3.0 Demand Forecasting for New Facilities

3.0 Demand Forecasting for New Facilities

Transportation planners frequently must estimate the extent to which a contemplated new transportation facility or project will be used upon its completion. These estimates of future use of a new facility are a critical consideration in the policy decision of whether or not to go ahead with the project. Overestimates of future use or underestimates can be equally devastating. Overestimates result in the construction of projects or facilities that will be underutilized, while underestimates result in the failure to build needed facilities, causing congestion and delays at existing inadequate and outmoded facilities.

This chapter addresses the issue of demand forecasting when the contemplated facility or project is new – i.e., situations in which planners do not have the benefit of a past record of facility use upon which to base a projection of future use. While the previous chapter focused on the issue of projecting future use of existing facilities to determine, in part, whether those facilities needed some expansion, this chapter deals with the issue of the projected use of new facilities. Included in this discussion are such projects as: a new freight airport; a new highway (e.g., an inter-county connector highway, a bypass route, an outer beltway, etc.); a new intermodal facility; or development of a new doublestack rail line.

This chapter discusses the steps necessary for handling this class of transportation planning problem. Planners confronting such matters must define the available universe of freight flows from which the new facility could draw business, and they must decide how this universe of freight is likely to grow in the future. The first section of this chapter discusses the identification of the universe of freight flows that might use a new facility, and the second section discusses forecasting changes in these flows.

Once the universe of relevant freight flows is established and projections for that universe developed, the issue shifts to an assessment of how much of the available freight traffic now and in the future would use the new facility. For most new facilities, most or all of the freight using the new facility will be shifted to the facility as a result of *route diversion*, i.e., the freight will continue to be transported via the same combination of modes used prior to the opening of the new facility, but the route used will be diverted to make use of the new facility instead of a similar facility that is now being used. In some cases, a modest portion of the freight using the facility will be diverted from another mode; and in some relatively unusual cases (such as a new waterway or a new rail line through an area without rail service) modal diversion will be the most significant source of freight using the facility. Also, a small amount of freight using the new facility may represent new freight movements stimulated by the establishment of the facility. The third section of this chapter discusses these sources of demand for a new facility in some detail, and the fourth section presents four procedures for estimating this demand.

The fifth section of this chapter provides a brief discussion of the analysis of alternative futures (discussed in more detail in Section 2.5.); and the chapter concludes with a case study describing the analysis of the demand for a new freight airport in North Carolina. Additional information on data sources, cost estimation, and mode diversion is contained in Appendices C, F, G and H.

■ 3.1 The Potential Freight Market

For most new facilities, most use would be drawn from a reasonably identifiable set of existing facilities with which the new facility would compete. In the case of a new road, the competing facilities consist of existing roads to which the new road would provide a reasonable alternate. These alternates may be relatively nearby (e.g., alternates to a new route through a metropolitan area generally consist of the existing routes traversing the area in the same general direction), or they may be more distant (as in the case of a possible new Interstate-quality highway designed to serve traffic currently using I-40 or I-70).

In the case of a new intermodal facility, the competing facilities consist of most or all of the facilities that have hinterlands that overlap the natural hinterland of the new facility. In the case of some types of facility (e.g., container ports), the hinterlands can be quite extensive, and the set of competing facilities might be relatively dispersed geographically.

The first step in estimating usage of a new facility is identifying those competing facilities from which most of the facility's traffic is expected to be drawn and identifying the types of traffic of interest (e.g., selected commodity groups, containerized or bulk traffic, etc.). For each of the competing facilities, data on the current volume of these types of traffic should be obtained. Published sources of such data were discussed in Section 2.1 and in Appendix C.

In performing this first step, consideration must be given as to how broadly to define the sets of competing facilities and types of traffic of interest. An overly broad definition will result in increasing the amount of data required and, more importantly, increasing the amount of subsequent analysis required to determine the portion of total identified traffic that likely would be diverted. In general, omitting facilities and types of traffic that are only expected to be minor contributors to total traffic using the new facility is analytically desirable, though one should recognize that a slight downward bias in estimated diversion would result.

■ 3.2 Forecasting Changes in the Market

The second step in estimating usage of a new facility consists of estimating expected changes in the volume of traffic identified in Step 1 that are likely to occur over the forecast period. These forecasts are obtained using the procedures discussed in Sections 2.3-2.5.

■ 3.3 Sources of Demand for a New Facility

Usage of a new transportation facility may come from several sources:

1. Diversion of traffic from a competing facility without any change in modes used;

2. Diversion of traffic from another mode;

3. Increased production by existing shippers in the area served by the facility; and

4. Establishment of new shippers in the area.

Of these four sources, the first, *route diversion,* normally will be the principal source of demand for the new facility. The second source, *modal diversion,* can be a significant source of demand for a facility that introduces a new mode to an area not currently served by that mode. However, most new facilities will result in very little true modal diversion (though there may be some reduction in access hauls to intermodal terminals).

The last two sources, representing *induced demand,* also are likely to be quite minor sources of demand for a new transportation facility. However, they are sources of particular importance to the area's economy and so they frequently may be viewed as an important reason for building the facility.

The first subsection below contains an extended discussion of route diversion, and the second contains briefer discussions of the two forms of induced demand. Procedures for estimating all four sources of demand for a new facility follow in Section 3.4.

Route Diversion

An individual freight movement is packaged and loaded on transportation equipment at the point of origin and discharged at the final destination, often with one or more intermediate transfers between modes, equipment types or carriers. Routing can be narrowly defined as an itinerary made up of modal linkages (highways, rail lines, ocean and air routes) and origin, destination and intermediate transshipment points (ports, airports, truck terminals, rail yards, intermodal hubs). A more general definition could incorporate the type of carrier, equipment and level of service (e.g., overnight large package routing via an integrated air carrier).

The factors which determine cargo routing patterns include:

- transportation infrastructure;
- cost and quality of service;
- specialized facility and service requirements;
- decision-making process and control; and
- competitive environment.

The routing of a freight shipment between points A and B will primarily be determined by the available modal linkages, with the range of options varying with type of shipment and number of compatible modes. A truck shipper may be able to choose among many different carriers and highway routings between two points, while a rail shipper may be captive to a single line with track to its facility. Similarly, an air-cargo shipper may be restricted to certain international airports due to limited air services to particular markets. Route diversion analysis requires the identification of competing routings for various markets and submarkets.

The capacity and quality of transportation infrastructure are major factors driving the cost and service characteristics of competing routes. For similar service options, transit time and transport cost frequently are the determining factors in routing decisions, with transit time affecting both the quality of service and operating costs for the carrier. The trade-off between cost and service often is differentiated in the routing options, such as the choice between a local terminal with limited services versus a regional hub with comprehensive but congested services. Again, the analysis of route diversion must, in most cases, consider the relative cost and time factors for the entire routing, not just a comparison with another similar facility.

Routing decisions may be restricted by special requirements for handling, storage or processing. For example, certain agricultural imports must be quarantined at U.S. government authorized facilities which are only available at certain ports and airports. Similarly, an overweight intermodal container may be restricted to routings that avoid roads on which overweight truck operation is not permitted. Market projections for new facilities should only include commodities and markets which are compatible with available facilities and services.

Within the context of the underlying economics and technical feasibility, the process for routing decisions ultimately determines the potential for route diversion. The routing of an individual shipment can be determined by the shipper, the consignee, the carriers involved, or third-party operators (e.g., freight forwarders) with multiple decision-makers often involved. A small package shipper may tender freight to an integrated carrier and neither know nor care about the true routing. On the other hand, a large barge shipper may operate private truck and barge fleets and have full control of door-to-door routing, including the ability to build new facilities. In estimating route diversion, it is critical to understand by who and how decisions are made.

Route-choice criteria can vary by shipment or type of shipment. Factors influencing route choice may include cost, transit time, service frequency, reliability, cargo security, and cargo-tracking capabilities. The selection of a particular facility may be direct or indirect. For example, an air exporter might choose an international carrier based on its authorized gateway airports, or might instruct its forwarder to use a particular airport based on cargo security. On the other hand, the shipper may select a "generic" service without regard to a particular routing. The rise of mini-bridge container routings in the ocean liner industry (e.g., Japan to U.S. East Coast via transcontinental rail service) was partially the result of shippers' general indifference to port selection for intermodal routings.

Routing patterns may also depend on whether the shipper or the consignee controls the transportation, an issue which typically is based on the terms of the sales. In international transactions, routing patterns can often be dictated by relationships between shippers and consignees with national transportation companies. For example, Japanese importers and exporters have traditionally controlled the U.S. inland transportation in both directions, resulting in a market advantage to affiliated Japanese ocean carriers.

Shippers often leave routing decisions to carriers, or to forwarders, brokers or other third-parties which select the carrier or carriers. Transportation providers will seek to optimize their own internal systems rather than individual movements, typically leading to patterns different from those based on individual shippers' decisions. In particular, carriers may have large fixed investments in certain routings which restrict the ability to shift service patterns. A new facility seeking to attract traffic can either entice a carrier to serve the facility or encourage shippers either to select a carrier using the facility or to direct their carrier to serve the facility.

A multi-modal example can be used to illustrate route diversion to new facilities. An electronics manufacturer is currently exporting containerized products to a buyer in central England using the following routing:

- truck from factory to rail yard in Chicago;
- rail to East Coast port;
- loaded on outbound container vessel in North Atlantic port rotation;
- discharged at U.K. container port; and
- truck to final destination.

The routes involved in this shipment include:

- roads between origin and rail yard;
- rail line to East Coast port for selected railroad;
- load and discharge port plus intermediate calls for liner service; and
- roads and highways between U.K. port and final destination.

The potential "diversions" for this shipment include:

- alternative truck route to rail yard;
- alternative rail routing to same U.S. port;
- alternative rail routing to different U.S. port;
- alternative ocean routing to same U.K. port;
- alternative ocean routing between different U.K. port; and
- alternative truck route to final destination.

The "new facility" options include:

- *New highway to rail yard (in U.S. or in U.K.)* – Route diversion would depend mostly on the comparative cost and time factors relative to existing routings. Unless the new highway directly parallels the existing route, the analysis would require comparing total costs and time including access from origins and destinations.

- *New rail facility for current railroad* – Route diversion would be determined mostly by the railroad which could dictate the use of a new facility assuming no difference in cost or service to the shipper or to other transportation providers with decision-making power.

- *New rail facility for competing railroad* – Route diversion would be based on improved costs or services over the existing facility. If the new railroad serves a competing U.S. port, the improved service might also shift port traffic.

- *New U.S. or foreign port terminal* – A new port terminal can divert traffic from existing terminals in the same port or from competing ports. As observed previously, the new facility could entice a carrier to serve both facilities or to replace the existing call by a call at the new facility. A new carrier could also initiate competing services. New traffic would include: (1) traffic for a new carrier serving the facility captured from existing ports and carriers; and (2) traffic from an existing carrier split or entirely diverted from the existing port.

The techniques required to estimate route diversion to new facilities include:

- a detailed estimate of carriers' or shippers' flows;

- comparative analysis of cost and service for routings with the new facility compared to current routings; and

- projection of the sensitivity of current flows to diversion using cost elasticities if available or, more likely, using comparable market situations.

Detailed cargo-flow data generally is not available and flow projections must be based on single-point traffic statistics (e.g., port and airport statistics) which can then be associated with specific commodity, service or carrier markets. "Shippers" must often be defined in general geographical and commodity categories for which routing distributions are developed (e.g., xx% of Midwest corn exporters ship via Port A). As noted previously, the required scope for the market definitions will depend on whether it is a localized or generalized competitive environment. The market for the fifth container terminal in a large ocean port may be based on projected patterns through that port alone, while a new type of facility might require a national analysis.

Having specified the baseline routing conditions, a comparison of relative costs and services can be used to "calibrate" the existing traffic patterns. Non-economic factors should also be considered. Unless the market is dominated by a few commodities or shipment types, this often requires developing prototype movements which are used to represent the spectrum of flows. A useful simplifying assumption is to incorporate all service and time differences into a total cost which can be used to compare routings. For example, an estimated inventory cost is often used as a measure of the service benefits from improved transit times or as a measure of the cost penalty for congestion delay.

Induced Demand

As observed previously, induced demand may result from increased production by existing shippers in the area and/or establishment of new shippers in the area. These two sources of induced demand are discussed briefly below.

Existing Shippers

In concept, any reduction in transport costs reduces the costs of existing firms in the area and increases their ability to compete with firms from other areas. In practice, except for producers of low-value commodities (e.g., grain), the transport-cost savings obtained by any single shipper as a result of a new facility is likely to represent a small fraction of one percent of the delivered price of the shipper's product. The effect on total production, and so on use of the new facility, is likely to be small and may not be worth estimating separately.

If analytic estimates of this effect are desired, they can be developed for each product of interest by estimating the annual volume of inbound and outbound movements associated with the product and estimating the transport-cost savings expected for these movements (using procedures presented in Appendix F). Expressing these savings as a percentage of the value of the product delivered annually and ignoring any economies of scale[1] produces an estimate of the maximum percentage reduction in the product price that can result from the reduction in transport costs. For manufactured products, in the absence of specific information on the price-elasticity of demand, unit elasticity can be assumed; i.e., a one percent reduction in price can be assumed to produce a one percent increase in shipments.

Demand for agricultural and mining products may be much more elastic. However, the supply of these commodities usually is quite inelastic. Accordingly, a reduction in transport costs is unlikely to have any significant effect on their shipment volume (though such a reduction may have a substantial positive effect on the profitability of local producers of these commodities).

New Shippers

A major reason for considering the development of a new transportation facility may be the hope that the facility would result in new shippers

[1] If economies of scale exist, an increase in production may result in some further reduction in costs. However, for manufactured goods, the small increases in production that are probable are unlikely to produce any significant economies of scale.

moving into the area. While such a new transportation facility may increase the attractiveness of the area to potential new shippers, actual decisions to locate in the area will depend both on the resulting transport costs and quality of service and on a variety of other locational factors.

A new road or intermodal facility may increase the attractiveness of the area served to new firms by improving accessibility to markets and decreasing transport costs. In concept, this effect could be greatest when the new facility makes practical a form of transport that was not previously available. For example, a new airport in an area that has no airports could enable a firm that requires air service to consider locating in the area. On the other hand, if service at the airport is relatively limited (as is likely in the case of a new airport), such a firm might not find the air service adequate for its needs.

If information is available on the expected inbound and outbound transportation requirements of a particular firm that is considering moving into the area, the procedures of Appendix F could be used to estimate the value to that firm of a prospective new transportation facility. However, whether or not this facility would actually cause the firm to locate in the area would depend on a variety of other factors, including overall accessibility to suppliers and markets, available industrial sites, labor costs, taxes, and, perhaps, financial inducements. The complexity of industrial-location decisions makes it difficult for outside observers to produce reliable judgments as to whether or not a firm will actually locate in a particular area; and the relatively small impact of new transportation facilities on total costs limits the likely effect of such new facilities on these decisions. Accordingly, in the absence of solid commitments by new firms to locate in the area, transportation planners probably should assume that such firms are unlikely to generate significant use of a new transportation facility.

■ 3.4 Estimating Demand

Potential procedures for estimating demand for a new transportation facility are:

1. Survey shippers and carriers to determine their likely use of the new facility;

2. Develop estimates from forecasts of the overall market (discussed in Sections 3.1 and 3.2) and information about the degree of market penetration by similar facilities that have been developed in the past;

3. Allocate the overall market among competing facilities on the basis of proximity and expected level of service; and

4. Perform a detailed analysis and comparison of total logistics costs (TLC) for shipments when transported via their current routings and when transported via the new facility.

Each of these procedures is discussed below.

Survey Shippers and Carriers

A survey is likely to be attractive to many planning agencies since a survey is capable of developing estimates of demand that are based primarily on the statements (and, perhaps, analyses) of the parties whose decisions will actually determine the extent to which a new facility actually will be used. However, the survey approach may be somewhat more complex than it appears, and use of this approach to obtain reasonable estimates of actual demand requires a good deal of care.

The steps required in performing a survey are:

1. Determine the universe of potential users of the new facility;

2. Select sample of firms to survey;

3. Prepare the survey questions;

4. Conduct the survey; and

5. Expand the survey results to produce an estimate of total usage of the new facility.

The first step in conducting a survey involves determining the universe of firms whose decisions will actually determine usage of the new facility. In the case of a new intermodal facility, it includes any air, water, or rail carriers that may decide to serve the facility. For a new road, the universe should include both private and for-hire truck operators that may use the road; however, for an intermodal facility, trucking companies should be excluded from the universe, since their usage of the facility will be determined entirely by the decisions of others.

In addition, the universe of relevant firms includes all firms that ship into or out of the area served (or, more properly, the subset of these firms that actually control the routing decisions of these shipments). In order to control the size of this portion of the universe, it probably is desirable to include only firms actually located in the area and to structure the questions they are asked so as to learn about both their shipments and their receipts.

The second step consists of determining which firms in the universe to survey. If the universe is small (relative to study resources), it may be practical to survey all firms in the universe. More likely, it will be necessary to survey only a sample of shippers and receivers (though it usually will be desirable to survey all carriers).

If a sample is to be selected, it frequently will be desirable to stratify the universe of shippers and receivers on the basis of industry, firm size, and/or location and to vary the sampling rates by stratum. For a new airport, high sampling rates may be desirable for shippers that are large, located relatively close to the airport, or ship and receive high-value goods that are relatively likely to go by air, with lower sampling rates used for other strata. Strata consisting solely of firms that are likely to make little or no use of the facility may be deleted from the survey with usage by firms in these strata treated as being negligible.

For each stratum, a reasonably unbiased sample of firms should be selected; e.g., by enumerating all firms and selecting every *n*th firm. If the universe is large, it may not be practical to identify all small firms individually. However, some care should be taken to make sure that, for any individual stratum, the percentage of firms sampled does not drop off as firm size (or shipment volume) declines or distance from the facility increases.

The third step is to prepare the survey questions. These should include questions relating to total volume of shipments originating and/or terminating in the area, the percentage likely to be shipped via the new facility, any effect the new facility is likely to have on shipment volume (induced demand), and identification of the decisionmaker (shipper, receiver or carrier) that would actually determine whether the facility is used. Responses from nondecisionmakers generally should be excluded from the analysis, except that responses from shippers and receivers that are not decisionmakers should be used as proxies when the actual decisionmaker is an out-of-area receiver or shipper.

The survey material should include appropriate information about the new facility and shippers should be provided with a description of the level of carrier services expected at the facility. The survey should be designed for clarity and to minimize the time and effort required by the respondents. Any major survey should be pretested on a small sample of respondents in order to identify wording that can be improved and areas where respondent burden can be reduced. Exhibit 3.1 contains a copy of an interview-survey form used by Leeper, Cambridge and Campbell in a study of demand for a possible rail/truck intermodal facility in Shelby, Montana.[2]

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[2]The Northern Express Transportation Authority – Port of Shelby, Leeper, Cambridge and Campbell, Inc., and Thomas, Dean and Hoskins, Inc., *Shelby Intermodal Exchange Facility – A Feasibility Study*, Shelby, Montana, July 1991.

Exhibit 3.1 Survey Form for Evaluating Demand for a Rail/Truck Intermodal Facility

NORTHERN EXPRESS TRANSPORTATION AUTHORITY (NETA)
Shelby Intermodal Exchange Feasibility Study
Market Survey Form - Shipper/Consignees

1. Interviewer ____________ Interview Date ____________
2. Interviewee ____________ Title ____________
3. Company Name ____________
4. Address (Street) ____________
   City/State/Province ____________
   Phone: ____________
5. Products: ____________, ____________, ____________
6. Use or interest in Toole County:
   a. ______ TOFC/COFC transfer
   b. ______ Container stuffing/unstuffing (CTS)
   c. ______ Container bulk loading/unloading
   d. ______ Warehouse storage ____ regular ____ refrig.
   e. ______ Warehouse distribution ____ regular ____ refrig.
   f. ______ Bulk storage and distribution ____________ (specify)
   g. ______ Forest products storage & distribution ____________ (specify)
   h. ______ Other storage, distribution ____________ (specify)
   i. ______ Manufacturing ____________ (specify)
   j. ______ Other office activity ____________ (specify)
7. Explain potential use: ____________

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Exhibit 3.1 Survey Form for Evaluating Demand for a Rail/Truck Intermodal Facility (continued)

8. What products and routings might benefit from transshipment in the Toole County?

Product	Tons	To	From	Conveyance	Point-to-Point Cost
					$
					$
					$
					$
					$
					$

9. Specifically what facilities, costs, conditions, incentives, etc. would cause you to transship through Toole County?

____

____

10. What products, processes or services might benefit from manufacturing, manipulating, administering distributing or marketing in Toole County.

Product	Storage Cost Per Sq. Ft.	Principal Market	Labor Cost Per Hour	Energy Cost
	$		$	$
	$		$	$
	$		$	$
	$		$	$

11. Specifically what facilities, costs, conditions, incentives would cause you to locate a facility in Toole County.

____

____

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Exhibit 3.1 Survey Form for Evaluating Demand for a Rail/Truck Intermodal Facility (continued)

12. Has your organization ever used or considered using a foreign trade zone in the U.S.? ______ Yes ______ No

    Explain: ____

    ____

    ____

13. Are any of the raw materials, subassemblies or finished products associated with your operation subject to any of the following in either the U.S. or Canada.

	U.S.		Canada	
Import Quotas	Yes ____	No ____	Yes ____	No ____
Customs duties	Yes ____	No ____	Yes ____	No ____
Assembly with U.S. Components	Yes ____	No ____	Yes ____	No ____
Assembly with Canada components	Yes ____	No ____	Yes ____	No ____
Assembly with components other than from U.S./Canada	Yes ____	No ____	Yes ____	No ____
Display, re-label, re-package or destroy	Yes ____	No ____	Yes ____	No ____

14. Which of your products are subject to highest Customs duties (regardless of the origin)

Product	Annual Tonnage	Custom Duty	Origin	Ultimate Destination
______	______	$ per	______	______
______	______	$ per	______	______
______	______	$ per	______	______
______	______	$ per	______	______

15. If a foreign trade zone were to be proposed for Toole County, would you provide a non-binding letter of intent to use for the application process? ______ Yes ______ No

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Exhibit 3.1 Survey Form for Evaluating Demand for a Rail/Truck Intermodal Facility (continued)

16. If you were to establish an office or operation in Toole County for ____________________, what types of positions or jobs would be established?

	Full Time	Part Time	Contract Full-Time	Contract Part-Time
Officers/Executives	______	______	______	______
Supervisors	______	______	______	______
Skilled	______	______	______	______
Semi-Skilled	______	______	______	______
Clerical	______	______	______	______
Labor	______	______	______	______

17. In general, how would you improve facilities and stimulate shipper services in Toole County?

____

____

18. Action items for NETA:

____

____

____

____

Return this questionnaire to:

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The fourth step consists of the actual conduct of the survey. Although several options exist, a telephone/mail/telephone follow-up procedure usually is capable of producing a high response rate with a relatively moderate expenditure of resources. This procedure starts with an initial set of telephone calls to determine that each firm actually is a potential user of the new facility, to identify the most appropriate respondent within the firm, and to enlist that person's cooperation in responding to the survey. In the case of large firms, routing decisions may be handled at a headquarters office rather than at individual facilities in the study area. If a firm is not a potential user of the facility, no further questions need be asked, but the firm should be retained in the survey sample as representative of a number of firms in the same stratum that are not expected to use the facility.

The survey forms are then mailed to the participating firms and the firms are given two or three weeks to respond by mail. Additional telephone calls are then made to each firm that does not initially respond in order to encourage a response and possibly to obtain a response verbally. The appropriateness of telephone responses will depend upon the specific questions asked and whether or not respondents are expected to review their records or perform any analysis before responding.

If telephone responses are allowed, firms that do not respond can be presumed to be uninterested in the new facility and so can be presumed to make little or no use of it. Even if written responses are required, non-respondents should be presumed to expect to make less use of the new facility than respondents.

The final step in the process is expanding the survey results to produce an estimate of total usage of the new facility by all potential users. A substantial amount of care is required in this step to avoid double-counting of responses.

For each stratum, total estimated usage by surveyed firms can be divided by the number of firms sampled (including non-respondents and firms that indicated that they would not use the facility) to obtain an estimate of usage per firm. If only written responses are used, some upward adjustment of this ratio is appropriate to allow for usage by non-respondents. The result is multiplied by the number of firms in the stratum to produce an estimate of total usage in the stratum. The use of this estimate presumes that the total number of firms in the stratum is known or has been reliably estimated and that the sample selected for the stratum was not biased toward higher-volume shippers (e.g., by picking the most visible members of the stratum.)

Finally, the estimates of total usage by stratum are added across strata to produce an overall estimate of usage of the new facility.

In performing the above step, some care will be required to determine that the shipper survey and carrier survey produce complementary estimates of facility usage; i.e., that the former survey provides an estimate of usage for shipments whose routings are determined by the shipper while the latter survey provides a corresponding estimate for shipments routed by the carrier. A careful review of survey responses will be necessary to avoid such double-counting.

Another, but usually less important, source of potential double-counting occurs in the case of shipments that both originate and terminate in the study area. If both shippers and receivers of such shipments claim responsibility for routing decisions, double-counting will result.

The resulting estimate of usage of the new facility will represent usage due to route diversion, mode diversion, and increased shipments to or from firms currently in the area. Shipments to or from firms that may be induced to move into the area by the new facility will not be explicitly represented in this estimate. However, the effect of excluding this source of usage is likely to be small.

A more significant issue is the extent to which usage is overestimated as a result of exaggerated forecasts of usage by respondents that expect to benefit from the new facility. Such exaggeration may take the form of carriers stating an unwarranted expectation of moving operations to the new facility and shippers overestimating expected increases in traffic volume (a natural occurrence even when there is no incentive to exaggerate). Satisfactory procedures do not exist for identifying such exaggeration and minimizing its effects on estimated usage of the new facility. The lack of such procedures limits the reliability of estimates produced by the survey approach.

Comparisons with Previous New Facilities

The comparison approach is a relatively attractive option, particularly in the early stages of the planning process. This procedure consists of:

1. Identifying similar facilities that have been developed recently;

2. Obtaining market-share data for these facilities;

3. Adjusting these market shares so that they are applicable to the proposed new facility; and

4. Applying the adjusted market shares to forecast demand in the study area to produce a range of estimates of forecast usage of the new facility.

The first step in the comparison process involves identifying other new transportation facilities of the types being considered that have been developed in the recent past (probably in the past 10 to 20 years), and selecting those facilities that are most similar to the facility being considered. The comparison approach presumes that at least some new transportation facilities of the type under consideration have been developed in the recent past. If not, this approach cannot be used and, perhaps more importantly, careful consideration should be given to identifying and understanding the reasons why no such facilities have been developed.

Factors to be considered in evaluating the similarity of facilities include facility capacity, geographic size of the relevant market area, geographic density of freight generated in the area (measured in weight or volume units per square mile), types of freight originating and terminating in the area, and characteristics of the existing facilities with which the new facilities must compete. Since good matches in all these factors usually will not exist, a fairly generous standard of "similarity" should be used and, if possible, several similar "comparison" facilities should be identified.

The second step in this process involves obtaining information about the shares of the relevant markets captured by the comparison facilities and the number of years required to attain that market share. This step entails the collection and interpretation of data and information from the operators of the comparison facilities. A useful adjunct to this activity would be the conduct of more extensive discussions with the facility operators in order to gain additional insight into facility planning and development processes.

At the conclusion of the second step, a very preliminary range of estimates of demand for the new facility should be developed by applying the market shares captured by each of the comparison facilities to the projected overall market in the area served by the new facility (see Section 3.2).

The third step involves a careful review of the differences between the market shares obtained by each of the comparison facilities and the market share likely to be obtained by the new facility. For each comparison facility, differences to be considered in this step include those in:

- *The market areas served by the two facilities.* Do both market areas extend into the natural hinterlands of competing facilities to an equal extent; or has one market area been defined relatively narrowly to areas close to the new facility or to the comparison facility, while the other has been defined to include a substantial amount of area in which shipments generated are relatively unlikely to use the new facility or the comparison facility?

- *Service by scheduled carriers.* Is there strong reason to believe that the new facility will receive the same level of (quality and frequency) of service by scheduled air, water, or rail carriers as the comparison facility?

- *Competition from existing facilities.* Are both the new facility and the comparison facility subject to the same degree of competition from other facilities in terms of proximity, facility capabilities and constraints (storage capacity, channel depth, runway lengths, etc.), level of service of scheduled carriers, etc.?

For each comparison facility, each of the differences relative to the proposed new facility should be analyzed and used as the basis for adjusting the comparison facility's market share to produce a market share that better represents the likely market share of the proposed new facility.

The result of this third step is a set of adjusted market shares, with one value derived from the original market share of each of the comparison facilities. The relative reliability of each of the adjusted market shares should be evaluated on the basis of the extensiveness of the Step 3 adjustments that were made and the degree of judgment required for these adjustments. Any outliers that are considered to be relatively unreliable should be dropped, and the remaining values should be used to define a range of likely market shares for the proposed new facility. Applying this range of market shares to the projected overall market produces a revised range of estimates of demand for the new facility.

As described above, the analysis explicitly reflects the effects of route diversion and any mode diversion. It does not produce separate estimates of induced demand nor is the projected overall market adjusted for any increase resulting from induced demand. However, since induced demand *is* included in data on usage of the comparison facilities, it is implicitly included in the market shares developed in Steps 2 and 3. Since induced demand is likely to be quite small in comparison to the overall market (which includes freight that continues to be shipped via competing facilities), exclusion of induced demand from the projected overall market is unlikely to have more than a small effect on the resulting estimates of demand for the new facility, and a correction for this omission probably is not warranted

Some operators of comparison facilities may have data that purports to represent the extent of induced demand attributable to the development of their facilities (and so, which presumably could be used to infer induced demand at a similar new facility). However, substantial care should be exercised in accepting such data at face value – such data frequently attribute all traffic growth to the advent of the facility in question without attempting to exclude the effects of normal growth in the area's economy that would have occurred even if the facility were not developed.

Evaluating Proximity and Level of Service

Another relatively attractive option for estimating demand for a new intermodal facility is to allocate the market between the new facility and competing facilities in the area on the basis of relative proximity and the relative levels of service expected to be provided at the various facilities. A variant of this approach is used in the Chapter 3 Case Study (presented in Section 3.6). This procedure consists of:

1. Developing a set of level-of-service (LOS) scores for the new facility and for all competing facilities that serve the study area;

2. Dividing the study area into subareas and, for each subarea, assigning a proximity score for each of the facilities;

3. Forecasting the annual freight volume of interest originating or terminating in each subarea;

4. Combining the LOS and proximity scores;

5. For each subarea, allocating the Step 3 freight volumes across facilities; and

6. Adding the estimates of freight volume allocated to the new facility across all subareas to produce an overall estimate of usage.

The first step in this procedure is to develop forecasts of the relative levels of service expected at the new facility and at each of the existing facilities servicing the study area. A level of service (LOS) score of 10.0 should be assigned to the facility with the highest level of service. Each of the other facilities should then be compared to this facility in terms of:

- Number of destinations or markets accessible via scheduled air, water or rail service from the facility (preferably weighted by the size of the destination market);

- Frequency of service to markets accessible via both facilities; and

- Any differences in carrier costs per unit of cargo for serving the two facilities (e.g., due to the higher cost per unit of cargo for using smaller vessels to serve low-volume markets and/or to access ports with limited channel depth).

These comparisons should then be used to assign LOS scores to each of the other facilities, with a LOS of 5.0 being assigned to a facility whose LOS, based on the above criteria, is half as good as that of the facility with the highest LOS.

For the existing facilities, the LOS scores should be derived using information about current service available at the facility and any expected changes during the forecast period. For the new facility, it will be necessary to develop reasonable forecasts of the level of service that would be provided. It is important that these forecasts be reasonable, since overestimating the level of service to be provided by the carriers will result in overestimating freight demand.

The second step in this LOS/proximity procedure involves dividing the study area into subareas (e.g., counties or county aggregates) and, for each of these subareas, assigning a proximity score to each of the facilities under consideration. Each score should be based on the road distance from the facility to the approximate centroid of economic activity in the subarea (e.g., from highway mileage tables for household goods carriers). A score of 10.0 should be assigned whenever this distance is less than 50 miles. Longer distances should produce lower scores, perhaps by dividing 50 by the distance and multiplying the result by ten.

The third step involves forecasting the annual volume of the freight of interest originating or terminating in each of the subareas identified in Step 2. Potential sources of base-year estimates are data from the Colography Group or Reebie Associates (see Appendix C). (The Chapter 3 Case Study describes the use of Colography Group data for analyzing demand for a new airport.) The base-year volume estimates may be used to distribute forecasts of the total volume of freight of interest across subreas; or, alternatively, forecasts of freight by subarea may be developed directly from the base-year estimates.

The fourth step involves computing an overall score for each of the facilities being considered. One option is to obtain this score as the product of the LOS and facility scores.

The fifth step involves allocating freight originating or terminating in each subarea among the competing facilities. For each subarea, this allocation should be proportional to the Step 4 scores (perhaps after eliminating terminals with very low scores).

The results of the fifth step can then be aggregated across all subareas of the study area to produce forecasts of the share of freight originating or terminating in the study area that would use each of the facilities serving this area. The resulting forecast of usage of the new facility represents usage due to route diversion, the primary source of usage. In some cases, a modest upward adjustment to this forecast may be made, on the basis of factors discussed previously, to reflect additional usage resulting from modal diversion and induced demand.

As described above, the study area will be a reasonable approximation to the entire area served by the new facility. However, it may exclude significant portions of the areas served by the competing facilities.

Accordingly, the usage forecasts produced for those facilities will represent only a portion of their actual usage.

The procedure can readily be modified to consider a more extended study area that includes most or all of the area served by all the airports under consideration. If this is done, then, with one additional step, usage forecasts can be produced for all the facilities studied. The extra step involves adjustments for a small amount of freight "leaking" into or out of the study area; i.e., out-of-area freight that is shipped via one of the facilities studied, and study area freight shipped via a competing facility that is not studied. In the Case Study, this modified procedure was used – the study area was taken to be the entire state of North Carolina plus selected counties in adjoining states, and freight forecasts were developed for each of the state's three major airports both with and without the addition of a proposed new all-cargo airport.

Another advantage of an extended study area, as suggested in the preceding paragraph, is that it permits the allocation system to be calibrated using data from a recent historic year. The calibration process involves performing Steps 1-5 using data for the base year and comparing the resulting allocation of freight among the existing facilities to the known freight volumes in that year. The judgmentally derived scoring system used in Steps 1, 2, and 4 is then reviewed and modified to improve the match between the allocations produced by the procedure and actual freight volumes. This optional calibration step (used in the Case Study) reduces the role of judgment and should improve the quality of the forecasts produced. However, judgment will still play a critical role in forecasting the level of service to be provided at the new facility.

Once the analysis has been completed, a review should be conducted to determine whether the Step 5 forecast usage of the new facility justifies the level of service assumed in Step 1. This review may make use of information about service provided at existing facilities with similar levels of usage. If the assumed level of service is higher than justified, it is unlikely to materialize; and, accordingly, actual usage would be lower than the forecast indicates. In this situation, two analytic alternatives exist.

The first alternative involves repeating Steps 1, 4, and 5 using a lower LOS for the new facility. Since a lower LOS will produce a lower forecast of usage, some experimentation may be necessary to determine the extent to which LOS must be reduced before the assumed LOS is justified by the forecast usage of the facility.

The second alternative is simply to accept, without further experimentation, the provisional conclusion that demand for the new facility is likely to be insufficient to attract the kind of service that will be necessary to make the facility viable.

Analyze Total Logistics Costs of Individual Shipments

The fourth procedure is the most disaggregate and the most difficult to implement. This procedure consists of:

1. Selecting a representative sample of shipments originating or terminating in the study area;

2. Estimating the total logistics costs for each of these shipments if shipped via its current route and if shipped via the new facility;

3. Determining the likelihood that the shipment would be diverted to go via the new facility; and

4. Expanding the Step 3 results obtained for the sample of shipments to represent the universe of shipments originating or terminating in the study area.

The first step consists of selecting a sample of shipments originating or terminating in the study area. This sample is usually stratified by commodity, and it may be stratified by other variables as well (e.g., by current modes used, by whether the shipment originates or terminates in the area, by subarea of origin or destination, etc.). An important consideration in constructing the sample is that it include a reasonable number of shipments representing each of the strata that are likely to contribute any significant amount of usage of the new facility.

The second, and most difficult, step involves estimating total logistics costs (TLC) for each shipment if transported via the new facility and if transported via its current route. A slightly simpler alternative is just to focus on estimating the differences between these two values of TLC. When only route diversion is involved, the principal potential contributors to this difference are:

a) Transport cost differences resulting from differences in the length of haul required by any one mode;

b) Transport cost differences resulting from differences in the efficiency with which the two facilities can be served (e.g., as a result of differences in vessel sizes); and

c) Differences in transit times and transit-time reliability resulting from differences in scheduled service at the two facilities.

Estimates of (a) and (b) can be developed using estimates of length of haul along with transport-cost information presented and referenced in Appendix F. Estimates of (c) require forecasts of differences in the level of service offered by carriers serving the two facilities as well as commodity-specific information about inventory costs and stock-out costs. For many shipments, the relative values of the two estimates of TLC will be significantly affected by the quality of service forecast for the new facility. The difficulty of developing a reliable forecast of quality of service, combined with the effort required to perform the rest of the Step 2 analysis, generally makes this procedure less attractive than the others.

The third step consists of estimating the likelihood that the shipment would be diverted to make use of the new facility. The simplest alternative for this step is to assume the decision will be made so as to minimize the analyst's estimate of TLC. A more complex and somewhat more reliable alternative is to use a logit formulation to assign shipment shares to the two alternatives, altering the effects of random errors in the analyst's estimates of TLC and in the shippers' perception of TLC, and altering the effects of random imperfections in carrier pricing.

The final step consists of expanding the estimates of usage of the new facility by shipments in the sample to represent a forecast of total usage of the facility. This step simply entails dividing the results for each stratum by the sampling rate (expressed as a fraction) and adding across all strata. The result represents usage of the facility as a result of route diversion and (if considered in Step 2) modal diversion.

As in the case of the preceding procedure, it is recommended that consideration be given as to whether the Step 4 estimates of facility usage are consistent with the level-of-service assumptions made for the new facility. If estimated facility usage appears to be inadequate to justify the assumed level of service, the analysis should be repeated assuming a lower level of services at the new facility.

■ 3.5 Alternative Futures

As the preceding discussion indicates, the private-sector decisions that determine demand for a transportation facility are more difficult to forecast in the case of new facilities than in the case of existing or replacement facilities. For this reason, a careful evaluation of the effect of alternative futures on the need for and likely success of a facility is even more important in the case of new facilities than in the case of existing facilities.

Procedures for performing such an evaluation have been presented in Section 2.5. These procedures are applicable to the case of a new facility as well as to that of an existing facility. However, in the case of a new facility, there are certain alternatives that should always be given careful attention – the possibility that one or more carriers or other expected major users of the facility will make substantially less use of the facility than anticipated. The circumstances under which such reduced use may occur should be carefully evaluated, and the sponsors of a new facility should determine in advance how they would deal with such a possibility.

If a survey procedure is used, some consideration should be given as to how best to perform the alternative futures analysis. Ideally, this analysis would be incorporated directly into the survey (e.g., by adding questions relating to the effect of alternative levels of service on usage). However, any such additional questions must be handled with care to avoid overburdening respondents and reducing their level of cooperation.

■ 3.6 Case Study: North Carolina Freight Airports

In 1991, the State of North Carolina's Department of Transportation commissioned a study to evaluate short and long term needs for the state's air cargo infrastructure.[3] The study included an inventory of the state's air cargo facilities and intermodal linkages, an analysis of system capacity, and traffic forecasts to 2010 for state airports. The study also evaluated the technical and market feasibility of the Global Air Cargo Industrial Complex (GACIC) concept which is currently being developed as the Global Transpark in Kinston, North Carolina. The GACIC analysis included a projection of new industrial activity attracted to the facility and the development of a forecasting model which allocates future demand among the state's primary cargo airports including various locations for the GACIC. This case study examines the demand forecasting techniques used for both the current airport system and one that included the GACIC.

Problem Definition and Research Objectives

The forecasting elements of this study required long-term forecasts for existing cargo airports in the state with an emphasis on the primary facilities at Charlotte (CLT), Raleigh-Durham (RDU), and Greensboro (GSO). These forecasts were required to determine the adequacy of existing and projected infrastructure. The GACIC portion of the study required the ability to define a new cargo airport with an indefinite location and capacity, also identifying new industrial activity to be attracted to the airport.

Air cargo demand forecasts for airports have traditionally been based on trend analysis, projecting future growth based on national trends and a continuation of historical growth. A primary reason for this strategy has

[3]*North Carolina Air Cargo System Plan and a Global Air Cargo Industrial Complex,* by Transportation Management Group, Inc., Leeper, Cambridge and Campbell, Inc., and COMSIS Corporation, February 1992..

been the limited availability of data beyond airport traffic statistics. This approach treats individual airports as independent of the larger markets in which they actually compete. This study incorporated a more detailed representation of the air cargo market, incorporating regional demand and market share analysis. The reasons for this more detailed analysis included:

- a requirement to forecast flows among multiple airports which share a common hinterland;
- a requirement to test various scenarios for the location and service profile for the GACIC; and
- a requirement to identify specific industries which might be attracted to a GACIC facility.

The following sections discuss the techniques utilized in generating the demand forecasts.

Market Characteristics

The process for forecasting demand in this case included measuring baseline activity and relationships and projecting them into the future under various development scenarios. The North Carolina air cargo market analysis isolated four primary areas of data and activity:

- Market Demand;
- Airport Traffic and Aircraft Activity;
- Cargo Routing Patterns; and
- New Industrial Activity for GACIC.

The characteristics, sources, and techniques used to describe these market elements are discussed in the following sections.

Market Demand

Market demand was defined by the volume, location, and type of air cargo shipments and receipts without regard for airport routing. The characteristics of market demand are shown in Exhibit 3.2.

The geographic market definitions were determined by:

- a requirement to identify sub-state cargo flows;

Exhibit 3.2 Market Demand Characteristics

Data Item	Source	Techniques/Comments
Geographic Regions	Study Team	North Carolina counties (NC), airport-based county groups for parts of surrounding 5-state region ("regional market areas" – RMA), and "All Other U.S."
Airport-Market Distances	Household Goods Carriers' Highway Mileage Tables	Distances based on published highway mileage tables between airports and county/RMA centroids.
Outbound Air Shipments by Industry Group and Origin Market Area	Colography Group	Data source only includes top 70+ industries (at 4-digit SIC level). Expansion to all industries based on Colography-supplied expansion factors modified based on aggregate totals.
Inbound Air Shipments by Industry Group and Destination Market Area	Census Foreign Trade Statistics Study Team	NC traffic estimated from ratio of inbound to outbound for NC airport traffic. RMA traffic estimated as percentage of total non-NC traffic based on outbound distribution. Total US traffic estimated from Census statistics.
Air Shipments by Industry and Market Area (Forecasts to 2010)	BEA Employment Forecasts by Industry and Region Colography Group Boeing World Air Cargo Forecasts	Regional cargo shipment growth based on combination of employment and cargo productivity growth by industry. Employment growth rates derived from BEA projections modified to match geographical and industry grouping. Cargo productivity growth estimated for top industries using trend analysis for Raleigh-Durham and Charlotte market areas (from Colography); growth rates constrained based on national aggregate projections. National totals projected using industry forecasts modified to match time frame.

- the ability of cargo airports to attract traffic from local, regional and national markets with closer origins and destinations more susceptible to capture; and
- the levels of detail available for various data sources.

Since all of the state's airports were included, the "local" market was defined as the entire State of North Carolina at the county level. A primary data source for cargo demand was the Colography Group's estimates of domestic and export air shipments generated by the top 73 manufacturing industries (defined at the four-digit SIC level) by U.S. county.[4] The "regional" market was defined as an aggregation of various "airport market areas" which are county groupings surrounding primary airports as defined by Colography. The "All Other U.S." market was defined as the rest of the national market as measured for all airports.

The primary technique required for the geographical-based data was associating the detailed county-based data with more aggregated data at the state or other levels. For example, the employment forecasts of the Bureau of Economic Analysis (BEA) are only available at the two-digit SIC industry level by state with more aggregate data available for BEA regions (larger county groups associated with major metropolitan regions) which did not match the Colography regions. In most cases, detailed county-based characteristics were assumed to mirror the average of data available for the larger regions.

As market proximity is a key factor in determining air cargo routings, the location of market origins and destinations relative to the study's airports was incorporated as highway distances between the airport and the "centroid" of the local and regional market areas. This geographical structure easily allowed the introduction of "new" airport locations as required in the GACIC analysis.

The total outbound market was estimated from the 73 industry totals using expansion factors provided by Colography as determined from national traffic totals. Inbound traffic was estimated based on flow characteristics for the state's airports and assumptions based on outbound distributions. The "All Other U.S." demand totals were calculated as the residual of national totals minus the regional market estimates.

The forecasting methodology utilized for market demand was designed to reflect the following characteristics of air cargo markets:

- Air cargo traffic represents a segment of larger manufacturing, trade and transportation markets. Market growth will incorporate national,

[4]The Colography Group, *U.S. Air Freight Origin Traffic Statistics*, Marietta, Georgia, annual.

regional and local economic trends. Employment growth trends were used to represent the general growth in regional outbound shipments. BEA employment forecasts for state industry groups and BEA county regions[5] were combined and modified for this purpose.

- The use of air cargo services relative to other modes has increased significantly due to the implementation of advanced distribution systems for both manufacturing and consumer markets (e.g., just-in-time) and the trend toward more globalized markets. The shift of the U.S. industrial base away from traditional heavy industry toward high technology manufacturing and service industries has also resulted in a trend toward more air service use. Historical Colography data for average air cargo production per employee (in pounds) was compared for 1983 and 1990, generating average productivity growth rates used in the forecasts for regional outbound shipments.

- Regional growth for outbound shipments was compared with national growth as projected in the Boeing Company's *World Air Cargo Forecasts*[6] resulting in traffic projections for the "All Other U.S." category.

- Inbound traffic estimates assumed the baseline distribution by market region to national totals based on the Boeing growth trends.

Airport Traffic and Aircraft Activity

The most common form of transportation data involves facility statistics for ports, airports or border points. The major drawback with most facility data is the lack of detail regarding the origin and destination of traffic and through routing information. This study attempted to correlate airport traffic volumes with the underlying demand and supply markets in order to produce more results which represented the underlying market relationships.

Baseline activity for North Carolina airports was derived from published carrier statistics modified and supplemented with information gathered in an interview program with airports, carriers and other air cargo firms. State airport traffic was then compared with national traffic totals (as estimated from the market demand totals). Exhibit 3.3 summarizes the characteristics measured.

Total state traffic combines airport statistics published by the Federal Aviation Administration[7] (for U.S. carriers), the Airport Operators Council

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[5]U.S. Department of Commerce, Bureau of Economic Analysis, *BEA Regional Projections to 2040*, U.S. Government Printing Office, October 1990.

[6]Boeing Commercial Airplane Group, *World Air Cargo Forecast*, Seattle, annual.

[7]Federal Aviation Administration, *Airport Activity Status of Certificated Air Carriers*, annual.

Exhibit 3.3 Airport Traffic Characteristics

Data Item	Source	Techniques/Comments
U.S. Airport Traffic (Baseline)	Colography Group Census Foreign Trade Statistics	Based on total U.S. Demand (see Exhibit 3.2).
State Airport Traffic (Baseline)	FAA Airport Activity Statistics AOCI Worldwide Traffic Report Census Foreign Trade Statistics (for Wilmington, NC, Customs District) Airline/Airport Interviews	International data only available by Customs District (in this case includes all state airports). Total inbound traffic is estimated. Total international outbound traffic includes re-allocation of traffic enplaned on domestic flights at state airports for transshipment at other U.S. international gateways. International inbound traffic assumes same expansion factors as outbound traffic. Domestic inbound traffic is estimated as the residual.
Total NC Airport Traffic (Forecast)	Market Demand Forecasts by Market Region Study Team	Airport projections match market demand forecasts (see Exhibit 3.2) with projected shifts in share (see below).
NC Primary Airports' Traffic (Forecast)	North Carolina Air Cargo Forecasting and Allocation Model	Model allocates total NC airport demand among primary airports based on proximity to regional markets and relative service levels. Model incorporates assumptions about traffic diversion to secondary airports.

International[8] (AOCI), and the U.S. Bureau of Census.[9] Some of the limitations encountered and techniques used include:

- Comprehensive international data was only available in the Census statistics for all airports in the Wilmington, North Carolina, Customs District which fortunately corresponded directly with the state's airports. International estimates for individual airports required a matching of carrier and airport data with the aggregate totals.

- The FAA statistics exclude international carriers and certain all-cargo operators, and only measure enplaned cargo.

- The AOCI statistics incorporate filings by member airports which are not verified. Statistics provided by individual airports were used to verify this source for the study.

- The definition of international cargo used in the market demand forecasts was based on the ultimate origin or destination of the cargo. Airport traffic data may be based on the originating flight (Census data) or type of air bill (FAA). International traffic which included a transshipment at a U.S. airport was estimated and re-allocated.

- Where inbound data was limited, it was assumed that patterns resembled outbound distributions.

Exhibit 3.4 summarizes the estimated baseline traffic.

In addition to traffic patterns, a representation of relative service patterns was required for the forecasting model. Service levels can be measured in terms of total cargo capacity modified to reflect the timing and type of capacity. The study team derived relative service levels for both the domestic and international markets based on the interview process and a comparison of freight-flow patterns with air-service patterns. These service indices were used in the allocation model and modified during the calibration process. Future service levels were projected based on general scenarios related to available capacity and carrier operating patterns.

Airport traffic flows were compared with market demand to establish baseline cargo routing patterns which were then projected and applied to future market demand (see below). Forecasts of traffic for individual primary airports (including the GACIC) utilized a calibrated route allocation model described in the next section. Secondary airport traffic was assumed to maintain the same share of the projected state total throughout the forecast period.

[8]Airport Operators Council International, *Worldwide Airport Traffic Report*, annual.

[9]U.S. Bureau of the Census, *U.S. Exports/Imports of Merchandise*, tape, annual.

Exhibit 3.4 1990 Baseline North Carolina Airport Traffic (tons)

	CLT	GSO	RDU	Subtotal	All Other Airports	Total
Outbound						
Domestic	55,995	10,857	28,818	95,670	2,005	97,675
International	10,121	14,248	6,287	30,656	0	30,656
Total	66,116	25,105	35,104	126,325	2,005	128,330
Inbound						
Domestic	44,887	5,397	31,267	81,551	1,971	83,522
International	14,088	19,833	8,752	42,673	0	42,673
Total	58,975	25,231	40,019	124,225	1,971	126,195
Total						
Domestic	100,882	16,254	60,085	177,221	3,976	181,197
International	24,209	34,081	15,039	73,329	0	73,329
Total	125,091	50,336	75,124	250,551	3,976	254,526
Percent of Total						
Domestic	55.7%	9.0%	33.2%	97.8%	2.2%	100.0%
International	33.0%	46.5%	20.5%	100.0%	0.0%	100.0%
Total	49.1%	19.8%	29.5%	98.4%	1.8%	100.0%
Inbound as a Percent of Outbound	89.2%	100.5%	114.0%	98.3%	98.3%	98.3%

1. International inbound traffic estimated as 139.2% of outbound traffic based on the ration of 1990 Wilmington import weight to reported international waybill exports.

2. Total inbound traffic estimated as percentage of outbound traffic.

Exhibit 3.5 Airport Aircraft Activity Characteristics

Data Item	Source	Techniques/Comments
Primary North Carolina Airports' Aircraft Activity by Type of Carrier and Aircraft	FAA Airport Activity Statistics Airline Interviews	Assume inbound patterns reflect outbound patterns.
Primary North Carolina Airports' Average Load per Flight Operations	FAA Airport Activity Statistics Airline/Airport Interviews Study Team	Cargo flight payloads estimated for nominal aircraft type.
Primary North Carolina Airports' Service Levels	OAG Air Cargo Guide Study Team	Relative service indices estimated for primary airports.

Forecasts of aircraft activity at primary airports were required for the capacity analysis, as well as to size the proposed GACIC facility. Exhibit 3.5 summarizes the characteristics measured. The baseline distribution between passenger and all-cargo flights for each airport was derived from the modified FAA carrier statistics for enplaned cargo. Inbound patterns were assumed to be the same. Average cargo load per flight operation were derived for both types of flights with passenger patterns assumed to remain constant during the forecast period. For all-cargo operations, average payloads were derived for general classes of aircraft type and weighted based on current and projected flight schedules. This structure was used to measure the impact of trends in equipment technology and fleet mix. Exhibit 3.6 shows how aircraft operations were projected.

Cargo Routing Patterns

The interaction between market demand and facility activity can be represented by cargo routing patterns which describe the facility's share of available markets. In this case, baseline cargo routing patterns were calibrated against current market and facility activity, and then projected for forecast years to derive facility traffic forecasts. The two-stage forecasting methodology first assigned total flows to North Carolina airports and then allocated that traffic among the primary cargo airports. Exhibit 3.7 describes the characteristics used to represent cargo flow patterns.

The state's share of available domestic and international cargo markets was derived for each of the market demand areas (North Carolina, regional market areas, and all other U.S.). U.S. Census statistics matching state of export shipments with the airport of exit provided information on the share of state airport traffic which originated in North Carolina. These results were modified to include international shipments loaded on domestic flights for transshipment at another U.S. airport (traffic which is not included in the Census totals).

The State of Export series was also utilized in estimating the share of state airport traffic originating from the regional market areas. BEA data measuring personal income for these regions was used to allocate state totals to the sub-state regions. Domestic market distributions were based on the interview program, as no routing data was available. Inbound traffic distributions were based on the outbound patterns, assuming each market region accounted for comparable shares of traffic in both directions.

The market share forecasts were based on the study team's analysis of historical trends and interviews with industry participants concerning future service development plans. Baseline shares were estimated for 2000 and 2010 and matched to projected demand totals in order to forecast total traffic. Exhibit 3.8 shows the structure used for these forecasts.

Exhibit 3.6 Summary Forecast of Aircraft Operations at the North Carolina Commercial Airports

	Charlotte				Greensboro				Raleigh-Durham			
	1990	1995	2000	2010	1990	1995	2000	2010	1990	1995	2000	2010
Total Cargo Traffic (000 Tons)	125.1	247.9	424.3	1,179.9	50.3	96.9	155.2	431.8	75.1	135.7	228.8	628.7
Cargo Activity – Passenger Operations												
Allocation of Total Traffic	38.5%	38.5%	38.5%	38.5%	8.1%	8.1%	8.1%	8.1%	35.5%	35.5%	35.5%	35.5%
Traffic (000 Tons)	48.2	95.4	163.4	454.3	4.1	7.6	12.6	35.0	26.7	48.2	81.2	222.5
Number of Flight Operations (000)	238.1	282.0	321.0	449.1	238.1	282.0	321.0	449.1	238.1	282.0	321.0	449.1
Average Pounds per Flight Operation	405	677	1,018	2,023	34	56	78	156	224	342	506	991
Equipment Mix – All Cargo Operations												
Percent of Total Operations												
Feeder	16.7%	19.0%	23.8%	14.3%	54.5%	46.2%	43.8%	47.4%	26.7%	26.3%	25.9%	25.9%
Jet – Small	50.0%	28.6%	14.3%	4.8%	36.4%	23.1%	12.5%	5.3%	60.0%	47.4%	33.3%	29.6%
Jet – Medium	33.3%	42.9%	42.9%	42.9%	9.1%	15.4%	31.3%	26.3%	13.3%	26.3%	37.0%	37.0%
Jet – Large	0.0%	9.5%	19.0%	38.1%	0.0%	15.4%	12.5%	21.1%	0.0%	0.0%	3.7%	7.4%
Average Payload (Pounds/Operation)												
Feeder	1,300	1,300	3,250	3,250	1,300	1,300	3,250	3,250	1,300	1,300	3,250	3,250
Jet – Small	24,000	24,00	26,000	26,000	24,000	24,000	26,000	26,000	24,000	24,000	26,000	26,000
Jet – Medium	45,000	45,000	48,750	48,750	45,000	45,000	48,750	48,750	45,000	45,000	48,750	48,750
Jet – Large	76,000	78,000	84,500	84,500	78,000	78,000	84,500	84,500	78,000	78,000	84,500	84,500
Weighted Average – Jet Operations	32,400	41,471	53,422	63,375	28,200	45,429	51,839	60,775	27,818	31,500	40,300	43,225
Weighted Average – All Operations	27,217	33,819	41,476	54,786	13,527	25,062	30,469	33,526	20,747	23,553	30,894	32,861
Cargo Activity – All Cargo Operations												
Allocation of Total Traffic	61.5%	61.5%	61.5%	61.5%	91.9%	91.9%	91.9%	91.9%	64.5%	64.5%	64.5%	64.5%
Traffic (000 Tons)												
Feeder	0.6	1.1	4.9	6.1	2.4	2.1	6.7	18.2	0.8	1.3	4.1	10.4
Jet	76.3	151.3	256.1	719.5	43.8	86.9	136.0	378.6	47.6	86.3	143.5	393.9
	76.9	152.5	260.9	725.6	46.2	89.1	142.6	396.8	48.4	87.5	147.6	404.2
Number of Flight Operations												
Feeder	942	1,717	2,996	3,784	3,728	3,280	4,096	11,213	1,245	1,956	2,493	6,378
Jet	4,711	7,299	9,587	22,706	3,107	3,827	5,266	12,459	3,424	5,477	7,123	18,224
	5,654	9,016	12,583	26,490	6,384	7,107	9,362	23,672	4,670	7,432	9,616	24,602

Exhibit 3.7 Cargo Routing Pattern Characteristics

Data Item	Source	Techniques/Comments
Total NC Airports' Share of Outbound Traffic by Market Origin (Baseline)	Census State of Export and Foreign Trade Statistics BEA, Local Area Personal Income Study Team	Share of export traffic originating in NC estimated using Census patterns for international flight enplanements averaged with study team estimates for other types of traffic. Share of exports from RMAs estimated using five-state Census totals with RMA portion based on county-based manufacturing earnings. Share of domestic outbound traffic based on study team interviews and industry patterns.
Total NC Airports' Share of Inbound Traffic by Market Origin (Baseline)	Study Team	Distributions based on outbound patterns for both domestic and international traffic.
Total NC Airports' Share of Total Traffic by Market Origin (Forecast)	Study Team	Shifts in market shares of regional traffic based on historical trends and assumed service development relative to competing airports.
Primary Airports' Share of State Airport Traffic by Market Origin (Baseline/Forecast)	North Carolina Air Cargo Forecasting and Allocation Model Study Team	Model calibrated to baseline traffic. Forecast market shares based on relative proximity to markets and service levels. Model accommodates "new" airport as represented by service levels and location relative to market areas.

Exhibit 3.8 Air Cargo Matrix Forecast 2010

	North Carolina Airports				Other U.S. Airports				Total U.S. Airports		
Origin/Destination	Inbound	Outbound	Total	% of US	Inbound	Outbound	Total	% of U.S.	Inbound	Outbound	Total
North Carolina	A	B	C		D	E	F		G	H	I
Domestic	616.4	720.9	1,337.3	72.159%	237.8	278.1	516.0	27.841%	854.3	999.0	1,853.3
International	325.4	233.7	559.1	61.283%	205.6	147.7	353.2	38.717%	530.9	381.4	912.3
TOTAL	941.8	954.6	1,896.4	68.572%	443.4	425.8	869.2	31.428%	1,385.2	1,380.4	2,765.6
Domestic % of Total	65.5%	75.5%	70.5%		53.6%	65.3%	59.4%		61.7%	72.4%	67.0%
% of All O/Ds	83.5%	83.8%	83.6%		2.1%	2.1%	2.1%		6.3%	6.5%	6.4%
Regional Market Area											
Domestic	102.5	119.9	222.4	9.627%	1,054.8	1,032.3	2,087.2	90.373%	1,157.3	1,152.2	2,309.5
International	44.6	32.0	76.6	10.601%	331.4	314.8	646.2	89.399%	376.0	346.8	722.8
TOTAL	147.1	151.9	299.0	9.860%	1,386.3	1,347.1	2,733.4	90.140%	1,533.4	1,499.0	3,032.4
Domestic % of Total	69.7%	78.9%	74.4%		76.1%	76.6%	76.4%		75.5%	76.9%	76.2%
% of All O/Ds	13.0%	13.3%	13.2%		6.6%	6.7%	6.7%		7.0%	7.1%	7.0%
All Other U.S.											
Domestic	9.0	10.5	19.5	0.093%	10,539.7	10,491.4	21,031.1	99.907%	10,548.7	10,501.9	21,050.6
International	30.5	21.9	52.4	0.319%	8,508.7	7,854.1	16,362.8	99.681%	8,539.2	7,876.0	16,415.2
TOTAL	39.5	32.4	71.8	0.192%	19,048.4	18,345.5	37,394.0	99.808%	19,087.9	18,377.9	37,465.8
Domestic % of Total	22.8%	32.4%	27.1%		55.3%	57.2%	56.2%		55.3%	57.1%	56.2%
% of All O/Ds	3.5%	2.8%	3.2%		91.1%	91.3%	91.2%		86.6%	86.5%	86.6%
Total U.S.											
Domestic	727.9	851.2	1,579.1	6,263%	11,878.8	11,755.5	23,634.3	93.737%	12,606.7	12,606.7	25,213.4
International	400.4	287.7	688.1	3.812%	9,021.6	8,340.6	17,362.2	96.188%	9,422.0	8,628.3	10,050.3
TOTAL	1,128.3	1,138.9	2,267.2	5,241%	20,900.4	20,096.0	40,996.5	94.759%	22,028.8	21,235.0	43,263.7
Domestic % of Total	64.5%	74.7%	69.7%		56.8%	58.5%	57.6%		57.2%	59.4%	58.3%

Forecasts for the primary cargo airports utilized a cargo routing model which allocated the assigned state totals based on a combination of proximity and service levels. The structure for the North Carolina Air Cargo Forecasting Model (NCACFM) is shown as Exhibit 3.9. The model's structure includes the following components:

- The forecasting of state airport traffic from the Colography baseline data base is incorporated within the model (shown as the top half of the exhibit).

- The primary airports are defined by their distance to the regional origin/destination (O/D) "zones" (North Carolina county or regional market area) and their relative service levels for the domestic and international markets. The airport with the highest service level was assigned a value of 100 percent with other airports' values set relative to that level. Forecast values were set relative to the baseline values based on anticipated service development patterns.

- Cargo originating or terminating at an O/D zone (and designated for a North Carolina airport) is assigned among state airports using an equal weighting of the relative service ratings and a distance comparison weighted towards the closest airport. The service and distance weighting factors were varied to calibrate model results to actual baseline market shares.

- Projected cargo volumes are utilized by the airport activity module which estimates flight operations.

The model's summary inputs and outputs are shown in Exhibit 3.10.

New Industrial Activity

The proposed GACIC facility would operate as a general cargo airport attracting regional cargo based on proximity and service levels, as well as a magnet to new industrial facilities attracted by the integration of industrial and transportation capabilities. The forecasting model was designed to accommodate a new "primary" airport which would compete for regional cargo which includes new traffic assigned to the county where the facility is located. The study included testing of three different locations for the facility with additional testing conducted in later phases of the development process.

The projection of new activity attracted to or near the GACIC facility was based on an extensive interview and analysis process which identified the types of industries which would best utilize the advantages of the facility and then profiled the industrial and transportation characteristics for those industries. The characteristics used to describe and estimate the new activity is shown as Exhibit 3.11.

Exhibit 3.9 North Carolina Air Cargo Forecasting and Allocation Model

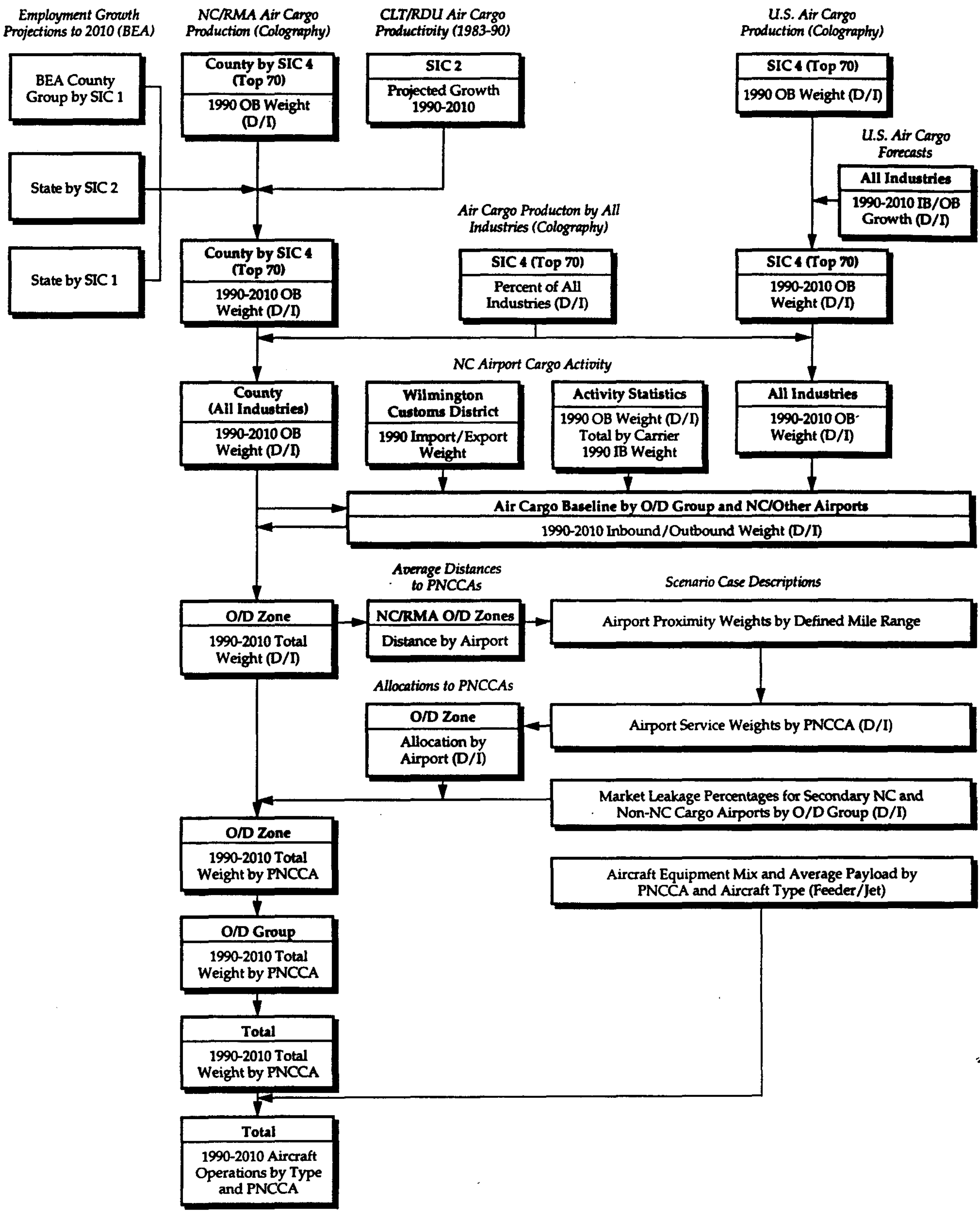

Exhibit 3.10 Base Case Calibration – Future Service/Leakage Shifts

U.S. Air Cargo Profile

	Air Cargo Traffic (000 Tons)				Average Annual Growth Rates		
	1990	1995	2000	2010	1990-1995	1995-2000	2000-2010
Domestic (inbound+outbound)	9,191.4	11,786.8	15,187.1	25,213.4	5.1%	5.2%	5.2%
Imports	2,529.9	3,515.3	4,838.9	9,168.9	6.8	6.6	6.6
Exports	2,316.7	3,264.5	4,557.3	8,881.4	7.1	6.9	6.9
International – Total	4,846.6	6,779.8	9,396.2	18,050.3	6.9	6.7	6.7
Total Traffic	14,038.0	18,566.6	24,583.2	43,263.7	5.8	5.8	5.8

	Regional Inbound/Outbound Traffic Ratios		Market Leakages					
			Percent of Total Traffic Leakage				Annual Diversion from Non-NC Airports - Forecast Period	
			NC Secondary Airports		Non-NC Airports			
Origin/Destination Group	Dom.	Int'l	Dom.	Int'l	Dom.	Int'l	Dom.	Int'l
NC Counties	0.8551	1.3920	1.56%	0.00%	37.84%	58.72%	0.50%	1.00%
Regional Market Area	1.0045	1.0842	0.00%	0.00%	95.37%	99.40%	0.25%	0.50%
All Other U.S. O/D's	N/A	N/A	0.00%	0.00%	99.91%	99.68%		

Airport Proximity Profile		NC Airport Relative Service Weight Profile								
			Domestic				International			
Mileage Range	Relative Weight	Airport	1990	1995	2000	2010	1990	1995	2000	2010
0-50 Miles	100	Charlotte	100%	105%	107%	107%	71%	77%	80%	80%
51-100 Miles	50	Greensboro	15%	20%	24%	24%	100%	85%	65%	65%
101-200 Milers	25	Raleigh-Durham	53%	48%	43%	43%	36%	44%	60%	60%
Over 200 Miles	10									

Exhibit 3.10 Base Case Calibration – Future Service/Leakage Shifts (continued)

Origin/Destination County/Area		Total Traffic Generated			Charlotte			Greensboro			Raleigh-Durham		
Total by O/D Group		Dom.	Int'l	Total	Dom.	Int'l	Total	Dom.	Int'l	Total	Dom.	Int'l	Total
North Carolina Counties	1990	254.2	140.4	394.6	85.9	18.9	104.8	14.3	27.0	41.3	53.9	12.0	65.9
	1995	467.2	243.8	710.9	168.0	40.2	208.2	35.0	44.8	79.8	91.8	27.8	119.6
	2000	740.6	378.0	1,118.6	280.0	72.3	352.3	68.7	59.0	127.0	137.1	62.6	199.7
	2010	1,853.3	912.3	2,765.6	755.7	209.8	965.5	184.0	169.4	353.6	368.6	179.7	548.3
Regional Market Areas	1990	328.8	130.4	459.3	9.8	0.3	10.1	1.5	0.4	1.9	3.8	0.1	3.9
	1995	612.8	220.3	833.1	23.3	2.7	26.2	4.6	3.0	7.6	7.9	1.1	9.0
	2000	978.6	335.7	1,314.3	45.6	8.0	53.6	10.6	6.5	17.1	13.6	4.3	17.9
	2010	2,309.5	722.8	3.032.4	148.1	33.8	181.9	33.0	25.8	58.9	41.2	17.0	58.2
All Other U.S. Counties	1990	8,608.4	4,575.7	13,184.2	4.8	5.0	9.8	0.7	7.1	7.8	2.5	2.5	5.1
	1995	10,706.8	6,315.7	17,022.5	6.0	7.5	13.6	1.2	8.3	9.5	2.8	4.2	7.1
	2000	13,467.9	8,682.5	22,150.4	7.7	10.8	18.5	1.7	8.8	10.5	3.1	8.1	11.2
	2010	21,050.6	16,415.2	37,465.8	12.0	20.4	32.5	2.7	16.6	19.3	4.8	15.3	20.2
Total U.S.	1990	9,191.4	4,846.6	14,038.0	100.5	242.2	124.7	16.5	34.4	51.0	60.3	14.7	74.9
	1995	11,786.8	6,779.8	18,566.6	197.5	50.5	2247.9	40.8	56.1	96.9	102.5	33.3	135.7
	2000	15,187.1	9,396.2	24,583.2	333.3	91.1	424.3	81.0	74.3	155.2	153.8	75.0	228.8
	2010	25,213.4	18,050.3	43,263.7	915.9	264.0	1,179.9	219.7	212.1	431.8	414.7	212.0	626.7

Exhibit 3.10 Base Case Calibration – Future Service/Leakage Shifts (continued)

	NC Primary Airport Total			Percent of NC Airport Total								
				Charlotte			Greensboro			Raleigh-Durham		
	Dom.	Int'l	Total	Dom.	Int'l	Total	Dom.	Int'l	Total	Dom.	Int'l	Total
1990	177.3	73.3	250.6	57%	33%	50%	9%	47%	20%	34%	20%	30%
1995	340.7	139.8	480.5	58%	36%	52%	12%	40%	20%	30%	24%	28%
2000	568.1	240.3	808.4	59%	38%	52%	14%	31%	19%	27%	31%	28%
2010	1,550.2	688.1	2,238.3	59%	38%	53%	14%	31%	19%	27%	31%	28%

Exhibit 3.11 New Industrial Activity Characteristics

Data Item	Source	Techniques/Comments
Target Industries for GACIC	Colography Group Industry Interview Program	Assumes GACIC would attract high technology companies dependent on air cargo similar to Silicon Valley plus expansion of industries already active in North Carolina. New plants would be attracted in and around GACIC. Selected top air-cargo producing industries (Colography industries) from Silicon Valley (Santa Clara Co. CA) and North Carolina based on plant size and air cargo productivity per employee in 1990. 14 from Silicon Valley and 8 from North Carolina (at four-digit SIC level).
Number of Plants and Employment for GACIC Industries (2000/2010 Forecast)	Colography Group Statistical Abstract of the United States FAA Airport Impact Study Industry Interview Program Study Team	Projected number of plants assumes share of existing Silicon Valley (15 percent) and North Carolina (10 percent) locations in 2000, expanding by five percent annually to 2010. Projected employees per plant in 2000 is assumed at 1990 levels with 1 percent annual growth to 2010. Employment for industries supporting manufacturing activity estimated based on U.S. ratio of transportation/public utility sectors to manufacturing sector. Total employment impact on state estimated using multipliers from FAA study (Measuring the Regional Economic Significance of Airports, October 1986).
Air Cargo Production (Tons and Value) for GACIC Industries	Colography Group Study Team	Growth in outbound cargo tons per employee for San Francisco market area (at two-digit SIC level) from 1983 to 1990 extrapolated to 2000 and 2010 and applied to 1990 averages for Silicon Valley/North Carolina industries. Average value per pound assumed at 1990 levels using constant dollars. Outbound cargo generated by industries supporting manufacturing activity assumed at 50 percent of manufacturing total. Inbound traffic assumed equal to outbound volumes.

The GACIC concept was developed based on trends toward integration of production and distribution systems and an increasing reliance on air cargo among the newest high technology industries. It was assumed that the priority industries would include top air cargo producing industries currently attracted to the Silicon Valley or currently prominent in North Carolina. The profile of industrial and transportation characteristics for each industry was based on baseline year activity for those areas.

The number of new plants assigned to the GACIC area in the forecast period was estimated from the current level of activity for the prototype areas. For example, it was estimated that the GACIC could attract 32 electronic computer facilities by the year 2000, equivalent to 15 percent of the current concentration in Santa Clara County.[10] Projected traffic and employment were calculated using average size and activity factors, as well as general assumptions concerning the balance and composition of activity. Exhibit 3.12 summarizes the projected new industrial activity.

Conclusions

The methodologies applied in this study were designed to project activity for both the existing state airport system and a new facility concept with no available prototype. The techniques used incorporated a wide variety of data sources and attempted to profile the relationships involved in air cargo markets accurately. Typical problems encountered included the synthesis of data with varying levels of detail and definitions, identifying and defining appropriate market ranges, and the incompatibility of historical data sets. The selected approach was designed to allow flexible scenario testing and assure that projected activity was based on a reasonable market allocation process as opposed to an independent trend projection of existing traffic.

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[10]The projected number of plants was based on anticipated growth in the industries over the forecast period and a reasonable share of "new" plant locations. Additional research for the master plan included a more detailed analysis of the probable development scenarios.

Exhibit 3.12 Summary of Air Cargo Produced by the GACIC and the Economic Impacts of GACIC Activities

	Forecast Year	
	2000	2010
Cargo Impact (Tons)		
New Traffic by Industry Type - Outbound	40,984	139,439
Manufacturing	20,492	69,720
Supporting Industries	61,476	209,159
Domestic Percent of Outbound Traffic	45%	40%
Ratio of Inbound-to-Outbound Traffic	1.0000	1.0000
New Traffic by Cargo Type - Summary		
(a) Domestic	27,664	83,663
Outbound	27,664	83,663
Inbound	55,328	167,327
(b) International	33,812	125,495
Outbound	33,812	125,495
Inbound	67,624	250,990
(c) Total	61,476	209,159
Outbound	61,476	209,159
Inbound	122,952	418,317
Employment Impact (Number of Full-time Jobs)		
Direct Employment		
Manufacturing	23,594	40,368
Transportation Support Industries	4,318	7,387
	27,912	47,756
Employment Multiplier	2.12	2.12
Total Employment	59,173	101,242
Revenue Impact (Million $)		
Direct Revenues		
Manufacturing	$3,411.2	$11,837.8
Transportation Support Industries	172.7	295.5
	$3,583.9	$12,133.3
Net State Impact (50% of Direct Impact)	$1,791.9	$6,066.6
Revenue Multiplier	2.12	2.12
Total Revenues	$3,798.9	$12,861.3