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Problems of Deep Draft Navigation Benefit Evaluation Procedures

by James Crew, Dr. Kevin H. Horn***

INTRODUCTION

Economic analyses of the benefits of channel improvements, primarily deepening to accommodate larger vessels, have been performed at most major U.S. ports since the late 1970s. Most studies are based on obvious trends of jumboization of the world fleet. The results of channel improvement investigations have been generally favorable for most ports. Based on these studies the Water Resources Development Act of 1986 (P.L. 99-662) authorized six deep draft harbor projects: (1) Mobile Harbor; (2) Mississippi River, Gulf to Baton Rouge; (3) Galveston Bay Area; (4) Norfolk Harbor; (5) Los Angeles and Long Beach Harbors; and (5) New York Harbor.

Harbor public improvement studies are performed by the U.S. Army Corps of Engineers (Corps). Feasibility studies are prepared by district Corps personnel and reviewed by division staff, headquarters staff, Board of Engineers for Rivers and Harbors (BERH) and Assistant Secretary of the Army (Civil Works). Deep draft navigation benefit evaluation studies are conducted under a set of guidelines, *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* usually denoted as *Principles and Guidelines* or P&G. In addition, the Corps has a series of engineering and planning regulations to provide planners with technical guidance for conducting deep draft navigation analysis.

The purpose of this paper is to address two pragmatic interrelated aspects of deep draft navigation benefit studies: the consistency of recently authorized deep draft harbor studies with the P&G and the typical problems that characterize the application of the P&G. The objective of the paper is to clarify the major problems that characterize application of the P&G to deep draft navigation benefit evaluation procedures. The paper will illustrate the complexities of practical implementation of the P&G and recommend how to avoid the problems that routinely characterize port planning studies. The paper will not address whether the P&G are theoretically correct or recommend improvements to the P&G. The paper contains a series of recommendations for how to deal with the problems and pitfalls that the conceptual nature of the P&G does not address (and was probably not designed to do so).

APPLICATION OF PRINCIPLES AND GUIDELINES

The P&G suggest nine steps to estimate navigation benefits. A flow chart of recommended navigation evaluation procedures from the P&G is reproduced in Figure 1. The flow chart is a static representation of the general steps inherent in benefit estimation. Interrelationships among the procedures are not completely delineated. The number of steps is arbitrary and not exhaustive or mutually exclusive. In addition, the nine steps do not address problems in application which is partly addressed in the P&G under the headings of: (1) multiport analysis; (2) ultimate origins and destinations; (3) sensitivity analysis; and (4) data sources.

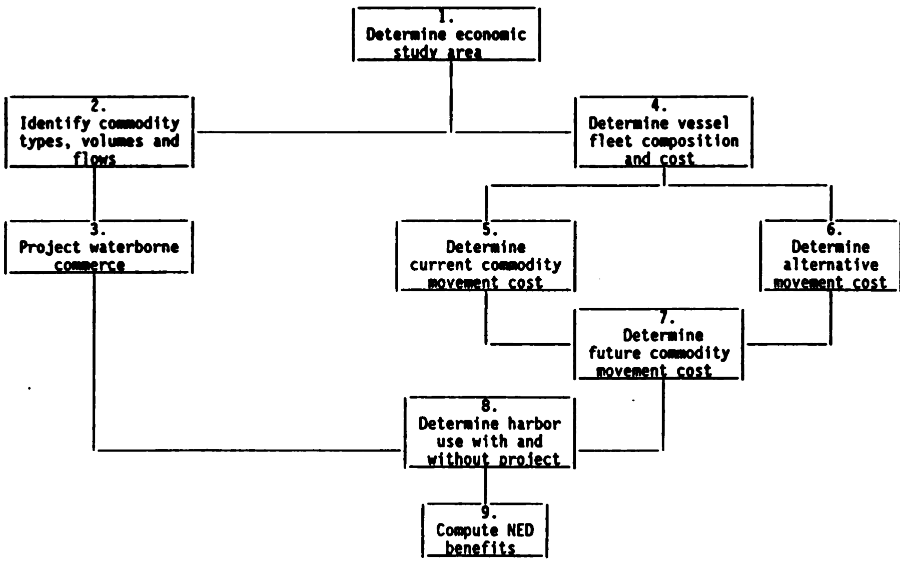
Figure 1 is conceptually clear, however, pragmatically difficult to execute due to numerous feedback relationships among the designated steps. The nature and importance of feedback interrelationships varies for different projects and associated benefits. Consequently, the P&G flow chart cannot be an exhaustive representation of everything the planner or analyst must do. In recognition of the importance of complex relationships among arbitrarily delineated study steps, this paper will present an overview of the major issues and problems that characterize systematic project analysis and benefit estimation. The overview of benefit estimation will focus on the practical problems of implementing the P&G based on a review of recent deep draft navigation studies.

CONFORMITY OF PROJECTS WITH P&G

Four main deep draft harbor improvement studies were reviewed to assess the adequacy of their analyses with the requirements of the P&G. The projects selected were: (1) Kill Van Kull and Newark Bay Channels (New York); (2) Norfolk Harbor and Channels

FIGURE 1

**Flow Chart of Deep-Draft
Navigation Benefit Evaluation Procedures**



*Source: Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Government Printing Office; Washington, D.C.; March 10, 1983), p. 61.

(Norfolk); (3) Mobile Harbor (Mobile); and (4) Deep Draft Access to the Ports of New Orleans and Baton Rouge, Louisiana (Lower Mississippi). Each project represents a large initial construction cost and has substantial estimated economic (transportation cost savings) benefits as follows: (1) New York - initial cost - $203.9 million; average annual benefits - $137.3 million; and benefit-cost ratio - 7.1; (2) Norfolk - initial cost - $417.4 million; average annual benefits - $173.1 million; and benefit-cost ratio - 3.5; (3) Mobile - initial cost - $338.1 million; average annual benefits - $50.1 million; and benefit-cost ratio - 1.6; and (4) Lower Mississippi - initial cost - $435.0 million; average annual benefits - $1,324.0 million; and benefit-cost ratio - 9.1. Each authorized project represents significant channel deepening as follows; (2) New York - expansion from 35 to 45 feet; (2) Norfolk - expansion from 45 to 55 feet; (3) Mobile - expansion from 40 to 55 feet; and (4) Lower Mississippi - expansion from 40 to 55 feet.

Each study was reviewed to determine its conformity with the P&G. All four projects reviewed only had cost reduction benefits (savings to existing and projected baseline traffic) with no shift of origin, shift of destination or induced benefits. Although the projects are conceptually similar for purposes of benefit estimation, differences between the project settings will affect execution of individual P&G steps. The projects' implementation of each P&G step will be reviewed, followed by an assessment of overall conformity with the P&G. Each step will be analyzed in terms of a practical minimum and probable maximum level of effort required relative to the overall guidelines.

Step 1: Determine Economic Study Area

The P&G stipulates that the economic study area that is tributary to the proposed improvement should be delineated, including discussion of the trade area relative to adjacent ports. A minimum effort to fulfill this step would be a general description of the port hinterland, including competing port hinterlands. A maximum level of effort would reflect commodity specific hinterlands and assessment of the port's competitive position in each hinterland. None of the studies identified commodity routing alternatives, except Lower Mississippi. All of the studies reflected a minimal level of effort with respect to step 1. New York indicated a 12 state hinterland for imports and exports. Norfolk presented descriptive data and a map of the Appalachian coal field. Mobile presented a tributary area for coal based on railroad rates. Lower Mississippi discussed diversion of oil imports to Louisiana Off-Shore Oil Pipeline (LOOP).

All of the studies effectively began with step two. None of the studies identified captive and competitive hinterlands except in a general descriptive manner. It appears that for all practical purposes the existence of the hinterland was assumed, supplemented by discussion of local transportation infrastructure adjacent to the port. The effective omission of step one may be acceptable for large ports where a dominant hinterland can be presumed, however, the failure to at least identify competing ports is not a correct prescription for studies of other ports or consistent with the P&G.

Step 2: Identify Commodity Types, Volumes and Flows

The P&G indicate that the types and volumes of commodities and origin, destination and vessel itineraries should be determined. The minimum level of effort would be to identify the major commodity flows via the port and competing ports and determine growth constraints. The maximum level of analysis would reflect identification of all commodity flows via the port and competing ports, including comparative origin to destination costs. None of the studies developed comparative origin to destination costs to provide a basis for evaluating alternatives. All of the studies performed the minimum level of required analysis. New York identified historical trends for major cargo categories, container, dry bulk and tanker. Norfolk only analyzed bulk commodities, coal and grain exports through the port. Mobile and Lower Mississippi identified all port bulk traffic as a basis for benefit estimation.

Step 3: Project Waterborne Commerce

The P&G have a wide latitude for discretion in projections. It would appear that the minimum level of analysis would reflect extrapolations of long term trends (bottom up) or disaggregation of macro (top down) forecasts to a range of competing ports. Bottom up projections should be tested for reasonableness. Top down projections should demonstrate that a fair share of the total was disaggregated to individual ports. The maximum level of effort would reflect commodity specific forecasts that account for overall supply and demand and are port-specific, reflecting capacity and constraints at alternate ports for hinterland resources, markets and inland transport. All of the studies reflect at least a minimal level of analysis. New York, Norfolk and Mobile extrapolated historical port trends. New York used personal income statistics in the hinterland in lieu of regional industrial production data and assumed that port terminal capacity would be reached in 1985. Norfolk used coal and grain projections from other studies (top-down). Mobile used Bureau of Mines coal projections for the existing traffic base, supplemented by user surveys and inclusion of almost all anticipated Tennessee-Tombigbee Waterway coal exports, commencing with completion of the waterway. Lower Mississippi used a top down forecast prepared for the Maritime Administration to extrapolate long term trends.

The variety of forecasting methods reflect the different mixtures of benefited traffic at the ports. The large volume of existing general cargo at New York relative to terminal capacity made forecasting relatively unimportant. Conversely, the small volume of export coal at Mobile made forecasting very important to the project. While all ports nominally addressed sensitivity analysis of forecasts, it was clearly unimportant for New York (assuming no multiport diversions) and critical for Mobile. Both studies paid scant attention to sensitivity analysis of forecasts, however, except for what would appear to be token accommodation of the P&G.

Step 4: Determine Vessel Fleet Composition and Cost

The P&G allow for a broad range of fleet projection methodologies and vessel cost data, however, internal consistency in fleet composition and vessel cost is stipulated. The minimum level of effort would reflect extrapolation of the composition of the current harbor fleet to reflect observed trends in relevant world fleet and coastal fleet for competitive ports. Maximum effort would reflect disaggregating present and future world and harbor fleets to benefited commodities, trade routes and itineraries.

The studies reflect different levels of effort based on the importance of fleet composition to project benefits. New York assumed no increase in vessel size. Vessel utilization at the harbor was based on average depths of three previous ports for different trade routes. Norfolk used National Coal Bureau logs to develop vessel size trends for three world area destinations. The port fleet of dry bulk vessels for coal and grain was projected estimating retirements and replacements. Mobile and Lower Mississippi assumed port fleet projections would resemble observed trends in the world fleet of bulk ships. Fleet data was analyzed for major trade routes and

Panama Canal constraints. The adoption of a world fleet for the harbor forecast resulted in a large change in the composition of the port fleet for the with project condition at Mobile and Lower Mississippi.

All studies performed more than the minimum level of fleet analysis, disaggregating vessels by benefited cargoes, itineraries and constraints. New York assumed that excess vessel capacity existed in the without project condition (light loading) with no justification or support for assumptions that vessels would be fully loaded in the with project condition.

Step 5: Determine Current Commodity Movement Cost

P&G provides for the full origin to destination costs prevailing at the time of the study for the with and without project conditions. A minimum level of effort would be to identify inland, transfer and ocean costs for a broad range of representative hinterland nodes, trade routes, benefited commodities and types of vessels. The maximum level of effort would determine the total origin to destination costs for all hinterland nodes, trade routes, benefited commodities and vessels. All four studies used average vessel operating costs developed by the Corps for different vessel itineraries. None of the studies discussed costs for hinterland modes or intermodal transfer. The omission of inland rate/cost analysis in these studies does not appear unreasonable given the large volume of relatively captive traffic presumed for each port. The omission of inland cost data is consistent with the observed pattern of descriptive treatment of hinterlands when only existing traffic is assumed relevant to benefit analyses. This methodology as previously noted is not desirable for smaller ports with less captive cargo.

Step 6: Determine Alternative Movement Cost

The P&G stipulate that the full origin to destination transportation costs should be determined for competitive harbors and non-structural alternatives. The minimum and maximum levels of effort in executing this step would be similar to step 5. None of the studies performed this analysis for competitive harbors. Non-structural alternatives such as lightering and topping off, and structural alternatives such as pipelines, were examined by Norfolk. Mobile and Lower Mississippi did not indicate analysis of any alternatives to deepening.

The cargo captivity presumption of the four studies could be offered as an efficient justification for the lack of multiport analysis. Clearly, the overall weak treatment of domestic hinterlands suggests that multiport analysis is not needed. While such truncated analysis may be cost effective for large ports, the lack of conformity with the P&G is not an acceptable model for analysis of ports with less captive traffic, such as automobiles.

Step 7: Determine Future Commodity Movement Cost

The P&G requires that relevant shipping costs during the period of analysis and future changes in fleet composition, port delays, and port capacity be estimated. The minimum and maximum levels of effort would be consistent with steps 5 and 6. All studies achieved a minimum level of analysis, albeit with some noticeable distinctions. New York offered no justification for the assumption that transportation costs in the with project condition would be reduced due to fully loaded container ships and retirement or redeployment of excess capacity. Mobile and Lower Mississippi analyses reflected a substantial shift in the size of the harbor fleet for the with project condition. None of the studies analyzed the effect of potential technological changes and reduction of vessel operating costs on project benefits. Vessel costs were assumed to remain constant in real terms over the life of the project.

Step 8: Determine Harbor Use With and Without Project

The P&G requires estimates of harbor use over time. Movement costs should be compared for each alternative, including the impact of uncertainty in use of the harbor, level of service and future inventories of vessels. A minimum level of analysis would include the major assumptions affecting the behavior of project users for both the with and without conditions. A maximum level of effort would indicate all assumptions and supporting documentation of user behavior. This step should accurately predict vessel operator and shipper behavior based on preceding steps.

All studies conformed with the minimum level of analysis, however, no documentation was presented to support user behavior in the with and without conditions. Norfolk and Mobile assumed vessel light loading in the without project condition, however, Lower Mississippi did not. New York allowed for light loading but excluded tidal delays. Norfolk included tidal delays. New York, Norfolk and Mobile allowed for vessel itinerary changes, however, Lower Mississippi did not.

Assumptions about user behavior in the studies primarily reflected engineering criteria rather than observation of actual practices. Mobile attempted to observe actual light loading and vessel utilization practices, however, the sample size was extremely small. It appears that actual practices of users were assumed to be consistent with design criteria. All studies had scant information on the expected behavior of vessel operators, particularly New York, where fully loaded container vessels were assumed for the with project condition. The lack of documentation of user practices in the New York study was succinctly addressed by the BERH, which indicated that the procedures used and assumptions made did not accurately reflect existing and future movements in the study area. The BERH also noted that supporting information providing details of sequential assumptions was not sufficiently documented to permit complete verification of the analysis.[1] The Lower Mississippi study similarly did not indicate shipper preference for a 55 foot channel, but assumed that the channel was the most desirable plan given the estimated benefits.[2]

Step 9: Compute NED Benefits

The minimum level of analysis would be a presentation of cost reduction benefits (existing traffic) and sensitivity analysis of commodity projections, vessel fleet forecasts and multiport alternatives. A maximum level of analysis would include estimation and sensitivity testing for other benefit categories: shift of origin; shift of destination; and induced movements.

All of the studies only computed cost reduction benefits. Sensitivity analysis was limited. New York had different commodity projections, however, no sensitivity analysis was performed of the assumption that more efficient use of existing container vessels and retirement of surplus vessels would result from deepening. Norfolk also performed a sensitivity analysis of commodity projections. Mobile attempted a sensitivity exercise on the long run trend in coal exports which had an incongruous effect of increasing annual benefits for both optimistic and pessimistic scenarios. No sensitivity analysis was done on the impact of potentially lower coal exports via the Tennessee-Tombigbee. Lower Mississippi assumed different commodity projections and rates of growth in the size of the existing fleet. For most of these studies sensitivity analysis appeared to be a pro-forma exercise.

IMPLICATIONS

A summary of the adequacy of the four major studies with respect to conformity with P&G is contained in Figure 2. Overall, the studies appear to meet the minimum thrust of the P&G requirements if the presumption of large captive hinterlands and traffic is accepted which effectively negates steps 1, 2, and 6. If the captivity assumption is relaxed the studies would be inadequate relative to the P&G requirements.

Given the relative magnitude of benefited cargo at three of these ports, the captivity assumption appears warranted on the basis of economy of effort. It is disturbing, however, that study resources potentially saved by omitting detailed hinterland and multiport analysis were not reallocated to determining and documenting user behavior. Overall, too little analysis appears to have been done on user perceptions and needs, especially New York and Lower Mississippi. The economic analysis suggests strongly that a supply side orientation exists rather than documentation of user expectations.

None of the studies are fundamentally flawed with respect to P&G. Each study exhibits project specific characteristics, however, which facilitates compliance with P&G. As a result the four studies reviewed should not be regarded as suitable models for other port analyses. Clearly, three of the studies had sufficient benefited cargo to justify some deepening. The danger in accepting these analyses is that they can become inappropriate prescriptions for other incomplete, fragmented studies at smaller ports where captivity cannot be presumed and competitive hinterlands are a reality.

PRACTICAL APPLICATION OF PRINCIPLES AND GUIDELINES: RECOMMENDATIONS OF WHAT THE PLANNING ANALYST NEEDS TO KNOW

The four studies reviewed in the previous section typify the most common problems associated with the clarity and application of the P&G. The P&G could be augmented with respect to clarification of the following most common problem areas characterizing deep draft navigation benefit evaluation procedures: (1) Base Case Conditions; (2) Fleet Analysis and Forecasts; (3) Commodity Analysis and Projections; (4) Multiport Alternatives; (5) With and Without Project Conditions; (6) Calculate Benefits and Costs; and (7) Conclusions/Finalization. This section will summarize these problems and within each area recommend a practical framework for implementation. The recommendations will focus on the practical aspects of what the planning analyst needs to know to avoid the problems that the P&G does not expressly address.

FIGURE 2

Adequacy of Deep Draft Navigation Analyses Versus Requirements of P&G

P & G Step:	Review Comments:
1. Define Area	None of the studies did this in an analytical manner. The study area was assumed.
2. Identify Flows	None of the studies produced comparative origin to destination costs to provide a basis to evaluate alternatives.
3. Forecast Commerce	Limited to projection of local port trends or top down disaggregation of existing forecasts with no indication of the reasonableness of allocations among competing ports. Phenomenal growth of Mobile coal exports primarily attributable export coal projections for Tennessee-Tombigbee Waterway.
4. Fleet Composition	Focus on world fleet and harbor fleet. Should consider competitive coastal and trade route fleets to account for differences between observed trends in world fleet and trends at competing ports.
5. Determine Current Cost	Captivity assumptions removed need for inland and transfer costs.
6. Determine Alternative Costs	Captivity assumptions removed need for multiport analysis.
7. Determine Future Costs	Used Corps vessel replacement costs. Do not incorporate potential improvements in marine technology that could reduce costs (and benefits).
8. Determine Use	Lack of documentation of user behavior. Reliance on design criteria to infer behavior rather than observe practices.
9. Compute Benefits	Scant attention to sensitivity analysis except where obviously required for commodity projections. Other more important determinants of benefits not subjected to sensitivity testing.

Base Case Conditions

The baseline for any port feasibility study is represented by P&G steps 1, 2, 4, and 5 (Figure 1). These steps collectively represent the status quo of the present environment of the port in the without project condition. The planner needs to know the following: (1) Scope of information necessary to analyze the port project; (2) Commodity movements; (3) Vessel fleet characteristics; and (4) Transportation costs.

The threshold information necessary to adequately conduct a feasibility study should include a clear statement of the problem(s) and proposed solutions. Surprisingly, deep draft studies characteristically have scant treatment of specific problems and proposed solutions. General problem and solution statements, such as deeper draft or wider channels are needed, do not provide the planner with sufficient basis to identify benefited traffic. Inattention to the interrelationships between physical and institutional constraints oversimplifies the planning setting. The planner needs to clearly delineate the domestic and international study areas related to current cargo transshipment through the port as the basis for benefit estimation.

The adequacy of the threshold scope of information will be reflected in specification of relevant (benefited) commodity movements, including origins, destinations, shipment sizes and vessel types. Vessel fleet characteristics and itineraries should be documented for benefited traffic. Current vessel operating practices in response to the problem should be identified such as light loading, lightering, tidal delays, and risk taking.

Current vessel costs should be compiled for traffic subject to cost reduction benefits. Vessel costs as a function of operation, delay, load factor and risk reduction should be identified. Transportation costs, incorporating inland and transshipment activities, will normally be needed for benefited traffic associated with shift of origin, shift of destination or induced movements.

The output of the base case step is that the planner has a comprehensive analysis of the current commodity distribution patterns and related problems for the port in the without project condition. Future commodity distribution patterns and problems can be ascertained by forecasts of vessels, commodities and alternatives.

Vessel Analysis and Forecasts

Step 4 of the P&G relates to determining future vessel fleet composition and cost. The base case fleet analysis of the port reflects part of a larger world fleet population unless special vessels are dedicated to the port. Changes in the characteristics of the relevant world fleet, which will affect the number, size and operation of vessels at the port for the with and without project conditions, must be forecasted. Generally, local port improvements have no impact on world fleet vessel characteristics, however, port improvements may affect the future distribution of the size of the world fleet serving the port.

Vessel forecasts begin with the characteristics of the non-specialized world, coastal, or trade route fleets serving the port. Trends in vessel characteristics, such as draft, beam, capacity and commodity specialization, and major constraints, such as operations at other ports, have to be identified. Trends in vessel characteristics should be related to forecasts of international trade, commodities and trade routes. An alternative to the complexity and cost of an interactive supply-demand model of vessels and cargoes is to assume that trends in vessel characteristics are supply oriented, reflecting observed trends in fleet size and distribution. The relevant world fleet or coastal fleet composition should be identified for trade route, commodities, and transport costs for benefited traffic.

The most difficult aspect of vessel analysis is the harbor fleet forecast with and without the project. Many studies overcome this hurdle by normalizing the harbor fleet with a distribution of vessel characteristics for projected coastal or trade route fleets. The rate of change of the normalized harbor fleet should reflect changes in the relevant world fleet. If the existing harbor fleet is structurally different compared to the relevant world or coastal fleet, the planner's dilemma is how much and how fast to integrate two disparate populations of fleet characteristics. Conceptually the long run relevant world, coastal or trade route fleet should resemble an unconstrained with project harbor fleet. The timing of the integration of two different fleet size populations will reflect the pattern of vessel deployments or retirements and changes in the composition of the harbor fleet in response to the with project condition.

When there is no structural change in the future harbor fleet other than to incorporate forecasted changes in the world fleet, project benefits based on transportation cost savings will be relatively limited unless significant constraints to efficient vessel operation exist. Significant shifts in the composition of a constrained harbor fleet in response to a project will usually induce substantial benefits based on economies of scale of larger vessels. Structural shifts in the future composition of the harbor fleet have to be consistent with vessel operations, fleet operator and shipper behavior, commodity projections and other constraints on efficient utilization of larger vessels to realistically exploit economies of scale in vessel size. The fastest way to develop large benefits is to invent a phantom fleet of large vessels that would immediately begin to efficiently serve the port in response to the with project condition.

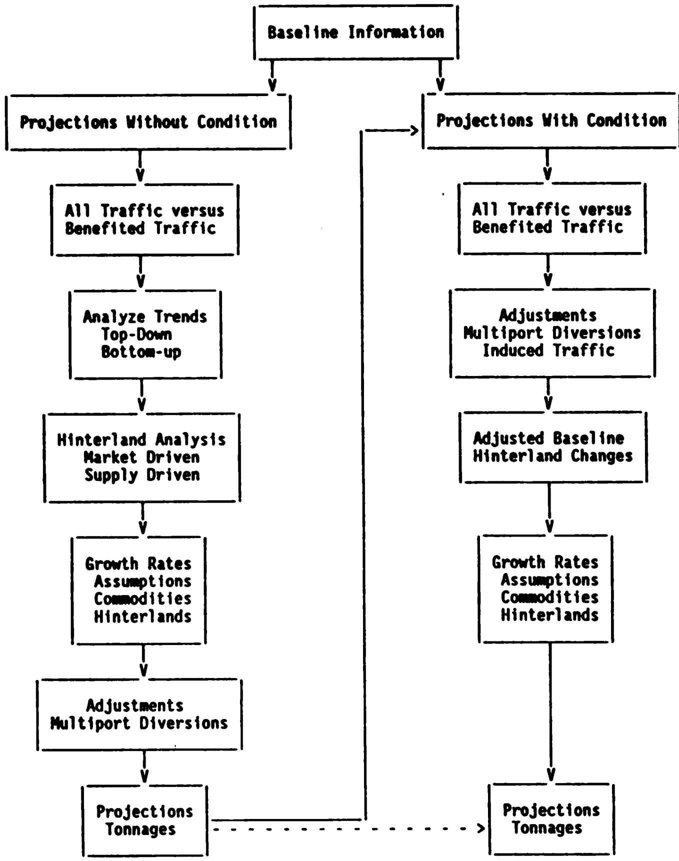
Commodity Analysis and Projections

Commodity analysis and projections for the with project conditions consists of three major elements: (1) forecast assumptions; (2) forecast methods; and (3) forecast intervals. The logic of commodity flow analysis and projections is presented in Figure 3.

All forecasts are based on premises about major uncontrollable factors affecting demand. The analyst must make assumptions about the variables affecting demand for the port. The number and kind of premises necessary to forecast traffic may be different for current traffic compared to traffic diverted or induced by the project. Unfortunately, most studies have not distinguished between forecasting premises pertaining to current traffic and premises applicable to forecasts of diverted or induced traffic. Failure to provide for this distinction

FIGURE 8

Logic of Commodity Flow Analysis and Projections



can effectively omit a forecast for diverted or induced traffic which characterizes many incomplete studies.

Another common mistake analysts make is to arbitrarily accept certain premises without acknowledging the sensitivity of the forecast to changes in the assumptions on which the forecast is based. Sensitivity analysis of commodity forecasts is based on changes in forecast assumptions. Important forecast premises should be selected for sensitivity analysis before the projection is made to explicitly incorporate sensitivity analysis into the forecast rather than treating it as a residual at the end of the analysis.

Forecast methods used in port studies can be characterized as "top down" or "bottom up." Top down methods require disaggregation of available forecasts for a broad geographic area or commodity to the particular port. Top down forecasts have been widely used for volatile bulk commodity markets such as energy and agriculture. The basic problem with any top down forecast is that someone else's projections are being disaggregated. In some instances the top down forecasts have focused on domestic trends, therefore foreign sector consumption has had to be inferred. In other instances allocating a "fair share" of an aggregated top down forecast to an individual port requires considerable subjectivity, as well as opportunity to inflate project benefits.

Bottom up forecasts involve projecting current traffic where an adequate data base exists. Bottom up forecasts are frequently used in lieu of a competitive hinterland analysis if stable long term trends exist.

The use of top down or bottom up forecasts will be determined by the character of current traffic subject to adjustment based on diverted and induced traffic. Forecasts are only relevant for benefited traffic, consisting of all cargo affected by reduced transportation costs. Harbor improvements will not uniformly affect all categories of vessels and commodities, therefore in the absence of congestion impacts of non-benefited traffic on benefited traffic, only a forecast of benefited cargo is needed.

Economic benefits under the P&G can be attributed to any change that reduces transportation costs. Commodities should be analyzed and forecasted based on the type of project impacts, such as vessel delay reduction, larger vessels, risk reduction and different vessel itineraries resulting in shorter voyages, reduced inventory, etc. The type of benefits that exist for the with project condition should determine the structure of the commodity forecast.

Failure to assign base year commodity flows to different project impacts relegates benefits analysis to obscurity. Unless the analyst identifies specific commodity flow benefit impacts for base year traffic, no objective basis for computation of benefits over the project life will exist. Failure to specifically disaggregate commodity flows with respect to project benefit categories usually characterizes improper project planning (specifications of base case conditions). The result is that benefited cargo is based on the analyst's subjective assessment of the merits of the project. Improper planning for commodity projections relative to benefit impacts ultimately results in planners' perceptions that not all benefits have been discovered. A flawed framework for traffic projections and benefit estimation is characterized by a trial and error analysis to find and quantify elusive benefits that the planner intuitively believes remain undiscovered. In projects of this type planners spend most of their time seeking to discover benefits rather than projecting relevant commodities by benefit category. This problem is particularly acute for smaller harbors when there is insufficient current cargo to justify the project.

Commodity projection adjustments to future base traffic result from the interaction of the with project condition and vessel fleet forecasts, capacity changes and multiport analysis. The timing of the adjustments of base traffic to incorporate diverted or induced traffic will be a function of the implementation of the project, including all user related investments and non-structural changes. If uncertainty of the timing of diverted or induced traffic exists, adjustments to base traffic should be subjected to sensitivity analysis.

Forecast intervals used for traffic projections do not have to coincide with the project life. A fifty-year period is prescribed for benefit cost analysis of waterway improvements, however, commodity projections over a shorter period of time may be warranted. For example, traffic may be projected over a twenty year period if no growth is envisioned beyond that period because of capacity constraints. The effect of discounting future benefits makes modest commodity growth projections relatively insignificant after twenty years at current discount rates exceeding eight percent.

The selected forecast intervals will be a product of integrating vessel fleet and commodity projections. The dynamics of both forecasts, together with multiport alternatives analysis, will indicate changes in the overall trends for base year traffic and adjustments to incorporate diverted and induced traffic. The technical forecasts of commodity flow, vessel fleet, capacity and multiport adjustments are usually done independently of each other. The role of the planner is to integrate the separate elements which should be compatible in terms of forecast intervals and premises. Integrating different forecasts can be especially subjective where the commodity projections are not linked to benefit categories delineated by vessel fleet and capacity forecasts. This environment is especially susceptible to heroic assumptions about benefited commodity projections and phantom fleets.

Multiport and Alternatives Analysis

The P&G step six is determine alternative movement cost. In spite of what would appear to be a clear mandate for multiport analysis, most studies bypass this step. Typically, the benefited cargo is assumed to be captive to the local port. Unless clear evidence of captivity exists, however, a systems analysis for competitive hinterland traffic should be conducted.

There are numerous practical and political problems that deter analysis of competitive port hinterlands. Defining competitive port hinterlands has substantial analytical and institutional requirements that often exceed the capabilities of commodity flow data or project resources. Projects which divert traffic from other ports effectively change port hinterlands. Multiport analysis can be viewed as a zero-sum game where sponsors of competing projects effectively divert away each other's traffic to justify their own improvements.

True multiport systems analysis is rarely done except in obvious cases where a project would divert cargo. In most instances multiport analysis is not possible unless the baseline conditions (P&G steps 1, 2, 4 and 5) are performed for a detailed hinterland analysis.

Alternatives analysis to the project largely consists of non-structural alternatives such as vessel design, and operations. Practically, there are few efficient non-structural alternatives to harbor improvements except for vessel monitoring, tidal delays, tug assistance, lightering and top-off. More exotic alternatives such as integrated vessels, offshore pipelines or bulk transshipment may be discussed to convey the obvious: non-structural improvements are not usually economically justified, however, feasible operational alternatives, including user behavior and perceptions, should be subjected to evaluation rather than casually dismissed.

With and Without Project Conditions

P&G step 8 succinctly directs the analyst to determine the use of the harbor with and without the project. Conceptually, this step is quite clear, however, it is pragmatically very difficult to execute. With and without conditions analysis frequently necessitates drastic simplifications to facilitate project evaluation unless all preceding steps have been done with reference to a comprehensive analysis of different project alternatives and the interrelationships between commodity projections, fleet forecasts and multiport alternatives.

Instead of being the most complex aspect of the study, analysis of with and without project conditions is usually the most succinct due to a number of simplifying assumptions. The observed silence of the P&G on the real complexities of distinguishing with and without project conditions is usually reflected in reports that characteristically assume that: (1) without project condition and existing baseline conditions are identical; (2) multiport diversions and project alternatives are not practical; (3) structural alternatives will be implemented by project users; (4) significant observed differences in operational practices do not exist or are not feasible in the future; and (5) the effect of time phased project implementation on fleet composition and commodity forecast is known with relative certainty.

The first step in properly comparing with and without project conditions is to incorporate future commodity flow characteristics into the without project baseline conditions. Adjustments to the baseline should be made to incorporate multiport and alternatives analysis into the baseline. The fleet composition for the without project condition should be delineated. As the commodity mix changes the fleet will have to be adjusted to reflect these changes. The fleet composition will also reflect any operational considerations, practices or constraints as well as any effects of user implemented projects.

The with project conditions consist of commodity flows and associated transport costs for each alternative. With and without project conditions will differ in response to specific project alternatives affecting commodity flows and fleet composition. It should be possible to understand the differences between with and without project conditions and the reasons these differences exist. If the analysis of with and without project conditions has been conducted correctly, it should be a straightforward matter to set forth differences in both textual and tabular form.

Calculate Benefits and Costs

P&G step 9 provides for computation of national economic development benefits. Harbor improvement projects have been traditionally justified by transport cost reductions, consisting of savings to existing and projected baseline traffic. Unless sufficient baseline data exists and multiport analysis has been realistically undertaken, other benefits, such as shift of origin, shift of destination or induced traffic, are moot. Consequently, it is very rare to see benefit estimation performed under the P&G for any category except savings to existing and projected baseline traffic. Cost reduction benefits typically reflect the impacts of deepening on shifts in vessel size, greater utilization of existing (light loaded) vessels or vessel maneuverability.

Report Presentation and Conclusion

The P&G provide appropriate insight into presentation of study results, documentation of assumptions and steps in the analysis, however, the subject of sensitivity analysis is not given particular attention for deep draft projects except in one sentence. Benefit estimation for deep draft projects should be subjected to a sensitivity analysis of the interaction of commodity forecasts, fleet forecasts and composition, and multiport alternatives. Most reports nominally address sensitivity analysis, however, rarely is a comprehensive sensitivity analysis presented. Clearly, this is one area where the P&G should be expanded given the practical complexities of deep draft benefit estimation articulated in this paper.

CONCLUSIONS

Economic analysis of the benefits of harbor improvements under the current *Principles and Guidelines* (P&G) is characterized by substantial judgement within a broad conceptual framework. A clearer conceptual framework, reflecting a revision of the P&G, will not necessarily make these studies more objective given the wide range of interacting variables and practical problems suggested but not fully articulated by the P&G. The practical problems of implementing the concepts of the P&G are significant, however, not insurmountable. Trade-offs obviously exist in study design and execution between legalistic conformity and practical accommodation of the P&G. The four studies reviewed in this paper contain different mixtures of adherence to the P&G, making comparisons between the adequacy of the analyses difficult, except on a case by case basis.

The results of this review of the application of the P&G suggest that substantial improvements are possible in future harbor studies and articulation of the practical problems implementing the P&G. Closer adherence to the P&G is required in future studies, however, the vagueness of the P&G with respect to applications contribute to the dilemma of improving the quality and reducing the subjectivity of deep draft benefit evaluation procedures. The sterile nature of the P&G are not particularly useful to project evaluation beyond a conceptual environment.

The P&G need to be supplemented by clear articulation of the problems and tradeoffs that routinely characterize deep draft navigation benefit evaluation procedures. The P&G lead the planning analyst through nine conceptual steps to evaluate deep draft navigation improvements. The P&G effectively tell the planning analyst what to do, however, no guidance is given to address significant practical problems, tradeoffs and interrelationships among the study steps. This paper represents part of a larger policy application manual under development to provide practical guidance to the planning analyst to implement and conform to the conceptual benefit evaluation framework succinctly stipulated in the P&G.

REFERENCES

Acting Assistant Secretary of the Army (Civil Works), *Kill Van Kull and Newark Bay Channels, New York and New Jersey* (Washington, D.C.: Committee on Public Works and Transportation, House Document 99-129, November 18, 1985).

Assistant Secretary of the Army (Civil Works), *Norfolk Harbor and Channels, Virginia* (Washington, D.C.: Committee on Public Works and Transportation, House Document 99-85, Volumes I, II and III, July 18, 1985).

Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (Washington, D.C.: U.S. Government Printing Office, March 10, 1983), pp. 58-67.

Mobile District, *Survey Report on Mobile Harbor, Alabama* (Mobile, Alabama: United States Army Corps of Engineers, Volumes I and 2, October, 1980).

New Orleans District, *Deep-Draft Access to the Ports of New Orleans and Baton Rouge, Louisiana: Feasibility Study* (New Orleans, Louisiana: United States Army Corps of Engineers, Volumes I, II and III, July, 1981).

ENDNOTES

* President, Transportation Research and Analysis Center.

** Department of Management, Marketing and Logistics, University of North Florida.

[1] Acting Assistant Secretary of the Army (Civil Works).

[2] Subsequently bulk shippers, primarily grains, indicated that a lesser depth was desirable. The project is being implemented to a 45-foot depth.