N76-15024

AN APPROACH TO MARKET ANALYSIS FOR LIGHTER THAN AIR TRANSPORTATION OF FREIGHT

Paul O. Roberts*
Henry S. Marcus**
Jean H. Pollock***

ABSTRACT: This paper presents an approach to marketing analysis for Lighter Than Air vehicles in a commercial freight market. After a discussion of key characteristics of supply and demand factors, a three-phase approach to marketing analysis is described. The existing transportation systems are quantitatively defined and possible roles for Lighter Than Air vehicles within this framework are postulated. The marketing analysis views the situation from the perspective of both the shipper and the carrier. A demand for freight service is assumed and the resulting supply characteristics are determined. Then, these supply characteristics are used to establish the demand for competing modes. The process is then iterated to arrive at the market solution.

The possibility of a revival of Lighter Than Air (LTA) vehicles results in numerous suggestions for possible missions. While LTA enthusiasts revel in the unique performance characteristics of large payload and extremely long flight range, some of the popularly suggested missions do not utilize these features with any degree of economy. Transport of outsized, bulky cargo such as reactor or machinery parts is frequently among the first missions associated with LTA. Hovering and lowering preassembled structures is also suggested.

Memories of the Hindenberg also apparently prompt ideas of passenger transport. To name a few: ferry service for passengers and cars across the English Channel, leisure cruises to the Caribbean, hotels for remote areas, as well as flying laboratories and dormitories for teams of scientists, researchers, surveyors or salvagers. Rescue

---

* Professor of Transportation, and Director of the Center for Transportation Studies, Massachusetts Institute of Technology, Cambridge, Mass.
** Assistant Professor of Marine Systems, and Executive Officer of the Commodity Transportation and Economic Development Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.
*** Graduate Student, School of Business Administration, Babson College, Babson Park, Mass.

missions after natural disasters are also mentioned.

Another suggestion makes the airship the candidate to introduce trade into the underdeveloped and inaccessible regions of Africa, South America, and Asia. Crop dusting, insect control, oil spill cleanup and mobile hospitals have also been entertained as LTA missions. Finally, military missions such as troop and supply carriers, weather and intelligence observation stations, and a platform for ocean surveillance are all considered as possibilities.

All of these proposed LTA missions share several salient features which should cause one to carefully consider the appropriateness of LTA use at all. These features include 1) a lot of "one-shot job" suggestions as to missions -- movement of reactor pieces and natural disasters are not everyday occurences; 2) the availability of much less expensive alternatives, such as large cranes, crop-dusting planes and stationary hotels and laboratories; 3) lack of a high volume, intense commercial base over which a rational allocation of the extremely high capital costs could be made, such as in many instances of trade development of underdeveloped areas with minimal trade volume.

In short, intense use must be made of an LTA in order to spread the high capital costs over as wide a useage base as possible as we will show subsequently. In addition, if the LTA is to become a success, mass production is desired. To meet these high volume requirements, commercial freight is the largest potential market for LTA's. In fact, commercial freight may be the <u>only</u> market large enough to support such a mass production process.

AN APPROACH TO MARKETING ANALYSIS

The market for Lighter Than Air craft depends necessarily on the market for their services. Although this paper concerns primarily the latter, it is necessary to consider the former to the extent that the size of the market for the craft influences the cost of the individual vehicles. This occurs in two ways: the amortization of the initial research and development cost over the vehicle fleet and the economies of scale in manufacture. The importance of the research and development costs can be demonstrated by considering the impact on aircraft cost of various fleet sizes. With an overall development cost of 100 million dollars, a fleet of 5 vehicles would have a share of 20 million each. For 25 vehicles, this cost would drop to 4 million, or if a fleet of 300 could be counted upon, the amortized cost would drop to almost $330,000 per vehicle. Thus, the financial viability of the concept could depend importantly on the fleet size initially planned for.

Supply Determinants

A first step in any analysis would be to determine for a given technology of transport what the costs of owning and operating the equipment are and what prices or tariffs would have to be charged in order to offer transport service. This depends on a number of factors which are well known and conceptually straightforward yet sometimes ignored in practice. These are:

- Annual corridor volume in tons
- Consolidation and deconsolidation possibilities
- Shipment size distribution
- Required frequency of service
- Seasonality
- Directionality

These factors all influence the choice of vehicle size and payload and the ability to maintain a given market share and equipment utilization. See Figure 1.

The overall volume of flow is obviously one of the most important factors since it directly influences the economies of scale which can be attained by the use of large equipment at big load factors. A single 5000 pound shipment being carried by truck incurs costs in the range of twenty cents per ton mile. If the truck were carrying 70,000 pounds, as many tractors hauling double trailers can, the cost drops to around a cent and a half a ton mile.

Large corridor volumes tend to beget even larger corridor volumes since greater volume means more frequent service, greater possibility for consolidation and deconsolidation and more opportunity to smooth out the irregularities caused by seasonality or directional movement. This tends to be especially true for those modes which carry big payloads such as rail and ocean shipping. Instead of shipping direct from origin to destination using the high cost mode, it may be worthwhile to use a feeder service to consolidate loads. See Figure 2.

<u>Measuring Cost and Performance</u>

The question is in the final analysis how much cargo can be attracted? This depends of course on the relative cost and performance of the modal offerings and how they are perceived by the shipper. The performance of a particular service is measured implicitly or explicitly by the shipper in his choice of mode and size of shipment. Included in this list of performance measures are:

- waiting time
- travel time
- time reliability
- probability of loss and damage
- special services such as refrigeration or in-transit privileges
- transport cost or tariff

Waiting time is that period from the time that a request for transport has been registered to the time the vehicle is in place ready for loading. Waiting time, along with travel time and time reliability, make up what the shipper may view as a lead time distribution in his inventory process. Because it is variable it must be protected

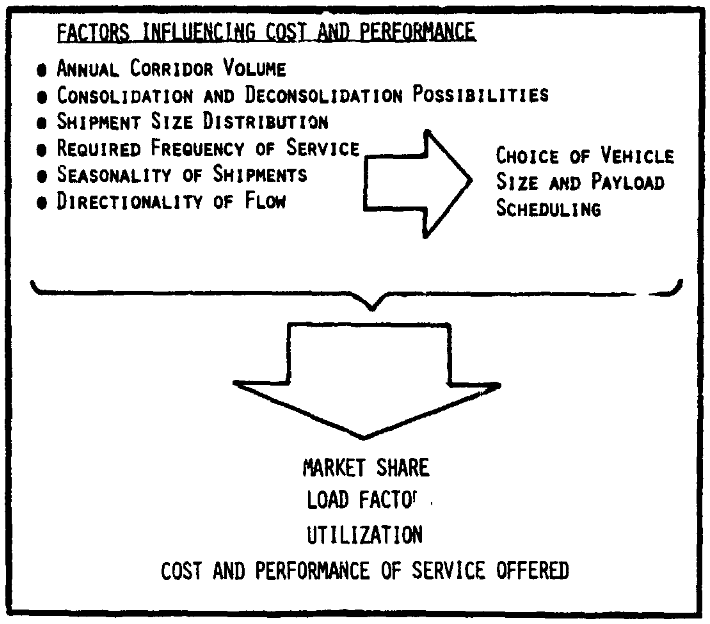


Figure 1. Factors Influencing the Cost and Performance of Services Offered

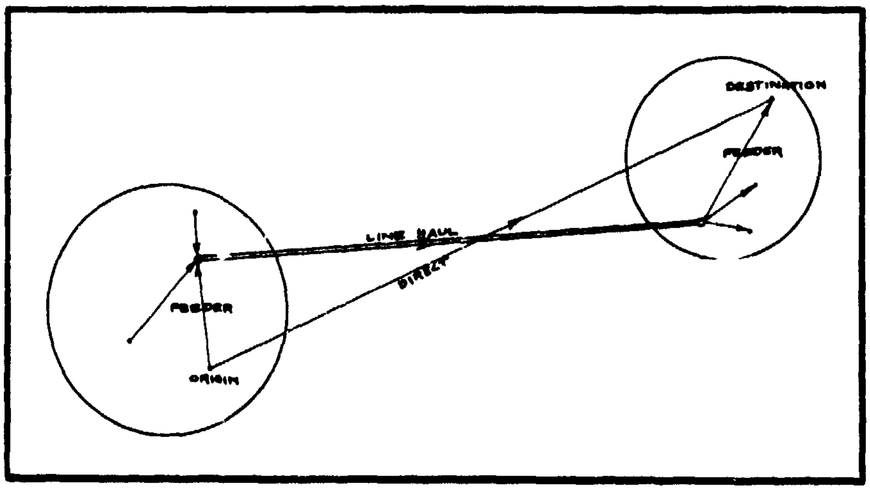


FIGURE 2. Consolidated Service Versus Direct Shipment

against by safety stock, ordering ahead or by fast shipment. Minimum shipment size and transport tariff combine to form the shipper's view of the size-rate schedule. See Figure 3.

Demand Characteristics

The way in which a shipper values specific elements of the performance achieved by a particular mode in routine shipment depends upon the characteristics of the commodity to be shipped. High value goods perceive travel time and travel time variability differently than do low value goods or goods for which there is no cost associated with stockout. The more important factors in the valuation of transport performance appear to be:

- value per pound
- density
- shelf life
- inventory stockout characteristics
- annual use volume and variability
- need for special environment, handling or services

These factors are used by the shipper in a subjective evaluation of the costs of transport. This evaluation whether performed explicitly using carefully derived costs by trial and error or by pure intuition and judgment results in a choice of shipment size, mode and frequency of shipment. See Figure 4. Obviously, the minimum shipment sizes and the transport tariffs found on the size-rate schedule of offerings influences this choice.

Supply-Demand Equilibrium

Thus, there is a supply-demand equilibrium process at work in the real world. The supply of transport services with certain costs and performance or level of service characteristics elicits a demand by shippers through their decisions on choice of mode, shipment size, and frequency of service. In the aggregate this demand is seen by the transport system as an annual corridor volume with a certain level of consolidation of shipments, weight size distribution, seasonality, and directionality of flow. See Figure 5. As changes occur there are adjustments first on one side of the supply demand system, then on the other. The process tends to be incremental and changes occur relatively slowly.

The analysis of this system can be accomplished by formalizing the decision processes and the costing procedures on a step-by-step basis following the flow shown in the diagram. The costing procedure is not trivial as many of the papers at this conference demonstrate. But, it is done on a day to day basis for existing modes and can be done for a potential new mode with some allowances for uncertainty. Note that the costing process does require a more or less complete design of facilities, personnel, procedures, etc., for a system whose extent can only be guessed at the outset. There are, however, more conceptual problems on the demand side.

TRANSPORT PERFORMANCE MEASURES

- WAITING TIME
- TRAVEL TIME
- TIME RELIABILITY
- PROBABILITY OF LOSS AND DAMAGE
- SPECIAL SERVICES
- MINIMUM SHIPMENT SIZE
- TRANSPORT COST OR TARIFF

FIGURE 3. TRANSPORT PERFORMANCE MEASURES

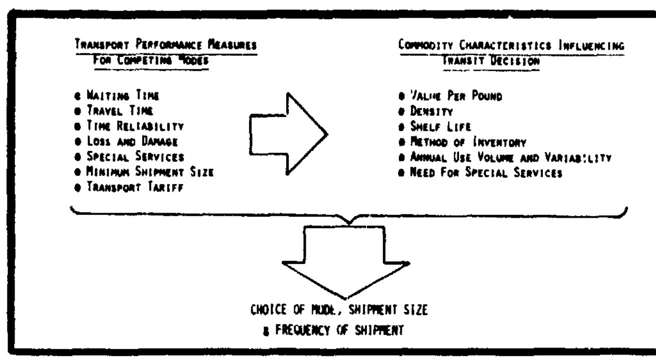


FIGURE 4. FACTORS INFLUENCING THE CHOICE OF MODE, SHIPMENT SIZE AND FREQUENCY OF SHIPMENT

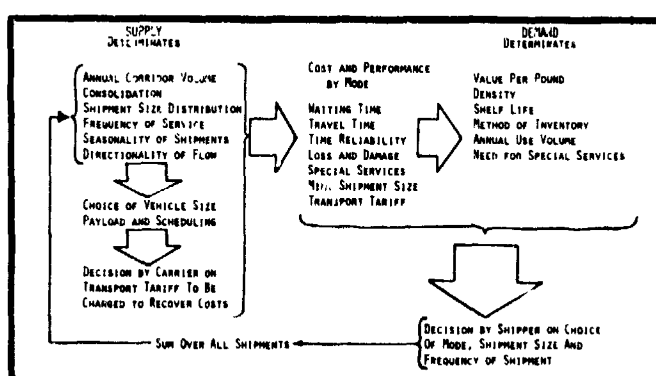


FIGURE 5. THE SUPPLY-DEMAND EQUILIBRIUM SYSTEM FOR FREIGHT TRANSPORT

Demand Modelling

Demand modelling for freight is still in its infancy. There are well-formulated models for urban passenger demand and the expectations are for usable models for freight in the not distant future. It is also possible to proceed item by item (or more realistically, market segment by market segment) to examine the choices open to a shipper and to decide on a rational basis what mode the shipper will choose. A problem always exists in deciding upon the makeup of the market segments and the definition of their commodity characteristics, but this can and has been done and our efforts to perform market demand analysis for a variety of market segments useful to our purposes here will be described later in this paper.

In attempting to apply this process to the case of Lighter Than Air craft which is more of a revolution than an incremental change, there is the question of how to "break into" the analysis circle. Should costs and performance be assumed and the demand analysis performed initially to determine volumes which are then used in the supply side analysis? Or should market volumes be assumed and used as input to the design and costing out of the supply side? Both should probably be done. Another problem is the markets to be addressed. It is difficult to start with the whole world. Some idea of market corridors and/or types of commodities to attempt to serve are needed as a point of beginning.

As a way into the problem and in an attempt to gain some pragmatic insights into what the possible freight markets are, it is useful to search for short-cuts that will reveal markets in which Lighter Than Air craft can offer superior service by all (or at least most) of the level of service performance measures stated previously. That is, we are looking for some markets that Lighter Than Air can steal. Some possibilities include those offered by classical modes such as container-ships, rail piggyback, truck, or air. There are also commodity markets such as dry bulk, neobulk, perishables, etc., that could be explored. In the next section we will examine some of these possibilities.

A THREE-PHASE APPROACH

In order to analyze potential markets for LTA vehicles, a three-phase procedure is used. The first phase provides an overview of line-haul costs and characteristics of competing modes of transport in the commercial freight market and then does the same for LTA with what figures there are available. The basic market position of LTA vehicles is then apparent.

Phase two presents a computer simulation model of the total origin to destination costs and times for competing modes. The ability to vary distance and commodity to be shipped provide cost data for a wide range of shipments and it is possible to compare LTA costs with those of the competition on many routes.

Phase three examines the shipper's demand side of the market analysis with another computer simulation model which reflects shippers' concerns in choosing a transport mode. The conditions under which LTA will be chosen can be analyzed for a number of market segments.

Phase 1 - Line-Haul Cost and Performance

Commercial freight markets are large and well-established; consequently the LTA vehicle will face immediate heavy competition. It is important to remember that aside from any annual growth of the market that an LTA vehicle can capture, the bulk of LTA business must be wrested away from the competition. For this reason, an analysis of the line haul, terminal costs and performance of the various modes will be presented.

If we consider the transcontinental U.S. market, a distance of 2500 miles, we see in Table 1 that there is a wide spread between the available revenue ton-mile costs of shipments by air, rail TOFC (trailer on flat car), and truck.

Research by the Southern California Aviation Council, Inc., shows that as the size of LTA vehicles increases, their unit costs decrease, as one might suspect. The largest LTA vehicle studied by the Council has a payload of 1,114 tons at 100 mph, and 1,032 tons at 200 mph. The construction cost of such a vehicle is estimated at $96.25 million. If we assume a 25 year life and a 4 percent residual value, a net present value system of representing the time value of money at an opportunity of 10 percent results in an annual equivalent capital cost of $10.56 million. (The Council calculates annual capital cost by a different method. Note also that the tax shelter of such an investment should also be considered.) Using the Council's data for all other cost data, the costs per revenue ton-mile figure for the LTA vehicle over a 2000 mile distance becomes 4.4¢ for the 100 mph craft, and 3.5¢ for the 200 mph craft. Consequently, adjusting for travel segments of equal distance (and varying definitions of costs), it would appear at first glance that the LTA vehicle costs place it lower than air or truck but higher than rail TOFC.

Since a listing of the modes by speed is identical to the one by costs, the LTA vehicle does not appear to dominate any existing mode in terms of both cost and speed. Therefore, the LTA vehicle will not simply replace an existing mode and take over its current market. The LTA market will, rather, depend on how the shipper trades off cost and speed and other factors in his analysis.

Phase 2 - Total Door to Door Performance

In Phase 2, a computer simulation is used to attempt to account for many of the factors omitted from the simple overview of Phase 1, such as varying distances, densities, cargo values, inventory carrying costs, or load factors in the calculation of total origin to destination costs and times.

The computer program calculates the following component costs:

- Pickup and delivery
- Inventory and warehouse

TABLE 1

RANGE OF LINE HAUL PLUS TERMINAL
COSTS PER REVENUE TON-MILE*
SURFACE VS. AIR TRANSPORTATION
1975

	LINE HAUL**	TERMINAL***	TOTAL RANGE	TOTAL MOST LIKELY
TRUCKING	2.67-4.23¢	.97-1.39¢	3.64-5.62¢	4.9¢
RAIL TOFC	1.17-1.38	.34-.40	1.51-1.78	1.8
AIR FREIGHT				
707	5.25-6.98	2.7-3.1	8.0-1-.08	8.8
DC-8-63	4.90-6.51	2.3-2.7	7.2-9.21	8.0
747	3.70-4.92	1.0-2.0	4.70-6.92	5.4

* COSTS REPRESENT THE DEFINITION OF OUT OF POCKET COSTS BY THE REGULATORY AGENCIES.

** TRUCK PLUS AIR BASED ON 100% LOAD FACTOR (WEIGHT BASIS). RAIL BASED ON 70,000-POUND SHIPMENTS.

*** RAIL TERMINAL EXCLUDES PLATFORM HANDLING. AIR TERMINAL INCLUDES ONLY TRAFFIC SERVICE EXPENSE.

SOURCE: THE FUTURE OF THE U.S. DOMESTIC AIR FREIGHT INDUSTRY, LEWIS M. SCHNEIDER, HARVARD UNIVERSITY, 1973, PAGE 133.

- Inland line haul
- Transoceanic or transcontinental line haul
- Terminal handling
- Packaging
- Cargo insurance
- Documentation

Importance of Cost Components - The density of cargo has a large impact on air freight costs, and all modes are sensitive to their design densities. Phase 1 data assumed that each mode carried cargo at its design density. The design densities of a truck or container is 20 lbs/cu.ft. and the design density of a containership is 43 lbs/cu.ft. The design density of a 747 is 10.9 lbs/cu.ft., while the average cargo density was 8.6 lbs/cu.ft. and ranged from 5.3 to 20.0 pounds. The difference between the design density and the average actual cargo density results in an increase of 27 percent in the effective cost per available ton-mile. The greater the deviation of the average cargo density from the design density, the greater the effective cost per available ton-mile, as borne out by the computer simulation.

The very nature of the commodities involved is a significant aspect of the market. Ocean carriers and railroads are generally thought to carry "low" value commodities for which delivery time is not generally critical and even the increased inventories necessitated by the time lag and additional warehouse costs involved still total far less than the cost of air shipment.

To better evaluate the differences in transit times of different modes, the computer simulation in Phase 2 assumes that the shipper incurs an inventory carrying cost equal to an annual charge of 10 percent of the value of the product. While air modes, including LTA vehicles, would appear to be natural carriers for high value cargo, it should be noted that only 18 our of 402 commodity groupings analyzed by the Transoceanic Cargo Study have average values more than $5.00 per pound. See Table 2.

While data in Phase 1 assume 100 percent load factors, and a 2500 mile distance, the computer simulation in Phase 2 allows these figures to vary. Rather than looking only at the costs and times of the line-haul mode, the computer simulation analyzes the total origin to destination costs and times, including those to perform consolidation and de-consolidation, showing the situation as it appears to the shipper.

For the sample computer runs shown in this paper, four commodities were used: meat, fruit, computers and leather goods, to give a wide range of densities and values. See Table 3. The airplane used in the computer program is a wide-bodied jet aircraft of the Lockheed L-500 or Boeing 747 class, which operates at a 70 percent load factor. The vessel is an 800 unit containership which operates at a 69 percent load factor. (The program is a modification of that presented in the Transoceanic Cargo Study by Planning Research Corporation, Los Angeles, California, 1971. Characteristics of the various modes of transportation are also taken from this study.) The authors feel that costs for the plane are biased

TABLE 2

TRANSOCEANIC COMMODITIES WITH VALUES IN EXCESS OF $5.00 PER POUND

DOTTO NUMBER	DESCRIPTION	DENSITY (POUNDS PER CUBIC FOOT)	VALUE PER POUND
864 I	WATCHES AND CLOCKS, INCLUDING PARTS	27	$11.80
681 E	SILVER, PLATINUM, & PLATINUM GROUP METALS, UNWROUGHT OR PARTLY WORKED	360	19.31
515 E	RADIOACTIVE & STABLE ISOTOPES, THEIR COMPOUNDS, MIXTURES, & RADIOACTIVE ELEMENTS EXCEPT URANIUM, THORIUM ORES, CONCENTRATES	NA	11.66
681 I	SILVER, PLATINUM, PLATINUM GROUP METALS, UNWROUGHT OR PARTLY WORKED	360	438.00
212 E	FURSKINS, UNDRESSED	34	12.16
714 E	OFFICE MACHINES & PARTS, INCLUDING COMPUTERS	30	9.41
736 E	ELECTRIC APPARATUS FOR MEDICAL PURPOSES, RADIOLOGICAL APPARATUS, & PARTS	21	5.22
861 E	SCIENTIFIC, MEDICAL, OPTICAL, MEASURING & CONTROLLING INSTRUMENTS,& APPARATUS, EXCEPT ELECTRICAL	30	5.63
614 E	FURSKINS, DRESSED, INCLUDING DYED	11	7.73
726 E	STEAM ENGINES, TURBINES, INTERNAL COMBUSTION, JET AND GAS TURBINES, AIRCRAFT & MISSILES, & PARTS	21	9.62
746 E	AIRCRAFT & SPACECRAFT, & PARTS	8	9.82
734 E	TELECOMMUNICATION APPARATUS & PARTS, INCLUDING RADIOS, TV SETS, NARAIDS	15	7.73
842 E	FUR CLOTHING & OTHER ARTICLES MADE OF FURSKINS EXCEPT HEADGEAR, ARTIFICIAL FUR, ARTICLES THEREOF	NA	25.50
212 I	FURSKINS, UNDRESSED	34	6.27
614 I	FURSKINS, DRESSED, INCLUDING DYED	11	6.74
746 I	AIRCRAFT AND SPACECRAFT, & PARTS	8	10.02
842 I	FUR CLOTHING & ARTICLES MADE OF FURSKINS AND FUR, EXCEPT HEADGEAR	NA	6.14
1 I	LIVE ANIMALS, EXCEPT ZOO ANIMALS, DOGS, CATS, INSECTS, AND BIRDS	6	9.30

SOURCE: U.S. DEPARTMENT OF TRANSPORTATION, ASST. SECRETARY FOR POLICY & INTERNATIONAL AFFAIRS, OFFICE OF SYSTEMS ANALYSIS & INFORMATION, TRANSOCEANIC CARGO STUDY-FORECASTING MODEL & DATA BASE, VOL. I, PREPARED BY PLANNING RESEARCH CORPORATION (WASHINGTON, 1971), PP. III-60 THROUGH III-65.

TABLE 3

COMMODITY CHARACTERISTICS USED IN SAMPLE COMPUTER RUNS

COMMODITY	VALUE ($/LB.)	DENSITY (LB./CU.FT.)
MEAT	.28	51
FRUIT	.13	34
COMPUTERS	9.41	30
LEATHER GOODS	1.72	8

downward, since no commercial aircraft that large exists and the costs for the ship are biased upward, because many containerships are much larger than the size chosen. Consequently, the choice of numbers should narrowly define the costs of the "market niche" to be sought after by LTA vehicles.

First Scenario - Results from the computer simulation of two scenarios moving cargo from an inland point in the U.S. across the ocean to an inland point in a foreign country have been developed. In the first scenario, cargo moves by truck from an inland U.S. origin 200 miles to either a seaport or airport, 3000 miles across the ocean by either ship or plane, and 200 miles inland to its foreign destination by truck. Figure 6 shows the total origin to destination cost in dollars per pound for air and ocean freight as the inland truck portions remain constant at 400 miles and the transocean distance increases from 500 miles to 6000 miles. The figure shows that the competition between air and containerships is most severe for high value-low density commodities (i.e., computers, leather goods, etc.) The cents per ton-mile costs for the plane and ship over transocean distances from 500 miles to 6000 miles are given in Figure 7. A key point discerned from this figure is that while the vessel costs per ton-mile decrease over the entire distance, the air costs per ton-mile increase, showing the tradeoffs being made by the plane between payload and fuel capacity.

Sample data for one particular ocean distance (3000 miles) for meat and computers are shown in Tables 4 and 5. In comparing modes of transportation for the same commodity, two key factors are inventory carrying costs, which reflect total transit times, and transocean line-haul costs. In comparing costs between commodities, the key factors are cargo insurance and inventory carrying costs, which both reflect the value per pound of each commodity.

If we hypothesize how an LTA vehicle will fit into this scenario, let us assume a 150 mph speed and a direct origin to destination trip with no feeder services. In by-passing all feeder services as well as pick-up and delivery, the LTA vehicle can make the trip in 0.94 days. The cost should be lower than that of air but higher than that of ocean. What we see here is that waiting times and inland feeder service times can have a major effect on the overall transit time, particularly for airlines. To the extent that LTA vehicles can by-pass terminals and travel directly from the origin to destination, they can save both time and money for the shipper.

In comparison with ocean, while the LTA vehicle will probably not ever be able to match the line-haul costs of containerships, for high value cargo the time differential may be more than enough to make the shipper choose the LTA vehicle. For extremely high value cargo, the large transit time using a vessel line-haul service may actually make it less expensive because of the inventory carrying costs involved to use the LTA vehicle in the cost framework shown.

Second Scenario - The second scenario compares a rail-ocean-rail trip with a truck-air-truck trip. The rail-ocean-rail trip is made up of a

TABLE 4

TOTAL 1975 ORIGIN TO DESTINATION COSTS*

OCEAN VS. AIR
COMMODITY: MEAT
DISTANCES: DOMESTIC INLAND TRUCK - 200 MILES
FOREIGN INLAND TRUCK - 200 MILES
TRANSOCEAN - 3000 MILES FOR BOTH PLANE AND SHIP

COST COMPONENTS ($/LB.)	OCEAN	AIR
PICKUP & DELIVERY COST	.00118	.00118
INVENTORY CARRYING COST	.00479	.00176
INLAND LINE-HAUL	.00499	.00449
TRANSOCEAN LINE-HAUL	.00120	.09825
TERMINAL HANDLING	.00251	.01772
PACKAGING	.00657	.00437
INSURANCE	.00081	.00198
DOCUMENTATION	.00024	.00024
TOTAL ($/LB.)	.02179	.12999
TOTAL $/TON-MILE	.01282	.07646
TOTAL # DAYS	16.9	6.2

*COST COMPONENTS (I.E., INVENTORY CARRYING COST, PACKAGING, ETC.) ARE TOTALS OF THE INLAND AND TRANSOCEAN SEGMENTS.

FIGURE 6

TOTAL ORIGIN TO DESTINATION COSTS

(INCLUDING 400 MILES OF INLAND TRUCKING)

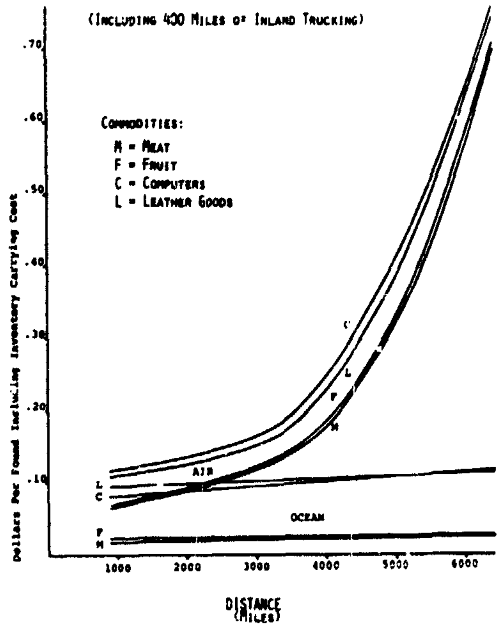


TABLE 5

TOTAL 1975 ORIGIN TO DESTINATION COSTS*

OCEAN VS. AIR
COMMODITY: COMPUTERS
DISTANCE: U.S. INLAND TRUCK 200 MILES
FOREIGN INLAND TRUCK 200 MILES
TRANSOCEAN 3000 MILES FOR BOTH PLANE AND SHIP

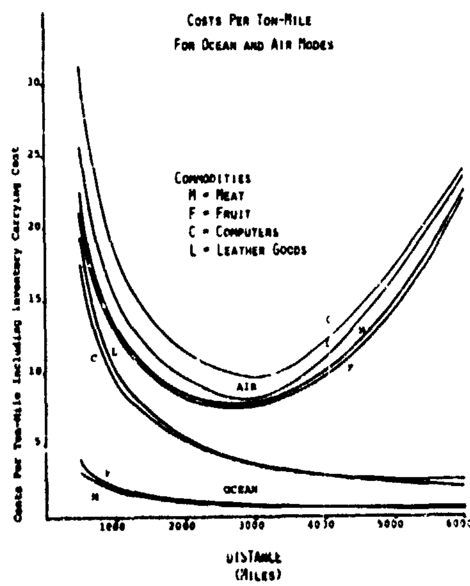
COST COMPONENTS ($/LB)	OCEAN	AIR
PICKUP & DELIVERY	.00118	.00118
INVENTORY CARRYING COST	.06424	.02362
INLAND LINE-HAUL	.00619	.00619
TRANSOCEAN LINE-HAUL	.00204	.09825
TERMINAL HANDLING	.00437	.01772
PACKAGING	.01115	.00743
INSURANCE	.00789	.02611
DOCUMENTATION	.00024	.00024
TOTAL ($/LB)	.09730	.18074
TOTAL $/TON-MILE	.06487	.10632
TOTAL # DAYS	15.9	6.2

*COST COMPONENTS ARE TOTALS OF THE INLAND AND TRANSOCEAN SEGMENTS.

FIGURE 7

COSTS PER TON-MILE

FOR OCEAN AND AIR MODES



1000 mile rail feeder service to the port, a 3000 mile ocean voyage, and a 1000 mile rail segment to the inland foreign destination. The truck-air-truck trip between the same origin and destination is composed of a 200 mile truck segment to the airport, a 4500 mile air trip, and a 200 mile inland segment to the foreign destination. This comparison is similar in concept to the situation shown in Figure 2, where the shipper has to decide whether to use surface inland feeder services over rather long distances to bring his cargo to a consolidation point for a particular carrier, or whether to ship by air in a manner more nearly resembling an origin to destination trip. A key factor in this decision is whether the shipment size is large enough relative to the mode of transportation to take the origin to destination alternative.

Sample data from computer runs of this scenario are shown in Tables 6 and 7. For a low valued good (i.e., meat), the cost of air freight over such a long distance may well be prohibitive. Even for a high value good, the costs may make air freight undesirable to the shipper. However, it should be noted that the difference between ocean and air becomes less for the higher value commodity. Again, the shipper is faced with the problem of cost versus time. For computers, this trade-off becomes $.105 per pound versus 12.6 days. An LTA vehicle going directly from the origin to destination at 150 mph could make the 4900 mile trip in 1.4 days; this time is considerably faster than the truck-plane-truck situation because of the time associated with the inland feeder systems. However, such a direct origin to destination trip requires the shipper to be able to fill most, if not all, of the LTA vehicle.

In many cases, the shipper is again left with the problem of trading off cost with time. While Phase 2 has included inventory carrying cost as one way to quantify the time involved, factors such as service reliability by mode and stockout costs are necessary to complete an analysis that would allow the shipper to directly choose the mode he wants. Phase 3 describes the demand characteristics which make such an analysis possible.

Phase 3 - An Analysis of the Transcontinental Surface Markets

Here, the emphasis will shift to the demand side. How does a shipper make the decisions concerning mode choice, size of shipment, and frequency of ordering? One way to approach the behavior of the shipper is to assume that he is a rational individual responsible in a fiscal sense for the ordering, transport, storage, and inventory control of a single item. This is a simplification of the actual world since for many items, multiple item inventory management is more realistic. But, for our purposes, it is useful to demonstrate in an uncomplicated way how he might reason to ship by one mode or another and how he goes about selecting the appropriate shipment size.

To simulate the decision making process of the shipper we used a computer program written to perform single item inventory management. The program develops optimum inventory strategies for a commodity defined by its use, rate and economic characteristics by selecting the order

TABLE 6

TOTAL 1975 ORIGIN TO DESTINATION COSTS*

OCEAN-RAIL VS. AIR-TRUCK

COMMODITY: MEAT

DISTANCE:

OCEAN-RAIL	U.S. INLAND	1000 MILES
	FOREIGN INLAND	1000 MILES
	OCEAN	3000 MILES
AIR-TRUCK	U.S. INLAND	200 MILES
	FOREIGN INLAND	200 MILES
	AIR	4500 MILES

COST COMPONENTS ($/LB.)	OCEAN-RAIL	AIR-TRUCK
PICKUP & DELIVERY	.00118	.00118
INVENTORY CARRYING COST	.00535	.00176
INLAND LINE-HAUL	.06022	.00449
TRANSOCEAN LINE-HAUL	.00120	.18167
TERMINAL HANDLING	.00251	.01772
PACKAGING	.00657	.00437
INSURANCE	.00114	.00198
DOCUMENTATION	.00024	.00024
TOTAL ($/LB.)	.07841	.21341
TOTAL $/TON-MILE	.03136	.08711
TOTAL # DAYS	18.9	6.3

*COST COMPONENTS ARE TOTALS OF THE INLAND AND TRANSOCEAN SEGMENTS.

TABLE 7

TOTAL 1975 ORIGIN TO DESTINATION COSTS*

OCEAN-RAIL VS. AIR-TRUCK

COMMODITY: COMPUTERS

DISTANCES:

OCEAN-RAIL	U.S. INLAND	1000 MILES
	FOREIGN INLAND	1000 MILES
	OCEAN	3000 MILES
AIR-TRUCK	U.S. INLAND	200 MILES
	FOREIGN INLAND	200 MILES
	AIR	4500 MILES

COST COMPONENTS ($/LB.)	OCEAN-RAIL	AIR-TRUCK
PICKUP & DELIVERY	.00118	.00118
INVENTORY CARRYING COST	.07186	.02363
INLAND LINE-HAUL	.06022	.00619
TRANSOCEAN LINE-HAUL	.00204	.18167
TERMINAL HANDLING	.00437	.01772
PACKAGING	.01115	.00743
INSURANCE	.00789	.02611
DOCUMENTATION	.00024	.00024
TOTAL ($/LB.)	.15895	.26417
TOTAL $/TON-MILE	.06358	.10782
TOTAL # DAYS	18.9	6.3

*COST COMPONENTS ARE TOTALS OF THE INLAND AND THE TRANSOCEAN SEGMENTS.

quantity, Q, the reorder point, R, and the mode of shipment, M, so as to minimize total logistics costs over a one-year time period. These costs include:

- ordering,
- transporting,
- storing,
- capital carrying, and
- stockout

The innovation in this program is in the way in which stockout is related to the lead time performance of the transport system and stockout costs are traded off against transport costs. Transport performance is defined using a schedule of minimum shipment sizes with their corresponding rates, loss and damage probabilities and out of pocket costs. It is important to note that the choices open to the inventory manager are all expressed in his decisions on Q, R, and mode once the annual use rate and its variability are known.

This approach of simulating the decisions of the inventory manager should allow us to gain a feeling for the mode choice and shipment sizes that will be made in a given transportation market for various commodities over a range of useage rates. However, there are too many commodities to approach the problem that way. It would be better to divide the entire universe of goods into commodity groups or market segments and treat each market segment individually. There is still a problem with multidimensionality. From the list of commodity attributes which are important in the selection of mode, which are the key 2 or 3 which best define a market segment?

- value per pound
- density
- shelf life
- inventory stockout characteristics
- annual use volume and variability
- need for special services

On this first round of the analysis, we have chosen value per pound and useage rate along with inventory stockout characteristics as the three descriptors to be varied. Other variables will have an average value, but will not be changed.

It is useful to digress a moment to clarify what is meant by inventory stockout characteristics. There is a period after the reorder point in the inventory cycle for which the inventory level is subject to chance. There is variability in both the useage rate and the lead time of the transport vehicle carrying the replenishment stock. If useage spurts up or transport is delayed, or both, there will be a stockout. During each reorder cycle there is a probability of stockout which can virtually never be eliminated though it can be minimized by reordering at a higher reorder point or by using a faster or more reliable mode. By inventory stockout characteristics we mean the nature of the costs that will be incurred.

There are a variety of possible stockout situations. For some commodities, there is an immediate loss of sale once a stockout has occurred. The vendor for ice cream in Central Park on a hot day experiences these stockout costs. He doesn't lose the value of the stock, but merely the contribution to overhead and profit. For other commodities there is not an immediate loss of sale since the customer may accept the excuse that the part which is currently out of stock has been backordered and that it is due to be in on Monday. Thus, there is a probability of sale loss which increases with number of days out. Still another situation is that which occurs in manufacturing when an item important in the assembly line causes the whole line to stop and the plant to be closed down. Each can be handled by varying the makeup of the stockout cost matrix as between number of items out of stock and number of days this condition has existed. This cost matrix is multiplied by the probability of being in each of these states to obtain the expected value of a stockout.

The total logistics costs associated with ordering, storing, carrying the invested capital and transporting by the various modes must be determined for each inventory strategy tried. A scheme for proceeding mode by mode to examine each break point on the transport size rate tariff schedule is used. For that break point the best reorder point is determined by a short search of possible R's and the selection of the one with the lowest total logistics cost. This procedure was used here to examine a four by four matrix of market segments for three different inventory stockout conditions on a transport corridor of 2500 miles. For this example, air, truck, and rail TOFC service was available.

Each market segment was defined by the value per pound, which ranged from $0.01 per pound to $10.00 a pound; by the annual useage rate, which ran from 10,000 pounds per year to 100 million; and by a probability distribution on the useage rate. See Figure 8. The unit cost of a stockout, the interest rate on the carrying cost of capital, the storage space per item, and a host of lesser variables were also employed.

The performance measures for each of the transport modes, their size-rate schedule and the transport lead time distributions used in the computations for each market segment are shown in Figure 9. The attempt here was to select transport tariffs and break points which were broadly representative of cost-based freight rates found in practice.

The computer runs were made for three separate inventory stockout situations. There were:

- No stockout costs
- Stockout results in immediate sales loss
- Stockout increases probability of plant closedown

For each market segment, the computer printed the optimum inventory policy by giving the shipment size, Q, the reorder point, R, the mode, M, the total logistics cost per pound, $, and the number of orders per

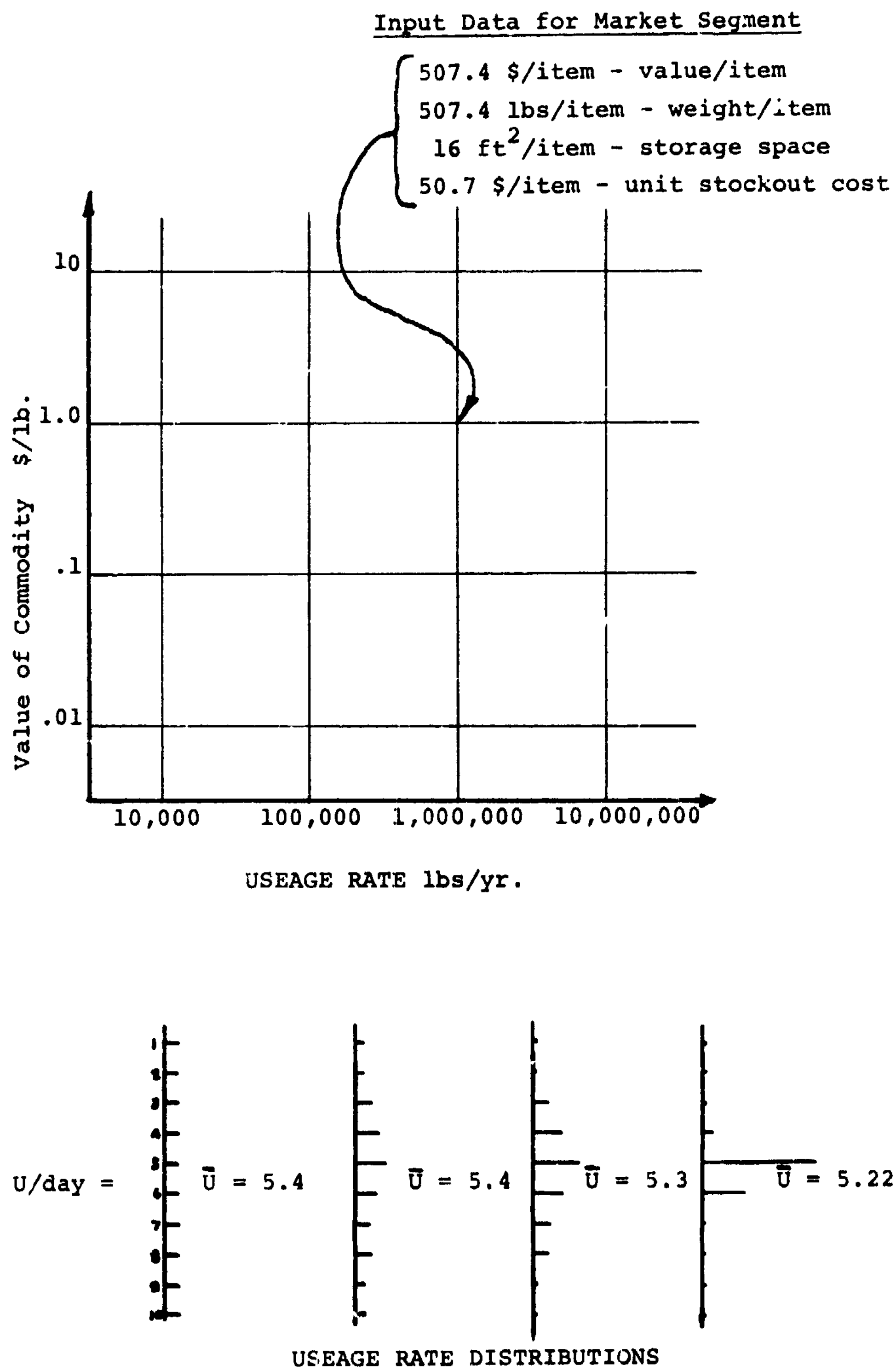


FIGURE 8. Market Segment Definition

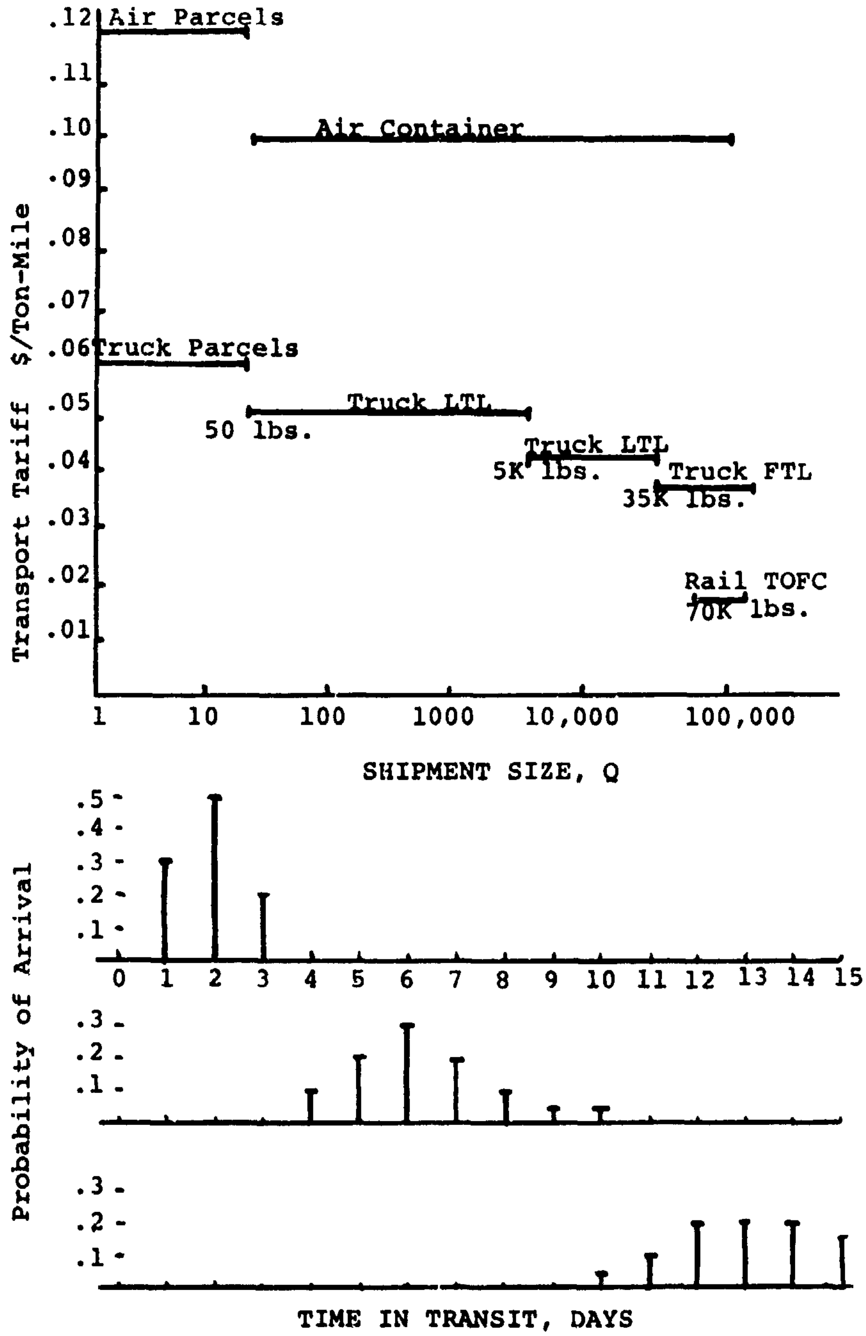


FIGURE 9 . Transport Size Rate Tariff Schedule and Lead Time Distributions by Mode

year, O. Close examination of the pattern of optimum policies reveals a pattern to the strategies which tends to shift as the cost of stockout changes.

For the case of no stockout cost, the reorder point is extremely low. See Figure 10. Since there is no cost of stockout there is no penalty for using slower modes so rail TOFC is used for the larger shipments. Full truckload is discontinuous, but this may be because of discreteness in the definition of market segments. Air freight has captured only the high value, low volume shipments.

For stockout with immediate sale loss, much the same pattern emerges; but truck has encroached on rail TOFC. See Figure 11. Also reorder points are high, especially for the less reliable modes amounting to more than half the quantity ordered in some cases. This causes total logistics costs to be slightly higher to reflect the higher capital carrying cost of the additional inventory.

For the case where the probability of plant closedown exists, air freight shipments have taken over one market segment from what was full truckload shipments in the previous case. See Figure 12. Surprisingly, this is the only change in mode though there has been an increase in reorder point especially for the slower modes.

Overall, the results look much as one might expect, though the stability is somewhat surprising. With higher order costs and higher interest rates on capital carrying there might be more switchover to air or truck from rail TOFC for the high value goods. Nevertheless, the results look reasonable with respect to mode choice and inventory strategy.

To get a feel for the viability of Lighter Than Air services introduced into this market, an additional computer run was made. For this run an assumption about lead time variability and size rate transport rates had to be made. It was reasoned that the lead time distribution for Lighter Than Air should be slower than air and faster than truck. The rate was placed at $.04 per ton-mile between LTL truck rates and FTL truck rates, and higher than rail TOFC, with a minimum shipment size of 35,000 pounds. In other words, the service offered was to be a fast "piggyback" service.

The results of this run are interesting. See Figure 13. Lighter Than Air service captured only the market segment previously served by FTL truck and by air freight. This seems to indicate that to compete effectively in this market, transport costs would have to be lower than FTL truck. Certainly lower costs would have increased the markets for Lighter Than Air.

This computer run considered only a 2500 mile transcontinental shipment. A complete analysis would have to look at shorter markets. In addition such an analysis would investigate the sensitivity of such factors as interest rates on capital carrying and higher storage charges.

FIGURE 10. Optimal Inventory Strategies for the Case -
NO STOCKOUT COSTS

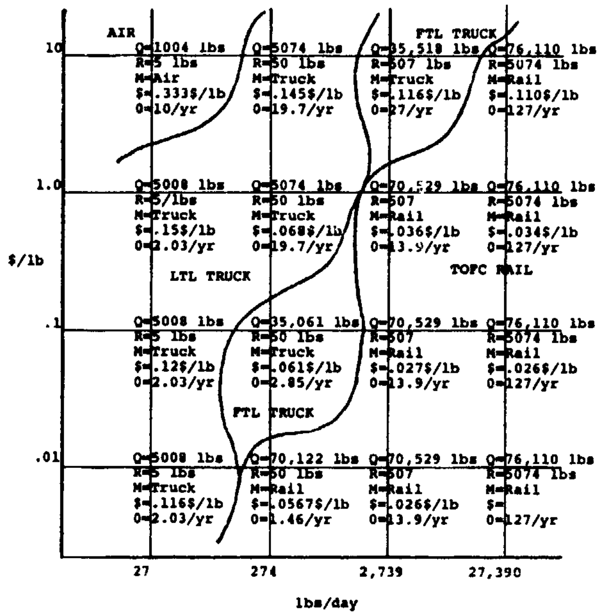


FIGURE 11. Optimal Inventory Strategies for the Case -
STOCKOUT RESULTS IN IMMEDIATE SALE LOSS

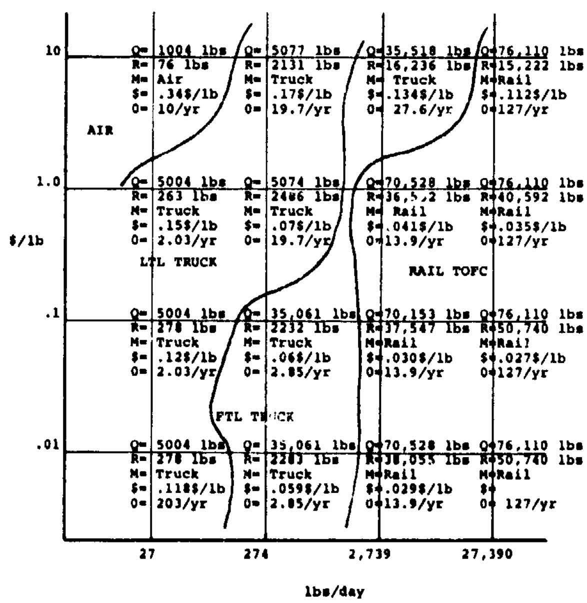


FIGURE 12. Optimal Inventory Strategies for the Case -

STOCKOUT INCREASES PROBABILITY OF PLANT CLOSEDOWN

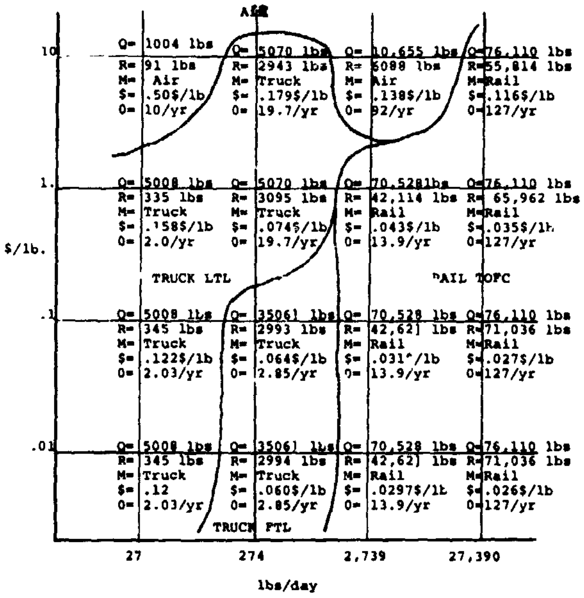
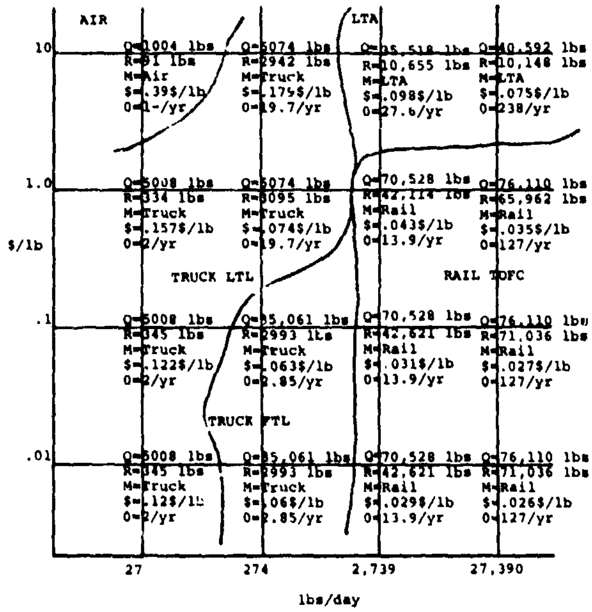


FIGURE 13. Optimal Inventory Strategy for the Case -

A PLANT CLOSEDOWN W/LTI.



To complete this analysis, the size of each market segment must be known. Without the size of each market segment, it is impossible to sum up the flows to determine overall tonnages by shipment size. In this case the market is a hypothetical one that might be compared with the one between New York and Los Angeles in distance, travel time, and transport rates. To get the sizes of each market segment some empirical work would need to be done. This would require more time and accessibility to data than we had available but should not be an impossible task.

CONCLUSIONS

Concept Viability

At this time it is difficult to conclude whether Lighter Than Air craft have a future or not. Certainly, lower costs per available ton-mile than those we have assumed here would make a stronger case for them. But, the terminal costs and performance are also important. They will closely reflect the care put into the design of an overall network. The problems associated with raising capital and obtaining hull insurance, et., will also be important. If a profitable concept can be found there will be a variety of environmental, institutional, and regulatory questions that will need to be addressed. There could well turn out to make or break the concept.

Thoughts for Further Marketing Research

The previous analysis has indicated that the LTA vehicle will perform best when the situation has the following characteristics: large annual volume resulting in relatively large LTA vehicles, relatively constant demand and directional balance causing high utilization, and origin to destination movements minimizing the use of feeder services. Existing modes of transportation have established markets with many of these characteristics. Further research, in part relying on the type of marketing approach described here, could determine which specific markets could be diverted to LTA vehicles.

In the maritime industry, neobulk shippers possess many of these characteristics. These shippers have too much volume per shipment to make it economical to use normal common carriers, yet do not possess enough cargo to make chartering an entire ship economically feasible. Specialized ships call on a network of such neobulk shippers offering them lower than normal prices on a contract basis with reliable service.

In the airline industry, shippers who charter entire airplanes for their freight on a regular basis could form potential markets for LTA vehicles. Agricultural products, especially fresh fruits and vegetables, are a possibility.

In the railroad industry unit trains of containers, either trailer-on-flat car (TOFC) or container-on-flat car (COFC) should be analyzed for possible diversion to LTA. The rail shipments differ from the air and water movements described above in that railroad (or the shipper using the railroad) normally provides a consolidation function prior to shipment.

Within these established markets, LTA vehicles could attempt to direct the higher value cargo from the ships and railroads and the lower value cargo from the airlines. If LTA vehicles were able to put together a network of customers, each shipping full LTA vehicle-load lots of cargo on a scheduled contracted basis (possibly on a direct origin to destination basis), the full economic potential of the LTA vehicle could be realized.

Analysis Needed

The type of analysis that must be conducted to determine the marketability of the concept is clear, however. It must address both supply and demand elements. It should start from a marketing concept to define the performance specifications for the system as a whole including terminal organization and operation. From this a detailed set of equipment costs and costs per ton-mile must be developed and translated into a rate structure. The concept can then be tested by using demand models to determine the choice of mode and size and frequency of shipment for each market segment. The market segments are then factored up to give the overall market share, revenues, costs, and overall profitability.

Once available the market analysis can be used with incremental changes to adjust the marketing concept to make it more profitable or attempt to find a concept that will be profitable.

REFERENCES:

1. Schneider, Lewis M., The Future of the U.S. Domestic Air Freight Industry, Harvard University, Graduate School of Business Administration, Boston, Mass. (1973).

2. Planning Research Corporation, Transoceanic Cargo Study, Los Angeles, Calif. (1971).

3. Southern California Aviation Council, Inc., Committee on Lighter-Than-Air Technical Task Force Report, Pasadena, Calif. (May 15, 1974).

4. Hunt, Jack R.; Levitt, Ben B.; Morse, Francis; Stehling, Kurt R.; and Vaeth, J. Gordon, "The Many Uses of the Dirigible," Astronautics and Aeronautics (October 1973).

5. Marcus, Henry S., "The Emerging Battle Between Containerships and Jumbo Jets," presented at the International Transportation Research Conference, Bruges, Belgium (June 1973).

6. Roberts, Paul O., "The Logistics Management Process as a Model of Freight Traffic Demand," prepared for the International Symposium on Freight Traffic Models, Amsterdam (May 1971).

7. Roberts, Paul O.; Hattock, Brock A.; and Collins, T. Jay, "Trains: A Computerized Transportation and Inventory System," Division of Research, Graduate School of Business Administration, Harvard University (June 1971).