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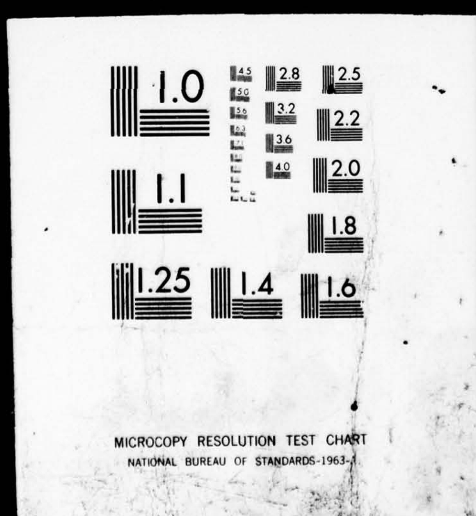

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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

THE APPLICATION OF
THE SURFACE EFFECT SHIP
IN U.S. OCEAN COMMERCE IN 1995

by

Richard Morten Joslin

December, 1978

Thesis Advisor: J. D. Horton

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This study evaluates the economic opportunities in 1995 of SESs (surface effect ships) in the carrying of commercial cargo in U.S. commerce, both foreign and domestic. The principal index of SES economic opportunity is the number of SESs that could be employed in U.S. commerce at freight rates that would cover costs of operations, plus a reasonable return on the owner's equity. Four routes of differing lengths and trade conditions

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The Application of the Surface Effect Ship in U.S. Ocean Commerce in 1995

by

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Submitted in partial fulfillment of the requirement for the degree of

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ABSTRACT

This study evaluates the economic opportunities in 1995 of SESs (surface effect ships) in the carrying of commercial cargo in U. S. commerce, both foreign and domestic. The principal index of SES economic opportunity is the number of SESs that could be employed in U. S. commerce at freight rates that would cover costs of operations, plus a reasonable return on the owner's equity. Four routes of differing lengths and trade conditions are studied; inter-Hawaiian Islands, New York to Puerto Rico, New York to Northwestern Europe, and San Francisco to Japan. Total U.S. foreign trade is projected as well as trade on the two domestic routes studied. Commodities potentially attractable to SES services are analyzed, and a modal split model is developed to estimate the SES market penetration potential under various conditions in competition with containerships and air cargo. An operational concept for SESs is developed and their freight rates and service characteristics are estimated.

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INTRODUCTION

A. BACKGROUND

SES (Surface Effect Ship) technology has been advancing rapidly and promises to perhaps provide transportation that is, in both speed and cost, intermediate to that of displacement ships and aircraft. The development of this high speed transport for commercial service may enable the United States to regain a degree of the maritime superiority it possessed immediately after WWII but has lost in the last two decades of national indifference to maritime affairs.

This long-awaited high speed fleet of the future took a giant step forward in December of 1976 with award to Rohr Marine, Inc. of a contract to design a 3,000 ton SES for the Navy capable of speeds up to 90 knots. The ship will be completed in 1982, according to current plans (1:32). Two years of sea trials will follow after the ship is delivered. The current SES R&D program had been initiated in 1967 at the request of the Maritime Administration. The Navy later joined the program in 1968. Due to rising cost, the Maritime Administration later dropped out of the program when the Office of Management and Budget refused additional funding for commercial applications.

Despite the U. S. experience, commercial feasibility of the SES has already been demonstrated in both the Soviet Union and Great Britain, where SES-type ships are now being used as high-speed ferries. Maritime Administration officials and representatives of the U. S. maritime industry are now waiting until the 3KSES is completed and all major R&D obstacles have been overcome, with the Navy footing the bill. After that, sometime in the mid to late 1980's, it is estimated commercial SES ships are likely to go into production with their integration into U. S. commerce by the mid 1990's.

The Carter Administration did try to delete the surface effect ship R&D program from the FY79 Budget, however, in May of this year the House of Representatives voted to restore the program. It left no doubt about its action, either, authorizing $93 million, or $400 thousand more than the Navy originally had requested. Asserting that the SES "represents a quantum jump" in the shipbuilding state of the art, the House committee report said the SES program "is this country's primary high-technology program that could provide a high-speed, eighty-knot and above, deep-water surface ship" for the post 1980 period (2:15).

B. OBJECTIVES

The objectives of this study were to identify trade areas suitable for SES operations, to evaluate the operational and economic feasibility of future SES commercial enterprises, to define vehicle and system operational support requirements, and to define and evaluate the national potential of the SES.

The study was undertaken to answer the following basic questions:

1. What will SESs do for the maritime industry? for the shipper? where?
2. What are the conditions under which the craft can be operated with a reasonable expectation of making a profit?
3. What type of operational support technology needs to be developed for the successful commercial implementation of this type of ship?

C. SCOPE

This study is principally concerned with waterborne cargo routes between U. S. ports or U. S. ports and foreign ports. Three categories of operations are examined: short range, medium range, and transoceanic. These routes generally represent specific routes of major potential cargo trade within the three categories of route distances. On the basis of study of these selected routes, total world potential for SESs in U. S. commerce has been developed for each of the three route categories.

The time frame selected for the study is 1995 because it was assumed, for purposes of defining SES potential, that the SES system could be a mature, competing transportation system by then. Thus, both trade and technology have been projected to 1995.

I. SES TRANSPORTATION SYSTEM

A. OPERATIONAL CONCEPT

The SES is analyzed in this study in the context of a total transportation system for commercial cargo. The SES transportation system is best described by considering its operational concept.

A typical SES configuration is shown in Figure 1-1. This ship uses rigid sidehulls, which contain the air cushion and also provide stability and some lift through their planning action. A flexible skirt is used on the fore and aft sections of the ship to complete the seal of the air cushion. Under ideal conditions, the ship can be driven at approximately 120 knots (100 knots is approximately the best speed to achieve minimum unit operating costs as will be later shown) by two water jets powered by marine gas-turbine engines. Other gas turbines turn lift fans, which supply the air cushion. For the purpose of this study, a 1000-3000 long-ton payload, 3000 nautical mile maximum range SES design was used.

The 1000-3000 long-ton payload of containerized cargo (for the SES shown) is carried in nine holds amidships. Each hold is sized for two levels of three 40-foot or six 20-foot long, 8-foot by 8-foot containers. Thus, total capacity is 54 forty-foot or 108 twenty-foot containers.

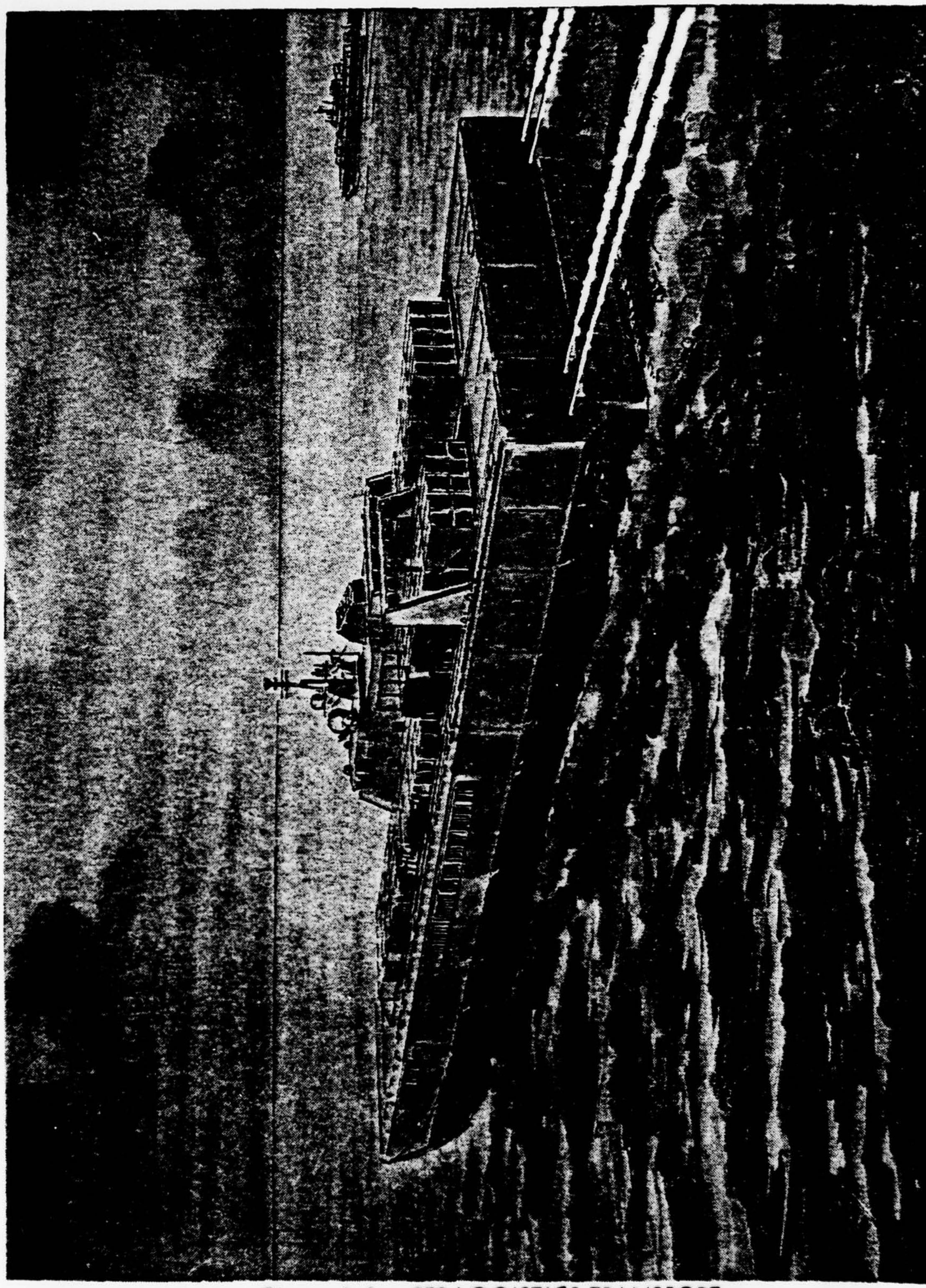

Figure 1-1 SES LOGISTICS TRANSPORT

The containers are loaded and unloaded vertically, in a manner similar to the method used in containership operations. An important factor favoring the use of vertically loaded/unloaded containers for cargo handling is the system's compatibility with current containership terminals. While the SES service could be established as a completely independent operation, it was believed that both special terminals and the establishment of new ground links for cargo access would be more of an overall cost detriment than a benefit to SES operations. It was further judged that the SES's best chance for success would be as an adjunct to existing containership operations, in providing a high speed, premium service for the portion of the total containership cargo that warrants this special service.

It is envisioned that the majority of SES-type cargo would arrive and depart the container freight station via common surface carrier. Thus, SES containers need not be truly intermodal, since they would only move between ports on SESs. Because of this aspect, the SES system could use lightweight containers typical of those being proposed for large scale airfreight operations. Such containers could be stacked two high.

Regarding the security of cargo within the SES, discussion with individuals knowledgeable of the anticipated SES stability, control, and seakeeping characteristics revealed that the SES is expected to provide a smoother ride than that provided by current displacement ships

(Ref. 3). This indicates that special packaging of shipments, other than normal containerization, will not be required.

A characteristic of the sidehull SES concept, which is addressed later in this chapter, is that its lowest operating cost is achieved in the range of 1000 to 1500 nautical miles. Beyond this range, operating costs increase because a larger ship is required in order to carry more fuel. Thus, midpoint refueling is required for the two long distance SES routes analyzed in this study. No refueling stops were considered necessary on the medium distance route between New York City and Puerto Rico, and on the short distance routes among the Hawaiian Islands.

The operating cost advantages of midpoint refueling will be described later in this chapter when overall SES operating costs are developed for each route. The additional shipping time necessitated by a refueling stop is relatively minor and SES market penetrations are not particulary sensitive to these short additional times as will be shown in chapter II.

The nominal least-cost cruise speed of the sidehull SES is approximately 100 knots. This means that automatic navigation, control, and collision avoidance systems will be required if the SESs are to operate safely in the waters off the major containership ports. These requirements are currently under study by the Navy for its 3KSES mentioned in the introduction of this study.

The remaining parts of this chapter discuss specific factors which affect SES operations. Achievable load factors are discussed first followed by data on weather and seas and their effects on SES operations. World harbors are briefly discussed and finally SES productivity and SES freight rates are developed.

B. ACHIEVABLE LOAD FACTOR

The load factor that an SES service might achieve is very important, as it directly affects freight rates. Load factor refers to the average load carried divided by the maximum design payload. Since most SES operating costs do not vary significantly with load, an SES that carries only 50 percent of its maximum capacity must charge twice as much per unit weight of cargo as one that carries a full load.

A number of independent factors affect the achievable load factor:

1. Container Tare Weights

Current intermodal marine containers weigh approximately three to four pounds per cubic foot of useable volume. If the SES system used special lightweight containers, such as those under consideration by the air-cargo industry, tare weights would approximate two pounds per cubic foot of volume. For those commodities for which the SES service tends to be the most attractive and which, as will be developed later, tend to represent the greatest proportion of SES traffic, an average minimum SES container tare weight would approximate 10 percent of the weight of the commodity as compared to 15 percent for current marine intermodal containers.

2. Monthly or Seasonal Variations in Traffic

Monthly or seasonal variations in traffic also directly affect the load factor. The reason is that the transportation service operator must provide capacity to meet peak demands. If he does not, buyers of his service will not rely on his capability of serving them and will seek other alternatives. The operator, thus, must make tradeoffs between the percent of peak demand he will attempt to meet and the resulting annual load factor. If he attempts to meet 100 percent of peak demand, the annual load factor will decrease. In a study done by Booz-Allen for the U. S. Department of Commerce, it was estimated that if the SES met 90 percent of peak demand, an average load factor of approximately 88 percent could be obtained with a reasonable maximum of six SESs on any one trade route (4:26). For the case where peak demand was met 75 percent of the time, the average load factor increased to approximately 93 percent. It was further estimated that most transportation services attempt to meet 90 percent of their peak demand requirements on the theory that their market will erode unless they can provide consistent service to their customers. Thus, the 75 percent cutoff point must be considered a very minimum approach.

3. Traffic Growth

If an increasing demand is to be met, new capacity must be added from time to time. When a new unit is added, it will cause a drop in load factor until full capacity is again reached and another unit is added. In the Booz-Allen study mentioned above, it was estimated that with a reasonable maximum of six SESs on any one trade route, an average load factor of 92 percent could be maintained with the addition of a new unit under conditions of increasing traffic growth. Using 3 SESs, which is considered the reasonable minimum on any trade route, would result in approximately an 83 percent load factor upon the addition of a new unit.

4. Daily Cargo Availability During the Week

The provision of frequent service will require that SESs sail several times each week. This may result in lower load factors because of the lower availability of cargo during certain times of the week. Although no specific data were available, based on information from officials of several commercial shipping lines (Ref. 5), a drop in load factors can range from 50 to 20 percent depending on the day during the week scheduled for sailing (higher rate less-than-container-load shipments tended to aggregate at the end of the week).

5. Achievable Load Factor

Combining the four effects on load factors, listed above, the following overall independent event load factors were computed, where:

Load Factor = (Tare Weight Factor)(Peak Demand Factor)(Traffic Growth Factor) (Sailing Day Factor):

Maximum Achievable Load Factor=(.90)(.93)(.92)(.95) = 73 percent

Probably Minimum Load Factor =(.85)(.88)(.83)(.80) = 50 percent

On the basis of these calculations, it appears that a practical maximum load factor may be 70 percent.

C. WEATHER

In completing the survey of potential SES routes, information on prevailing weather and wave heights was obtained. Brief descriptions of the weather patterns on the principal routes of interest follows:

1. North Atlantic Ocean

Winter weather in the North Atlantic consists of frequent widespread storms, with high winds and considerable snow or rain and some fog. This severe weather gradually diminishes to fairly calm conditions in summer, with only occasional storms. Fog, however, becomes quite prevalent along the east coast of North America. During the fall, the frequency of storms increases to its maximum, generally in December. These weather conditions are most severe at the higher latitudes and decrease substantially in the southern portion of the North Atlantic.

2. North Pacific Ocean

Northern routes across the North Pacific also are subject to frequent storms in the winter with much rain and wind. The frequency of storms is much lower in the southern parts of the North Pacific, i.e., on the routes between the U. S. and Japan via Hawaii. Storm activity decreases substantially in the summer months, but fog tends to be widespread in the North, while occasional violent tropical cyclones (typhoons) occur in southern waters.

3. Central American Caribbean Waters

Weather in this area generally remains quite mild throughout the year. Temperatures generally remain in the 70-85°F range. Gale winds (over 34 knots) tend to be infrequent, but do increase in frequency during the winter months. The most severe weather is associated with occasional tropical cyclones, which tend to begin occurring in June, and reach their peak activity in September.

4. Hawaiian Islands

Climatic features are tradewind influences throughout all seasons, variations in rainfall over adjacent areas, and uniform temperatures that vary slightly during the year. Thunderstorms and hail are infrequent; severe storms, such as hurricanes, are rare. Weather that interferes with shipping is rare; there is mist and rain rather than fog. Southerly winds (Konas) and accompanying weather on the leeward side of the islands occur between October and April, often including heavy rainfall and cloudiness. Near gale winds rarely occur.

D. EFFECT OF SEA HEIGHT ON SES OPERATIONS

In order to evaluate the effect of sea heights on SES schedules and fuel reserve requirements, an analysis was made as part of this study of the sea heights over a specific route to determine the variations in average and maximum sea heights. A route between New York and the English Channel was selected for the analysis because of the large quantity of information available.

A study of marine weather observations for the year 1974 was obtained from Commander, Naval Weather Service Command, Washington, D. C. (Ref. 6). The study covers the area of the North Atlantic Ocean that includes the North Atlantic Shipping Lane Routes. The output of the study is a record of the average wave height and maximum wave height encountered for each of a number of North Atlantic crossings.

To relate this wave height information to SES schedules and fuel reserve requirements, the effects of wave height on SES speed and range were estimated. This is shown in Figure 1-2 for the SES design addressed in the Operational Concept part of this chapter. Relative to the effect of average wave height on schedules, it can be seen that speed changes only about two knots per foot of change in average wave height up to ten feet for a given installed power. For the probable lowest operating cost design condition of 100 knots at a five foot average wave height, this means that only a 2 percent change in trip time is caused by a one-foot change in average wave height. Above 10 feet, speed changes about 3 knots per foot to 12 feet, 7 knots per foot to 14 feet, and 14 knots per foot to 20 feet (Ref. 3).

Using the average wave height data, the average schedule variations were computed as a function of the cumulative percent of average wave height. These data are presented in Table 1-1. Thus, it can be seen that schedule variations will exceed 5 percent less than 20 percent of the time. For wave heights greater than 14 feet on the normal trade route, schedule variations were minimized by plotting a more southerly circuitous route from data taken from reference 6 to enable the SES to maintain a higher operating speed through waves less than 14 feet in height. The higher wave heights occur mostly in the first quarter when traffic is generally less than average anyway. Thus,

TABLE 1-1

AVERAGE SCHEDULE VARIATIONS
VERSUS CUMULATIVE PERCENT OF AVERAGE WAVE HEIGHT

CUMULATIVE PERCENT OF TIME	AVERAGE WAVE HEIGHT (EQUAL TO OR LESS THAN)	AVERAGE SCHEDULE VARIATION (PERCENT OF SCHEDULE EQUAL TO OR LESS THAN)(2)
10	3.3 feet	-4.0 percent
20	3.8	-2.6
30	4.2	-1.8
40	4.6	-1.0
50	5.1	0
60	5.5	+1.0
70	6.0	+2.0
80	7.0	+5.0
90	14.0	+30.0
96	20.0(1)	+50.0
100	20.0	+50.0

(1) Maximum design wave height equal to 20 feet.

(2) Assuming a schedule design speed of 100 knots over 3,400 nautical miles, i.e., 34 hours.

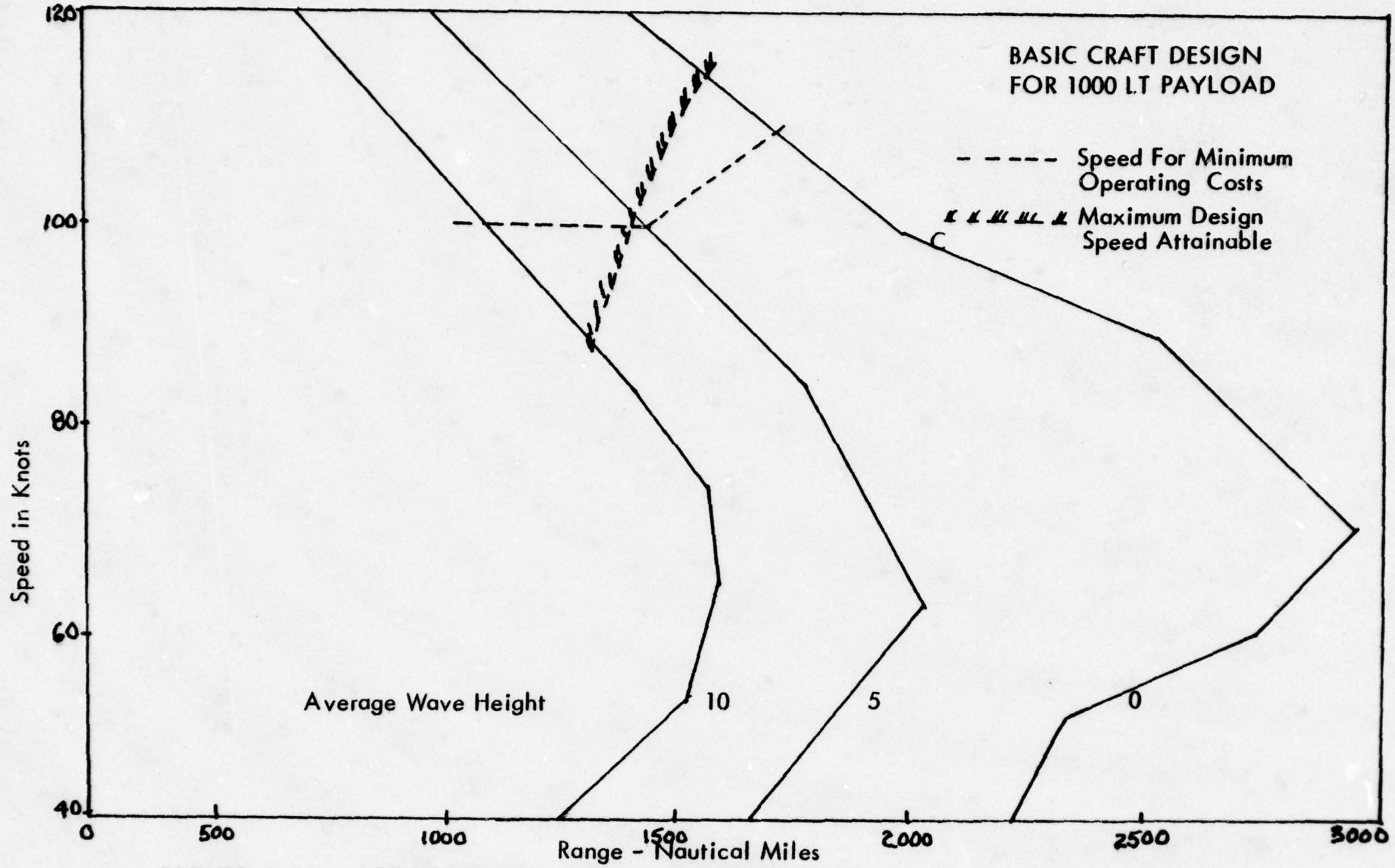

FIGURE 1-2 CRUISE SPEEDS VERSUS ACHIEVED RANGE FOR THREE AVERAGE WAVE HEIGHTS (Source: Ref. 10)

payloads would be lighter and the SES could achieve a slightly faster speed than normal through these higher waves. It appears that substantial schedule slack times are not required due to changing sea enviornments.

Relative to required fuel reserves, Figure 1-2 indicates that the effect of slowing due to heavier seas will not substantially decrease the achievable range, hence alleviating the need for substantial fuel reserves. With substantially improved satellite weather observation and forecasting systems expected in the 1990's, it is likely that sea conditions can be accurately forecast beyond the duration of a nominal SES voyage. Therefore, the minimum fuel reserve required by law of 25 percent (Ref. 7) is deemed satisfactory for most SES operations.

E. HARBOR FACILITIES

Pertinent information regarding the harbors and containership terminals on potential SES routes is summarized in Ref. 8. The Harbor facilities reviewed are as follows:

1. Dutch Harbor, Amaknak Island, Aleutians
2. Goteborg, Sweden
3. Kobe/Osaka, Japan
4. London (Tilbury), England
5. New York, New York
6. Oakland, California
7. Ponta Delgada, St. Michael's, Azores
8. Rotterdam, Holland
9. San Juan, Puerto Rico
10. Yokohama/Tokyo, Japan
11. Honolulu, Hawaii

As the SES does not require any particularly specialized major marine facilities, it appears that SES operations can be easily conducted around the world making use, as required, of existing containership marine facilities available in most major ports.

F. PRODUCTIVITY

SES productivity is defined simply as the annual tonnage an SES can carry over a given route. Factors affecting productivity include: payload, speed, distance, and various nonproductive activities such as refueling, port entry and exit, loading and unloading, schedule slack, and maintenance.

The productivity of a 1000-ton-payload, sidehull craft cruising at 100 knots is examined in the following paragraph for four route distances:

1. New York City-northwestern Europe route via the Azores, a distance of approximately 3,700 nautical miles;

2. Oakland-Japan route via Amaknak Island, a distance of approximately 4,900 nautical miles;

3. New York City-San Juan, Puerto Rico Route, a distance of approximately 1,400 nautical miles;

4. Honolulu-Kahuliu route, a distance of approximately 100 nautical miles.

Before developing possible SES productivities for each route, the various nonproductive times are discussed below.

1. Port Entry and Exit

Entry and exit of most major world ports requires the use of a licensed channel or harbor pilot, or both. Sometimes there is a delay in pilot availability. Harbor movements are slow, because maximum speeds allowed are in the 5 to 10 knot range. The SES could operate at minimal cruise speed up to the docks at the lower speeds. Assuming that the harbor is near open water, it would take about an hour on the average to enter or exit a major world port. For the Hawaiian Island ports that do not require a pilot and that are easily accessible from open water, the average port entry or exit time would be about one-half hour. Exceptions to the above would be London and Yokohama/Tokyo where reduced speed requirements would extend port entry and exit times to 2 and 4 hours respectively. An additional 2 to 3 hours would be involved in the clearing of customs/immigration/pratique upon arrival.

2. Loading and Unloading

A container crane normally is able to perform approximately 30 load/unload operations an hour thus being able to unload and load 54 forty-foot containers (1000 long tons) in about two hours (Ref. 9). Allowing an extra hour for delays in getting started, for removal and replacement of hatch covers, and other miscellaneous servicing tasks that might not be accomplished during actual unloading or loading, the total dock time is estimated at approximately three hours.

3. <u>Refueling</u>

Refueling during the three hour unloading/loading can be accomplished if the system is designed to use scaled-up high speed refueling techniques now utilized for aircraft. Present scale high-speed refueling for aircarft is done via a pressurized hose system instead of gravity feed. The rate is 300-500 gallons per minute. Scaled-up systems which could deliver 1000-1500 gallons per minute would allow refueling of the SES in two hours (fuel capacity 207,500 gallons minus 25 percent reserve onboard ÷ (2 x 60) = 1300 gallons/minute requirement). Capability to receive this rate of refueling of JP-5 is part of the SES design characteristics (Ref. 10) and present refueling capability at the two midpoint refueling locations would be readily adaptable. Midpoint refueling, however, will require added schedule time. An average estimate for midpoint refueling, including approximately one-half to one hour to enter and leave the refueling harbor, is three hours.

4. <u>Schedule Slack</u>

Slack must be built into any schedule so that small unplanned delays will not cause repeated late departures. For a system with rather long underway times subject to the variables discussed earlier (effect of the seas), a minimum schedule slack time of 5 percent appears satisfactory.

5. Additional Maintenance

Maintenance requirements of an SES are not well understood at present and have only been derived in gross terms for costing purposes on the basis of experience with aircraft and small air cushion vehicles. However, to focus on this potential problem area, and using the 100-300 long-ton payload, 3000 nautical mile maximum range SES design used in this study, approximately 18 maintenance manhours per operating hour are estimated (10:32). If one assumes that 75 percent of this (13.5 manhours) is associated with major periodic ship maintenance and inspections, then approximately 167 manhours (4.5 manhours x 37 operating hours) of maintenance time would be required per trip between New York City and Europe. Consequently, if maintenance was performed during unloading/loading times, refueling times, and some maintenance was performed by crew members, no additional maintenance time would have to be added to the schedule.

6. Total Schedule Times, Utilization, and Productivity

The one-way SES schedule times estimated on the basis of the time elements discussed above are summarized and totaled in Table 1-2 for the three major routes and the typical inter-Hawaiian Island route that were studied. An SES average cruise speed of 100 knots is used. The maximum possible number of trips per week is shown; however, this

TABLE 1-2

ESTIMATED ONE-WAY SES SCHEDULE TIMES
(1000 LT PAYLOAD)

SCHEDULE TIME ELEMENTS	NEW YORK CITY TO EUROPE	SAN FRANCISCO TO JAPAN	NEW YORK CITY TO PUERTO RICO	HONOLULU TO KAHULUI
Cruise at 100 knots (hr)	37	49	11	1
Port Entry/Exit (hr)	4-5	4-5	2	1
Sub-total operating time (hr)	41-42	53-54	13	2
Mid Point Refueling (hr)	3	3	0	0
Unload/Load (hr)	3	3	3	3
Sub-total (hr)	6	6	3	3
Schedule Slack (hr)	3	3	1	1
TOTAL	50-51	62-63	20	6
Maximum number of trips per week	3.5	2.8	8.4	28
Scheduled Trips Per Week	3	2	7	21
Annual Utilization(1) (hr)	5,900	6,400	5,600	3,200
Available Annual Productivity Per 1000 Long-Ton SES (Long Tons)	150,000	125,000	350,000	1,050,000

(1) Fifty weeks of operation per year

number is not believed to be realistic in terms of an actual schedule. It is postulated that SES sailings should be scheduled at the same day and time each week to achieve consistent scheduling from the standpoint of the shipper. Thus, the maximum achievable number of sailings per week has been adjusted to balance schedules. The annual utilization (i.e., the annual number of hours the SES is underway) and the productivity of the SESs operating on the balanced schedules are also shown. In determining annual utilization, it was assumed that the SES would be pulled out of service for major overhaul and inspection for two one week intervals each year. Productivity is expressed in the number of long-tons an SES can carry each year over each route.

G. DEVELOPMENT OF REQUIRED FREIGHT RATES

Total SES required freight rates consist of the following principal elements:

1. Directing operating costs (DOC)
2. Maintenance overhead
3. Administration and overhead
4. Port charges

1. Direct Operating Costs

Bell Aerosystems, the engineering subcontractor for the Stanford Research Institute, developed a series of

SES designs and their direct operating costs which were used by the Institute in a study performed for the Department of Commerce, Maritime Administration. These SES designs, their principal design factors, and their estimated direct operating costs are described in Ref. 10. Specific information is brought forward from that study to develop total SES operating costs.

Figures 1-3 and 1-4 summarize the direct operating costs related to achieved range for 1000 and 3000 long-ton payload SESs, respectively. Direct operating cost, as used for SESs, includes all costs of directly operating the SES (crew, fuel, maintenance, etc.) plus the costs of the capital invested in the SES and its spare parts.

All the curves in the figures were derived as variation from baseline craft designs using a 10 percent return on owners equity (ROE). This curve is the second one from the top in each figure. The Baseline craft represented Bell's best judgment as to the most likely achievable characteristics of a sidehull SES in 1990, based on what is known and postulated about future developments in SES marine technology. The lines below the baseline indicate lower DOCs that would be achieved if optimistic or "best" design or cost factors could be achieved. These estimates were also Bell's judgment as to what might optimistically be achieved by 1990. The optimistic design factors are used individually or in aggregation. The DOCs achieved when the optimistic cost factors were all used together

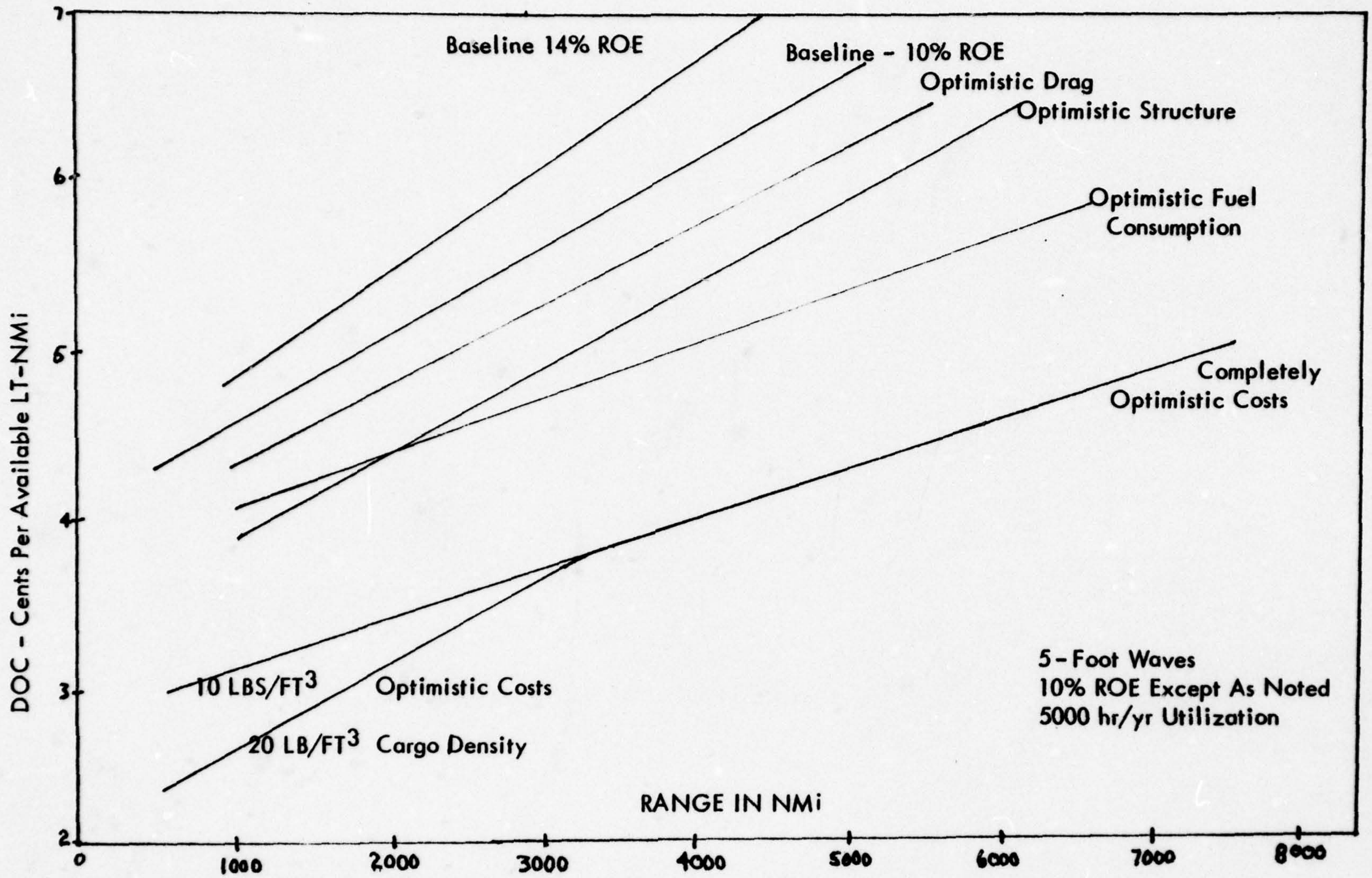

FIGURE 1-3 SES DIRECT OPERATING COST VERSUS ACHIEVED RANGE 1000 LT PAYLOAD

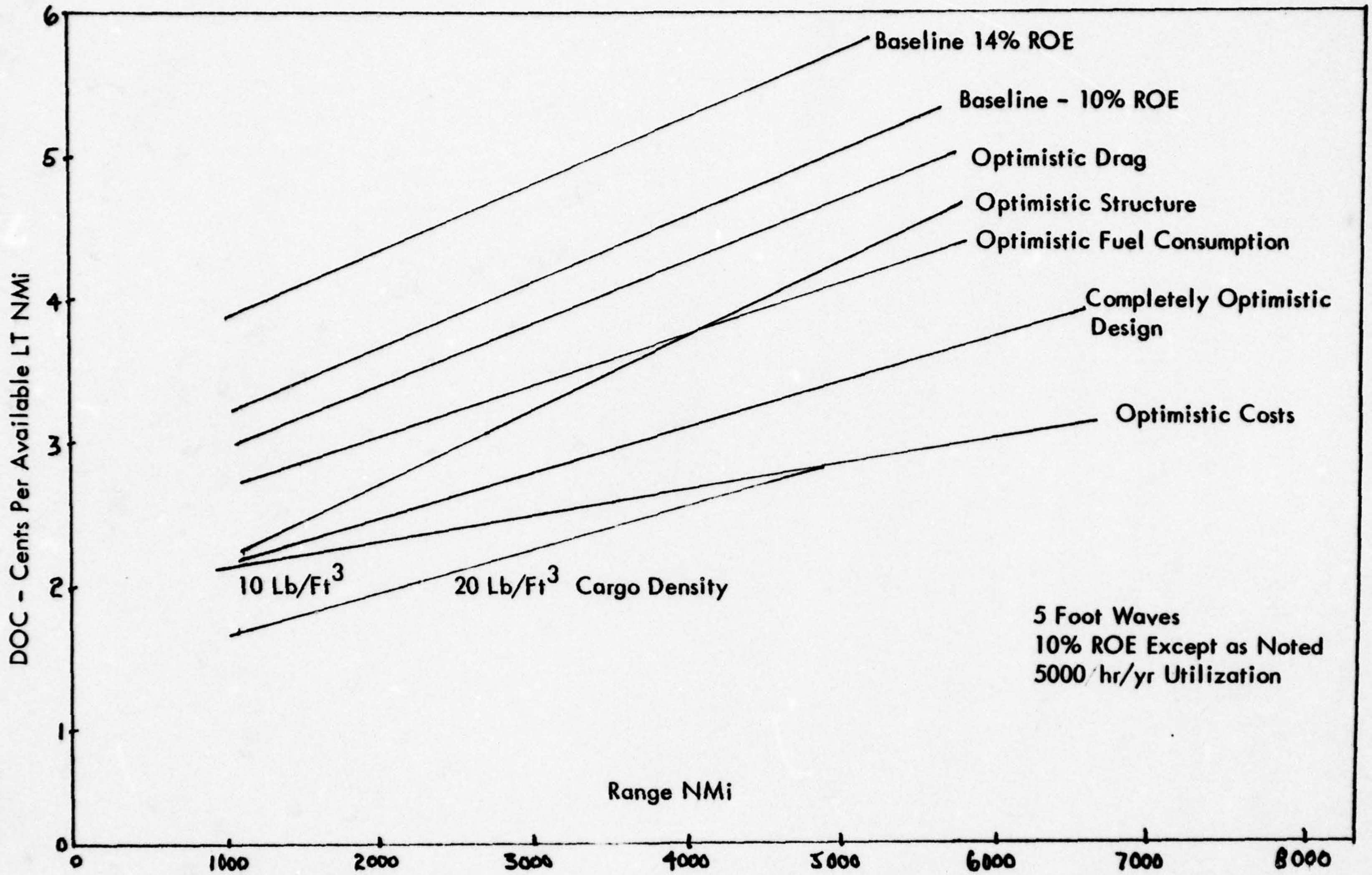

FIGURE 1-4 SES DIRECT OPERATING COSTS VERSUS ACHIEVED RANGE , 3000 LT PAYLOAD

are also shown by the bottom curve for two different cargo densities. A curve showing the baseline costs at 15 percent is also shown.

Since the DOCs shown were based on a 5000-hour annual utilization and a 5 foot average wave height, corrections must be made to derive DOCs for a specific route. These correction factors (which are multiplied by the uncorrected DOCs) are shown in Table 1-3. They were derived on the basis of data and computational methods presented in the Stanford Research Institute study. Increased utilization lowers the average capital cost, which generally represents about 40 percent of total DOC, by spreading it over a greater number of operating hours. This effect is seen on the major routes, where utilization has increased above 5000 hours. The reverse is true for the Hawaiian Island route. Changes in average wave height, of course, directly affect DOC.

Figures 1-3 and 1-4 also indicate the advantages of midpoint refueling on the Europe and Japan routes. The nonstop design range for the New York City-northwestern Europe route is 3400 nautical miles--as opposed to 2100 nautical miles--when refueling is accomplished in the Azores. If one uses either the completely optimistic design DOCs or the optimistic cost DOCs, a reduction of 12 percent is achieved for the shorter design range. This, together with a 2 percent reduction due to a lower average

TABLE 1-3

DOC CORRECTION FACTORS FOR VARIATIONS IN UTILIZATION AND WAVE HEIGHT (5,000 Hours/Year Utilization and an Average Wave Height of 5 Feet)

	NEW YORK CITY TO EUROPE	SAN FRANCISCO TO JAPAN	NEW YORK CITY TO PUERTO RICO	HONOLULU TO KAHULIA
Annual Utilization (hr) (Balanced Schedule)	5,900	6,400	4,600	3,200
Correction Factor	.96	.94	.97	1.17
Average Route Wave Height (ft)	4.5	6.5	4.0	2.0
Correction Factor	.98	1.03	.96	.94
Overall Correction Factor	.94	.97	.93	1.10

wave height on the southern route provides a small but worthwhile reduction in DOC even though the route is approximately 9 percent longer.

The refueling stop on the San Francisco-Japan route at Amaknak Island requires only approximately a one percent increase in distance while reducing design range from 4800 to 2850 nautical miles, and DOC by approximately 18 percent.

2. Maintenance Overhead

Maintenance overhead includes capital costs of facilities and administrative costs that are directly associated with the maintenance function. For airline operations, these generally represent a very small proportion of total operating costs. Since the SES will have some resemblance to aircraft in its propulsion system and lightweight structure, it was decided that application of the normal airline maintenance overhead of 180 percent of maintenance labor would be a satisfactorily realistic estimate of this expense item (Ref. 11). Estimated SES maintenance labor is approximately five percent of DOCs (10:32). Thus, maintenance overhead would be 1.8 x .05 or .09 of DOC.

3. Administrative and Overhead (A&O)

A&O expenses cover the overall management of SES operations, including advertising, sales, and commissions. Since SES operations may be conducted as an adjunct to an existing containership service, use of the same A&O rate seems warranted. This is 16.2 percent of total expenses (Ref.9).

4. Port Charges

Port charges are a relatively very minor expense item when specific ports are frequently used. Based on an average for the ports under consideration, a typical port charge for a 1000 long-ton SES would be approximately $1,000 per year plus $750 per call. Thus for 150 calls per year, port charges would be approximately $.80 per available long-ton of capacity.

5. SES Required Freight Rates

SES required freight rates may now be developed for each of the routes under consideration. These are shown in Table 1-4 for the baseline DOC estimates and for three sets of optimistic or "best" estimates. The formula used in deriving these costs is shown below and is based on the DOCs shown in Figures 1-3 and 1-4, the overall correction factors derived in Table 1-3, the A&O and maintenance overhead factors, and a 70 percent maximum realistic load factor.

Required freight rate =

$$\frac{(\text{DOC x Correction Factor})(1+\text{A\&O Rate})\left(\begin{array}{c}1+\text{Maintenance}\\ \text{Overhead Rate}\end{array}\right)}{\text{Load Factor}}$$

TABLE 1-4

SUMMARY OF SES REQUIRED FREIGHT RATES
AT 70 PERCENT LOAD FACTOR
(CENTS PER LONG-TON - NAUTICAL MILE)

		NEW YORK CITY TO EUROPE	SAN FRANCISCO TO JAPAN	NEW YORK CITY TO PUERTO RICO	HONOLULU TO KAHULIA
DESIGN RANGE (NMI)		2,100	2,850	1,400	100
PERCENT INCREASE IN COSTS DUE TO ADDITIONAL DISTANCE FOR MIDPOINT REFUELING		8.8%	1.3%	N/A	N/A
REQUIRED FREIGHT RATE (¢/LT-NMI)					
BASELINE	1000 LT	8.0	8.7	6.5	11.0
	3000 LT	5.8	6.4	4.6	---
BEST DESIGN	1000 LT	5.5	5.8	4.5	7.9
	3000 LT	3.9	4.2	3.1	---
BEST COSTS	1000 LT	5.3	5.7	4.3	7.4
	3000 LT	3.7	4.0	3.0	---
BEST DESIGN/ COST	1000 LT	3.7	3.8	2.9	5.3
	3000 LT	2.5	2.6	2.0	---

In deriving the required freight rates for the combined "best" design factors and "best cost factors, the "best" cost DOC was reduced in proportion to the ratio of the "best" design DOC to the baseline DOC. It should be noted that achieving all of the "best" design factors and all of the "best" cost factors must be considered a highly tenous possibility.

Without questioning the realism of combining the several "best" design factors, the rather low return on owner's equity can be seriously questioned with regard to the "best" cost factors. The rate used was only approxmately 10 percent when in fact the shipping industry in the recent past has been earning 11 to 12 percent on owner's equity before taxes. If the SES is to benefit the maritime industry, it should offer something better, say 14 percent or perhaps even 17 percent, to put new financial life and competitiveness into a declining industry and to attract new capital sources. The increase in required freight rate would be approximately 12 percent if the 14 percent return on owner's equity were achieved, and 20 percent if the 17 percent return were earned.

II. PROJECTION OF U. S. FOREIGN TRADE BY SES

A. INTRODUCTION

This chapter describes the potential of SES cargo transportation through an analysis and projection of U. S. foreign trade volume and the potential SES market share associated with it. The word market refers to the total volume of cargo that is potentially attractable to an SES service. Thus, the SES market excludes those commodities that have very low value or other characteristics that make them clearly not attractable to premium transportation.

In conducting the analysis the economic development and trade potentials of the present and future were analyzed first. For purposes of the analysis, the countries of the world were grouped into thirteen trade areas (regions as follows:

Region 1 Canada

Region 2 Mexico, Central America, and the Caribbean

Region 3 Northern South America

Region 4 Southern South America

Region 5 Western Europe and Scandinavia

Region 6 Western and Central Mediterranean and Central Europe

Region 7 Eastern Mediterranean

Region 8 Soviet Union, Eastern Europe, and Red China

Region 9 North and Northwestern Africa

Region 10 South and Southwestern Africa

Region 11 Indian Subcontinent, Persian Gulf area and East Africa

Region 12 Japan and Korea

Region 13 Southeast Asia and Oceania

U. S. foreign trade was analyzed by trade area, considering such factors as economic development and growth of U. S. foreign trade.

This analysis led to a total trade forecast for 1995 in dollars. The fundamental forecasts were made, in most cases, in dollar values rather than in tonnages because dollar values are generally more predictable. Estimates were made for the separate trade areas and for six principal commodity code groupings within each trade area.

Value-per-pound data were taken from the Statistical Abstract of the United States published by the U. S. Department of Commerce (12:51-56). Values were presented in the abstract for each commodity code group, by region, considering the different mixes of commodities that move between the United States and the different trade areas. From these, the total U. S. foreign trade forecast was converted to tons.

The final and key step was to obtain the SES market analysis. Here, the purpose was to develop the percentage of the total trade in specific commodities that might be attracted to the SES and then to estimate the fraction of the total SES market that would be captured by an SES service. Such an analysis was conducted by the Standford Research Institute (Ref. 13). Factors such as value, containerizability, perishability, fragility, density, size, and whether or not the products were shipped alive were considered in the percentage estimates developed in that study. The SES percentages were then applied to the trade totals to derive the SES market. Finally a modal split model was developed to determine the SES market share between air and displacement ship service modes.

B. A PROJECTION OF THE WORLD ECONOMY, 1976-1995

Based on the theory of competitive world markets, one generalization that can be made about world economic progress from now through 1995 is that it will not be uniform. In fact, it appears quite certain that the spectrum of economic successes and failures will continue to be quite broad. Economically, some countries will advance rapidly and others slowly.

To predict which countries will be in which stages of industrial development in the future is almost impossible, but the following represents a reasonable consensus of present opinion:

1. The most consistent economic progress will be made by mature economies such as those existing in the United states, Canada, Western Europe, and Japan.

2. The Communist countries will, by and large, show a fairly consistent growth during this period. Soviet Union and East European countries are moving into the mass consumption stage and this may provide an added stimulus to growth. Red China, through its recent overtures to Japan and other Western countries, may within the next 10 to 15 years achieve a stage of rapid economic growth.

3. A small number of lesser developed countries has recently been moving rapidly toward achieving mature economy status. Examples include Mexico, Venezuela, Taiwan, Spain, Israel, Korea and Indonesia.

4. Another group of lesser developed countries is somewhat distant from a period of rapid economic growth. The prospects in these countries are sufficient to warrant a prediction that within the next 10 to 15 years they will achieve a stage of rapid growth. Included in this group are Iran, Nigeria, Algeria, Saudi Arabia, and most of Latin America.

5. As for the remainder of the lesser developed countries, the outlook is for a continued slow rate of economic growth. This is true for most of the countries of Africa and some of Latin America and the Middle East Countries.

1. General Foreign Trade Implications Based on the Above Projections

Assuming that rapid expansion of foreign trade will proceed in parallel with rapid economic development, the following projections are considered reasonably accurate with respect to the areas that are likely to experience the most rapid increases in the volume of foreign trade and to the composition of that foreign trade.

a. Southeast Asia (Primarily Taiwan, Phillippines, Hong Kong, Korea, and Indonesia)

To some extent, this geographic area may duplicate the experience of Japan during the 1960's. These countries require raw materials and heavy industrial equipment; in turn, they are likely to become substantial exporters of all types of consumer goods and other manufactured products.

b. Mediterranean Area (Primarily Spain, Portugal, Yugoslavia, Turkey, Greece, and Israel)

This area is developing a very substantial industrial base as well as a strong tourist economy. Most of these countries need industrial raw materials and production equipment and can be expected to export consumer goods.

c. Mexico and Caribbean Area

The rapid economic development of Mexico as well as a continued expansion of tourism in the Caribbean area will lead to a very rapid expansion of trade with the United States. Trade with the Caribbean area will consist primarily of exports from the United States. Increased trade between Mexico and the rest of the world will be concentrated in manufactured goods and petroleum products.

d. South America (Primarily Brazil, Venezuela and, to a lesser extent, Peru, Chile, and Columbia)

These countries are developing their raw material resources, which should contribute to expansion of foreign trade. Also, during this period, this area should begin to export manufactured products to the rest of the world. Imports will consist primarily of raw materials and production equipment.

e. Soviet Union and Eastern Europe

East-West trade will continue to expand rapidly. Primary imports sought by the Communist bloc will be industrial equipment. Exports will include all types of commodities, raw materials, consumer goods, equipment and the like.

f. Middle East (Primarily Iran, Kuwait, Libya, Saudia Arabia, and the United Arab Republic)

Due to the tremendous influx of capital from the export of petroleum, these countries should experience very rapid economic growth. These countries require raw materials, heavy industrial equipment, many types of commodities, and consumer goods.

While the countries and regions described above are likely to experience the greatest expansion in foreign trade, the foreign trade of developed countries will continue to expand and, in 1995, trade among the mature economies (U. S., Canada, Japan, and Western Europe) will still represent the largest portion of total world trade, with the possible exception of some of the Middle East Countries.

2. <u>Basis for Projection of U. S. Foreign Trade Volume through 1995</u>

U. S. Foreign trade volume has maintained a fairly stable relationship with GNP since WWII (14:321). The U. S. economy has expanded enormously during this time; foreign commerce has done the same (14:721). However, within this steady overall growth, there have occurred a number of significant changes in foreign trade with respect to (a) composition by commodities, and (b) composition by destination.

a. Composition by Commodities

U. S. foreign trade statistics are based on the Standard International Trade Classification (SITC), which specifies ten commodity codes numbered from 0 to 9. They are:

0	Food Items	Major Raw Material Codes
2	Basic Raw Materials	
3	Mineral Fuels	
4	Animal and Vegetable Oils and Fats	
1	Tobacco, Tobacco Products and Beverages	Major Manufactured Goods Codes
5	Chemicals	
6	Manufactured Materials	
7	Machines and Transport Vehicles	
8	Manufactured Products	
9	Miscellaneous, not otherwise Classified	

With respect to the U. S., in 1967, the top import commodity groups were Code 6, 7, and 0, respectively.

Raw materials accounted for 9.3 billion or 34 percent and manufactured goods accounted for 16.4 billion dollars or 61 percent of total U. S. imports. By 1976 raw materials accounted for 42 billion dollars or 35 percent and manufactured goods accounted for 78 billion dollars or 65 percent of imports. Since 1949, the composition of U. S. imports of raw materials and manufactured goods has changed drastically. In 1949 the proportions were almost reversed from what they were in 1976, with raw materials accounting for 66 percent and manufactured goods for 33 percent of imports. Of the raw materials categories, only Code 3 has shown substantial growth. Among manufactured commodity groups, all have increased substantially (14:720).

The export side experienced a similar drift. During 1967, export of major manufactured commodities accounted for 69 percent and in 1976 for 74 percent of the export total, and raw materials for 29 and 26 percent respectively. In 1949, exports in the major manufactured commodities amounted to 60 percent, while exports of raw materials amounted to 38 percent (14:719).

The major factor in the increase in foreign trade since the end of World War II has been the growth in trade in manufactured commodities among industrialized countries. This fact is substantiated by the above.

b. Composition by Regions

U. S. foreign trade with Canada (Region 1) and Mexico, Central America, and Caribbean (Region 2) have expanded in line with total foreign trade growth. In the case of Region 1, however, the growth has been more rapid.

For Regions 3 (Northern South America) and 4 (Southern South America) the situation is quite different. Both imports and exports have been relatively constant with the exception of Venezuela, where large petroleum shipments have resulted in exports to the United States of nearly 135 percent of imports (14:721).

U. S. trade with Regions 5 (Western Europe and Scandinavia) and 6 (Western Mediterranean and Central Europe) have expanded rapidly since the early 1950's. While the expansion has covered both imports and exports, U. S. imports from Region 5 have increased at a somewhat faster rate than exports.

U. S. trade with Region 9 (North and West Africa) and Region 10 (South Africa) have shown only limited growth, with the exception of the petroleum producing countries of Nigeria, Libya, and Algeria.

U. S. exports have also grown rapidly in trade with Region 11 (India, Pakistan, East Africa, and the Persian Gulf). The increase was caused primarily by food, grain, and machinery shipments to India and Pakistan and manufactured products to Iran. Imports to the United States grew less rapidly with the exception of Saudi Arabia where imports (POL) were 186 percent of exports (14:721).

U. S. trade with Region 12 (Japan and Korea) has shown the fastest rate of growth among all the areas, primarily as a result of trade expansion with Japan. Since 1965, imports have exceeded exports by a margin of 3 to 2 with Japan while trade has remained almost equally balanced with Korea (14:721).

Trade with Southeast Asia and Oceania has grown significantly since 1960. Before 1960, there had been little change.

2. Significant Conclusions

Based on past trends, the following conclusions were reached in assessing the future course of U. S. foreign trade.

The past trend toward U. S. imports and exports of manufactured goods being a significantly larger percentage of foreign trade than raw materials will continue, though perhaps at a less accelerated pace. (1) The reasons for this conclusion include the continuation of differential price movements between manufactured goods and raw materials, which result from the substitution of manmade raw materials for natural raw materials, and the continuation of the trend toward miniaturization, which results in the use of less raw materials.

With respect to the geographic pattern of U. S. foreign trade, it is likely that the bulk of such trade will

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[1] Available data indicate a probable real growth rate of GNP of 4 percent per year through 1995. The volume of Imports/Exports growth should follow this trend.

continue to be with other industrialized nations. Western Europe, Canada, and Japan will continue to be the primary trading partners of the United States.

While U. S. trade with the three major regions mentioned above will expand in the future, trade with other areas will show a more rapid increase. The primary candidate regions for major expansion of trade are 2, 6, and 13. To a lesser extent, the increase in U. S. trade with regions 3 and 11 may also be above average. U. S. trade with all other regions will continue to be of lesser significance.

C. A PROJECTION OF U. S. FOREIGN TRADE BY REGION AND COMMODITIES FOR 1995

Given the obvious difficulty of preparing a detailed projection to 1995 of all U. S. exports and imports by commodity codes and destination, for the purpose of this analysis the projection was limited, first, to only those regions that, from the point of view of export and import value, are likely to be significant U. S. trade partners in 1995 and, second, to those broad commodity codes that contain predominantly high value goods. The projections made are presented as reasonable assumptions rather than as well documented projections.

Of the 13 regions discussed earlier, seven account for more than 85 percent of present U. S. foreign trade volume (Ref. 14). On the basis of the analysis made here, these seven regions will account for at least as great a share of

U. S. foreign trade in 1995 as they do now, and probably more. Further more, these seven regions will account for an even more preponderant share of the two-way high value foreign trade projected for the U. S. in 1995. The regions selected for analysis are:

Region 1 Canada

Region 2 Mexico, Central America and Caribbean

Region 3 Northern South America

Region 5 Scandinavia and Western Europe

Region 6 Western Mediterranean and Central Europe

Region 11 Japan and Korea

Region 13 Oceania and Southeast Asia

For each of the above regions, a tentative projection of total U. S. regional foreign trade in 1995 was made with the exception of Regions 1 and 2. These two areas, which represent a significant proportion of trade and were thus included in the earlier forecast, have little waterborne trade with the United States (with the exception of Region 1 Great Lakes Shipping).[2] Hence, they have been excluded in further calculations leading to derivation of the SES market share. In addition, a breakdown has been made of the five product categories that contain most of the manufactured or perishable commodities for which a shipper should be willing to pay a premium rate for faster transportation. These are code 1 (tobacco and beverages),

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[2] As this study only addressed ocean commerce, SES application on the Great Lakes was not considered.

code 5 (chemicals), code 6 (manufactured materials, code 7 (vehicles and machinery), and code 8 manufactored products). The remaining commodity codes have been grouped into an "all other codes" class.

1. Region 3 (Northern South America)

U. S. trade with Region 3, which currently amounts to 4 percent of total U. S. foreign trade, is assumed (see Table 2-1) to remain at that same percentage level in 1995. At present, U. S. trade with that region is quite unbalanced. A very large proportion of U. S. imports consists of petroleum and petroleum products and iron ore, while exports are primarily manufactured products.

Growth in U. S. imports will occur as raw material imports are increased, and as industrial production in Venezuela and Colombia grows to provide for some exports from those countries. To be noted is that U. S. imports from Region 3 contain some food products suitable for containerization.

The projected growth in manufactured exports will occur primarily in code 7. The projected growth in manufactured imports is expected to occur primarily in chemicals and manufactured materials.

Table 2-1

U. S. FOREIGN TRADE WITH REGION 3[3]
(Billions of Dollars)

	Commodity Codes							
	1	5	6	7	8	Subtotal	All Other Codes	Total
1976 U.S. exports	0.1	0.4	0.3	1.5	0.3	2.7	0.3	3.0
1995 U.S. exports	0.2	1.2	0.6	3.7	0.6	6.3	0.4	6.7
1976 U.S. imports	*	0.3	0.1	*	0.1	0.5	3.5	4.0
1995 U.S. imports	8	0.6	0.1	8	0.2	0.9	6.0	6.9

* Insignificant; less than 10 million dollars

2. Region 5 (Scandinavia and Western Europe)

The assumptions underlying the projections of U.S. foreign trade with Region 5 (shown in Table 2-2) include the following:

1. U. S. trade with Western Europe will expand at less than the average rate (4 percent per year).

2. The rapid growth of imports from Region 5 will continue with the result that by 1995 there will be a moderate trade surplus in favor of Western Europe.

3. Raw materials, primarily grain and certain industrial raw materials, will continue to represent a

[3] 1976 figures are taken from Ref. 12; 1995 figures are projections based on historical and forecasted economic trends.

significant proportion of U. S. exports. On the other hand, the proportion of U. S. imports that are manufactured products will continue to remain high.

4. No significant change in the mix of U.S. manufactured exports is projected; however, among manufactured imports, commodity codes 5 and 7 are expected to show the greatest growth.

Table 2-2

U. S. FOREIGN TRADE WITH REGION 5[4]
(Billions of Dollars)

	Commodity Codes							
	1	5	6	7	8	Subtotal	All Other Codes	Total
1976 U.S. exports	0.9	1.8	1.7	6.3	1.3	12.0	6.0	18.0
1995 U.S. exports	1.5	2.7	2.7	11.0	2.3	20.2	10.4	30.6
1976 U.S. imports	0.8	1.0	4.7	5.8	2.4	14.7	2.7	17.4
1995 U.S. imports	1.6	2.7	9.3	11.7	6.2	31.5	2.5	34.0

3. Region 6 (Western Mediterranean and Central Europe)

The share of Region 6 in U.S. total foreign trade is assumed to increase from 6 percent to 7 percent in 1995 (see Table 2-3). The primary reason for this projection is that Italy, Spain, Switzerland, and perhaps Portugal are expected

[4] 1976 figures are taken from Ref. 12; 1995 figures are projections based on historical and forecasted economic trends.

to show a rapid economic growth through 1995. Industrial development in those countries is proceeding rapdily and much of this development is export directed.

It is also assumed that imports from Region 6 will grow faster than U. S. exports to those countries, with the result that the region will develop a trade surplus with the United States.

Most of the increase in manufactured exports is expected to occur in Commodity Code 7. In manufactured imports, codes 6, 7, and 8 are expected to receive the bulk of the increase.

TABLE 2-3

U. S. FOREIGN TRADE WITH REGION 6[5]
(Billions of Dollars)

	Commodity Codes							
	1	5	6	7	8	Subtotal	All Other Codes	Total
1976 U.S. exports	0.2	0.5	0.5	2.3	0.5	4.0	3.2	6.2
1995 U.S. exports	0.2	1.2	1.2	4.3	1.2	8.2	3.2	11.4
1976 U.S. imports	0.1	0.3	0.8	1.2	1.4	3.8	0.7	4.5
1995 U.S. imports	0.1	0.9	2.1	3.6	3.9	10.6	1.8	12.4

4. Region 12 (Japan and Korea)

U.S. trade with Region 12, which has expanded very rapidly since 1953, will continue to grow rapdily for the

[5] 1976 figures are taken from Ref. 12; 1995 figures are projections based on historical and forecasted economic trends.

next 20 years. It is postulated that U. S. trade with Region 12 will amount to 15 percent of total U. S. trade in 1995, the same proportion of total U.S. trade as occurred in 1976.

U. S. exports to Japan, in particular, and also to Korea include a large proportion (see Table 2-4) of raw material exports, grain, cotton coal, and phosphate. In contrast, practically all of the region's exports to the United States consist of manufactured goods. It is predicted that the same imbalance will persist in the future, even though U.S. manufactured exports will probably increase.

The bulk of the increase in manufactured exports will occur in Commodity Codes 5 and 7. In manufactured imports, the largest increases will occur in Codes 7 and 8.

Table 2-4

U. S. FOREIGN TRADE WITH REGION 12[6]
(Billions of Dollars)

	Commodity Codes							
	1	5	6	7	8	Subtotal	All Other Codes	Total
1976 U.S. exports	0.2	1.6	0.8	3.0	0.4	6.0	6.0	12.0
1995 U.S. exports	0.2	4.2	1.6	7.5	0.8	14.3	10.0	24.3
1976 U.S. imports	*	0.5	5.0	5.5	5.5	16.5	1.5	18.0
1995 U.S. imports	*	0.8	6.0	10.0	11.0	27.8	3.0	30.8

* Insignificant; less than 10 millions dollars

6 1976 figures are taken from Ref. 12; 1995 figures are projections based on historical and forecasted economic trends.

5. Region 13 (Oceania and Southeast Asia)

U. S. trade with Region 13 will grow at a rate considerably greater than the average growth rate of 4 percent. The basic reason for this projection is that it is assumed that such countries as Taiwan, Indonesia, the Phillippines, as well as Australia, and New Zealand will lrow at a rate faster than the average economical growth rate. As a result U.S. trade with these countries is likely to expand very rapidly. In terms of exports to the United States, many of the countries included here are likely to participate in replacing Japan as the traditional exporter of inexpensive consumer goods to the United States (see Table 2-5).

Table 2-5

U. S. FOREIGN TRADE WITH REGION 13[(7)]
(Billions of Dollars)

	Commodity Codes							
	1	5	6	7	8	Subtotal	All Other Codes	Total
1976 U.S. exports	0.4	0.9	1.1	4.4	0.4	7.2	3.2	10.4
1995 U.S. exports	0.8	2.1	2.2	9.0	0.4	14.5	9.0	23.5
1976 U.S. imports	*	1.0	3.0	0.8	3.2	8.0	4.0	12.0
1995 U.S. imports	*	3.3	10.0	2.1	8.6	24.0	5.0	29.0

* Insignificant; less than 10 million dollars

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7 1976 figures are taken from Ref. 12; 1995 figures are projections based on historicaland forecasted economic trends.

At the same time, it is assumed that U. S. exports of industrial equipment to region 13 will expand considerably to facilitate the economic growth of this area. Again, a significant amount of the "raw material" imports from this region include food products that can be shipped in containers. Thus the balance of potential containerized shipments of exports and imports should be fairly close.

Most of the increase in manufactured exports will occur in Commodity Code 7. In manufactured imports all categories will experience substantial growth, with the exception in Codes 6 and 8.

D. SES MARKET ANALYSIS

This section describes the method used to estimate the fraction of the total SES market that would be captured by an SES service. First, a general discussion of the commodities and shipments that are likely to require premium transportation is presented. This is followed by a discussion of the method used in the Stanford Research Institute (SRI) study to develop data to serve as a basis for designing a modal split model. Finally, development and application of the model is discussed.

1. Appraisal of Factors Affecting SES Penetration

Shippers of most commodities that could move in world trade will find the benefit of the premium speed of

SES service is not justified by its higher cost. These shippers will choose conventional transportation. Others will place an even higher premium on speed and will choose air movement. The essential question to be answered is: "Are there shipments of commodities that would be attracted to a service whose costs and speeds are intermediate between those of air cargo and conventional surface shipping?"

Previous research, Refs. 15 and 16, has identified a number of factors that may influence the decision to use a premium form of transportation. These factors are discussed below. They are not all mutually exclusive; they tend to overlap and to exist in combinations with respect to particular shippers and commodities. The concept of total distribution costs is also discussed in this section.

a. High Value

In considering products that are likely to be shipped at high transportation rates, one has a tendency to think of products having a high value per pound. This is natural in view of the fact that many of the products now shipped by air do have this characteristic and because the rates charged by surface carriers, both inland and ocean, tend to be higher for high value products than for low value products. However, closer analysis indicates that it cannot be concluded from these facts alone that high value products are inherently potential cargo for an SES service at premium rates.

The more closely the services offered by a group of carriers resenble each other, the more difficult it is for the carriers to charge different rates, since shippers will abviously select the lowest rate and shift their traffic from carriers having higher rates. It is only when a particular service appears better than others in the eyes of shippers that higher rates can be charged. The important question is whether the value of SES service will appear to the shippers of high value goods to be greater than the value of conventional surface service.

The possible savings associated with high value shipments are a reduction in inventory investment and/or a reduction in idle time associated with the movement of a costly asset such as a computer. With the exception of a few items of extremely high value per pound, it is difficult to find examples in which a few days' reduction in inventory investment alone will justify a significant transportation cost differential. Other factors, such as the storage characteristics of the product and lead time required by suppliers to replenish stocks, are usually more important in determining the relationship of transportation speed and cost to other aspects of inventory management. Thus high value alone is seldom sufficient reason to move a product by premium transportation.

b. Perishability

For commodities that have a short useful life, speed in transportation is essential. Even though the freight rate may be high, fast transportation may be less costly overall because of the losses that would otherwise be sustained through product deterioration during slower service. Examples of perishable cargoes are fresh foods, flowers, and nursery stock. An item amy also be considered perishable due to its rapid obsolescence in its particular market. Examples of this type of perishability are high sytle clothing, merchandise to be featured in a special sales promotional event, and merchandise that may be sold only during a particular selling season or holiday period.

c. Unpredictable Demand

Reorders of goods within a selling season may be considered a type of perishability that leads to the use of fast transportation. Such reorders arise largely as a result of an unpredictable amount of demand for the items reordered. There are also other circumstances that lead to the use of premium transportation because the time at which demand occurs is unpredictable. A prominent example is repair parts for machinery and equipment. In such cases it is more economical to pay a premium price for fast transportation of replacement parts than to maintain local inventories of these parts and incur the cost of warehousing, preservation, accountability, and capital investment.

d. Emergencies

A common reason for using airfreight cited by shippers is "emergencies," by which they describe a variety of situations. Scheduled shipments may be delayed, lost, or damaged, leading to a sudden need for a replacement. Work stoppage anywhere along the line of supply may require unusually fast shipment to enable planned operations to continue. Casualty losses of various kinds lead to sudden needs for repair and replacement materials. Rush orders to maintain market position with customers, whatever the cause, are viewed as emergencies by suppliers and often lead to the use of premium transportation.

e. Savings in Shipping Costs Other Than Rates

The reasons often cited for using airfreight include savings in the costs of packing, pilferage, breakage, and insurance over the costs that would be experienced on shipments via other types of carrier. A well run SES service should share these characteristics of airfreight to a considerable extent.

f. Total Distribution Cost in Logistics Management

In theory, shippers should make mode choices on the basis of maximizing profit. Generally this rule would mean selecting the mode that has the minimum total distribution cost. The components of total distribution cost include the costs of transportation, warehousing, inventory, security, shortage and damage, packing and packaging, materials handling, and distribution administration. Proponents of airfreight are increasingly successful in demonstrating how a total distribution system cost orientation can lead to overall economies when using premium transportation. Such arguments also hold, in principle, for SES service as well.

E. MODAL SPLIT ANALYSIS

1. Modal Split Data

Three alternative approaches were considered to collect data for development of an SES modal split model.

The first would have entailed analysis of a large number of actual shipments. This approach was not adopted because of the magnitude of the process and the time constraints on this study.

The second approach would have entailed an analysis of the judgements of shippers as to the conditions under which they would choose an SES service. Interviews with a representative number of shippers revealed that most could not easily visualize the benefits that an in-between service such as an SES would provide.

The approach finally chosen was to make use of a study by SRI (13:Chap.9). In this study, analysts representing the fields of naval architecture and marine operations, ocean shipping, aviation economics, aviation systems and operations, international trade, and industrial economics were given a series of case problems concerning shipments of SES commodities that were to be apportioned among air, sea, and SES transportation modes. The case problems studied included movements in each of the six commodity code groupings described in the previous section and on trade routes between the United States and Europe, Japan, and Puerto Rico from coastal and inland U. S. origin points.

The trade routes studied were:

1. Philadelphia, Pa. to San Juan, Puerto Rico
2. Newark, N. J. to Amsterdam, Netherlands
3. Chicago, Ill. to Frankfurt, Germany
4. Stockton, Calif. to Tokyo, Japan
5. Detroit, Mich. to Tokyo, Japan

For each of the five geographical areas presented, the following three potential SES services were considered from both an optimistic (only a 10 percent chance the SES movement would be greater) and pessimistic (only a 10 percent chance the SES movement would be less) basis:

1. Air cargo and containership versus 100 knot, low cost SES
2. Air cargo and containership versus 80 knot, medium cost SES
3. Air cargo and containership versus 60 knot, high cost SES

Therefore, each analyst developed 180 independent estimates of SES cargo volume based on 30 case problems (5 areas x 3 services x 2 attitudenal variables) for each of 6 commodity groups.

Some of the factors considered by the analysts besides time and cost were value per pound, frequency of emergencies, packaging requirements, total size of shipment, fragility, and perishability. The analysts were also provided data on the variation in the percent of commodity movement by air, as a function of the distance between origin and destination. The data reflect the fact that, because the difference between the air and the sea rate increases as the distance increases, few commodities can accomodate the greater premium for air transportation over long distances.

Based on the foregoing data, the analysts estimated the SES fractions for the various cases using the modal split model described below. The SES fractions represent the estimated percentages of the total U. S. import and export market that would be attracted to the SES service if it were made available.

2. Development of the Modal Split Model

Over twenty different mathematical formulations of a modal split model were postulated. The analysits' estimates were analyzed both individually and in total; thus, for each commodity grouping seven kinds of models were developed: six using individual data from each of the six analysts, and one for the estimates of all analysts combined. Standard multiple regression techniques were used, and the runs produced estimates of the values of the parameters of the model. Also, corrected R^2 values (the square of the correlation coefficient) and the ratios of the standard error of the parameter to the value of the parameter were computed. The values of R^2 for the models of the individual analysts were quite high, generally in the range of 0.8 to 0.95. The values of R^2 for the models representing the combined data were significantly lower, indicating that the analysts differed substantially in their estimates. These values generally range between 0.3 and 0.4.

Both theoretical and empirical considerations were employed in the selection of the best model. Theoretically, a model should display characteristics that agree with economic and mathematical principles. Empirically, various indicators were used to compare the models, including a measure of the degree of agreement between the SES fraction computed by the model and the average of the analysts' estimates of the SES fraction for each case. If the SES fraction computed by the model agreed closely with the analysts' average, it rated highly on this criterion.

The modal split model finally adopted has the following form:

$$\begin{aligned} P = \ & + B_1 \ln T_s + B_2 \ln C_s + B_3 \ln(C_a - C_s) + \\ & B_4 \ln(T_s - T_a) + B_5 \ln(T_c - Ts) + \\ & B_6 \ln(C_s - C_c) \end{aligned}$$

Where: P_s = The SES fraction of the total market

T_s = Door to door SES travel time

T_a = Door to door air travel time

T_c = Door to door containership travel time

C_s = Door to door SES cost

C_a = Door to door air cost

C_c = Door to door containership costs

and the Greek letters Alpha (α) and Beta (B) are the location constant and the regression coefficients that were estimated in the multiple-regression. It is from the application of this model that the SES market fractions utilized in Table 2-6 were derived. Figure 2-1 presents curves of the SES fraction generated by the model for one of the case examples, Newark, N. J. to Amsterdam. These curves represent the optimistic and pessimistic estimates for commodity code 8. The time and cost of the air and containership services are 1 day and 9.4 cents per pound, and 8 days and 3.2 cents per pound, respectively. For example, an SES service with a 4-day travel time and a 6 cent per pound cost would capture, optimistically, approximately 30 percent and pessimistically, about 16 percent of the market.

F. DERIVATION OF TONNAGES OF SES POTENTIAL COMMODITIES

In Tables 2-1 through 2-5, a dollar value is listed for both imports and exports for each of the six commodity code

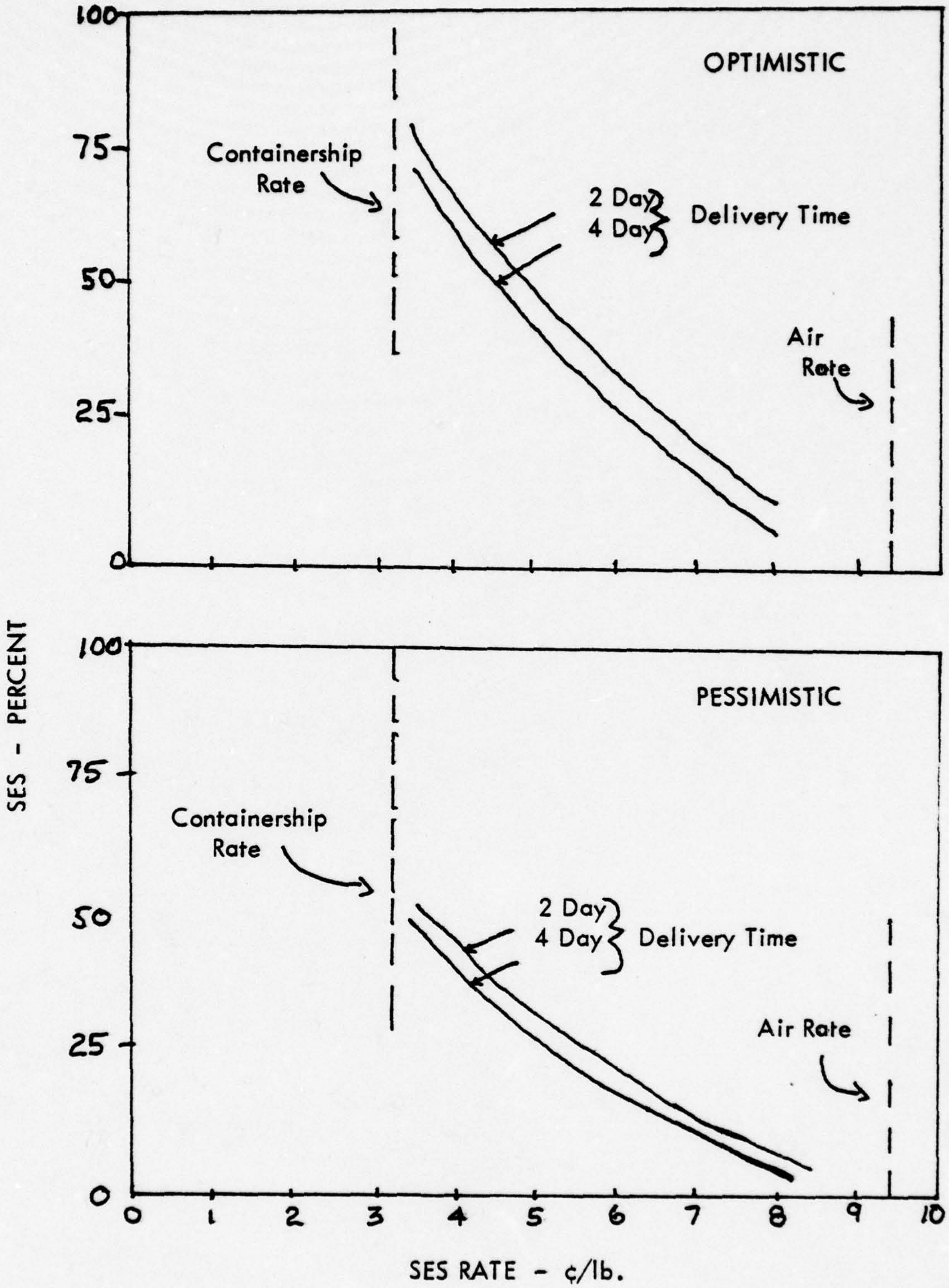

FIGURE 2-1 MODAL SPLIT RESULTS - COMPARISON OF OPTIMISTIC AND PESSIMISTIC ESTIMATES. COMMODITY GROUP 8, NEWARK, N.J. to AMSTERDAM

groupings and for each of the principal U. S. world trade regions for which 1995 trade projections were made. These 60 averages were used as the principal basis for converting the projected U. S. foreign trade volume from dollar units to long tons of cargo.

To convert the 1995 international trade estimates in dollars into units of weight, unit dollar per pound values for 1976 were taken from available trade statistics (Ref. 12). The next step in deriving the tonnages of commodities that might be carried by an SES service was to estimate the fraction of the total of each commodity group that represented SES potential. This calculation was based on the data developed using the modal split model.

The 1995 potential SES tonnages and the SES market for each commodity grouping and for each trade area were computed according to the following formula:

$$\text{SES Tonnage} = \frac{\left(\begin{array}{c}\text{1995 dollar trade}\\ \text{in 1976 dollars}\end{array}\right)\ (\text{SES market fraction})}{(\text{1976 dollars per pound})\ (\text{2240 lbs. per LT})}$$

The results of the application of the formula are shown in Table 2-6. Totals for each basic commodity grouping in each of the five major potential SES trade areas are also shown as are the overall totals for the commodity groupings and for the areas. The total SES potential movement in 1995 is estimated to be 42 million long tons imported and 21 million long tons exported.

Table 2-6

DERIVATION OF 1995 SES POTENTIAL IMPORT AND EXPORT TONNAGES BY MAJOR COMMODITY GROUPING AND TRADE AREA (1976 CONSTANT DOLLARS)

	COMMODITY CODES											
	1				5				6			
REGIONS	$M	1976 $/LB	SES Fraction	M LT	$M	1976 $/LB	SES Fraction	M LT	$M	1976 $/LB	Fraction	M LT
3-Imports	0	.23	1	0	600	.02	.001	0	100	.10	.03	.01
Exports	200	.48	.6	.10	1,200	.08	.08	.54	600	.26	.19	.19
5-Imports	1,600	.34	1.0	2.10	2,700	.08	.10	1.5	4,300	.07	.04	1.10
Exports	1,500	.55	1.0	1.20	2,700	.14	.10	.86	2,700	.30	.19	.76
6-Imports	100	.24	1.0	.19	900	.14	.10	.29	2,100	.34	.17	.47
Exports	200	.62	1.0	.14	1,200	.18	.14	.42	1,300	.28	.19	.39
12-Imports	0	.14	1.0	0	800	.13	.23	.63	6,000	.14	.03	.57
Exports	200	.59	1.0	.15	4,200	.09	.05	1.04	1,600	.06	.06	.71
13-Imports	0	.22	1.0	0	3,300	.04	.10	3.68	10,000	.33	.15	2.03
Exports	800	.50	1.0	.71	2,100	.12	.12	.94	2,200	.25	.19	.75
TOTALS:												
Imports	$1,700			2.19	$8,300			7.6	$22,500			4.18
Exports	$2,900			2.30	$11,400			3.8	$ 8,400			2.80

NOTE: (1) Dollars are in millions and indicate total dollar trade
(2) SES Potential is shown in millions of long tons (MLT)

Table 2-6

DERIVATION OF 1995 SES POTENTIAL IMPORT AND EXPORT TONNAGES BY MAJOR COMMODITY GROUPING AND TRADE AREA (1976 CONSTANT DOLLARS)

	COMMODITY CODES								TOTALS		
	7				8				All Other		SES
REGIONS	$M	1976 $/LB	SES Fraction	M LT	$M	1976 $/LB	SES Fraction	M LT	$M	M LT	M LT
3 - Imports	0	.48	.93	0	200	.91	1.0	.10	6,000	0	.2
Exports	3,700	.91	.91	1.65	600	1.43	1.0	.19	400	.04	2.70
5 - Imports	11,700	.67	1.17	4.3	6,200	1.43	1.0	1.94	2,500	1.78	12.70
Exports	11,000	2.0	.90	2.2	2,300	2.50	1.0	.41	10,400	1.5	6.90
6 - Imports	3,600	.71	.92	2.08	3,900	1.67	1.0	1.04	1,800	.48	4.50
Exports	4,300	2.0	.90	.86	1,200	3.33	1.0	.16	3,200	0	2.00
12 - Imports	10,000	.56	.77	5.4	11,000	1.07	1.0	4.03	3,000	2.56	13.80
Exports	7,500	2.50	.90	1.2	8,000	2.50	1.0	1.20	10,000	0	3.20
13 - Imports	2,100	1.25	.90	.68	8,600	1.40	1.0	2.13	5,000	2.51	11.60
Exports	9,000	1.25	.91	2.93	4,000	1.67	1.0	1.25	9,000	.80	6.20
TOTALS:											
Imports	$27,400			12.46	$29,900			9.24	$18,300	7.33	43.0
Exports	$35,500			8.84	$ 5,300			3.21	$33,000	2.35	21.0

NOTE: (1) Dollars are in millions and indicate total dollar trade
(2) SES Potential is shown in millions of long tons (MLT)

III. DEMAND VERSUS SUPPLY FOR THE SES

The principal purpose of this chapter is to provide an estimate of the number of SESs that could be accommodated in U. S. foreign and domestic commerce on four principal trade routes. To determine this number, the classic economic comparison of demand versus supply is used.

Demand in this case is defined as the tonnage of shipments that would be attracted to an SES service at various freight rates. Since the tonnages will vary with the rates at which the SES service is offered in relation to air rates, containership rates, and other factors to be addressed later, a demand curve can be constructed indicating that as SES rates are lowered, more and more shipments will be attracted to the SES service.

The supply curve, on the other hand, represents the rates that must be changed for the SES service as a function of the number of SESs employed. The rates must cover all operating costs plus a profit, or return on owner's equity. A true SES industry supply curve should show some rate decrease as the number of ships employed increases to a point where the addition of another ship does not provide any further efficiencies and then begin to rise after that point. For the number of SESs addressed in this study, the supply curves remained nearly constant for each of the four design and cost factors shown in Table 1-4 (Baseline, Best Design, Best Cost, Best Design/Cost).

The point at which the decreasing demand curve crosses the supply curve represents the maximum number of SESs that the market will accommodate.

The derivation of both the SES demand and supply curves requires a large quantity of inputs and calculations. The principal determinants of the SES supply curve, required freight rates, were developed in chapter 1. The principal determinants of the SES demand curve were outlined in the SES Market Analysis and the Derivation of SES Tonnages of chapter 2.

For this chapter, demand curve computations for the two long distance routes and the one medium distance route were taken from Ref. 13, Chapters 6-8. The computations were made for numerous assumed SES freight rate inputs, for three SES speeds, for three frequencies of SES service, and for three different categories of inland movement. Also, the sensitivity of demand to changes in air and containership rates were extracted from Ref. 13, Chapters 10 and 11.

A. NEW YORK CITY - NORTHWESTERN EUROPE ROUTE

1. Demand

The computed 1995 demand for 100-knot SES service on this route is shown in Figure 3-1 as a function of SES freight rates. Both imports and exports are shown plus a "total" curve, which was derived by summing both the export and the import tonnages and plotting the result against the average of the two rates (i.e., for 1 million LT per year, the export rate of 2.5 cents and the import rate of 1 cent are averaged for 1.7 cents and plotted against a total of 2 million LT per year).

The total curve, then, shows the SES tonnages at the average of the export and import rates that would achieve a 100 percent directional load factor up to the maximum export tonnage. In other words, it is assumed that an SES operator would charge differential rates, thus keeping his tonnage directionally balanced and his directional load factor at a maximum.

The demand shown is based on a 100-knot SES service providing four sailings per week from each port served. It is postulated that for the inland movement of cargo, the shippers will use whichever common carrier, truck or rail, has the lowest rate to and from the marine terminal where, in this case, the SES cargo is containerized or decontainerized. The impact of these and other assumptions on SES

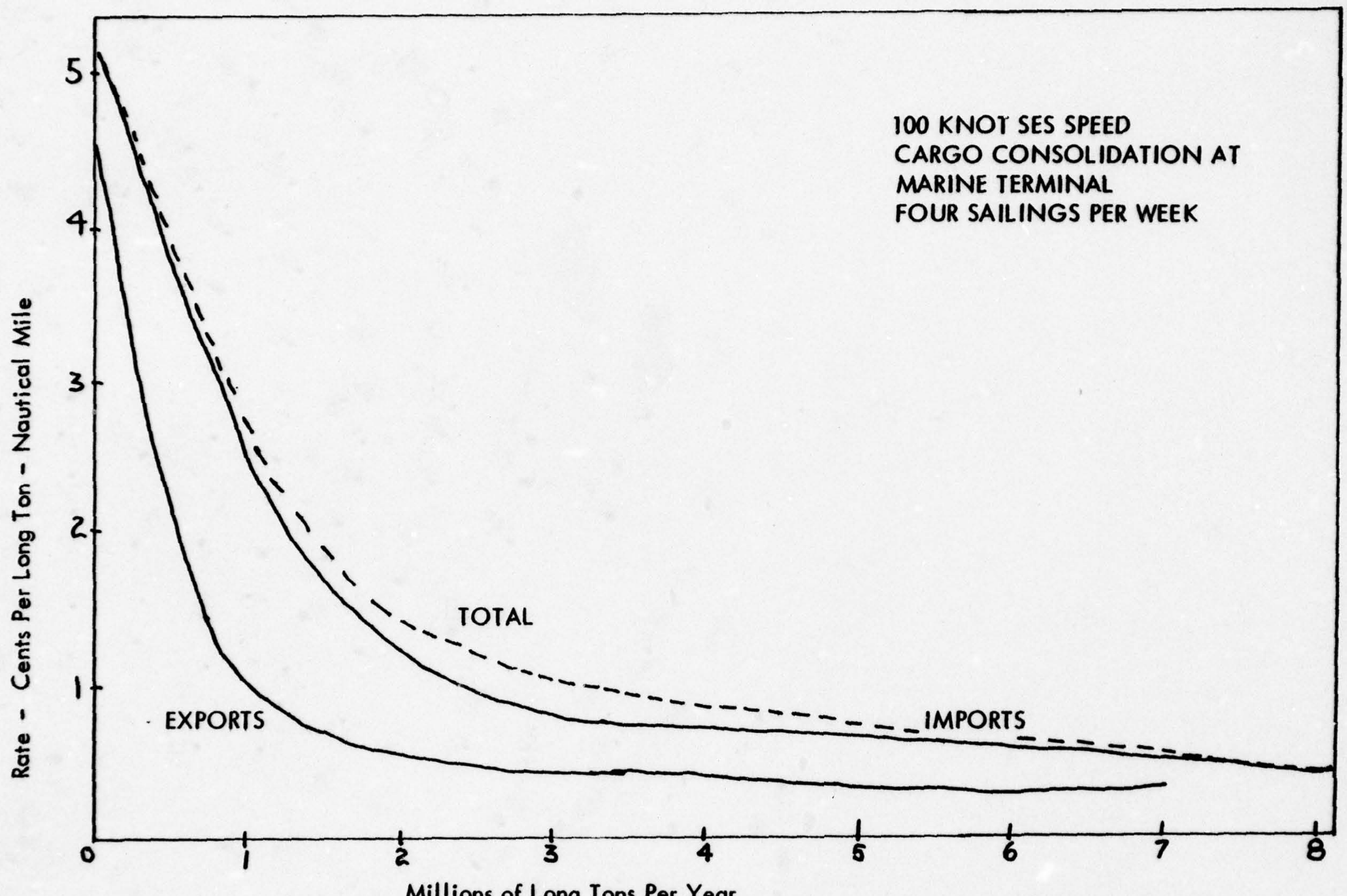

FIGURE 3-1 1995 SES DEMAND NEW YORK CITY - EUROPE demand, and the resultant number of SESs required, will be shown later. First, however, the SES supply curves are developed.

2. Supply

The SES supply curve for the New York City-Europe route is shown in Figure 3-2. This curve is simply a plot of the of the SES rates (based on the four design and cost assumptions developed in chapter 1) versus the annual tonnages that various numbers of 1000-3000 long ton payload SESs could carry (data from chapter 1). Both the rates and the number of SESs are based on a load factor of 70 percent which was also derived from chapter 1.

3. Demand Versus Supply

SES demand is compared with supply in Figure 3-3 by superimposing the total demand curve on the supply curves. Demand curves for one and two sailings per week have also been added, but these variations produce a relatively small change in demand.

Only three 1000-long ton or three 3000-long ton payload SESs would be required to satisfy demand at the SES required freight rates that could be achieved by combining both optimistic or "best" design and "best" cost factors. Using only the "best" cost factors or a somewhat lesser optimistic combination of "best" design and "best" cost

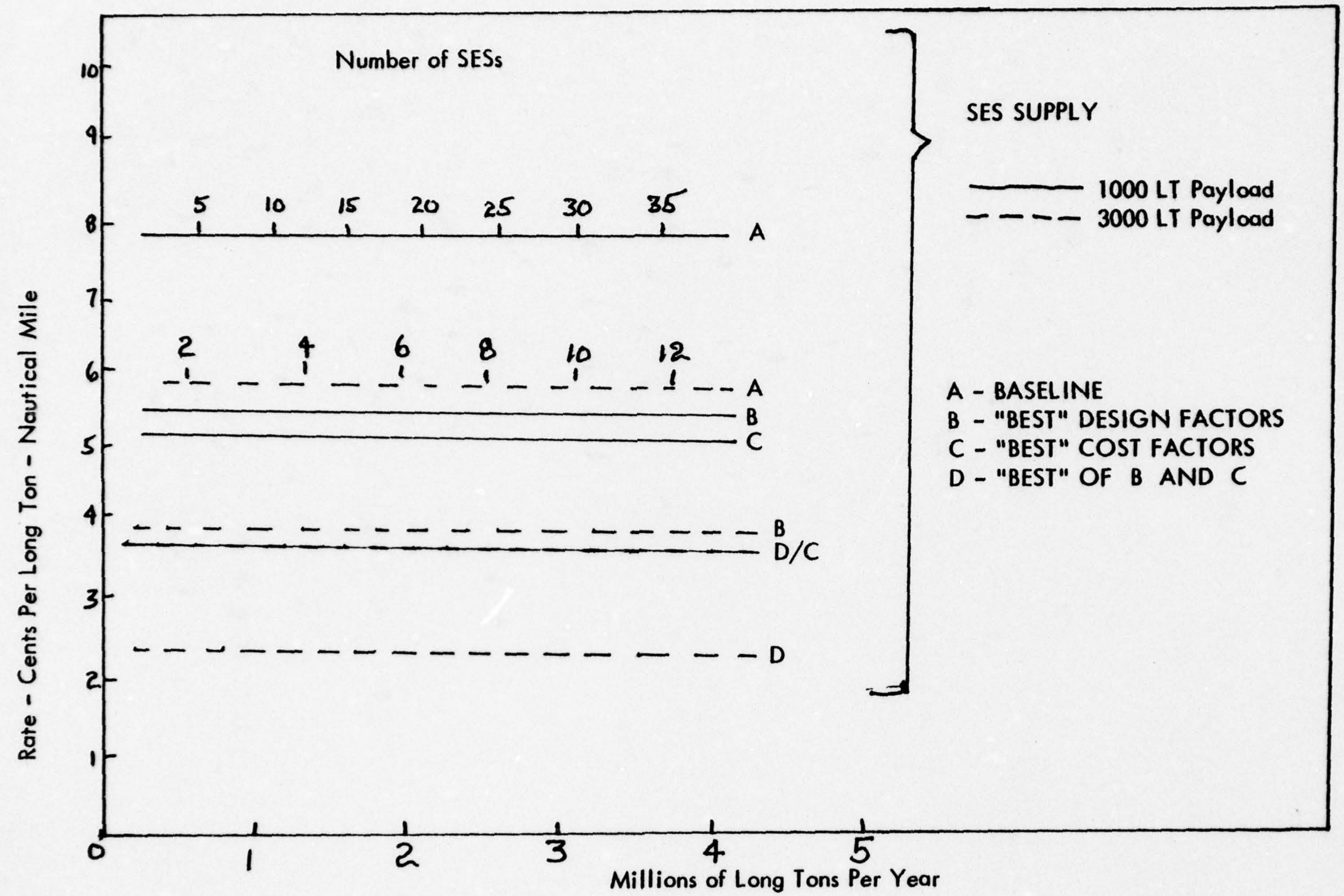

FIGURE 3-2 1995 SES SUPPLY NEW YORK CITY - EUROPE

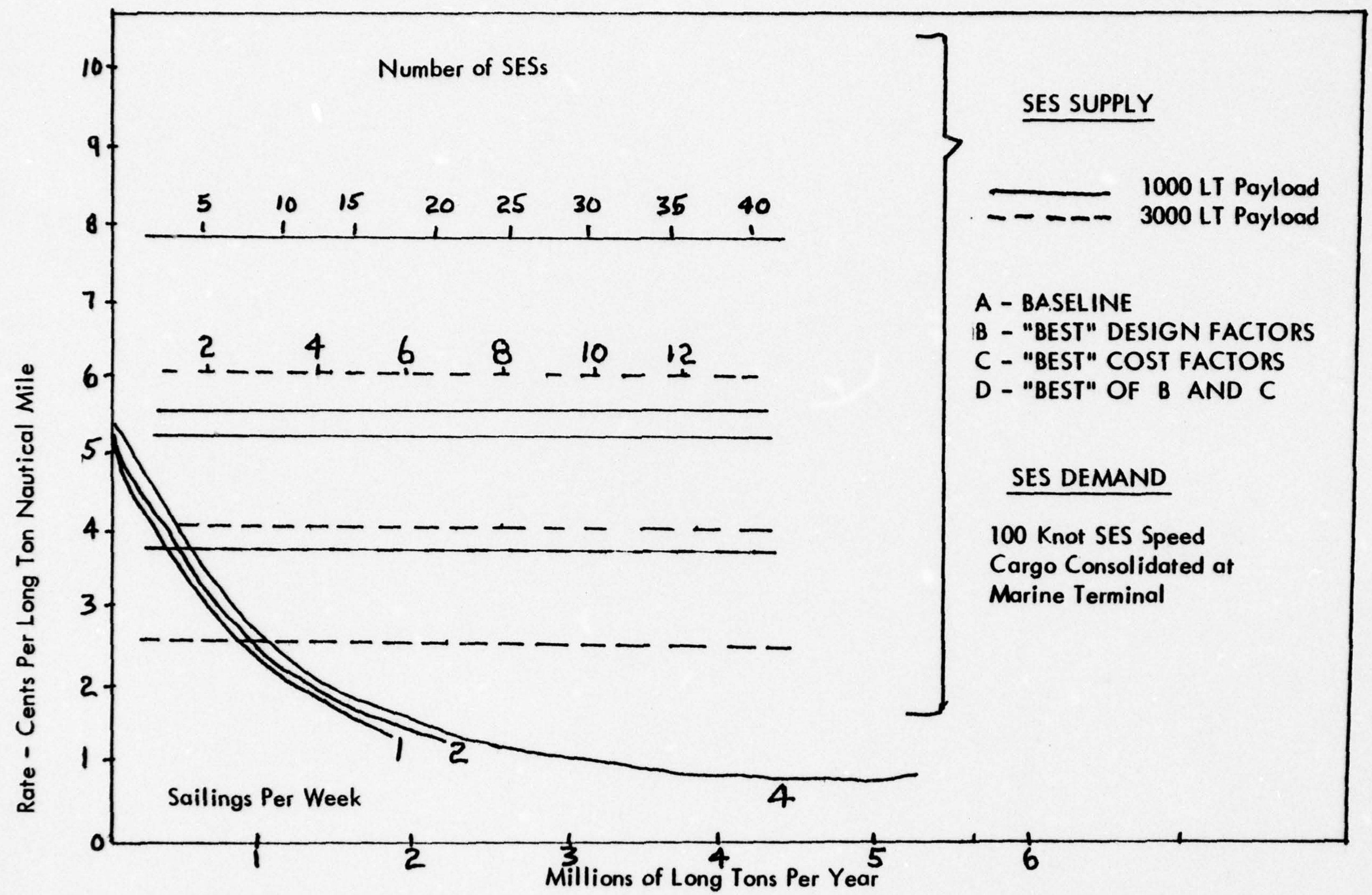

FIGURE 3-3 1995 SES DEMAND VERSUS SUPPLY NEW YORK CITY - EUROPE factors, Figure 3-3 demonstrates that demand is insufficient to fully utilize the capacity of a single SES or either size. Similarly, with the baseline case, no SESs could be profitably used.

4. Sensitivity to Input Assumptions

The numbers of SESs required to satisfy the demand for SES service under various sets of input assumptions are summarized in Table 3-1. The following paragraphs provide a discussion of the sensitivity of demand to each of the principal assumptions shown in the table.

a. SES speed

The modal split model was exercised using speeds of 60 knots and 150 knots, in addition to the basic speed of 100 knots. At 60 knots, the number of SESs required to meet the demand was reduced to two 1000-long ton or two 3000-long ton payload SESs if the "best" design and cost factors were achieved. At design and cost factor freight rates higher than this, the demand for the 60 knot SES was not sufficient to fully utilize the capacity of either of the two SESs. No change in the number or tonnage of the SESs was required at 150 knots which indicates the very low sensitivity of demand to SES speed, particularly above 100 knots.

Table 3-1

NUMBER OF SESs REQUIRED TO SATISFY DEMAND UNDER VARIOUS CONDITIONS
NEW YORK CITY - EUROPE

INPUT ASSUMPTIONS	INLAND MOVEMENT CATEGORY (1)	NUMBER OF SESs REQUIRED: 1000 LT PAYLOAD A(2)	B	C	D	3000 LT PAYLOAD A	B	C	D
Most Likely Competition									
100 Knots	1	0	0	0	3	0	0	0	3
60 Knots	1	0	0	0	2	0	0	0	2
150 Knots	1	0	0	0	3	0	0	0	3
100 Knots	2	0	0	0	2	0	0	0	2
100 Knots	3	0	0	0	2	0	0	0	3
Air Rates at 150 Percent									
100 Knots	1	0	1	2	7	0	2	2	4
Air Rates at 75 Percent									
100 Knots	1	0	0	0	0	0	0	0	1
Containership Rates at 150 Percent									
100 Knots	1	0	0	0	3	0	0	0	3
Containership Rates at 75 Percent									
100 Knots	1	0	0	0	2	0	0	0	2

(1) See Inland Movement Section of Sensitivity to Input Assumptions Section of this Chapter
(2) See Figure 3-3

b. Inland Movement

Three categories of inland movement were investigated:

1. Shipment by truck or rail common carrier (whichever had the lower average rate) to the marine terminal for consolidation into containers; with the reverse process at the destination end.

2. Consolidation at origination and deconsolidation at destination into containers of less-than-container-load lots at inland points.

3. Direct movement of container loads between shipper and consignee.

Each category required different freight rates and shipment times. Nevertheless, since both competing services (air and containerships) would enjoy the benefits of these differing assumptions of how freight would be handled during inland movement, these assumptions prompted no large change in demand for SES service.

c. Air Cargo Rates

An increase of 50 percent in air cargo rates resulted in an increase in SES demand principally at the higher SES rate levels. If air cargo rates are reduced by 25 percent, the number of SESs required drops significantly.

d. Containership Rates

A 50 percent increase in containership rates did not change the required number of SESs, whereas a 25 percent reduction in containership rates produced only a slight increase in SES demand.

e. Modal Split Model

As was shown in chapter 2, the modal split model is based on individual estimates by six analysts. Of the optimistic and pessimistic estimates that were made for various conditions, their averages tend to differ from the overall average used in determining SES demand by as much as ± 25 percent. Since SES demand estimates are affected by changes in the modal split model, the numbers of SESs estimated in Table 3-1 required to satisfy SES demand also depend upon the accuracy of the modal split model.

f. The SES Market

The market from which SES demand was computed is based on a projection of total trade as well as a projection of the fraction of this trade that an SES might attract. The 1995 trade movement projections are estimated to have roughly an overall accuracy of ± 20 percent. This level of accuracy is also applicable to the required number of SESs presented in Table 3-1.

B. SAN FRANCISCO - JAPAN ROUTE

1. Demand versus Supply

The SES demand and supply curves for the San Francisco-Japan route are shown in Figure 3-4. The general

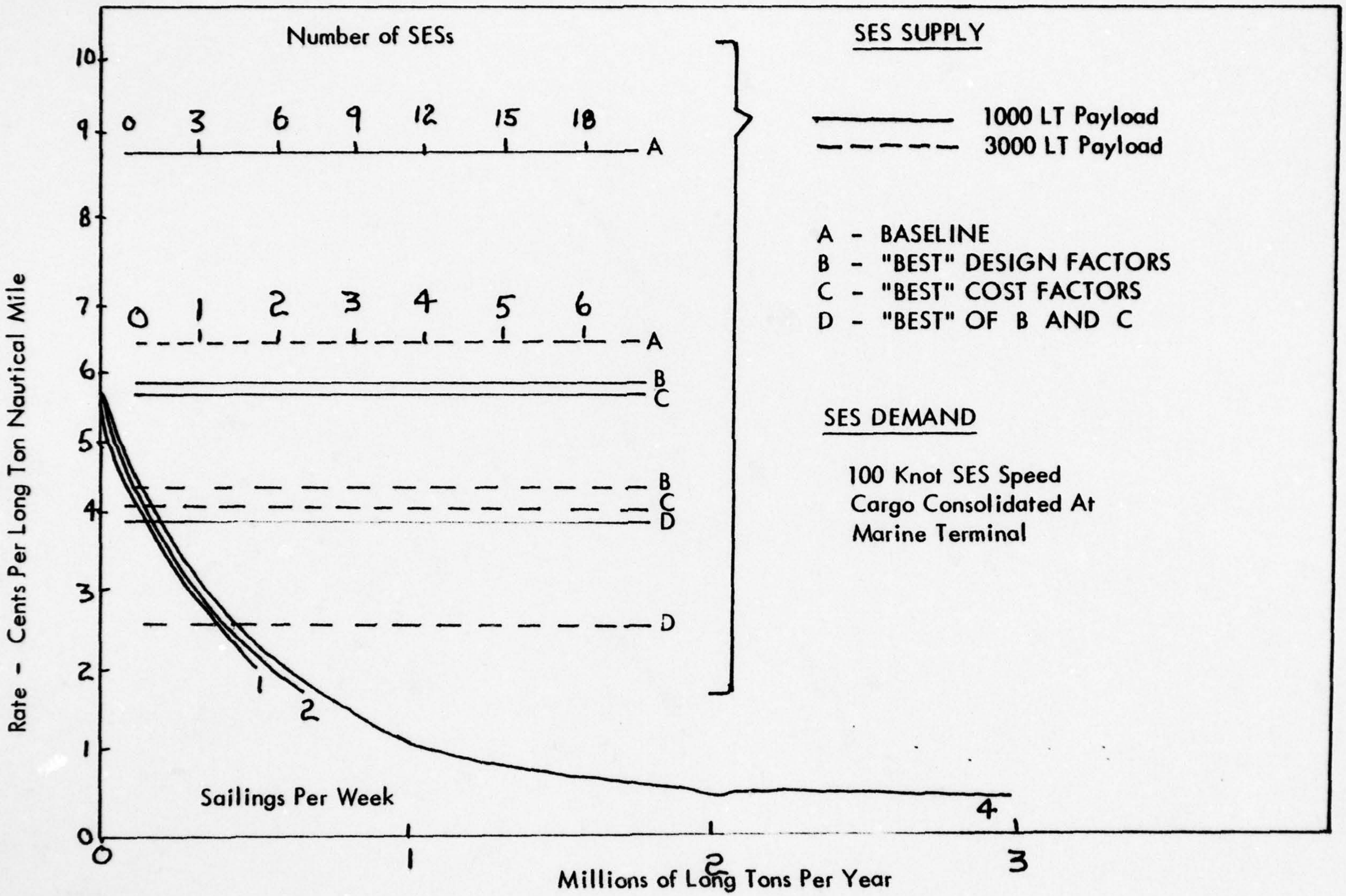

FIGURE 3-4 1995 SES DEMAND VERSUS SUPPLY SAN FRANCISCO - JAPAN relationship between demand and supply is approximately the same as that shown earlier for the New York City-Europe route.

2. Sensitivity to Input Assumptions

The numbers of SESs required to satisfy the SES demand on this route are summarized in Table 3-2. The earlier general remarks concerning sensitivities of results to variations in inputs apply equally to this route.

C. NEW YORK CITY-PUERTO RICO ROUTE

1. Demand versus Supply

The SES demand versus supply curves for the New York City - Puerto Rico route are shown in Figure 3-5. In comparison with the previous two routes, the lower SES supply curves now intersect the SES demand curves at lower levels (due principally to the higher United States flag containership rates used). Even so, only moderate numbers of SESs are required at the lowest or most optimistic SES supply rates. The reason for this is that the SESs have an annual productivity on this route of two to three times that which they had on the two routes examined previously.

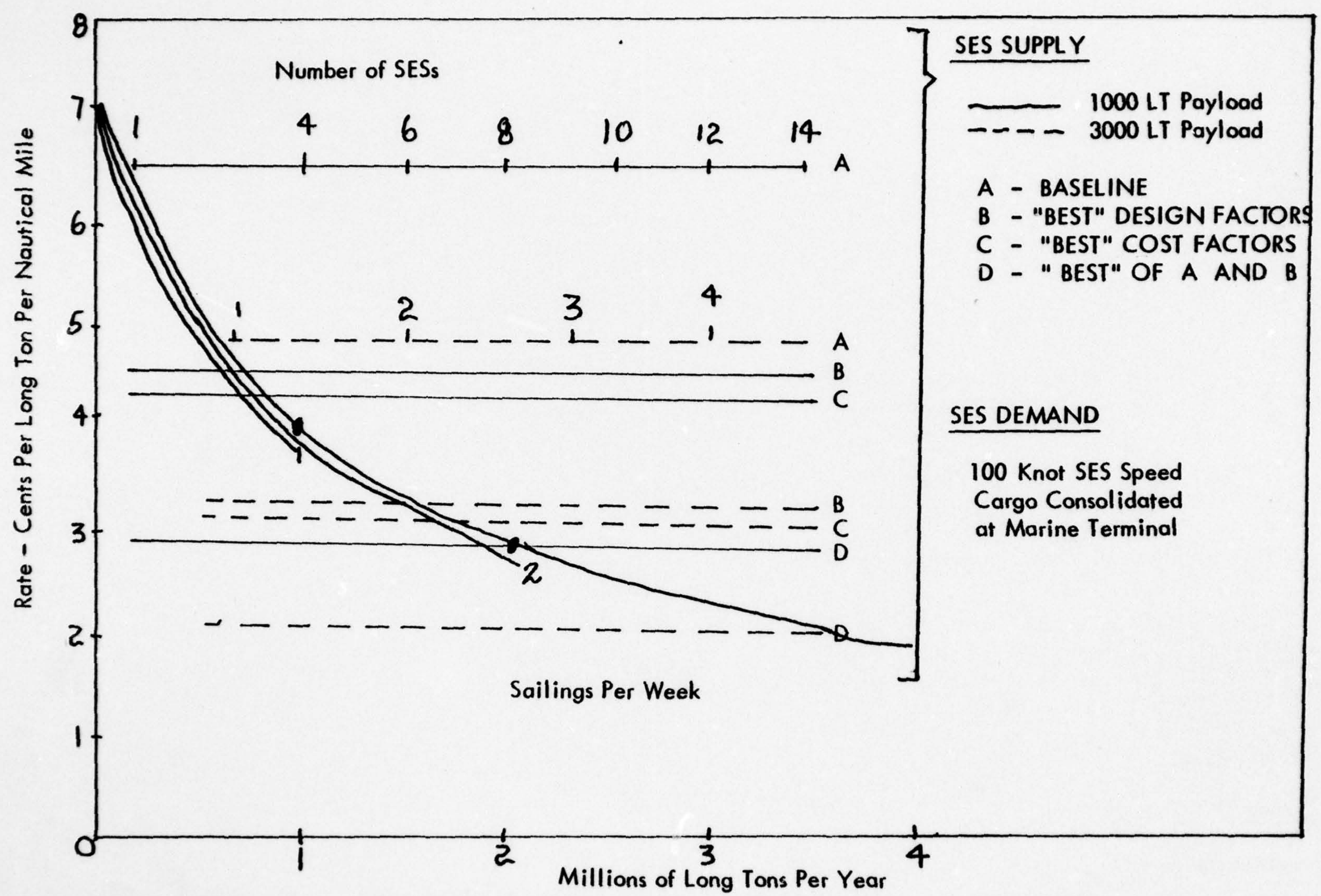

FIGURE 3-5 1995 DEMAND VERSUS SUPPLY NEW YORK CITY - PURETO RICO

Table 3-2

NUMBER OF SESs REQUIRED TO SATISY DEMAND UNDER VARIOUS CONDITIONS
SAN FRANCISCO - JAPAN

INPUT ASSUMPTIONS	INLAND MOVEMENT CATEGORY(1)	NUMBER OF SESs REQUIRED: 100 LT PAYLOAD				3000 LT PAYLOAD			
		A(2)	B	C	D	A	B	C	D
Most Likely Competition									
100 Knots	1	0	0	0	1	0	0	0	1
60 Knots	1	0	0	0	1	0	0	0	1
150 Knots	1	0	0	0	1	0	0	0	1
100 Knots	2	0	0	0	0	0	0	0	1
100 Knots	3	0	0	0	0	0	0	0	1
Air Rates at 150 Percent									
100 Knots	1	0	1	1	4	0	1	1	2
Air Rates at 75 Percent									
100 Knots	1	0	0	0	0	0	0	0	1
Containership Rates at 150 Percent									
100 Knots	1	0	0	0	1	0	0	0	1
Containership Rates at 75 Percent									
100 Knots	1	0	0	0	1	0	0	0	1

(1) 1 - Container Terminal Consolidation: (2) - Inland Consolidation: (3) - Shipper Filled Containers
(2) A, B, C, D - Refers to Various SES Rates: See Figure 3-4

2. Sensitivity to Input Assumptions

The numbers of SESs required to satisfy demand on this route under different input assumptions are shown in Table 3-3. The sensitivities to various input assumptions are generally consistent with those developed for the two earlier routes, except that the general level of required SESs is higher.

For instance, the sensitivity of SES demand to air cargo rates is apparent at the higher SES design and cost factor freight rates when the air rate is increased, and overall when the air rate is reduced. The same tends to be true for variations in containership rates. Since United States flag rates were used (because (1) foreign competition is prohibited on this route and (2) U. S. flag rates are approximately double the foreign flag rates), the difference between containership and air cargo rates is much smaller than for the previous routes. Hence, small changes in these rates will tend to produce significant changes in the numbers of SESs required at the SES rate levels closest to the competitive rates.

It is interesting to note that when containership rates are lowered 50 percent, to approximately the level of foreign flag ship rates, the number of SESs required to satisfy demand drops to the same low levels as on the two previous routes. This would probably be the effect on rates if foreign flag competition were allowed on this route.

Table 3-3

NUMBER OF SESs REQUIRED TO SATISFY DEMAND UNDER VARIOUS CONDITIONS
NEW YORK CITY - PUERTO RICO

INPUT ASSUMPTIONS	INLAND MOVEMENT CATEGORY(1)	NUMBER OF SESs REQUIRED: 1000 LT PAYLOAD				3000 LT PAYLOAD			
		A(2)	B	C	D	A	B	C	D
Most Likely Competition									
100 Knots	1	0	2	3	8	0	2	2	5
60 Knots	1	0	2	2	7	0	2	2	4
150 Knots	1	0	2	3	8	0	2	2	5
100 Knots	2	0	3	3	8	0	1	2	5
100 Knots	3	0	3	4	9	1	2	3	5
Air Rates at 150 Percent									
100 Knots	1	0	4	5	9	1	2	3	5
Air Rates at 75 Percent									
100 Knots	1	0	0	0	3	0	0	0	3
Containership Rates at 150 Percent									
100 Knots	1	0	4	4	10	1	3	3	5
Containership Rates at 75 Percent									
100 Knots	1	0	1	1	3	0	1	1	2

(1) 1 - Container Terminal Consolidation: 2 - Inland Consolidation: 3 - Shipper Filled Containers
(2) A, B, C, D Refers to Various SES Rates: See Figure 3-5

D. INTER-HAWAIIAN ISLANDS ROUTE

The requirement for SESs on inter-Hawaiian Island route was assessed in a much simpler fashion than that used for the previous three routes as on these routes the principal competition for the SES is containerships. It was believed that because of the short distances involved, the SES could not offer shippers any practical advantages in its greater speed. On the basis of rate differences, it is believed that SESs could not economically compete with air or containership services on inter-Hawaiian Island routes.

IV. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The Department of Commerce has long recognized the commercial value of the surface effect ship (SES). Twelve years ago, the Maritime Administration of the Department of Commerce issued this statement:

> ...The interests of the Maritime Administration are not limited to conventional ships upon the sea. ...There are two ways to solve the competitive problem we confront. One is to try to improve the old ways of doing things. We are doing that. ...The other approach is to seek completely new ways of carrying cargo competitively. ...One of the most promising responses to the search for new and competitive systems is the surface effect ship. We have been studying the economic and technical feasibility of this craft for the past year. Our progress has been significant and substantial (17:18).

Now, 12 years later, the United States still does not have a program for the commercial development of surface effect ships. While the United States has stood still, the Soviets and British have built up a competitive surface effect shipbuilding industry for passenger ferries. For this reason, among others, this study was undertaken to analyze the economic opportunity for SESs to carry commercial cargo in United States commerce, both foreign and domestic, in 1995. The principal index of SES economic opportunity used in the study is the number of SESs that can be employed in U. S. commerce at rates that will cover costs of operations, plus a reasonable return on owner's equity. It was believed that this index would indicate the acceptability and the magnitude of the benefit of SES service to shippers, and the profitability of SES operations available to SES operators. The year 1995 was selected for the study because it was felt that, by that time, large SESs with payloads of at least 3000 long tons could be fully operational.

To focus more specifically on distinctively different types of SES operations, routes of three differing lengths were studied: long-over 2000 nautical miles; medium-500 to 2000 nautical miles; and short-less than 500 nautical miles. After projecting foreign trade volume to 1995 and determining what the potential SES market share of this trade would be, four "case" routes were selected for detailed study:

1. New York City to Northwestern Europe
2. San Francisco to Japan
3. New York City to Puerto Rico
4. Inter-Hawaiian Island routes.

The results of the above study, which were presented in the last chapter, indicate that in the future there will exist a viable niche for commercial SES service between the services provided by containerships and air cargo planes in U. S. foreign commerce.

The U. S. is dependent for more than two-thirds of its life support on the Merchant Marine (Ref. 18). Yet, since WWII, the U. S. shipping industry has suffered from a creeping malaise. In the 1950's, about 42 percent of U. S. imports/exports were carried by the U. S. flag merchant marine. In the 1960's this percentage dropped to 10 percent and in the 1970's to 5 percent (Ref. 19). In other words, 62 percent of U. S. support is now provided by foreign merchant shipping. It would appear that the U. S. flag merchant ship is fast becoming an "endangered species." Each year more and more U. S. flag vessels are transfered to foreign "flag of necessity" vessels (20:48). These transfers represent further potential loss of U. S. control over the ships for logistic support of the DOD in time of war and they represent a peacetime loss of "balance of payments" revenue (a matter of current economic concern in some circles). The time has come to examine viable alternatives to ensure that commercial shipping is available to draw from in time of war as well as to revitalize the U. S. flag merchant marine to make it once again a viable force in world shipping. The SES could be a possible answer and it merits further investigation.

A. RECOMMENDATIONS

Further study is recommended to answer the following questions:

1. Will the 3K SES presently being constructed by Rohr Marine for the Navy be readily adaptable to commercial use once its development is completed or will a major independent commercial development effort be required?

2. Is current SES passenger ferry technology readily adaptable to large scale commercial SESs for cargo movement?

3. Will the deregulation of the airline industry result in a significant reduction in the potential SES market share in the future?

4. Would SESs of a smaller scale than that addressed in this study be feasible for commercial use on the Great Lakes where ice packs preclude waterborne shipping 3 to 4 months out of the year by barges and displacement ships?

5. Should DOD fund commercial development of the SES in conjunction with the Department of Commerce because of the significant advantages which the SES would have over conventional displacement ships in speed and reduced vulnerability, which would preclude the requirement for naval escort vessels in military logistics support of NATO and Western Pacific forces?

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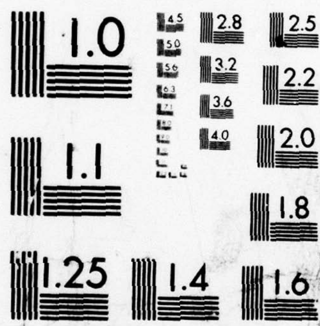

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