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A Review of Coastal Navigation Asset Management Efforts within the Coastal Inlets Research Program (CIRP) Part 2: The Channel Portfolio Tool

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PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) summarizes research efforts that have taken place since the 2008 fiscal year (FY) within the Coastal Inlets Research Program (CIRP) concerning asset management of coastal navigation channels. Specifically, the details concerning the conceptual basis and application of the Channel Portfolio Tool (CPT) are described. The CIRP work unit responsible for all of the efforts described herein is referred to as Coastal Navigation Portfolio Management (CNPM).

BACKGROUND AND OVERVIEW: In response to a direct request from USACE-HQ, beginning in July of 2008 the CIRP started development of the Channel Portfolio Tool (CPT). This web-based software uses the proprietary, dock-level tonnage database maintained by the Waterborne Commerce Statistics Center (WCSC), part of the Corps' Institute for Water Resources (IWR) Navigation Data Center (NDC), for determining the extent to which dredged channel depths are utilized by commercial shipping. CPT provides an objective, consistent basis by which channels may be compared quickly to others for prioritization of Operation & Maintenance (O&M) funding, thereby providing improved justification for annual O&M dredging budget items. The preliminary, proof-of-concept version of CPT received positive feedback in a briefing to examiners from the Office of Management and Budget (OMB) prior to the end of FY08. These same examiners had indicated previously to USACE-HQ personnel that improved justification such as that provided by CPT is a required precondition for increased outlays from the Harbor Maintenance Trust Fund (HMTF), which carries a net balance of several billion dollars due to annual revenues exceeding outlays (GAO, 2008).

Prototype development continued in FY2009, along with CPT rollout efforts to the targeted Corps user community, including presentations at the National Dredging Meeting in Washington, D.C. and the Western Dredging Association's (WEDA's) annual dredging conference (Mitchell and Walker, 2009). In addition, a paper describing the conceptual basis for CPT as well as proposals for how it could be employed throughout USACE was published in the International Association of Dredging Contractor's (IADC's) quarterly publication *Terra et Aqua* (Mitchell, 2009).

FY2010 efforts focused on migrating the CPT prototype functionality to a web-based platform. The web version of CPT is presently available at this URL: <https://cpt.usace.army.mil>. The conversion to an internet environment ensures ready access to the CPT application for the Corps user community, and maintains consistency within the underlying datasets and application functionality as performance enhancements and refinements continue to be implemented. At present, the CPT application is only available to USACE personnel operating on computers

connected to the Corps network; however, discussions are ongoing with the NDC to ensure compliance with non-disclosure requirements and subsequently release CPT for use by other federal agencies and for public access.

MOTIVATION FOR O&M CHANNEL PRIORITIZATION: The USACE actively maintains navigation channels in over 360 individual projects nationwide, while the total number of authorized federal projects exceeds 1400. These range from the deep-draft coastal entrance channels with depths of up to 50 ft, to much smaller, shallow-draft channels that support navigation for commercial fishing and recreational use. Many of the larger deep-draft projects often contain dozens of individual channels and sub-reaches, and the cumulative length of maintained channels within a single project can sometimes exceed 50 miles (e.g. Houston Ship Channel – 53.3 miles; Calcasieu River and Pass – 72.1 miles; and Baltimore Harbor and Channels– 79.4 miles).

During the five years covering FY04-FY08, the Corps averaged \$770 million annually in O&M dredging expenditures in support of the navigation mission. Allocation of this funding across the portfolio of projects is done through an *ad hoc* decision process, wherein several thousand individual O&M work items submitted to USACE-HQ are evaluated and either funded at the requested level or denied. As described in the Navigation Budget EC (Engineering Circular) (Dept. of the Army, 2009) a variety of factors are taken into consideration during this evaluation, including total project commercial tonnage, District and Division rankings of work items, project usage codes (e.g. Harbor of Refuge, Subsistence, etc.), and time since last appropriation, among others. Although no single factor guarantees approval of a particular budget request, an annual baseline of 10 million total project tons provides for general direction of funding towards high-use commercial ports and waterways. This results in roughly 59 navigation projects receiving priority for navigation O&M dredging funding, with smaller projects being potentially passed over. Table 1 summarizes the distribution of annual O&M funding across the portfolio of coastal navigation projects for FY2011. These results are based on an independent analysis conducted by the author of budgetary figures provided by USACE-HQ, and they should not be interpreted as official Corps budgetary statistics. Note that according to this information provided by USACE-HQ, the top 59 navigation projects, though given priority over channels and ports with lesser amounts of commercial tonnage, still only received about half of the total O&M dredging outlays during FY2011.

Table 1. Breakdown of USACE navigation* O&M funding requests and expenditures (FY11) across high, medium, and low tonnage projects.			
Project Grouping	O&M \$M Requested (% of all \$ Requested)	O&M \$M Awarded (% of all \$ Awarded)	% of Requested Funding Awarded
Tons > 10M (59 projects)	\$922.4 (41.2%)	\$449.7 (66.6%)	48.8%
10M > Tons > 1M (97 Projects)	\$552.5 (24.7%)	\$152.0 (22.5%)	27.5%
1M > Tons (210 Projects)	\$765.6 (34.2%)	\$73.7 (10.9%)	9.6%
All Navigation Projects	\$2,241* (100%)	\$675.4* (100%)	30.1%

* for Harbor Maintenance Trust Fund (HMTF) eligible projects only; figures do not include \$100.5M in requests for miscellaneous items such as state-level project surveys covering multiple navigation projects.

Table 1 makes clear that dredging requirements have far outpaced the funds that are released each year from the HMTF to finance USACE O&M dredging activities. These funding shortfalls are occurring while the Corps is being pressured simultaneously by external calls for improved performance-based budgeting (e.g., O’Keefe et al. 2007, Transportation Research Board (TRB) 2004, and the previously mentioned calls from OMB). In addition, with the imminent expansion of the Panama Canal, the next generation of oceangoing vessels is expected to be larger than ever, prompting US port authorities to push for major deepening efforts to remain competitive within the global marketplace. Such deepening efforts are well known for increasing the year-to-year maintenance dredging requirements within Corps navigation projects (see for example, Rosati, 2005), indicating that the constrained funding environments seen in recent years for navigation O&M are likely to continue for the foreseeable future.

CHANNEL PORTFOLIO TOOL (CPT) DATA SOURCES: In light of the issues raised above, rational allocation of limited dredging funding across the vast inventory of Corps-maintained channels requires a consistent, objective basis for comparison. A prioritization framework and decision-support tool is needed to allow for improved justification of O&M budgeting at all levels of Corps management. Project managers and District operations personnel need to be able to defend their budget requests and dredge their navigation projects so as to optimize local and regional economic benefits. Likewise, at the Division and USACE-HQ levels, limited dredging funds across regions must be allocated according to a rational, transparent methodology using consistent performance metrics.

The dock-level tonnage database maintained by the Waterborne Commerce Statistics Center (WCSC) provides a level of detail and breadth of coverage for the national marine transportation system that is sufficient for an objective basis of comparison. CPT allows the tonnage data to be queried and presented in a straightforward, yet flexible manner. This is accomplished by matching the large WCSC tonnage database to a spatially defined network of maintained channels and waterways. Entries in the tonnage database are routed from origin to destination through this network using standard shortest-path logic. The cumulative statistics for tons, \$-value, vessel draft, commodities, and traffic type are compiled for each individual link in the network, and the CPT interface provides a straightforward means of querying and filtering the data to suit user specifications. In this manner, CPT provides a convenient means for quickly analyzing the extent to which maintained depths for any single segment of maintained channel or waterway are utilized by commercial shipping.

Spatially Defined Waterway Network

The central concept underlying CPT is that the USACE portfolio of maintained navigation channels and waterways is an interconnected transportation *system*. That is, waterborne traffic utilizing any one portion of the system also likely transits other portions during the course of its journey. Likewise, the impacts to waterborne commerce from the physical condition (i.e. channel controlling depth) of any given navigation channel are not isolated within just that channel; they are realized system wide, in all other portions of the waterway network through which transiting tonnage also travels. To capture this aspect of the waterborne transportation infrastructure adequately, Corps navigation channels and sub-reaches are represented within CPT as part of a comprehensive, fully-connected network of spatially defined links and nodes.

Each channel and sub-reach is created individually using the straightforward Path feature within the Google Earth™ geographic information program and saved with appropriate naming (e.g. Mobile Outer Bar Channel, Ambrose Entrance Channel, etc.) as a simple .kml (Keyhole Markup Language) file. The CPT compiler program subsequently reads the geo-coordinates contained within these .kml files to assemble a complete spatial network of channels, sub-reaches, and deep-water connector links. Though the .kml paths are drawn so as to reasonably approximate the real-world channel centerlines, it should be noted that CPT does not require exact spatial matching for end-to-end connections between reaches. Individual reaches need only come within 500-ft of each other to be snapped together by the CPT compiler, thereby forming a connection in the network.

The rationale for using the Google Earth™ .kml paths to define reaches is based on a desire to keep the underlying network flexible enough to suit differing needs and preferences among the various USACE Districts and Divisions. Since no centralized, standardized spatial database of Corps navigation channels is presently available, it is anticipated that District and Division users will prefer reach definitions tailored to the unique nomenclature and/or stationing utilized locally for surveying and maintenance dredging. Using the .kml definitions within the freely-available Google Earth™ environment provides a very flexible, easily accessible means of updating the waterway network to suit user needs and to keep up with any potential future changes to the USACE navigation portfolio. Figure 1 shows the breadth of coverage of the waterway network constructed for use with CPT.

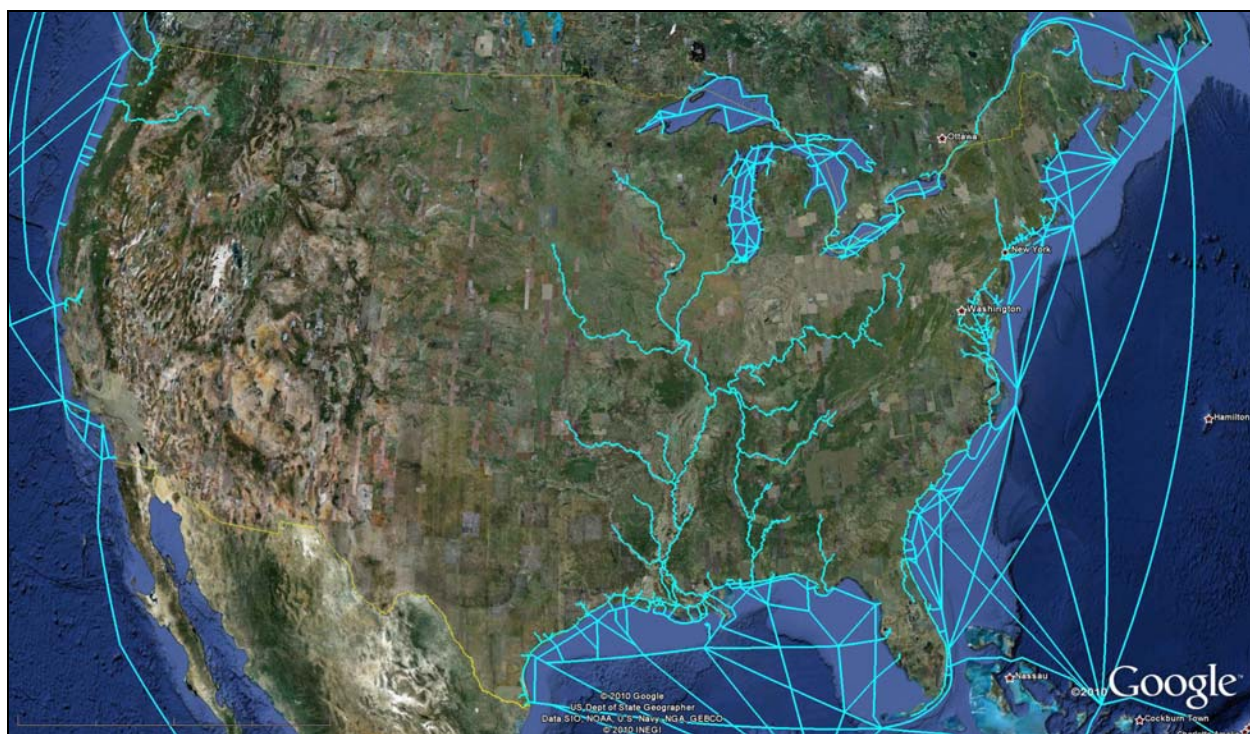


Figure 1. Google Earth view of waterway network used by CPT.

CPT coverage extends to inland portions of the waterway infrastructure as well, and no portions of the network are in any way cut off from any others. The network includes coverage of Alaskan and Hawaiian ports and channels; however, these are not shown in Figure 1. Figure 2 provides a closer,

more detailed view of the waterway network at the Ports of Los Angeles and Long Beach, CA. Note that individual berthing terminals and side channels are represented with single, distinct links in the waterway network, allowing detailed waterborne commerce reports to be generated with CPT for each of these segments of waterway. The color-coding is present simply to differentiate individual reaches and side channels. Wherever possible, links in the network are defined so as to follow known channel centerlines and deep-water shipping lanes. As they are created, the individual .kml path files are placed within a folder hierarchy based on the Corps' own civil works organizational structure. For example, the .kml file representing the Mouth of the Columbia River is placed within the Portland District folder, which is itself found within the Northwest Division folder. This hierarchy makes selection of individual channels via the CPT interface much more straightforward and intuitive.



Figure 2. CPT Dock-reach assignments at the Port of L.A.-Long Beach.

Navigation Data Center Docks Database

The linkage between the WCSC tonnage database and the spatial network of maintained channels and sub-reaches is made possible by the geo-referenced Master Docks database of port facilities operating on US waterways. This database is maintained by the Navigation Data Center (NDC) and is available online at: <http://www.ndc.iwr.usace.army.mil/data/datapwd.htm>. The database presently contains nearly 10,000 distinct entries, with detailed descriptions concerning facility type, storage capacities, intermodal connections, and operator information. Most of the dock facilities in the database also have latitude and longitude coordinates provided.

These coordinates provide the spatial information needed for matching each dock to the corresponding maintained segment of waterway within the USACE portfolio of navigation projects.

The CPT compiler finds the individual .kml file with the closest spatial coordinate to each dock and then assigns that dock the corresponding channel and/or sub-reach. Since the dock facilities represent the locations wherein waterborne commerce enters and/or leaves the network of maintained navigation channels, this nearest-neighbor search is critical for properly crediting each channel segment with the waterborne commerce it supports. Figure 2 shows the effectiveness of this approach for assigning docks to the individual berthing terminals and side channels within the Ports of Los Angeles and Long Beach, CA. Each dock is shown as a small circle, and the color coding matches those of the associated reaches. The nearest-neighbor searching and matching is conducted every time the CPT compiler is executed. This ensures that any needed updates to the dock-reach assignments due to changes made to the underlying network of .kml paths since the previous compilation will be made automatically. Therefore, even significant changes and/or updates to the waterway network, as defined by the .kml paths, present no difficulties for assigning docks to their respective waterway segments.

Waterborne Commerce Dock-level Tonnage Database

The Waterborne Commerce Statistics Center (WCSC) maintains the official USACE statistics concerning commercial utilization of navigation channels, waterways, and ports. These figures are aggregated at the project level and published each year in a series of reports entitled *Waterborne Commerce of the United States* (IWR, 2009). However, at the full level of detail, these data are considered proprietary and are therefore not released to the public due to non-disclosure requirements of the U.S. Bureau of the Census (US Dept. of Commerce, 2007). These data are available for use by Corps employees for the purposes of advancing the navigation mission.

Each cargo and vessel movement record in the full WCSC database contains an origin and destination code referencing a geo-coded entry in the Master Docks database. The CPT preprocessor uses routing information within the WCSC database as well as Dijkstra's algorithm (Ahuja et al. 1993) for determining the shortest paths through a network to tabulate usage statistics for all reaches defined in the spatial network of waterways. The CPT user interface subsequently allows for quick, straightforward access to this new database, with flexible query settings and filters to help meet user requirements. Since the CPT is under continuous development with interface features changing frequently, users are referred to the CPT wiki page for step-by-step instructions concerning use of the application: <http://cirp.usace.army.mil/wiki/CPT>.

CPT RESULTS: With the preprocessing steps completed, the CPT web-accessible user interface can be used to quickly obtain information concerning individual reaches in the waterway network. Figure 3 gives an example chart for one portion of the Houston Ship Channel (HSC) for 2008.

This “draft profile” chart shows the cumulative amounts of commercial tonnage transiting this reach over the course of the year at each 1-ft increment of maintained channel depth. Note the additional color-coded breakdown concerning traffic type; the internal tonnage is seen to be confined to the shallow-draft depths, while the deepest depths are comprised almost exclusively of foreign imports and exports. A second version of the draft-profile chart is provided in Figure 4 for the same portion of waterway. In this instance, a commodity breakdown has been invoked, showing the relative amounts of the top 3 commodities using the HSC that transit at each 1-ft increment of depth. The majority of the deep-draft tonnage is shown to be crude petroleum, and

the color-coding corresponds with the imported tonnage shown in Figure 3. The purpose of displaying the tonnage amounts transiting at each 1-ft increment of depth is to make the point that much of the “total tonnage” utilizing a given stretch of waterway simply is not affected by the year-to-year shoaling activity that maintenance dredging typically addresses.

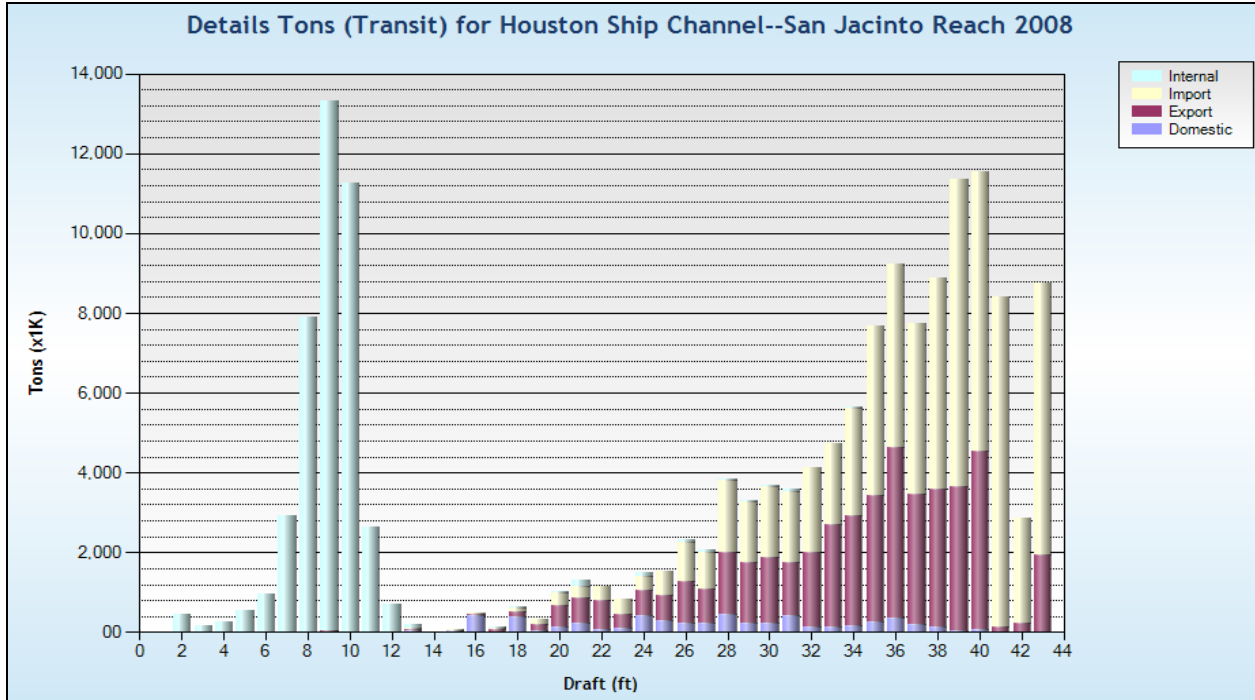


Figure 3. Example of CPT draft-profile chart and traffic type breakdown.

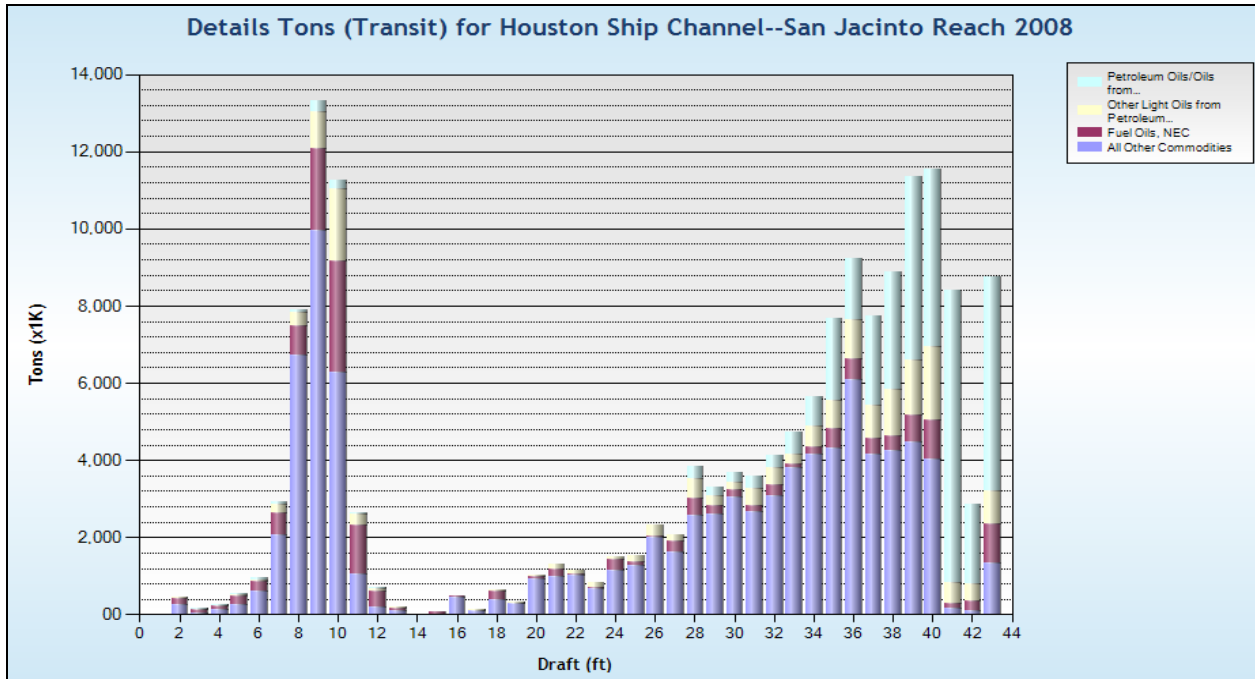


Figure 4. Example of CPT draft-profile chart and commodity breakdown.

Therefore, for the purpose of prioritizing maintenance dredging work packages, there is a rational basis for assigning more importance to the tonnage transiting at the deeper, shoal-vulnerable depths.

CPT allows for this sort of analysis in two ways: 1) using a default shoaling rate that is applied equally to all selected channels, and 2) via a user-upload capability that allows for actual channel condition reports to be reflected directly in the CPT rankings of channels. In both instances, present channels conditions and shoaling rates are compared to the draft profile to determine the amount of cargo that is impacted directly by channel shoaling conditions. This metric is then used by CPT as an objective basis by which all other channels under consideration can be compared and ranked for maintenance funding.

The folder hierarchy mentioned previously for housing of the .kml files is used by CPT to conduct “Rollups” of groupings of multiple channels. This feature is essential for evaluating dredging work packages that cover more than a single reach or channel. A simple summation of the tonnage totals for multiple channels will result in double counting of any cargo that transits more than one selected channel, therefore CPT employs a consolidation step to ensure that transiting commodities are only counted once towards the system totals. Using this powerful feature, charts such as those shown in Figures 3 and 4 can be generated that show consolidated statements of commerce for entire navigation projects, or even entire Districts and Divisions.

The basis of comparison for prioritizing channels for maintenance dredging is not limited to tons disrupted by shoaling activity. CPT uses separate tables obtained from published Department of Commerce figures to assign a dollar value per ton for each commodity type in the WCSC database. This allows for dredging work packages to be ranked in terms of the monetary value of potentially disrupted cargo. Another metric for comparison is made possible by the shortest path routing that CPT conducts during preprocessing. By tracking the actual routes that commodities travel from origin to destination, CPT is able to generate useful flow patterns as shown in Figure 5.

These Google Earth flow diagrams readily allow visualization of region-to-region commodity movements. However, for the purposes of improved justification of maintenance dredging investments, this feature can be used to generate metrics such as ton-miles and \$-miles for any given segment of maintained waterway. This provides a powerful systems-level basis of comparison, since these metrics reflect the criticality of any given reach to the rest of the waterborne transportation infrastructure.

SUMMARY: This CHETN presents a brief summary of the motivation for and underlying conceptual framework of the web-accessible Channel Portfolio Tool (CPT). The specifics of the user interface and functional architecture will likely change as the tool undergoes continued development; however, the systems-based approach to navigation channel portfolio management represents a promising path forward for the Corps. In a time of constrained budgets and an uncertain fiscal outlook for civil works O&M, the Corps must use limited resources optimally so as to maximize national benefits while also providing objective, consistent justification for annual maintenance dredging investments. CPT provides a straightforward, accessible decision-support package for achieving these objectives.

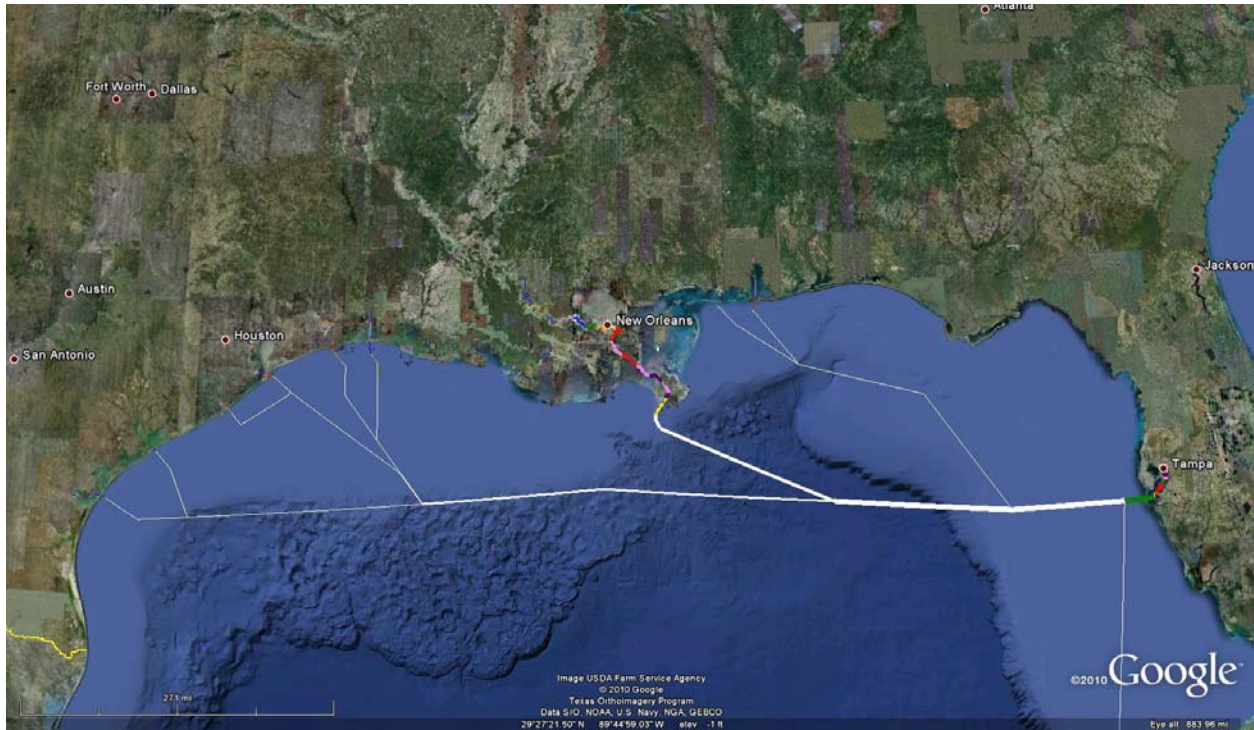


Figure 5. Commodity flows between Tampa, FL and other Gulf of Mexico ports.

POINT OF CONTACT: This CHETN is a product of the Coastal Navigation Portfolio Management Work Unit of the Coastal Inlets Research Program (CIRP) being conducted at the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory. Questions about this technical note can be addressed to Dr. Ned Mitchell (Phone: 601-634-2022, e-mail: Kenneth.n.mitchell@usace.army.mil). For information about the Coastal Inlets Research Program (CIRP), please contact the CIRP program manager, Dr. Julie D. Rosati, at 251-694-3719 or Julie.d.rosati@usace.army.mil. This technical note should be cited as follows:

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