# Executive Summary

Port operations are at the heart of some of the most dynamic metropolitan centers in the world: London, New York, Los Angeles, Singapore and Hong Kong, to name a few. Ports are critical cogs in national and local economies, but their operations are associated with slow, heavy trucks and trains, congestion and pollution. The negative impacts on their surroundings hinder growth, jeopardizing sustainability of the economic benefits.

The twin ports of Los Angeles and Long Beach are perfect examples of these forces at work. They receive more than 40% of U.S. containerized imports, and support 3 million jobs nationwide. They also account for 50% of emissions in the Los Angeles basin. A 3× growth forecast for imports over the next decades raises doubts about the ports' capacity to accommodate further escalation in traffic. Expansion of port facilities requires tens of billions in infrastructure investment, and is opposed by neighborhood organizations that cite elevated cancer rates, noise, vibration, light pollution and traffic congestion.

This project set out to address this problem set in the national supply chain. A vision of a Metropolitan Transportation Information System (METRIS) was proposed by members of this research consortium in 2004, in which real-time data on the transportation system would create live information products, and in conjunction with optimization models and decision support systems, would streamline transportation operations, also addressing environment and security. Funding from the U.S. Department of Transportation's (USDOT) Research and Innovative Technology Administration (RITA) supported an implementation of METRIS in the San Pedro ports of metropolitan Los Angeles.

The Consortium was led by the University of California, Santa Barbara, with Digital Geographic Research Corporation, the University of Washington, the California Marine and Intermodal Transportation Systems Advisory Council (CALMITSAC), and consultants Patty Senecal and John Glanville. A Steering Committee, consisting of experts in port operations, highway operations, geographic information systems (GIS), and large scale tracking, assisted with strategic guidance. Private and public agencies signed up as cost-sharing partners.

## Research Components

The research was built around 5 components:

1. Acquisition of GPS data on movement of goods off the ports; techniques to model port entities, operations and their data streams, and to relate GPS data to underlying geographic layers.
2. Basic time-space analyses on the GPS data, to develop information products that could address immediate concerns of port freight stakeholders, such as trucking firms, marine terminals, and local government agencies.
3. Optimization modeling to address inefficiencies in the management of empty containers, in particular their redundant haulage over tens of kilometers between the ports and hinterland warehouses.

4. Optimization modeling to utilize real-time truck location data to synchronize truck arrivals with port operations, particularly the time-consuming extraction of containers from grounded stacks.
5. Outreach to the port freight community, and investigation of a path towards commercial deployment of the analytical techniques and models.

### Data Acquisition

About 250 drayage truckers operating principally in the San Pedro ports were recruited and instrumented with GPS and telematics devices, that communicated their location in real time. The principal hurdle in this process was the combined effect of a severe economic downturn, that dropped cargo volumes 20% in 2008-2009, and a protracted legal conflict between the ports and the trucking industry, triggered by the Clean Trucks Program. These and other forces resulted in attrition of roughly half the drayage trucking fleet operating in the San Pedro ports. By mid-2009 the industry found some stability, it was ripe for new technology to be installed in a fleet of new trucks, and recruitment was timely and highly successful.

This research component included two architectural components: (a) specification of a data model for port and highway operations, building on the Esri-UCSB UNETRANS data model of 2000-2001, and (b) development of conflation algorithms to relate GPS data to underlying GIS layers, a problem generally known as map matching. This latter research project was later developed into a separate research project funded by the National Geospatial-Intelligence Agency.

### Basic Analyses

Several local agencies were eager for information products based on MeTrIS. Transportation researchers in planning and academic organizations have historically relied on periodic “intercept surveys” (i.e. conducted by intercepting drivers at rest stops or using police cruisers) to understand the flow of goods. Round-the-clock GPS data proved vastly superior as a data source. We produced the first maps of origins, destinations, routes, congestion spots, and specialized innovative products such as flow “drainage,” showing how port traffic along a freeway is distributed among major freeway exits. We generated maps showing variation in freeway travel time in the course of the day, and drive-time comparisons between routes.

For participating trucking firms, we generated real-time reports on vehicle location. Particularly useful to the trucking industry was a set of results documenting queue waits outside marine and rail terminals. This proved to be controversial, as some representatives of marine terminal operators were opposed to the release of such figures. Nevertheless, the industry as a whole demonstrated readiness for this flow of objective information to resolve long-standing disputes on queue time.

### Empty Container Management

The principal storage site for empty containers is at marine terminal properties at the ports. Consequently, after containers are emptied in warehouse destinations in the Inland Empire, 40-80 km east of the ports, they are hauled back to the marine terminals. When exporters are in need of empty containers, they have them transported from a marine terminal, load and return them for export. This results in considerable redundant transportation of empties. At the height of San Pedro's trade activity in 2007, empty hauls represented 10,000 trips to the port daily, or 400,000 km daily in truck travel.

We proposed a set of inland Empties Storage Yards (ESY), that would store an inventory of empty containers for export use. The number and capacity of ESYs would be determined by optimization and decision support models, based on patterns of supply and demand of empties; supporting information systems would track and balance inventories. Our models show that just one or two ESYs would deliver considerable benefits: truck travel could be reduced by 75,000 km daily, resulting in 4,500 fewer port entries, savings of 20,000 liters of fuel and 50 tons of $CO_2$ per day.

A solution previously promoted by the ports, the Virtual Container Yard (VCY), was unsuccessful. We believe this was due to insufficient consideration of institutional and human factors, and that a physical yard, supported by appropriate policies, would receive greater industry acceptance.

### *Synchronization*

The most time-consuming operation in a truck transaction at a marine terminal is the extraction of a container from a grounded stack. If the container is near the bottom of the stack, the boxes above it must be relocated to gain access to it. Trucks queues develop, causing waits that can extend for hours.

Clearly, containers should be sorted so that those most likely to be requested in the short term are shuffled towards the top of each stack. Knowledge of a truck's location within the metropolitan area and its progress towards the port is one valuable clue to whether or not the driver is likely to keep his appointment (if an appointment system exists) and how soon a container will be requested. Crane operators can use this information in deciding where to reposition boxes while sorting.

The principal difficulty with this proposition is that it appears to require a high penetration of GPS locators in the trucking industry to provide dense information on the sequence of truck arrivals, to be useful to a crane operator. This made it difficult to deploy a working prototype in the ports in the time-frame of the study. However, benefit models were developed based upon varying assumptions of penetration and the quality of information that could be derived from incomplete polling of the port truck fleet. The models predicted that in the best case, given real-time location and arrival sequence information on all trucks combined with optimal sorting of the stack, operations could proceed 15% faster. Moreover, the research concludes that some benefits can be realized even with low penetration of tracking and information flow.

### *Outreach and Commercialization*

Outreach was an essential dimension of the project from the outset, to recruit participants for tracking, and to generate feedback from the freight industry for the modeling proposals that were to follow. Project staff frequently presented project overviews and updates to industry organizations, particularly the Harbor Trucking Association and the Harbor Association of Industry and Commerce. Federal, state and local government officials were briefed on progress. Two web sites were maintained, one with an academic flavor hosted by UCSB, that focused on the research components, the other with an industry orientation, hosted by DGRC. The consortium also undertook to design and maintain the web site for the broader remote sensing program on behalf of USDOT, to assist with its outreach goals.

The vehicle tracking component of the project has obvious commercial potential, that pre-dates the project and is not unique. The modeling components are original and unique, but as they represent a departure from current practice and some cost-benefit complexities, they require a period of consultation and gestation to gain industry acceptance. Commercialization strategies were explored, that would initially offer popular tracking services, and later combine modeling and planning. The analysis concluded that tracking on its own would be a difficult service to offer in that the field of competitors is large, but that in the long term the advantages of specific port-oriented efficiency offerings could differentiate the service.

## *Conclusions*

This project advanced technologies and models of immense scope, which could have been the subject of several years of study. An early challenge was to define its boundaries. With a 2-3 year timeframe, the goal could not realistically have been to bring significant change in practice to the San Pedro ports. Only a small sample of vehicles could be tracked. The modeling methods relied on widespread subscription, which could not be achieved in the short term.

Hence the approach was to establish, by modeling, simulation and real data where possible, that significant benefits could be achieved by adopting the suggested strategies of extensive fleet behavior analysis, empty container management and port synchronization. While there were difficult institutional barriers to implementation, we took the position that the prospect of universal benefits—not just in traditional measures of transportation efficiency such as Vehicle Kilometers Traveled (VKT) and Average Annual Daily Traffic (AADT), but also by mobilizing billions of dollars' worth of stagnant goods inventories—would at least stimulate and sustain dialog.

The project exceeded expectations and was remarkably successful in evolving the mindset of the port freight community. Most major trucking firms participated, and continue to subscribe to MeTrIS. This was the first and still the only technology that could monitor queues outside marine terminals, objectively, accurately, continuously and cost-effectively. At least one terminal is reported to have changed its practices in response to MeTrIS information, expanding its land bridge service. The project was given generous coverage in the *Journal of Commerce* and the *Cunningham Report*, the two dominant industry reports. Federal, state, local and industry officials expressed unanimous support and approval.

However, this work is only a beginning. Major challenges remain to be addressed. Implementation of empty container management requires that the economic and other interests of all parties be addressed. Motor carriers derive revenue by moving empty containers; they are unlikely to support policies that stifle that revenue. A system of carbon credits, that offsets revenue losses incurred in the interests of environmental responsibility, may be the answer. Terminal operators need to be convinced of benefits to themselves, rather than just to trucking firms, by improving efficiency (the research establishes that this is the case); and ultimately the proposed solutions will succeed or fail depending on the acceptance by and training of crane operators and truck drivers.

A significant and deliberate omission was air quality considerations, such as truck emissions while idling, their impact on health, and implications for siting public facilities such as schools, playgrounds and health care facilities. It was felt that air quality was a substantive area of research in itself, and would constitute a distraction from other directions of this study.

At the time of writing this report, in late 2010, most of the trucking firms that had participated in the study had signed on for the commercial rollout of the MeTrIS tracking program. Separately, a consortium of ports, marine terminals, trucking companies and beneficial cargo owners were in discussions about purchasing regular reports on congestion levels in and around marine terminals, developed from MeTrIS observations. In short, the technologies proposed and developed in this study are already deployed, and for now are proving to be commercially sustainable.

### *Recommendations*

We recommend the following to maximize the future benefits of the study:

1. The program of gathering location data from port trucks must continue. A commercial service has been launched, and motor carriers have responded enthusiastically.
2. Marine terminals, motor carriers, ports and beneficial cargo owners should agree on appropriate metrics of “turn time” and strategies to reduce it. At the time of writing, a Turn Time Stakeholders Group (TTSG) had been constituted and was in discussion with consortium members.
3. The scope of MeTrIS data should expand, to include payload and intended destination in real time.
4. A conference should be held among selected goods movement players, to address the establishment of Empty Storage Yards (ESYs) and incentives to use them.
5. Marine terminals and motor carriers should be encouraged to implement the synchronization proposals advanced by this research effort.
6. Port planners should be prepared to consider radical changes in the process of container pickup, including (a) a “taxi service” analogy in which, at peak congestion times, any truck is assigned the next available container, (b) land bridges, (c) container racks.
7. In cooperation with MARAD and FHWA, RITA should assist in the promotion of solutions to facilitate freight movement in the vicinity of this critical national facility.

The optimization models explored in this project necessarily simplify reality. However, they should not be dismissed on those grounds. They suggest that massive benefits can be realized. With $80 million in goods passing through the ports each working hour, the cost of inefficiency is exceedingly high, not just in economic terms, but also in terms of future readiness, environmental and security vulnerability.