Chapter 2
A Computational Modeler's Tour of the Port of Houston

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Abstract When one thinks of Houston a variety of different economic activities might come to mind: energy, space, and medicine. Typically one does not think first of transportation. However, the transportation enterprise in the Houston area is massive. Houston is one of the few places in the world where the various modes of transportation: rail, highway, maritime, inland waterway, pipeline and air converge. Approximately 90% of the volume and 70% of the value of goods transported worldwide takes place at sea. These general percentages also apply for the Houston region. Our focus will be on the maritime sector in particular the Port of Houston and the Houston Ship Channel.

2.1 Introduction

The Port of Houston is a 25 mile complex comprised of public terminals and more that 150 private industrial sites along the 52 mile Houston Ship Channel. It stretches from close to downtown Houston to Galveston Bay. In terms of international waterborne tonnage the Port of Houston ranks first in the United States (US) and second in the US in terms of total cargo handled. The Port has the second largest petrochemical complex in the US. It refines over 35% of the nation's gasoline and 80% of it aviation fuel. The annual economic impact of the Port of Houston is estimated to be over 178.5 billion dollars (Port of Houston Authority 2016). Given the enormity of the economic activity: environmental, safety, and security concerns are all of paramount importance. Even a short term interruption of activity results in a loss of millions if not billions of dollars. Any protracted disruption of traffic on the Houston Ship

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Channel and its more than 150 port facilities would have a catastrophic impact on the U.S. economy. The Houston Area is subject to extended annual fog closings of the Houston Ship Channel. These fog closures catch the attention of national and international media sources. Computational science and mathematical modeling may not normally be associated with maritime activity. In what follows, we shall use the Port of Houston/Houston Ship Channel as a lens through which computational and mathematical scientists can view their operations, environmental concerns, and security issues. Through this one can determine that modeling, computation, simulation and analysis can and do play an important role in the maritime enterprise.

2.2 Traffic Operations

In many ways the management of traffic in and out of the Port of Houston via the Houston Ship Channel resembles the scenario of air traffic control at a major airport. Over 11,000 vessels (blue water) visit the Port of Houston. This breaks down into a daily average of over 300 vessel arrivals, a figure exceeding the daily arrival of passenger planes at Stockholm Arlanda Airport. The Houston Ship Channel is also one of the nation's busiest barge transportation lanes (brown water). It intersects with the Intracoastal Waterways which runs for over 3,000 miles from Boston to the Rio Grande connecting Houston with the Eastern Seaboard of the United States. In additional it connects the Midwest and South Central US via the Mississippi/Missouri, Ohio/Allegany and Tennessee/Tombigbee Rivers. Added to this blue water and brown water traffic there is a large fishing and shrimping fleet, massive recreational craft activity and cruise ship operations in and out of the both the Port of Galveston and the Port of Houston.

Vessels operating on the high seas and on the coastal and inland waterways are monitored by Automatic Identification Systems (AIS). AIS technology gathers and transmits data such as vessel identification as well as track and monitor position, course, and speed. The transmitted information is displayed on radar like screens on board other vessels and on land based operations center such as the Port of Houston. Screens at land based operations centers such as the Port of Houston provide real time representation of regional maritime activity and in many ways resemble what one sees at an air traffic control center. AIS information is primarily for traffic monitoring and collision avoidance and to provide information about a vessel and its cargo to local authorities who oversee waterborne trade (Board 2003). The U.S. Coast Guard Vessel Traffic Services (VTS) depends heavily on AIS systems in their crucial role monitoring and controlling vessel traffic.

2.3 Scheduling and Logistics

Industry is driven by profits and profit margins. Consequently, it faces an ongoing challenge of optimizing supply chain networks. Supply chains have become global, making maritime shipping the primary link within many supply chains. It is therefore understandable that a critical component of supply chain optimization is a proper scheduling methodology. It has been estimated that a 7% annual reduction in logistics costs in refining translates to 23% increase in profitability (Burns 2014). Despite the fact that the dominant proportion of the transportation of goods worldwide is maritime, maritime scheduling has been studied much less extensively than rail, truck or plane transport (Burns 2014). Although these modes of transportation have similarities in terms of scheduling, ship fleet planning problems are differentiated from those of other modes of transportation (Al-Hamad et al. 2012): ships operate continually around the clock without buffers of planned down time that can absorb delays; they have higher uncertainty in their operations due to their higher dependence on weather conditions, technology and operating over long distances with long time horizons. Vessels frequently cross multiple national and international jurisdictions. Typically they carry mostly liquid and dry bulk cargo, and often nonmixable products in separate compartments (Christiansen et al. 2007).

Inventory Routing Problems (IRP) which integrate inventory management with maritime vessel routing and delivery have been a subject of active study for the past thirty years. Prior to this period despite an awareness and an interest in distribution and inventory problems little had been done to integrate the two. This can be attributed to previous limitations on computational capacity and the association of non-availability of advanced algorithms, capable of handling large and complex combinatorial problems (Coelho et al. 2013). IVP's can be static or dynamic depending upon whether or not all information is known in advance or is revealed over time. Depending upon the certainty of the information the problems can be deterministic or stochastic.

The Port of Houston accommodates a variety of different types of cargo: bulk cargos which haul oil, chemicals and grains; intermodal container cargos, and break bulk cargo that must be loaded individually. Common examples of break bulk cargos include: oil field equipment, automobiles, steel, wind turbine propellers, bailed goods, heavy equipment, and drums. Each of these cargos present a different set of unique scheduling and logistics problems. However, each must be coordinated with dockside scheduling at the Port of Houston.

Refinery and petrochemical plant operations involve: marine terminals, process terminals and pipelines. Inventory levels depend upon process scheduling, demand at the depots and availability of pipelines. The complexity of the problem becomes apparent with the realization that realistic optimization models need not only to account for process scheduling at the refineries, demand at the depots and pipeline availability but they also have to be able to account for variability in transit time and uncertainty of demand over a time horizon greater than 40 days (Persson and Göthe-Lundgren 2005).

Issues unique to port container terminal operations are receiving more attention due to increasing importance of marine transportation systems. The most important objective for a port container terminal is to increase its throughput or, in particular, to decrease the turnaround times of ships (Al-Hamad et al. 2012). This entails optimizing turnaround time and effective of allocating and scheduling of key resources, such as berths, yards, quay cranes, yard cranes and trucks (Ng and Mak 2005). Break bulk cargo handling is more labor intensive than either container handling or the handling of bulk cargos such as crude oil or refined products. Although break bulk cargos can at times be loaded onto vessels directly from rail cars, trucks, or discharged from vessels directly to the chosen mode of transportation. They are commonly delivered to dockside warehouses prior to the arrival of a vessel and taken from the warehouses to the quays for loading. Similarly discharged cargos are usually unloaded onto quays and taken to warehouses or storage areas where they await transfer to trucks or rail. Rail and truck scheduling and routing issues have been studied extensively (Hwang 2005). However, warehouse scheduling has remained a challenge. It is a complex combinatorial optimization problem with various constraints whose computational complexity increases exponentially with scale (Yang et al. 2013).

2.4 Security and Safety Issues

Goods from countries all over the world come into the Port of Houston making it (along with other major seaports worldwide) a tempting target for the launch of a major terrorist attack with devastating consequences.

2.4.1 Physical Security

Ports contain a number of specific facilities that could be targeted by terrorists. In addition to vessels and infrastructure, terrorists may seek to attack maritime communities using ships or containers on ships as delivery vehicles for weapons of mass destruction or by exploiting chemicals, explosives in cargo ships, onshore industrial operation, and storage tanks in populated port area (Parfomak and Frittelli 2007). A well-organized and implemented attack on the Port of Houston could inflict a high number of causalities and cause catastrophic economic damage of to both the nation and world economies. Maritime attacks have occurred in a variety of ports worldwide and terrorists have a variety of options at their disposal. Terrorism threat in the maritime domain may come in various forms. Weapons or explosives may be concealed in containers, ships may be used as weapons to destroy critical infrastructure, or terrorists may illegally cross the borders to launch attacks in the homeland. Much emphasis has been has been placed on the security of containerized cargo however it is important to recognize other vulnerabilities as well (Bakir 2007).

The Houston Ship Channel is spanned by three major bridges. Each of these structures is subject to damage resulting from collisions with ships or barges, storm, or even terrorist activity (for example the Brooklyn Bridge and possibly the Golden Gate Bridge, have been unsuccessfully targeted). Such occurrences would result in and in some cases have resulted in a shutdown of the channel or portions thereof.

2.4.2 Plant Explosions

There are about two major explosions around the world every year in the refinery and petrochemical industry (Lewis 2006). Petrochemical plant and refineries are inherently hazardous due to the materials that they handle and their manner of operations. There is always a risk of explosions, fire, and the release of toxic substances (Khan 1999). Accidental scenarios in refineries, petrochemical and other installations handling flammable chemicals in bulk include pool fire, jet fire, flash fire, boiling liquid expanding vapor explosions and vapor cloud explosions. Individuals and communities can be injured by the effects of the fire, the explosion, and by the release of chemicals (Birwas 2000). There is a mandate for the enhancement of safety in the design or the designs of renovations of these facilities but design must be accomplished within the constraints of an appropriate level of cost. Here simulations can play an important role. They serve as a tool for optimal choice of design while addressing safety concerns within the constraint of an appropriate level of cost. Numerical Simulations based on Computational Fluid Mechanics (CFD) can be used in a wide of facilities including refineries, petrochemical plants, gas processing plants and LNG plants to predict gas dispersions, blast pressures both near and far field and structural responses (Takahashi and Watanabe 2010). A wide variety of CFD based models for gas explosions exist each with its own strengths and weaknesses. Improvements in both the physics and the numerics are required for greater confidences in the predictions of the models (Lea and Ledin 2002).

2.4.3 Cyber Security

In addition to conventional physical attacks there is a rapidly growing threat of cyber-attacks (Obama 2013). US ports are very vulnerable to cyber-attacks. US ports rely as much upon networked computers and control systems as they do upon shore-side labor. However, it is both surprising and disconcerting that little attention has been paid to the security of networked systems that undergird port operations and no cybersecurity standards for US ports have been put in place (Kramek 2013). Networked systems are involved at all stages of maritime transport: they track maritime cargo from the time a container is filled overseas until it reaches its final destination, networked control systems are employed involved in cargo loading and discharging. Cranes and other systems use optical recognition along other technologies to locate, scan, and manage aspects of port terminal operations. Scanners and radio frequency identification devices (RFID) track cargoes and as well as trucks and rail car entering and exiting ports. The U.S. Coast Guard has identified cyber-security vulnerability as a major concern and have initiated proactive dialogue with the maritime industry.

The Port of Houston has a sophisticated fiber optic network of security cameras, radars, sonar sensors, and other systems which continually monitor the progress of a vessel up and down the Houston Ship Channel. Networked systems optically scan cargo and manage its movement throughout as well as into and out of Port of Houston facilities. Cranes, fuel farms, HVAC systems, and access control systems are monitored. However, the emphasis is upon physical not cyber security (Kramek 2013). The situation is further complicated by the fact that Port of Houston authorities lack cybersecurity knowledge of most of the privately owned port facilities of oil, gas and chemical tanker ships. The oil and gas and petrochemical industries utilize networked systems govern that all aspects of their operations. What, if any, cybersecurity measures these privately owned facilities have in place is mostly known only to the entities that own and operate these facilities. They work independently in an autonomous environment. SCADA systems abound in production, refining and petrochemical plant operations creating a valid concern that a compromise of SCADA system could produce a major spill or explosion (Bronk 2014). The cyber threat comes from a variety of sources: terrorists (international or domestic); activists, pressure groups, single-issue zealots; disgruntled employees or contractors; and criminals (e.g., white collar, cyber hacker, organized opportunists) (American Petroleum Institute 2003).

The U.S. Coast guard requires all vessels to maintain a vessel security plan. Likewise, the U.S. Coast Guard also requires all terminals to maintain a facility security plan (FSP). Information security threats exist on board the vessels as well dockside. Given its primary importance and prevalence in maritime traffic safety, it is essential that AIS information be secure. In this regard (Balduzzi et al. 2014) recently conducted a comprehensive survey of AIS from both the soft and hardware perspectives. They were able to identify several specific threats affecting AIS implementation and protocol specifications. These include disabling AIS communications; tampering with existing AIS data; triggering alerts to lure ships into navigating to hostile sea space; or spoofing collisions to possibly bring a ship off course.

2.4.4 Work Place Safety

Work accidents and safety programs to prevent them are expensive. Indeed the National Safety Council estimated (2002) that economic loss from workplace accidents was almost $150 billion dollars a year (do Carmo et al. 2010). Ports are a dangerous places to work. Dock workers face many hazards during the loading and unloading of cargoes as well as from movement and operations of vehicles. Moreover, most accidents in ports are serious or fatal. Typical workplace transport hazards are: loading and unloading, reversing, driving on dockside or in container storage areas, falls, coupling and uncoupling on dockside and on the ship. Container operations present the risk of accidents from specialized lifting equipment such gantry cranes, transtainers, slewing cranes and special fork lift trucks (AMEPA 2008).

Safety programs can be described as a dynamic set of interventions implemented at the work site for the purpose of reducing the likelihood of accidents and/or reducing the severity of such incidents should they occur (do Carmo et al. 2010). Safety interventions may and do include training, meetings, protective gear, equipment modifications, inspections, changes in procedure, and safety monitoring. Because they can be expensive, time consuming, and disruptive it is important to have assurance a priority of their effectiveness. Resources are always limited and consequently there is a need to develop optimizing strategies to decrease accidents at minimal cost. This is both a human resource development problem and a statistical forecasting problem. Statistically one can approach the problem with the systematic collection of data and the application of statistical forecasting methodology to identify a time lagged mathematical relationship between the implementation of interventions and the number of incidents (do Carmo et al. 2010).

2.5 Environmental Issues and Threats

The Port of Houston has many environmental challenges and threats. Some are anthropogenic, some are natural and some are combination of the two. Resolution of these issues and mitigation of the threats will present computational challenges and interesting opportunities.

2.5.1 Hurricanes

Hurricanes are an annual threat to the Port of Houston and the 150 other private facilities located along the Houston Ship Channel. Hurricanes are defined as rapidly rotating storm systems characterized by a low-pressure centers, strong winds, high waves, storm surges and a spiral arrangement of thunderstorms that produce heavy rain. Although the wind and rainfall associated with hurricanes is fearsome and capable generating significant damage, the Galveston Bay region which includes the Houston Ship Channel is extremely vulnerable to storm surge flooding. In 2008, the land fall of Hurricane Ike made landfall slightly east of the Houston Ship Channel and produced a storm surge that flooded inland areas stretching from Galveston Bay to well over 100 miles eastward. Hurricanes are rated in terms of increasing intensity on a scale from 1 to 5. Ike was "only" a Category 2 storm yet it caused over $25 billion dollars in damages. Research indicates that had Hurricane Ike made landfall 30 miles southwest of its original landfall location, it would have generated 18 ft of surge in the Houston Ship Channel and 15 ft inundating the populated areas, industries and facilities areas on the west side of Galveston Bay. Thousands of people who chose not to evacuate could have died. The environmental impact to Galveston Bay and economic devastation to the Houston-Galveston region and US would have been enormous (Blackburn et al. 2014). It is highly probable that a Category 3 or 4 winds will come ashore on the western side of Galveston Bay. If this occurs one can expect a 25 to 30 foot storm surge. If the Houston-Galveston Area has failed to protect critical infrastructure against a 25-foot to 30-foot surge, a surge of this magnitude could literally destroy the economy of the Houston region, if not the United States. In addition to the economic disaster, such a surge would likely inflict massive environmental damage if the hazardous materials and oil presently stored adjacent to the ship channel were to spill into adjacent neighborhoods as well as Galveston Bay (— 2010).

Hurricanes are inevitable and nothing can be done to lessen the amount of rainfall or dampen the force of the winds. However, there is the potential to mitigate the effects of storm surges by the construction a system including: dams, floodgates, and levees. Major storm surge projects have been constructed in Holland, the UK and Russia. Constructing such a system to protect the Houston Ship Channel would be a massive engineering project costing billions of dollars and it cannot proceed in a hit or miss fashion. The design of the system will require the development of robust, realistic computational models validated by historical data of storm surge, wave action and costal not only for the analysis of future risk and real time forecasting but perhaps most importantly for the optimal design of infrastructure to mitigate the impact of future events. In the aftermath of Hurricane Ike and its predecessor, there have been significant advances in numerical modeling of storm surge, wave, and coastal flooding. We currently have at our disposal a variety of models incorporating different physics and numerics. Most of these models are two or three dimensional incorporating the physics, complex bathymetry and topography of the domain as well as tide and wave action however, there is significant variance in their computational speed, domain size and resolution. Uncertainties of storm surge and coastal flooding calculations come from a variety of sources, including model physics, model domain and grid, model dimensionality, parameterization of model processes (e.g., surge-wave interaction, interaction with topographic features), and input data (model forcing such as wind, precipitation, tides), open boundary condition and bathymetry and topography data (Blackburn et al. 2014)

2.5.2 Air Quality Issues

Air pollution is a problem in urban areas worldwide and the Greater Houston-Galveston, Texas region, is no exception. The emissions from ships, diesel trucks, locomotives and other equipment coupled with emissions from the industries along the Houston Ship Channel have been identified as the major contributors to Houston's problem. Air pollution levels in Houston have been monitored for the last four decades. The Texas Commission on Environment Quality reports that air quality in Houston is monitored more closely and analyzed with more intensity than perhaps anywhere in the country (Bethel et al. 2006) with more monitors tracking over 130 chemical pollutants. However, the Houston air quality monitoring network is primarily designed to track levels the six pollutants (ozone, particulate matter, carbon monoxide, sulfur dioxide, lead, and nitrogen dioxide) for which and The United States Environment Protection has established health based standards.

Houston's most pressing and major problem is ozone. Houston meets the EPA standards for 5 of the 6 pollutants on the list, but does not meet the standards for ozone. Regretfully, the local situation regarding high levels of troposphere ozone concentrations in the Greater Houston Galveston has become recognized as being among the nation's worst (Bethel et al. 2006; Rivera et al. 2014). Consequently, Houston finds itself mandated by the Federal Clean Air Act of 1970 (amended 1990) to meet EPA standards. The Clean Air Act further stipulates that computer modeling be used to plan air pollution reduction. These computational models need to be validated by historical data obtained from the air quality monitoring system. Ozone is not released directly into the atmosphere but is created by the photochemical reaction of substances such as volatile hydrocarbons and the oxides of nitrogen sulfur that are released anthropogenic, from industrial complexes, mobile sources and biogenic from natural sources. The rate of product is highly effected by factors such as the amount of sunlight, temperature and the humidity. Area concentrations are dependent upon wind patterns as well. The computer models rely upon simulations based upon the computation of solutions to complex systems of partial differential equations to simulate emissions, air movement, chemical reactions, and resultant ozone concentrations. The basic mathematical equations describing the atmospheric production and distribution of ozone and other pollutants are weakly coupled system of reaction advection diffusion equations. This system incorporates a variety of processes such as chemical reactions, temperature, condensation processes as well as transport, thermal, and turbulent diffusion. Emissions become part of the boundary data. Even simple prototypes can involve over twenty equations (Stockwell et al. 2011) and a realistic model would couple hundreds of equations (Fitzgibbon and Langlais 2002). Once confidence of the validity of the models is obtained, the task becomes one of modeling various methods of abatement of emissions sources on the boundary in such a way as to bring ozone concentrations down to a level of attainment of the EPA standard.

2.5.3 Biological Invasions

Without entering into the esoteric controversy of the precise scientific definition we will use an online definition of biological invasion as: the process by which species (or genetically distinct populations), with no historical record in an area, breach biogeographic barriers and extend their range. Non-indigenous organisms which have been introduced into ecosystems are the second greatest cause, after habitat destruction, of species endangerment and extinction worldwide. In the United States, nonindigenous species have been estimated to do more than $130 billion annually to agriculture, forests, rangelands, and fisheries (Schmitz and Simberloff 2001). Maritime transport is also widely recognized as a primary if not the dominant invasion pathway by which non indigenous animal and plant species are introduced to ecosystems (Miller et al. 2011). Indeed the role of shipping in the biological invasion of North America has its antecedent in the early 17th Century with the inundation of New England and the Mid-Atlantic by a wave of rats, insects, mice, and aggressive weeds from Europe. In the 1930's Fire Ants from South America were introduced to North America via the Port of Mobile (Caldera et al. 2008). Today, several thousand nonindigenous species are established and new potentially invasive species arrive every year. For example, in Texas, an exotic snail carries parasites that are spreading and infecting native fish populations. In the Gulf of Mexico, a rapidly growing Australian spotted jellyfish population is threatening commercially important species such as shrimp, menhaden, anchovies, and crabs (Schmitz and Simberloff 2001).

Biological invasions have accelerated in recent decades putatively as a result of the dramatic growth of global trade and transport. Invasive species can be transported by a variety of different mechanisms including: cargo, hull fouling, and the loading and discharge of ballast water. Ballast water taken in or discharged by large ships to maintain stability is assumed to represent the world's largest invasion vector (Caldera et al. 2008). Ballast water from cargo ships has been implicated in transporting a South American strain of cholera to the Gulf of Mexico, leading to fish and shellfish contamination. Ballast water discharge is also responsible for the introduction of "red tide" algae to the waters of several countries, contaminating shellfish and threatening human health.

It is possible to employ sophisticated genetic and statistical methodology to identify the geographic source of invading non-indigenous species ex post facto (Seebens et al. 2013). However, we do need to have eradication efforts to control invading species and we need to have prophylactic measures in place that limit their ability to cross geo-barriers. We also need to develop robust, comprehensive predictive models of biological invasions that take into account ship routing, port environments and biogeography (Caldera et al. 2008).

2.5.4 Infectious Disease

The spread of infectious disease is closely related to the concept of bioinvasions. Long distance transport of pathogens is a major factor in the global spread of infectious disease. Initially, new infectious diseases could spread only as fast and far as people could walk. Then it was spread as fast and far as horses could gallop and ships could sail. With the advent of truly global travel and the globalization of world trade we have seen more new diseases than ever before become potential pandemics (WHO 2004).The World Health Organizations reports that one hundred outbreaks of infectious diseases were reported to be associated with ships between 1970 and 2000. Reported outbreaks included legionellosis, typhoid fever, salmonellosis, viral gastroenteritis, enterotoxigenic E coli infection, shigellosis, cryptosporidiosis and trichinosis (WHO 2004). Pathogens can be introduced via viremic passengers and crew, transported livestock, produce, and cargo. Containerized cargo greatly enhances the probability of the introduction of pathogens (Reiter 2010). Recently, epidemic diseases such as West Nile Virus and St. Louis Encephalitis have been introduced to the United States. These viruses are transmitted to humans by infected arthropods and are called arboviruses. In each case it is not exactly clear if the disease was introduced by viremic individuals infecting local arthropod populations or by transmission to humans from infected arthropods in infesting cargos or baggage. Dengue and Malaria are similarly transmitted arboviruses and there is a continuing threat that they will be introduced by shipping particularly from underdeveloped country. The Port of Houston as do other international seaports has the challenge of preventing the introduction of infectious disease through shipping without creating disruptions or barriers to the free flow of commerce. Mathematical models (both discrete and continuous) can be employed to predict the circulation and spread of a disease through a given population or populations in a given geographic subsequent to its outbreak and to help plan strategies for public health interventions (Reiter 2010). However, we need to develop models which address the global transmission of viruses.

2.5.5 Oil Spills

Given the extensive refining and petrochemical activity the Houston Ship Channel and the Port of Houston, there is always concern about oil spills. Oil spills have the potential to shut down the channel for protracted periods of time thus they not only can have a devastating environment effect and damage the local community they can create severe economic damage. The environmental damage is often long term because the principal components of crude oil, polycyclic aromatic hydrocarbons, can last for years in sediment and in marine environment and can be very difficult to clean up. The rupture of transporting tankers as a result of collisions with other vessels (typically ships or barges) or with infrastructure or running aground is a major and the most dramatic source of large spills. Such occurrences are caused by people and cannot be prevented altogether. However there are ways to mitigate the risk that include: improving the design of ships with double hulls and smaller individual tanks, enhanced control and monitoring of vessel traffic, strict enforcement of regulations, and insuring the proper training of crews. A more common albeit less dramatic and less visible cause of maritime oil pollution is what one might call operational. Operational spills are caused by human error or malfeasance. For example operational spills can result from the improper handling of bilge water or during the cleaning of tankers after offloading (Schmitz-Felten 2016).

The computational modeling of oil spills has been an active area of research over the past twenty five years and many issues are yet to be resolved (Reed et al. 1999). Computational models can be used to predict the evolution and behavior of an oil slick and they can be an important tool for managing the response after a spill. Models range from simple particle models to complex multi-physics systems that couple hydrodynamic and meteorological models as well as incorporating chemical and physical process and biodegradation (do Carmo et al. 2010). In order to be useful in assessment of the implementation of containment measures simulations of numerical model should be sufficiently fast to incorporate real-time information. The models must be sufficiently robust because in real situations there is uncertainty in both the quantity of oil spilt and some of its material properties (Reed et al. 1999).

References

— (2010) Numerical models of storm surge, wave, and coastal flooding

Al-Hamad K, Al-Ibrahim M, Al-Enezy E (2012) A genetic algorithm for ship routing and scheduling problem with time window. Am J Oper Res 2:417–429

AMEPA, Australian Marine Environmental Protection Association (2008) Main causes of oil pollution by ships

American Petroleum Institute (2003) Security vulnerability assessment for the petroleum and petrochemical industries, Washington DC

Bakir NO (2007) A brief analysis of threats and vulnerabilities in the maritime domain. In: Managing critical infrastructure risks. Springer, Heidelberg, pp 17–49

Balduzzi M, Pasta A, Wilhoit K (2014) A security evaluation of AIS automated identification system. In: Proceedings of the 30th annual computer security applications conference. ACM, pp 436–445

Bethel HL, Sexton K, Linder S, Delclos G, Stock T, Abramson S, Bondy M, Fraser M, Ward J (2006) A closer look at air pollution in houston: report of the mayors task force on the health effects of air pollution. Institute for Health Policy University of Texas School of Public Health, Technical Report

Birwas SK (2000) Technical aspects of hazards management in refineries and petrochemical plants. In: Petroleum refining and petrochemical based industries in Eastern India. Allied Publishers, New Delhi, pp 43–52

Blackburn JB, Bedient PG, Dunbar LB (2014) SSPEED Center 2014 Report. Technical report SSPEED Center, Rice University, Technical Report, 56 p

Board Transportation Research (2003) Shipboard automatic identification system displays: meeting the needs of mariners. National Research Council (US), Committee for evaluating shipboard display of automated identification systems

Bronk C (2014) Hacks on Gas: Energy, Cybersecurity, and US Defense. Baker III Institute for Public Policy, James A

Burns MG (2014) Port management and operations. CRC Press, Boca Raton

Caldera EJ, Ross KG, DeHeer CJ, Shoemaker DDW (2008) Putative native source of the invasive fire ant Solenopsis invicta in the USA. Biol Invasions 10(8):1457–1479

Christiansen M, Fagerholt K, Nygreen B, Ronen D (2007) Maritime transportation. Handb Oper Res Manag Sci 14:189–284

Coelho LC, Cordeau J-F, Laporte G (2013) Thirty years of inventory routing. Transp Sci 48(1):1–19

do Carmo JA, Pinho JL, Vieira JP (2010) Oil spills in coastal zones: predicting slick transport and weathering processes. J Open Ocean Eng J 3: 129–142

Fitzgibbon WE, Martyenko A (2002) Mathematical analysis of atmospheric pollution models. Technical Report

Hwang, S-J (2005) Inventory constrained maritime routing and scheduling for multi-commodity liquid bulk

Khan AA (1999) Risk assessment in the petrochemical industry. In: First international seminar (SAFE 99) in safety and fire engineering

Kramek CJ (2013) The critical infrastructure gap: US port facilities and cyber vulnerabilities. Federal Executive Series Policy Papers, Brookings Institution

Lea CJ, Ledin HS (2002) A review of the state-of-the-art in gas explosion modelling. Health and Safety Laboratory

Lewis S (2006) SHEPERDs delight: a new tool for explosion exceedance

Miller AW, Minton MS, Ruiz GM (2011) Geographic limitations and regional differences in ships ballast water management to reduce marine invasions in the contiguous United States. Bioscience 61(11):880–887

Ng WC, Mak KL (2005) Yard crane scheduling in port container terminals. Appl Math Modell 29(3):263–276

Obama B (2013) 2013 State of the union address. Speech given at U.S. Capitol, Washington, DC, February 4, 2013

Parfomak PW, Frittelli J (2007) Maritime security: potential terrorist attacks and protection priorities. DTIC Document

Persson JA, Göthe-Lundgren M (2005) Shipment planning at oil refineries using column generation and valid inequalities. Eur J Oper Res 163(3):631–652

Port of Houston Authority (2016) About the Port

Reed M, Johansen Ø, Brandvik PJ, Daling P, Lewis A, Fiocco R, Mackay D, Prentki R (1999) Oil spill modeling towards the close of the 20th century: overview of the state of the art. Spill Sci Technol Bull 5(1):3–16

Reiter P (2010) The standardised freight container: vector of vectors and vector-borne diseases. Revue Scientifique et Technique (International Office of Epizootics) 29(1):57–64

Rivera C, Mellqvist J, Samuelsson J, Lefer B, Alvarez S, Patel MR (2014) Quantification of NO2 and SO2 emissions from the houston ship channel and Texas city industrial areas during the 2006 Texas air quality study. J Geophys Res Atmos

Schmitz DC, Simberloff D (2001) Needed: a national center for biological invasions. Issues Sci Technol 17(4):57–62

Schmitz-Felten E (2016) From OSHwiki

Seebens H, Gastner MT, Blasius B (2013) The risk of marine bioinvasion caused by global shipping. Ecol Lett 16(6):782–790

Stockwell WR, Lawson CV, Saunders E, Goliff WS (2011) A review of tropospheric atmospheric chemistry and gas-phase chemical mechanisms for air quality modeling. Atmosphere 3(1):1–32

Takahashi K, Watanabe K (2010) Advanced numerical simulation of gas explosions for assessing the safety of oil and gas plant. INTECH Open Access Publisher

WHO (2004) Ships and public health. Intergovernmental working group on the revision of the international health: regulations. Working Paper 12 (12 January 2003)

Yang W, Deng L, Niu Q, Fei M (2013) Improved shuffled frog leaping algorithm for solving multi-aisle automated warehouse scheduling optimization. In: Asian Simulation Conference. Springer, Heidelberg, pp 82–92

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