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A Methodology for Accurately Predicting Demand for Airlift of Military Cargo to Overseas Destinations

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LOGISTICS DEPARTMENT
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McLEAN, VIRGINIA

FOREWORD

This article was presented as a paper at the 30th National Meeting of the Operations Research Society of America in Durham, N.C. on 17 October 1966. The information represents the opinion of the authors and not necessarily that of the Research Analysis Corporation.

George S. Pettee
Chairman, Research Council

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A Methodology for Accurately Predicting Demand for Airlift of Military Cargo to Overseas Destinations

ABSTRACT

Recent developments in aircraft technology will create greater airlift capabilities at lower costs. How will this increased capability be effectively utilized by the Department of Defense? Time-series extrapolations of air-cargo demand have been made in the past for the civil sector of our economy and similar projections have been proposed for military airlift planning. These proved less than successful when compared with actual tonnages generated. This paper will explore a different methodology for predicting airlift demand in the military establishment. Basic data, consisting of approximately 3.8 million commodities and millions of shipments recorded on magnetic automatic data processing tapes, are obtained from all DOD supply management activities. Two information files are established. One is a catalogue file reflecting the physical characteristics (weight, cube, price, etc.) of the commodities which influence total distribution costs of delivering the items to overseas destinations. The second is a demand file containing the actual volume and traffic flow of the commodities. From these files, total distribution costs for air and surface movement are computed by a mathematical model for each commodity to determine the break-even air rate. The economically air-eligible commodities are then correlated with the volume and traffic flow to determine the elasticity of demand at various air ton-mile rates. Based on known operating costs of new aircraft, logical requirements for airlift can be established. At the same time, criteria for selecting air-eligible commodities are based on economic considerations, thus producing the least-cost method of supplying overseas activities.

Introduction

Although C-5A-type aircraft are being procured by the Department of Defense (DOD) primarily for emergency deployment of combat units and other wartime contingency purposes, they will transport part of the normal resupply demands of overseas activities during peacetime periods. DOD recognizes this situation and has commissioned RAC to measure the economic benefit derived from being able to use part of the capability of the airlift fleet to satisfy peacetime movement requirements.

As a basis for measuring this benefit the potential requirements for air transportation must be predicted for the 1970's. Gross-type linear forecasts of civilian domestic air-freight demand have been made. Figure 1 compares these forecasts with the actual tonnages generated. The years listed vertically over 1965 are the years in which the predictions were made and the dots represent the predicted levels for 1965. The solid line reflects the actual tonnages generated. This figure is not meant to depreciate these efforts: most of the predictions were based on the relation of the air-freight demand to gross national product or on other indicators that evidently were not adequate as parameters.

Because of the tariff arrangement that Military Air Command (MAC) now imposes, another approach to predicting the demand for military airlift, which is based on the economic utilization of airlift, is suggested. Since the use of military standard requisitioning and issue procedures and automatic data processing equipment, accurate and retrievable data are maintained for all military shipments. Specific commodities by Federal stock numbers are recorded here on magnetic tape, reflecting the quantity and frequency of demand by destination. At the same time the physical characteristics of the commodities that influence the total distribution costs are also recorded on magnetic tape. Unfortunately this wealth of information is not readily available to the civilian air-freight industry.

These military data make it possible to identify commodities shipped overseas that are economically eligible for airlift delivery on a total-distribution-cost basis with the lower ton-mile costs of the C-5A-type aircraft. Figure 2 reflects the specific costs that are being considered. The solution sought is the air ton-mile rate that will equate the total costs of shipping by air or by surface methods.

The elasticity of demand for airlift at various ton-mile rates can be determined by considering the volume and flow of the eligible commodities. Figure 3 is a basic illustration of the demand trend. When air eligibility is based on economic considerations, the lower the ton-mile rate, the greater the tonnage that can be moved by air. The main task is to determine the exact shape of the curve and the actual ton-mile rates and tonnages.

The data base for the work is necessarily empirical, but demand for certain classes of commodities can be correlated with present force structures.

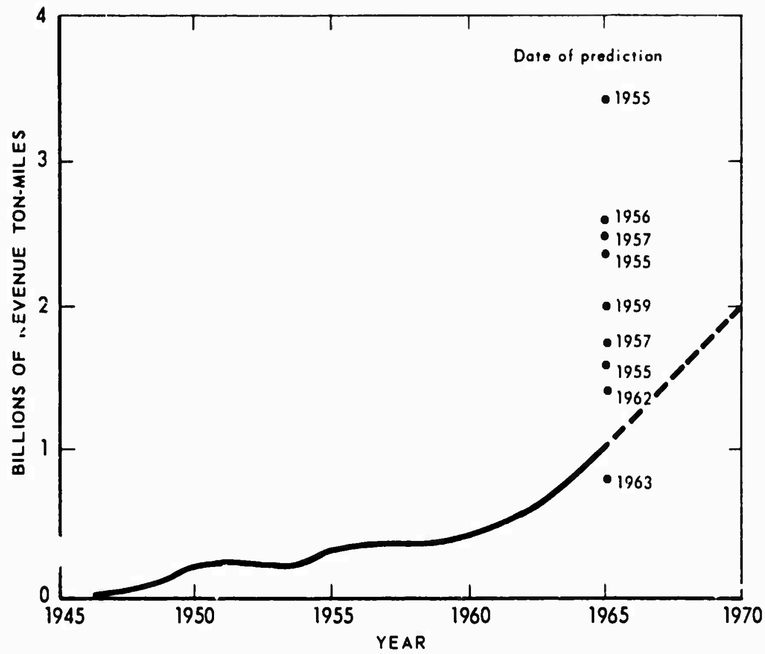

Fig. 1—Air-Freight Forecasts Compared with Tonnage Generated

US domestic.

• Predicted levels for 1965

Destination: ______________________

Federal Stock Number: ______________________

Item	Differential costs	
	Air	Water
Loss and damage	—	—
Packaging	—	—
Pipeline	—	—
Intransit warehousing	—	—
Inland line haul	—	—
Line haul	X	—
	$ Σ	$ Σ

Fig. 2—Model for Selecting Air-Eligible Commodities

By basing calculations on Joint Chiefs of Staff estimates of force structures in the 1970's, the total demand can be projected, and using the model the economically-air-eligible portion can be isolated.

Other than for the Air Force's "Hi-Value" program, the present criteria for selecting commodities for air shipment are established by priority rather than by economic considerations. Why then is economy considered a potentially decisive factor? Programs such as the Air Force's "Hi-Value" program indicate a change in the overall situation.

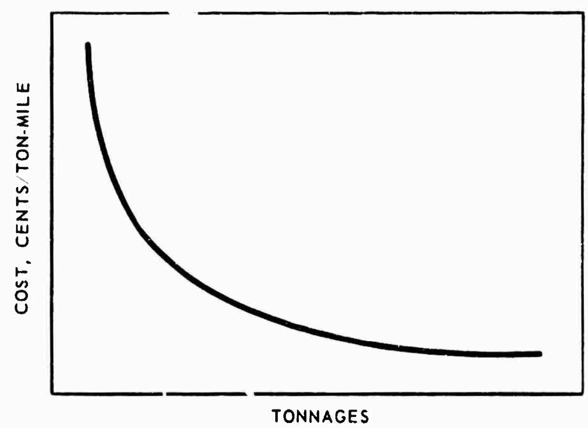

Fig. 3—Demand for Air Transportation

To measure the economic benefit of moving cargo by air, airlift cargo must be of a type that economically justifies airlift. However, there will be some priority and emergency demands to be satisfied by air transportation in peacetime, where the cost of the delay to the user justifies the faster, premium type of transportation. In this latter sense, shipment by air is a premium mode of transportation, although when comparing airlift and waterlift on a total-distribution-cost basis, in many instances shipment by air is cheaper.

Air and Water Linehaul Rates

On strictly a linehaul basis, it is obviously cheaper to ship by water. On a short-ton basis with a ratio of 5 measurement tons to 1 Ston or a density of 10 lb/cu ft, present Military Sea Transport Service rates range from 2.5 to 3 cents/ton-mile. In FY66 the average MAC rate is 15.5 cents/ton-mile, based on an 80 percent outbound-load factor and a 30 percent inbound load, for an overall load of 55 percent of capacity. Commercial air freight can offer a lower rate: United Airlines quotes a rate of 8 cents/ton-mile for Sears, Roebuck shipments to Hawaii, predicated on volume shipments. Lockheed is forecasting a 4.3 cents/ton-mile direct-operating cost for the military version of the C-5A. It is apparent that the efficiencies of the new aircraft are closing the gap between water- and air-linehaul costs.

Loss and Damage Rates

Although the government is a self-insurer, loss and damage do represent an expense. Depending to a large extent on destination, 10 to 20 cents per $100 in commodity value should be allowed for loss and damage when shipping by air. The type of commodity as well as the destination influences the costs of loss and damage when shipping by water. Depending on these variables, costs for water shipment range from $1.00 to $1.75 per $100 in commodity value, representing a cost 5 to 17½ times greater for water shipment than for air shipments. This significant difference could very well eliminate the gap between future air- and surface-linehaul rates for some commodities.

Packaging Costs

This factor will also have a considerable impact on the selection of commodities for air movement. The increase in net weight for air shipments approximates 10 percent; for water shipments the increase exceeds 30 percent. Packed gross-weight charges for preparing goods for air shipment range from $1.50 to $3.00 per 100 lb; for water shipments the charges for the same commodities range from $7 to $12 per 100 lb. Thus there is a double penalty for shipping by water: the increase to net weight is greater and the packing charge computed on gross weight is considerably more than for air shipments.

Pipeline Costs

In this area only the difference in transit times (not a reduction in overseas inventory levels) is being considered. Optimum air-transit times average about 4 days door to door, whereas surface-transportation time can easily be more than 45 days. If costs are computed as a function of the interest rate, value, and time, the costs for air shipments amount to 3.6 cents per $100 in commodity value, and water shipments cost 48 cents per $100 in value. This factor weighs heavily in favor of air transportation.

Intransit Warehousing and Handling Costs

For door-to-door shipments by air transportation, handling is required only at origin and destination. Surface shipments, on the other hand, require extra handling at the water ports of embarkation and debarkation, and temporary warehousing at the port of embarkation is necessary. Army port-handling charges are $19.60 per Ston at US ports, $5.54 at European ports, and $8.70 at Far-Eastern ports.

Inland Linehaul Costs

Air terminals for international cargo movements can be located close to origins and ultimate destinations. In contrast, water ports are immovable. Therefore inland surface distances using water transportation can be expected to significantly exceed connecting distances for air shipments. Surface linehaul rates in the US average 8 cents/ton-mile; in Europe they approximate 4.8 cents and in the Far East 8.8 cents. Again this element of total shipping cost favors air transportation.

Table 1 lists commodities that are not presently considered air eligible; both could be airlifted at a total-cost savings with the lower-ton-mile costs of the C-5A-type aircraft.

History is about to repeat itself. The present roles of air and water transportation in the intercontinental movement of goods are being influenced by the same factors that affected railroads and motor carriers in the 1920's and 1930's. During those years, when motor carriers were referred to by

TABLE 1

Savings Realized by Airlifting Items

(CONUS to Germany)

Factors considered	Airlift	Surface lift
Paint Rollers—FSN-80205984079[a]		
Gross cube	—	0.39
Consolidation factor, %	—	80
Gross weight, lb	2.2	2.6
Packaging cost, dollars	0.055	0.161
Loss and damage, dollars	0.006	0.038
Pipeline, dollars	0.003	0.029
Intracontinental linehaul, dollars	0.062	0.079
Warehousing, dollars	0.011	0.026
Surface (water linehaul), dollars	—	0.225
Total cost, dollars	0.137	0.558
	0.421←0.099 ton-mile	
	0.558	
Mattress—FSN-72102743780[b]		
Gross cube	—	10.4
Consolidation factor, %	—	80
Gross weight, lb	33	39
Packaging cost, dollars	0.825	2.418
Loss and damage, dollars	0.021	0.142
Pipeline, dollars	0.0095	0.106
Intracontinental linehaul, dollars	1.007	1.287
Warehousing, dollars	0.165	0.39
Surface (water linehaul), dollars	—	5.99
Total cost, dollars	2.027	10.333
	8.306←0.131 ton-mile	
	10.333	

[a]6.7 lb cube, $1.92 lb; 2 lb, 3 cube, $3.84 doz.
[b]3.75 lb cube, $.47 lb; 30 lb, 8 cube, $14.15 per unit.

railroaders as "horseless carriages," railroads enjoyed a virtual monopoly of domestic overland transportation. As the trucking industry developed, certain traffic diverted from rail to motor transport. This diversion can be seen in Fig. 4. The traffic in the early years naturally consisted of higher-value merchandise that could readily absorb the higher trucking rates. More important, the nature of the commodities demanded services that only the motor carriers could provide. The transport unit, the motor truck, was much smaller than a railroad train and could offer morc frequent schedules. Such flexibility was particularly attractive to less-than-carload shippers; massive consolidations were unnecessary and delays were curtailed. Transit times were significantly decreased, and motor carriers tailored their services to their customers' needs. Door-to-door pickup and del:very were provided; equipment

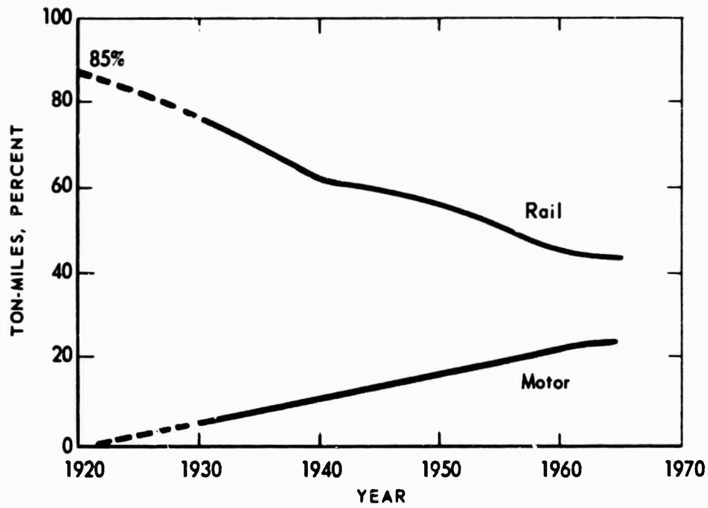

Fig. 4—Fe:centage Shares of Rail and Motor Transport
Intercity ton-miles.

TABLE 2

Cargo Movements

(April–September, 1964)

Branch of service	Total movement, thous of Stons	By air, thous of Stons	Percentage by air
Army	1,026,000	14,300	1.4
Navy	437,000	10,200	2.3
Air Force	372,000	36,200	9.7
Total	1,835,000	60,700	3.2

was adapted to the type of cargo handled; expensive packing and crating requirements were eased; and at the same time loss, damage, and pilferage decreased.

With the advent of larger aircraft having greater productive capabilities, ton-mile air costs will dip considerably. Air transportation will be able to compete with motor carriers. Air transportation, as compared with water transportation, will have the same advantages as the motor truck had over the freight train: greater flexibility in scheduling, comprehensive coverage approaching door-to-door service because air routes are not limited to shipping lanes or ports of call, minimum-packaging requirements, minimum loss and damage experience, and time savings. Table 2 shows cargo movement by air for the period April–September 1964 for the various services.

Conclusions

What will be the impact of this technological development on military-global transportation in the 1970's?

(a) There will be a significant shift from water to air transportation for commodities not now considered air eligible. The potential is great.

(b) With more tonnages being generated, inland military aerial ports will be feasible for overseas shipments, thus creating more direct air service.

(c) Shorter pipelines will be possible, with a corresponding reduction of inventory and warehousing costs, and the quick response to varying requirements will avoid the obsolescence of supplies.