide emissions, one type of criteria pollutant
SSA Marine Inc.– Stevidoring Services of America, Inc., renamed in 2003
Straddle carrier
STS – Ship to Shore gantry crane, used to load/unload containers from ocean going vessels
TEU – twenty foot equivalent unit
TLS – Truck Licensing System
UP – Union Pacific Railroad
VOCs – volatile organic compounds
VPA – Vancouver Port Authority
WUT – Washington United Terminal

Glossary of Terms

Bobtail trip: trip made by a drayage truck without a chassis attached, example of single-cycling equipment

Bom-cart: a specific type of chassis with sloped sides to increase ease of container loading and unloading. Used to haul containers within a terminal.

Break bulk cargo: Non-containerized general cargo stored in boxes, bales, pallets or other units to be loaded onto or discharged from ships or other forms of transportation. (See also: **bulk** and **container**.) Examples include iron, steel, machinery, linerboard and wood pulp

Carrier (or Freight Carrier): Companies that haul freight, also called "for-hire" carriers. Methods of transportation include trucking, railroads, airlines, and sea-borne shipping.

Drayage: the movement of containers to/from a port to distribution centers or rail yards

Emissions footprint: a measure of the emissions associated with the combustion of fossil fuels as part of the everyday operations of an enterprise

IMO: International Maritime Organization. The United Nations' specialized agency responsible for improving maritime safety. Provides mechanism for cooperation among governments regarding regulations and practices relating to technical matters affecting shipping engaged in international trade; encourages and facilitates general adoption of the highest standards regarding maritime safety, efficiency of navigation and prevention of pollution from ships.

Intermodal: involving two or more different modes of transportation in conveying goods, such as truck and rail

Port authorities: Local government entities whose role is akin to landlords that lease lots for a wide variety of activities, including cargo loading and unloading. Port authorities also have a mission to provide economic development. They are not responsible for providing shore-side operations, which is the responsibility of terminal operators (see below) or steamship operators who also provide landside operations.

RFID: Radio Frequency Identification. Technology used for tracking. RFID tags can be used to track container movements based on a radio frequency signal. Radio frequency transceivers are now in common use. The latest radiation detection portals and container scanning equipment are being combined into a single unit and capture images of trucks moving at speeds up to ten mph. Large ports would need several to ensure that the screening process would not slow the flow of trucks.

Shipper (or consignor) — The person or entity for whom the owners of a ship agree to carry goods to a specified destination at a specified price.

Shore-power or cold-ironing: practice of plugging a ship into electric power at the dock to shut down the ships engines while at berth

Stevedore: Company that provides equipment and hires workers to transfer cargo between ships and docks. Stevedore companies may also serve as terminal operators. The laborers hired by the stevedoring firms are called stevedores or longshoremen.

Straddle carrier: Container terminal equipment, which is motorized and runs on rubber tires. It can straddle a single row of containers and is primarily used to move containers around the terminal, but also to transport containers to and from the transtainer and load/unload containers from truck chassis.

Terminal operator — The company that operates cargo handling activities on a wharf. A terminal operator oversees unloading cargo from ship to dock, checking the quantity of cargoes against the ship's manifest (list of goods), transferring of the cargo into the shed, checking documents authorizing a trucker to pick up cargo, overseeing the loading/unloading of railroad cars, etc.

TEUs – Twenty-foot Equivalent Units. A standard unit of measure for container shipping. A forty-foot container is 2 TEUs. More useful than metric tons for measuring import-export activity, since the weight of containers may vary drastically.

Transtainer: A type of crane used in the handling of containers, which is motorized, mounted on rubber tires and can straddle at least four railway tracks, some up to six, with a lifting capacity of 35 tons for loading and unloading containers to and from railway cars.

Yard hostler: a vehicle used in terminal operations to move containers from one area of the terminal to another

Appendix C: Definition of Muda

What is Muda?
Muda is Japanese for "waste," "futility," or "purposelessness." A familiar example of muda is air travel. The book *Natural Capitalism* notes, "often you can't get a direct flight to where you want to go. Instead, you must somehow get to a major airport, fly in a large airplane to a transfer point quite different from you actual destination, become "self-sorting cargo" in a huge terminal complex once you arrive there, and board another large plane going to the destination you originally wanted. Most travelers tolerate this because they are told that it's a highly efficient system that fully utilizes expensive airplanes and airports. Wrong. It looks efficient only for the tautological reason that the airplanes are sized for those large hubs, which are designed less for efficiency than to monopolize gates and air-traffic slots, thus reducing competition and economic efficiency as well as convenience." [52]

The Eight Categories of Muda

Overproduction - Manufacturing or acquisition of products before they are needed or processing of unnecessary information, (i.e. forms or data that are not needed).

Idle time, Waiting or Delay - Refers to both the time spent by the workers waiting for resources (tools, supplies, parts, or information) to arrive, the queue for their products to empty as well as the capital sunk in goods and services that are not yet delivered to the customer. In today's economy, all information (money is a form of information) should be.

Unnecessary Transporting, Conveyance or Movement - Unnecessary movement of products, people, or information. Transporting materials, parts or finished goods into or out of storage (inventory) or between processes. Each time a product is moved it stands the risk of being damaged, lost, delayed, etc.

Unnecessary Processing - Providing higher quality or extra operations than are necessary to meet the customer's needs. Using more expensive equipment or tools where simpler ones would suffice. Having meetings or people at meetings that are not needed. Also, there is a particular problem with this item as regarding people. People may need to perform tasks that they are over qualified for so as to maintain their competency. This training cost can be used to offset the waste associated with overprocessing.

Unnecessary Inventory - Maintaining excess inventory, supplies, work in process (WIP), or finished goods in order to compensate for process inaccuracy or the other mudas. WIP represents a capital outlay that has not yet produced an income either by the producer or by the consumer. Inventory is a sign or symptom of waste somewhere.

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[52] Lovins et al. Natural Capitalism. New York: Back Bay Books. 1999. p 126. Original quote from Womack and Jones, *Lean Thinking.*

Unnecessary Motion - As compared to transportation, motion refers to the producer or worker. This has significance to damage, wear, and safety. It also includes the fixed assets, and expenses incurred in the production process. Examples include not focusing on ergonomic design, any wasted motion to pick up parts or stack parts. Any wasted walking or moving around. Wasting time looking for things in a cluttered workspace or desk, lack of organization.

Defects, Correction, Repair or Rework - Design of goods that do not meet customer needs. Performing the same task a second time, rescheduling, and capacity losses. Any mistake correction activity. Quality defects prevent the customer from accepting the product produced. New processes must be added in an effort to reclaim some value for the otherwise scrap product.

Underutilizing Employees, Oversight or Inspection - Employees have skills in addition to what they were hired for, it is wasteful to not take advantage of these skills as well. E.g., not using the full productive capacity of all employees' creativity and thinking power.

Appendix D: Muda Worksheet

Muda Worksheet
Waste = Opportunities

Consider the following categories of muda. On a separate sheet, record any ideas that come to mind regarding muda at the ports. (At this early brainstorming phase, there are no bad ideas.) The following points are meant only to prompt your thinking. Some may not apply to your particular situation.

Waste streams — Potential for:

- Reduction
- Elimination
- Reuse or repair
- Sale
- Composting

Inefficient Process

- Unnecessary processes
- Alternative technologies that can perform the same task more efficiently.
- Material and energy losses
- Running equipment when not needed
- Lighting usage
- Insulation and heat exchange
- Leaks
- Transmission and distribution losses
- Flow and friction
- Piping layout and sizing
- Equipment inefficiency
- Equipment with lower life-cycle costs
- Process control
- Maintenance programs and commissioning
- Temperatures, pressures and flow rates that are different that that which is required.

(continued)

Muda is Japanese for "waste," "futility," or "purposelessness." A familiar example of muda is air travel. RMI's book, *Natural Capitalism* notes," often you can't get a direct flight to where you want to go. Instead, you must somehow get to a major airport, fly in a large airplane to a transfer point quite different from you actual destination, become "self-sorting cargo" in a huge terminal complex once you arrive there, and board another large plane going to the destination you originally wanted. Most travelers tolerate this because they are told that it's a highly efficient system that fully utilizes expensive airplanes and airports. Wrong. It looks efficient only for the tautological reason that the airplanes are sized for those large hubs, which are designed less for efficiency than to monopolize gates and air-traffic slots, thus reducing competition and economic efficiency as well as convenience."

Bottlenecks, Waiting or Delay

- Time spent waiting in queues and for resources (tools, supplies, parts, or information) to arrive.
- Capital sunk in services or equipment that are not being utilized.
- Operations costs for idle equipment.

Unnecessary Transport, Conveyance or Movement of products, people, or information, for example:

- Wasted motion to pick up parts or stack parts or containers
- Moving information in excess steps or through multiple checkpoints or locations
- Un-ergonomic design
- Wasted movement

Unnecessary Activities

- Providing higher quality or extra operations than are necessary to meet the customer's needs.
- Using larger or more expensive equipment or tools where smaller, simpler ones would suffice.

Defects, Correction, Repair or Rework

- Performing the same task twice, rescheduling, capacity losses, and any mistake-correction activity.

Underutilizing Employees, Oversight or Inspection

Employees often have skills beyond those for which they were hired. Putting these skills to work can benefit the company and the employee. For example:

- How might employees' creative thinking be better used?
- How might one employee (a supervisor, inspector, or manager) support another in performing his/her work?

Appendix E: Breakout Group Participant Lists

Ports Innovation Workshop Day 1 Breakout Groups

Goods coming in (ships & cold-ironing)

Larry Bennett	Capt. C. M. Leng
Mike Burke	Cindy Lin
Barbara Cole	Mr. Mike Lingerfelt
Tim Farrell	Christopher McKesson
Caroline Fluhrer	Mike Moore
Eric Hanson	Mr. Y. K. Park
Chris Von Kannewurff	Michael Shaw
Mr. G .S. Kim	Greg Stuhr
Eric Kimbrough	Joel Swisher

Goods in port (cargo-handling & intermodal)

Bruce Anderson	Peter Ressler
Charlie Botsford	Charlie Sheldon
Jim Flanagan	Darrell Stephens
Ginny Hessenaur	Linda Styrk
Phil Hogman	Jeff Thomas
Galen Hon	Herald Ugles
Stephanie Johns	David Van Holde
Brian Mannelly	David Ward
Chris Page	John Waters
Rod Peeler	

Goods Leaving (Trucks & intermodal)

Sharon Banks	Dave Kircher
Jeannie Beckett	Bryan Most
Rick Catalani	Larry Nye
Hadi Dowlatabadi	Michael Ogburn
Sarah Flagg	Jim Reichman
John Gray	Mike Southards
Tom Ison	Steve Stivala
Mike Jagielski	Mike Zachary
Stephanie Jones	

Business Opportunities

Lynn Best	Sue Maurmann
Mark Brady	Dennis McLerran
Brendan Dugan	Diana Meister
Rich Feldman	Peter Murchie
Wayne Grotheer	Mr. K.S. Pahk
Andrew Johnson	Lou Paulsen
B. Lee Kindburg, PhD	Stefan Seum
Michael Kinsley	Y.C. Shing
Mr. J.H. Lee	

Ports Innovation Workshop Day 2 Breakout Groups

Trucking	Emerald A
Dave Kircher	Wayne Grotheer
Sharon Banks	Eric Kimbrough
Mark Brady	Cindy Lin
Steve Sasala	Peter Murchie
Tim Farrell	Michael Ogburn
Sarah Flagg	Mike Southards

Port Electrification	Emerald B
Mike Jagielski	Galen Hon
Lynn Best	Stephanie Johns
Bryon Boerner	Peter Ressler
Doug Bors	Darrell Stephens
Charlie Botsford	Joel Swisher
Andy Evancho	David van Holde
Rich Feldman	John Waters

Next Generation	Emerald C
Bruce Anderson	Mike Moore
Caroline Fluhrer	Bryan Most
Eric Hanson	Larry Nye
Captain C. M. Leng	Chris Page
Amory Lovins	Lou Paulsen
Bryan Mannelly	Herald Ugles
Chris McKesson	

Logistics	Emerald D (Lunch Room)
Sue Mauermann	Dennis McLerran
Ginny Hessenauer	K. S. Pahk
Phill Hogman	Rod Peeler
Tom Ison	Stefan Seum
Stephanie Jones	Mike Shaw
Jeannie Beckett	Chris von Kannewurff
Mike Lingerfelt	Mike Zachary

Vessels	Emerald E & F (Main Room)
Barbara Cole	Y. K. Park
Brendan Dugan	Charlie Sheldon
Jim Flanaghan	Y. C. Shing
G. S. Kim	Greg Stuhr
Lee Kindberg	Linda Styrk
Michael Kinsley	Jeff Thomas
J. H. Lee	Andrew J. Zent
Dianna Meister	

Appendix F: Breakout Group Roadmap Worksheet

Innovation Workshop for Business and Sustainability

Roadmap Worksheet

Please answer the following questions using your best estimates, based on what you know right here, right now. Feel free to use additional paper. Detailed analysis and development will follow the innovation workshop.

Title of your suggested program or project initiative:

Purposes, Goals and Benefits
Answer the following questions in terms of the three aspects of sustainability below.

Business:
Problem(s) to be solved:

Desired results, outcomes or benefits:

Environment:
Problem(s) to be solved:

Desired results, outcomes or benefits:

Community and other social aspects:
Problem(s) to be solved:

Desired results, outcomes or benefits:

Details
Description of initiative, including scope of work:

Timeline (with phases if necessary):

Suggested program team and team leader:

Suggested location:

Challenges
What is likely to be the biggest challenge to the success of this initiative and what are possible ways to overcome it?

Analysis
What questions should be answered before proceeding with this program? Include questions regarding possible barriers, drawbacks, and uncertainties. Who has the knowledge to provide answers to these questions?

Design
How will the program be designed and who should be involved in the design?

First Steps Toward Implementation
What are the first few steps toward carrying out this project and who should be responsible for each?

Step 1:

Step 2:

Step 3:

And, to ensure this initiative gets started:
Who will do what next? When will they do it?

Who (here today):

What:

When:

If your subgroup has extra time, answer the following.

Linkages
In what ways might this project support, link to, or increase the benefits of projects being proposed by other workshop subgroups?

Partnerships
Who needs to be part of this project, or understand it, in order for it to succeed?

Assumptions
On what assumptions is your project based? Have you explored the validity of each?

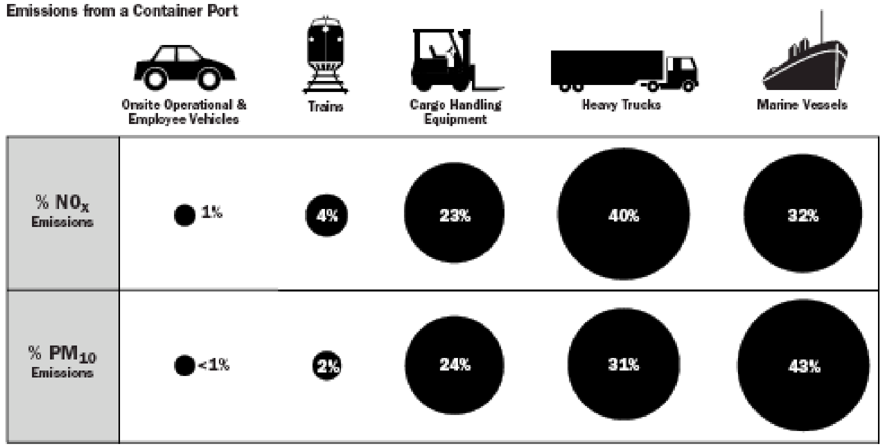
Alternatives
What alternatives were considered and why were they rejected?

Appendix G: Day Two Presentations

Port Electrification

Electrifying Equipment

FIGURE 1-1
Average Contributions of Various Port-Related Sources to Total Nitrogen Oxides (NO_x) and Particulate Matter (PM_{10}) Emissions from a Container Port



Preferred Technology	PHEVs	Hybrid Locomotives	Electric Hostlers & RMG	Hybrids Retrofit APU	Electric Tug (power from ship)

Results – Rough Calculations

- 80 Hostlers need 2 MW at terminal
  - ~800,000 gallons diesel/year
- 50 Strads/25 RTGs need 3 MW at terminal
  - Electric RMGs preferred technology
- 4 STS cranes need 3 MW at terminal
  - Already provided

- **Port Electrification Strategy**: Focus on yard hostlers as entry point

Roadmap

- Strategic Partners
  - Technical – ie. hostler supplier, batteries, etc.
  - Utilities
  - Puget Sound Maritime Air Forum
  - Funding
    - EPA West Coast Collaborative
    - DOE/PNNL
    - Ports/Cities
    - State of Washington
    - PSCAA
    - EPRI
    - BC Hydro/Vancouver/Port of Vancouver
    - Google.org
    - Lung Association
    - Partners
    - Health and welfare – perhaps ILWU???
    - Grants

Roadmap

- Phase 1
  - Business Case and evaluation
  - Technology evaluation
- Phase 2
  - Prototypes at each Port
- Phase 3
  - Larger demonstration – Whole terminal?

Roadmap cont'd

- Phase 1 - Business Case
  - Cost of demo
  - Cost of resources
  - Life cycle cost analysis
    - Est. operating cost $16/hour - $35,000/year/hostler
  - ROI investigation
  - Timeline
  - Value proposition
  - Benefits/Risks
    - Operating and maintenance costs
    - Ergonomics
    - Emissions

Phase 1 Team

- Darrell Stephens (SSA), Galen Hon (POT), Peter Ressler (POS), Rich Feldman (Apollo), Mike Jagielski (ILWU), Lynn Best (SCL), Andy Evancho (Tacoma Power)
- Task: Complete Business Case
- Additional Support?
  - Ports?
  - Terminal Operators?

Beyond Phase 1

- Phase 2
  - Prototypes at each port
  - Use existing electrical infrastructure
  - OEM involvement
- Phase 3
  - Larger demonstration – whole terminal?

Vessels Group Presentation Day 2

Summary of Options:

1. One clean fuel
2. Switch fuel aux/main
3. Redesign ship/engine
4. Plug ship in/alternate emission technology
5. Operational changes – more efficient/network

General Actionable Items:

1. SHORE POWER – DEVELOP INTERNATIONAL STANDARDS – WORK WITH SAN PEDRO EFFORT
2. PORT TO MANAGE DEPARTURE EVOLUTION
3. ID PROMISING EMISSION TECHNOLOGY AND PERFORM DEMOS VALIDATE TEST DATA
4. SHARE DEMONSTRATION DATA AMONG SHIP COMPANIES AND AGENCIES – WEST COAST DISTRIBUTION COLLABORATIVE PAGE – CLEARING HOUSE
5. INCENTIVIZE SHIPPING COMPANIES TO DEMONSTRATE EMISSION TECHNOLOGIES, e.g., OFFER "GRANDFATHERING"
6. JOINT PROGRAM – LEAD BY 2 PORTS, PSCAA AND A FEW IN THE INDUSTRY TO PARTICIPATE IN TEST TECHNOLOGIES (EMISSIONS) AS AND WHICH PROTECTS INDUSTRY PARTNERS
7. ANY STANDARDS SHOULD BE PERFORMANCED BASED (NOT TECH BASED)

Development Opportunities

Participants asserted that, regarding all options that were discussed, no substantial improvement can take place until one set of air-quality targets was developed (some preferred "target" to "standard"). The group agreed that the various stakeholders should be coordinated to influence:

1. U.S. agency-driven and congress-driven actions to implement Annex VI and North American SECA
2. IMO action on cleaner standards for green ships
3. Develop Consistency in PPCAC mitigation measures

Also the ports should work with their various industry partners in the following ways regarding:

Fuel switching opportunities for auxiliary engines at dock

- Implement projects in which ships switch fuels in port
- Develop incentives to promote switching fuels (PR Fed)
- Compile and publish data reflecting experiences of switching fuels in auxiliary engines
- Recognition – Celebrate Successes

Fuel switching opportunities for main engines

- Compile and publish data reflecting experiences of switching fuels in main engines
- Convene stakeholders to determine feasibility
- Recognition – Celebrate Successes

Shore power
- Develop international standards, consider using San Pedro experience

Other emissions technologies
- Identify promising technologies
- Perform demonstrations and validate test data
- Share demonstration data among ship companies and agencies, for example, the West Coast Diesel Collaborative web page
- Incentivize shipping companies to test emissions technologies and protect them from having their test result in unreasonable regulations.

Important general considerations repeated often in the conversation:
- Shippers need common standards globally to make this work. They can’t develop on-board technologies for every local technology and standards
- All standards should be performance-based not technology-based. The former encourages innovation and uses the market; the latter discourages innovation and quickly becomes obsolete.
- Industry competitors should begin sharing information on successful efforts to reduce emissions. One industry representative indicated that he intended doing so.
- Celebrate successes
- Joint program should be lead by POT, POS and PSCAA and few industry representatives to experiment/participate/test emission technologies and also protect industry partners

Next Steps
Who: Port of Seattle, Port of Tacoma, Puget Sound Clean Air Agency and customer representatives
What: Reconvene these players to better define the initiatives and develop action items
When: By mid- February

Logistics Roadmap – Presented to Plenary Session Second Afternoon

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Title of your suggested program or project initiative:
Information Guru: Development of centralized, consolidated transportation information system that results in better logistics and reduced emissions in Puget Sound

Purposes, Goals and Benefits
Answer the following questions in terms of the three aspects of sustainability below.

Business:
Problem(s) to be solved:
Inefficiencies in supply chain logistics system from lack of information where it is needed and could be used to optimize system. Used to alleviate multiple handling and unnecessary drays/trips/motion of containers.

Desired results, outcomes or benefits:
Increased efficiencies: reduces costs; increased service reliability and increased quality. Improve balance the equipment & assets. Eliminate friction points. Enhanced freight mobility

Environment:
Problem(s) to be solved:
Extra trips and handling result in emissions such as Diesel Particulate Matter and GHG emissions each time

Desired results, outcomes or benefits:
Save energy and reduce energy.

Community and other social aspects:
Problem(s) to be solved:
Health impacts from emissions, impacts from excess trips including: traffic, noise, lights. Not addressing these issues puts economic benefits of Ports and their customers at risk.

Desired results, outcomes or benefits:
Reduce impacts listed above. Cleaner air. Continued and increased support from community. Creation of clean jobs. Continued collaborative relationship with regulators.

Details
Description of initiative, including scope of work:
Development of consolidated transportation information system that results better logistics and reduced emissions in Puget Sounds.

- Identify participants and stakeholders
- Identify what kind of information each participant needs: influence database design:

- Form team: Ports of Seattle and Tacoma lead effort: one month. (by 3/1)
- Identify what must be common (not proprietary) information.
- Business Process mapping:
- Define deliverables, benefits and cost
- Decide who should manage/administer this system and how should be managed.
- Identify funding resources,
- Inventory, benchmark systems that are out there: eModal, Cargosmart, GT Nexus, Inttra, Marine Exchange, Port of Tacoma Business Exchange System.
- Publish RFP for vendor. 9/1
- Provide scalability by starting with focus on operations, expanding later to address broader marketing issues
- Tie use of data to environmental issues.
- Look to industrial leaders for best practices in reducing environmental impacts of supply chain.
- Deliverable in Summer of '08.

Timeline (with phases if necessary):
RFP goes out around June 1.

- Form team: Ports of Seattle and Tacoma lead effort: one month. (by 3/1)
- Publish RFP for vendor. 9/1
- Deliverable in Summer of '08.

Suggested program team and team leader:
Mike Zachary and Linda Styrk

Suggested location:
Paris, Bora Bora, Snowmass, Sequim

Challenges
What is likely to be the biggest challenge to the success of this initiative and what are possible ways to overcome it?

Stakeholder buy in: demonstrate benefit to potential participants

Trucking Presentation Day 2

Goal

- Create a new business model that values cleaner, more efficient trucks

Road Blocks

- Need to quantify where we are and measure costs/impacts of each action
- Method of distributing cost along the supply chain
- Cost of newer trucks
- Freight rates don't value energy/emissions
- Improve financial stability of owner-operator business model
- Minimize environmental impact without negatively impacting productivity in transferring cargo from port to consignee
- Better utilization of trucks
- Shippers aren't asking for cleaner trucks to move their cargo

Opportunities

- Pilot programs to test concepts that have been evaluated for effectiveness
  - Feebate pilot program to pay higher per container rates to truckers who drive cleaner trucks
    - Work with shipper, steamship line, terminal operator and brokers
  - Express lane for clean trucks at terminal gates
  - Leasing pilot program to get truckers into cleaner trucks
- Work with partners to create clean cargo program across West Coast
- Truck design competition to create efficient drayage trucks
- Evaluate cargo movement options that might reduce or eliminate on-road drayage
- Are there other innovative ways to deal with the drayage step?
- Establish metrics that look at the environmental footprint of the whole system

<u>NuPORT</u>

GOAL = Minimize energy required to get widget from Shanghai to U.S. locations

How can we achieve this goal?

Zero dwell, zero emissions, move once, on-time, goods not air, remove weight, transparent info, & reward correctly

<u>Assumptions:</u>

1. Reducing energy use will require slowing-down and desurging the sea leg (e.g. we need 1,000 containers/day not 8,000 one day per week (smaller vessels, more points)
2. The initial leg is point-to-point
3. Data on RFID tag is readdressable in real-time
4. Must improve upon existing expenditure of energy

<u>Two Variables</u>:

1. Size of Package
2. Type of Conveyance

CONTAINER-BASED OPPORTUNITIES:

1. SeaSnake: Pacific ocean conveyor belt (floating, waterproof containers)
2. Decouple Power from Cargo (return multiple power units)
3. Rubik's Cube In-Transit Sorting
4. Non-Scale-Based Way of Reducing Tare
5. Air-hockey deck/Airmats
6. Transverse Block Discharge
7. Longitudinal Cassette Discharge

INDIVIDUAL-PACKET OPPORTUNITIES (i.e. Fedex Meets Container Ships – Physical Packet Switching):

1. Ocean Pipeline Batches
2. Uniform bar code system for all packages
3. Automated sorting to destination bins

Appendix H: Marine Vessel Emissions Demonstrations and References (Stefan Seum)

ENVIRON

Stephanie Johns
Rocky Mountain Institute

Kingston, ONT, January 30, 2007

Hi Stephanie,

Following up on our conversation and my comments on the findings for the Innovation Workshop at the Ports of Seattle and Tacoma, I am providing you with some references on the implementation of advanced emission control technologies. In general there are fuel-related measures and technology related measures (there are also design-related measures, which I will not include). Fuel measures include low-sulfur fuels as well as other modified fuels. I will focus on low-sulfur fuels. Technology measures include the implementation of advanced engine technologies as well as after treatment technologies.

In the past years a tremendous amount of experience has been collected with many of those technologies. Some of this information is publicly available, others is within the domain of private companies. In regards to distillate versus residual fuel, it is mostly economics that have prevented the wide-spread introduction of distillates. Bunker prices for distillates (marine diesel oil – MDO and marine gas oil – MGO) are usually more than twice then that for heavy fuel oil, the residual fraction. (http://www.bunkerworld.com/markets/prices/) Many of the advanced after treatment technologies require distillate fuels. Thus, I would argue that it is merely a question of technical feasibility than a question of economics and the uneven playing field that gets in the way for implementing advanced fuels and technologies, as I had laid out in a report prepared for Starcrest. (Starcrest Consulting Group & Allee King Rosen & Fleming, 2002) I hope that the references I provide will support that case. A more detailed analysis into ship experiences, soliciting the information out there, would probably benefit the findings of a strategy for the Ports in Seattle and Tacoma and the State of Washington.

The use of distillate fuels and low sulfur residual fuels in marine engines:

Most marine vessels use heavy fuel oil (HFO) for propulsion and auxiliary engines. The wisdom that vessels burn lower sulfur fuels for their auxiliary engines only applies to a small number of vessels. HFO is the residual fraction of an incomplete refining process and it accumulates many pollutants in that residual fraction. Pollutants include sulfur, heavy metals, aromatic pollutants and others. Today's legal cap on sulfur in HFO of 4.5% has very little effect because the global sulfur average is about 2.7%. However, with increasing demand for lower sulfur fuels, i.e. through the installation of Sulfur Emission Control Areas, as well as with increased demand for low-sulfur land-side distillate fuels, higher concentration of pollutants in residual fuels can be expected in the future. The International Maritime Organisation (IMO, 2000) refers to a 4-5% reduction of CO_2 when switching from HFO to MDO. This has been confirmed by tests (Corner & Gorton, 2002)

Lowering the sulfur level, and thus in particular sulfuric acid and toxic particulate matter emissions, can be implemented by:

- Blending high sulfur HFO with low sulfur fuels
- Desulfurizing HFO
- Switching to lower sulfur distillate fuels (MDO and MGO)

Experiences:
The most prominent experience has been made by Wallenius Marine, which has tested both low sulfur HFO as well as MDO over years. The results were positive from the perspective of emission reductions, operational and technical feasibility. Maintenance was reduced greatly as well as overall fuel consumption. However, the break-even cost for switching makes Wallenius proposition to a costly one.

(Corner & Gorton, 2002); http://www.walleniusmarine.com/qse.jsp?art_id=45) Wallenius only experienced a problem with blended HFO fuel in the beginning of the test phase. Since then they abstained from blended low sulfur HFO.

MAN B&W provides guidelines on using low sulfur marine fuels and describes only potential problems when switching back and forth between HFO and MDO in the switch-over phases. Furthermore, changes in the lubrication system might be necessary. Otherwise MAN B&W guarantees there engines run on low sulfur fuels. The experience is vastly based on land-side applications and can be translated to marine engines. (MAN, 2006)

The Baltic Sea is an area where many more ships operate on low sulfur fuels due to the differentiated fairway and harbor dues in Baltic ports. The Swedish Maritime Administration reports about 1,200 ships using low sulfur marine fuels in the Baltic Sea. Furthermore, about 50 ships in the Baltic plus another 50 ships elsewhere are using Selective Catalytic Reduction (SCR) for advanced NO_x control

SCR is the most sophisticated NO_x control technology but it also comes with a price and has spatial requirements. By December 2001, 25 commercial ships in the Baltic had received a NO_x certificate due to the implementation of SCR systems. (Swahn, 2002) The main manufacturer of marine SCR systems, Siemens and Haldor Topsoe, as well as the major marine engine manufacturer refer to dozens of experiences with SCR and other control technologies.
http://www.wartsila.com/,en,productsservices,productportfolio,product,,34117625747816384,no,8012.htm
http://www.manbw.com/category_000246.html. Shipping companies that have gathered experience with emission controls or low sulfur fuels include several European ship operators as well as four bulk carriers calling at a California Port since 1990.

Other emission control technologies recently tested include humidification of the intake air (HAM) or direct water injection (DWI), sulfur scrubbing and others. More information from state run research can be found at
Canadian trial of a water injection system: http://www.tc.gc.ca/tdc/projects/marine/g/menu.htm
European Research on various Emission controls: http://ec.europa.eu/environment/air/transport.htm#3
Including a report on the experience with sea-water scrubbing and other marine control measures. (Entec, 2005)

References:

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