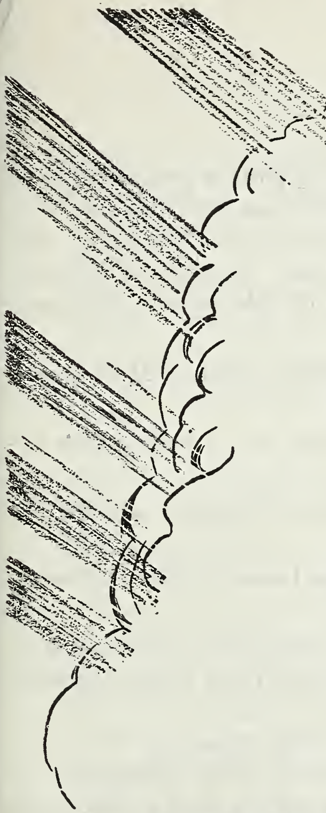
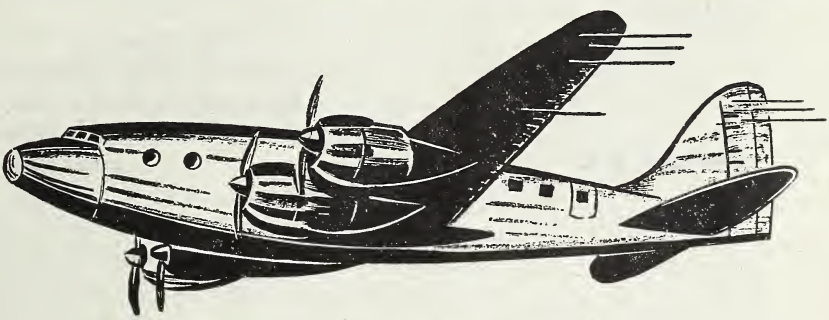


AIR TRANSPORT

of Agricultural Perishables



Prepared by the
Working Group on Conversion of Marketing
Facilities and Methods
of the
Interbureau Committee on Postwar Programs

Miscellaneous Publication No. 585
U. S. Department of Agriculture

Foreword

This publication is one of several dealing with postwar readjustments in the marketing of agricultural products, prepared under the direction of a Working Group of the Interbureau Committee on Postwar Programs. The Working Group completed this report in July 1945. Members of the group who actively participated in the preparation of this report and assume responsibility for its contents are:

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Washington, D. C.

Issued January 1946

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Air Transport of Agricultural Perishables

Conclusions and Recommendations

The tremendous increase in the production of planes and the training of personnel to meet the demands of war created both a problem and an opportunity for the aircraft industry—a problem of adjusting the industry to peacetime requirements and an opportunity to develop the usefulness of the airplane in commercial transport far in excess of its prewar use.

The potential usefulness of the airplane for the transportation of agricultural commodities cannot be measured solely in the tonnage of perishables it may carry. Many agricultural commodities now being transported by surface carriers will be hauled by the airplane unless the surface carriers improve the techniques and equipment they are now using. New improvements in equipment and better handling methods by the surface carriers probably will be adopted at an accelerated rate if the airlines threaten to capture a substantial part of their tonnage. As a pace setter for the transportation industry the airplane may benefit producers and consumers more indirectly than directly.

Transport aircraft should be considered in terms of potential carrying capacity under modern methods of operation rather than as a specific number of planes. The strides the airline industry has made in economies of operation and in the utilization of equipment have increased the carrying capacity of air transportation during the last few years. The following comparisons were made between the annual potential capacity of 5,000, 10,000, and 15,000 surplus assumed war transport aircraft (20 percent four-engined and 80 percent two-engined) and the ton-miles produced by the various surface carriers in 1939.[1]

[1] For purposes of convenience, annual ton-miles per aircraft were calculated on the basis of data in two previously published reports of the Bureau of Agricultural Economics and the Edward S. Evans Transportation Research. Data for the C–54A (the representative wartime four-engine transport) are taken from Post-War Air-Transport Costs and Markets for Lettuce, by R. W. Hoecker and Richard Kermit Waldo, July 1944, and for the C–47 (the representative two-engine type) are from Postwar Air Transportation of Fresh Strawberries and Tomatoes from Florida to Detroit, Michigan, by R. W. Hoecker, March 1944.

These data yield an annual ton-mileage figure of 4,394,197 per plane for the C–54A and 2,005,918 per plane for the C–47. Annual passenger-miles per aircraft were calculated to be 14,484,510 for the C–54A and 6,815,604 for the C–47. These were based on data in the two aforementioned reports, plus an average length of haul per passenger and an average passenger load factor, which were in line with prewar United States domestic airline experience. The maximum passenger capacity of the converted C–54A was taken at a conservative 40 and the converted C–47 at 21.

In presenting data on the carrying capacity of transport planes (fig. 1) it is realized that available cargo in the United States suitable for transport by aircraft is not likely to be adequate to utilize fully a large proportion of these planes.

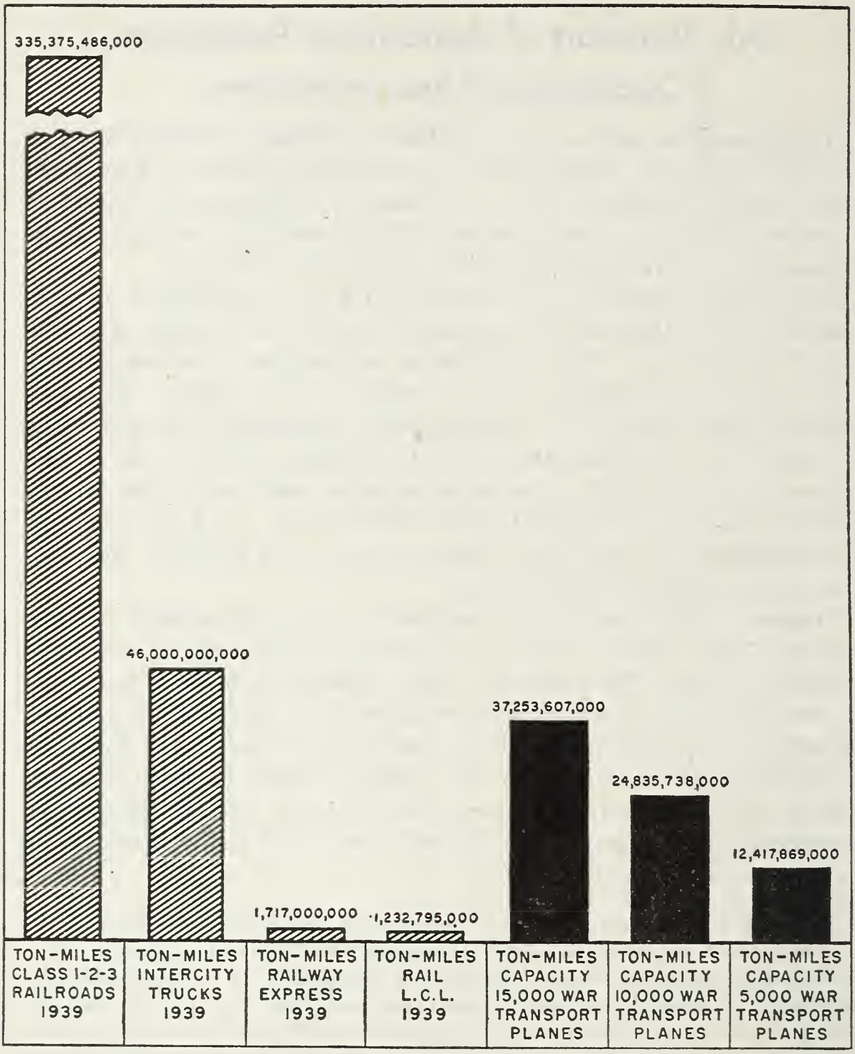

Figure 1.—Ton-miles of freight hauled by railroads and intercity trucks in 1939 and the ton-miles capacity of surplus war transport planes.

Reconversion costs for freight carrying would be relatively low. However, reconversion costs for passenger carrying probably would be sufficiently high to limit the use of surplus transport planes for this purpose. Availability to airlines of new and improved equipment would also be a limiting factor. A relatively small number of surplus planes may be used by the airlines until more modern equipment becomes available.

Agriculture's principal interest in air transportation is in the speed with which the airplane can transport perishable products to distant markets and as a method of opening new markets for postwar surpluses of perishable agricultural commodities. The continued development of air-freight transportation will make it possible for producers to ship products to many markets that are not now accessible because of present inadequate transportation facilities. This will apply particularly to the subtropical areas of Florida, Texas, and California, and to Central and South America.

Air transportation will permit shipments of fully matured and ripened products of excellent quality instead of products in various degrees of ripeness and maturity as now necessitated because of the longer time required for land transport. Air freight will make possible the retailing of perishables in eastern markets 24 hours after harvest. Rail freight from California requires 10 days or more to reach the eastern seaboard.

The quantity of agricultural products which will move as air cargo depends largely upon: (1) The absolute cost of air transportation and the relative cost in comparison with other modes of transportation, (2) the extent to which reduction can be made in other marketing costs of the products shipped by air, (3) the extent to which air transportation will cause an increase in the demand for the product, (4) the quantity of industrial products that will move as air cargo, and (5) the available ground facilities for handling the planes and cargo.

Although several test shipments of agricultural products have been made, they serve only as guideposts and indications of what may be expected when larger quantities of produce may be shipped by air. Many of the shipments were necessarily made in cargo holds of passenger planes, where handling and transportation conditions were not typical of what could be expected in regular all-cargo plane transportation. Air-borne produce must be handled by shippers, wholesalers, and retailers by methods substantially different from those used in marketing rail-borne produce. A new field with new requirements has been opened to the package industry. Pilots and airline operators must learn a new business. The present limited test shipments have served often to show the extent of the problems to be solved rather than to furnish answers to them.

New developments in packaging and in the art of merchandising agricultural perishables will be necessary to maximize the use made of the advantages of air transportation. Air transportation may aid and may require a more streamlined method of marketing and special facilities may be built to expedite the handling of air cargo. Growers must learn to pick and handle produce properly for air shipment. Officials of the aircraft industry must adapt their planes to proper cargo handling and give adequate attention to refrigeration, ventilation, stowage, and efficiency in handling.

Quality superiority of air-borne produce over surface-borne produce must be proved, and then the public must be educated to the facts. Shipments of commodities should not be based on the expectation or the hope of building a business on curiosity sales.

To insure maximum economic use of the new facilities available to agriculture, the potentialities in air transportation should be given the greatest practicable freedom for development. Existing passenger airlines operating as common carriers may prove to be the best agent to haul air freight. On the other hand, new airlines organized as contract carriers to haul air cargo only may prove to be the best agent. Either of these or any other type of operation should be given a free opportunity to prove its ability to carry air freight economically. Regulations should be kept to the minimum by the Civil Aeronautics Board or by the Civil Aeronautical Administration in the experiment stage of the volume movement of freight. Certainly some safety regulations would be in order but it is questionable whether they must be the same as for passenger-plane operation. Some of the safety regulations for the operation of planes carrying all-cargo loads might be liberalized in the light of the Army's experience with cargo flying.

This analysis is limited almost entirely to the period immediately following the end of the war, because this is the most critical period for the aircraft industry. Projections into this period can be made more easily than into the more distant future. As new planes and techniques are developed, costs probably will decrease and the volume of traffic probably will increase.

Present Development of Air Cargo

Air cargo has been transported in conjunction with passengers until recently. The plane used by most airlines during the last several years has been the Douglas DC–3. It was first used by the airlines in 1936. This plane accommodates 21 passengers. Baggage, mail, and express weighing up to 1,000 pounds can be carried in compartments fore and aft of the passenger compartment. The plane's cruising speed is 170 to 180 miles per hour.

Another Douglas plane, the DC–4, was introduced in 1942. This plane is twice the size of the DC–3 and was designed to carry 42 passengers in commercial operations. The C–47, the military adaptation of the DC–3, will carry about 8,500 pounds of cargo, and the C–54A, the military adaptation of the DC–4, will carry about 17,000 pounds of cargo.

Other planes in extensive use at present are the Consolidated C–87, with cargo capacity of about 10,000 pounds, the Curtiss-Wright C–46, with cargo capacity of about 16,000 pounds, and the Martin "Mars" flying boat, with a cargo capacity of at least 38,000 pounds. The Fairchild C–82 has recently been developed for cargo operations and has a capacity of about 16,000 pounds. All of the cargo weights assume flights of 1,000 miles.

The rapid rate of increase in traffic of the domestic airlines and the greatly increased traffic per airplane and miles flown are shown in table 1.[2]

In 1941, the last prewar year, three fourths of the number of airplanes in operation in 1930 flew more than four times the number of plane-miles and transported many times the number of passengers and much greater quantities of express and mail. This had been made possible because the planes

[2] Italic numbers in parentheses refer to Literature Cited, p. 44.

TABLE 1.—*Summary of domestic air-carrier operations, 1930–42 (1, p. 22)*

Calendar year	Planes (number)	Plane-miles (thousands)	Passengers [1] (thousands)	Passenger-miles (thous.)	Express (ton-miles)	Mail (ton-miles)	Airway mileage
1930	497	31,993	375	84,051	----------	[2] 3,140,205	--------
1935	356	55,380	747	313,906	1,089,802	4,132,708	28,267
1936	272	63,777	1,021	427,740	1,860,809	5,741,436	28,874
1937	282	66,072	1,103	476,603	2,156,070	6,698,230	31,084
1938	253	69,669	1,343	557,719	2,173,706	7,422,860	35,492
1939	265	82,572	1,876	749,787	2,705,614	8,585,011	35,213
1940	358	108,800	2,959	1,147,445	3,469,485	10,035,638	41,054
1941	359	133,023	4,061	1,491,735	5,242,529	12,900,405	47,703
1942	176	110,103	3,533	1,474,784	11,717,604	19,610,777	36,442

[1] Includes revenue and nonrevenue. These data on number of passengers contain duplications to an indeterminable extent due to multiple count on connecting routes.
[2] 1931 total; no figures available for earlier years.
Statistics supplied by the Civil Aeronautics Administration *(1, p. 21)*.

were larger, speedier, and more durable. All of these developments have helped to decrease costs.

Operating revenue of the domestic airlines by fiscal years is shown in figure 2. In 1943 the sharpest rate of rise was in express revenue, with the other components tending to level off. The revenue from express has been only a small portion of the airlines' total revenue.

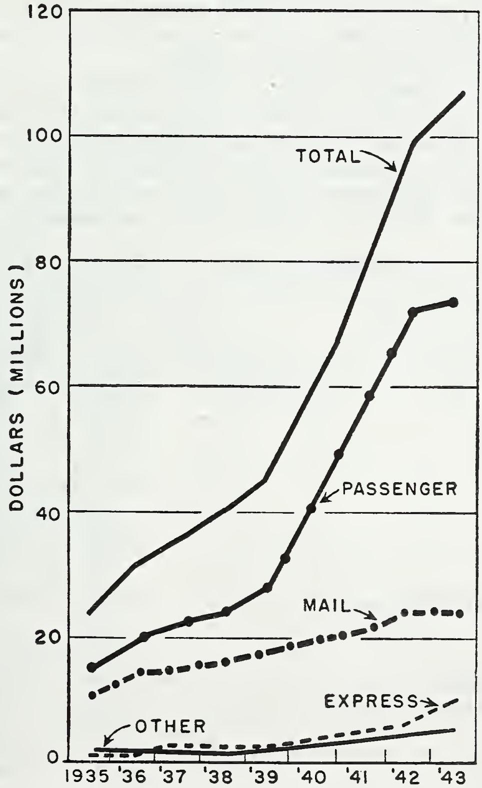

FIGURE 2.—Operating revenue of the domestic airlines by fiscal years ended June 30.

The Railway Express Agency handles practically all of the cargo hauled by the airlines. The coordination of air and rail express service in one agency has proved a convenience to the public. Approximately 30 percent *(1, p. 38)* of the air-express shipments move part of the way by rail express. The air-express service consists of the transportation of cargo by airplane from airport to airport by the airline. Receiving the shipment from the consignor, transportation of the cargo to the airport, and delivery of the shipment to the consignee from the airport are parts of the service performed by the Railway Express Agency. Revenue from the express shipments is shared by the airlines and the Railway Express Agency. As illustrated in figure 1, air express represented only a small portion of the airlines' total revenue. In 1942 the average air-express load per revenue plane-mile was 118.3 pounds or 4.5 percent of the average total pay load. Before the number of planes operated by the airlines was reduced, when the Army took over a large number for military use, there usually was an excess of weight-carrying capacity so that the express load seldom required a reduction of the passenger or mail load. Express has been a valuable additional source of revenue to the airlines derived from the utilization of unused weight-carrying capacity on regular passenger flights.

Because of the wartime reduction in the number of planes available to the airlines and the consequent capacity loading of planes with passengers, it has been feasible to fly planes for express shipments exclusively. When normal airline operations are possible, the average passenger-load factor probably will be at a lower level and there will be excess weight capacity for express shipments on the scheduled passenger flights.

A summary of the Railway Express Agency's air express shipments in the month of April 1941 is given in table 2.

Of all express shipments, cut flowers accounted for 3.63 percent and food and raw samples for 1.78 percent, totaling about 5.41 percent. The remainder of the shipments were not agricultural perishables. The average length of haul of air express in the United States in 1942 was 1,081 miles.

The greatest use of planes as a means of hauling cargo has been made by the Army and the Navy. In 1944 military personnel in the Army and

TABLE 2.—*Air-express analysis, April 1941 (1, p. 42)*

Commodity group	Percent of total		
	Shipments	Weight	Charges
Machinery, hardware	23.26	31.67	32.77
Printed matter	15.11	28.06	16.62
Store merchandise	13.39	9.25	12.09
Motion picture films	4.32	5.62	7.42
Electros, matrices	6.11	3.51	4.07
Cut flowers	3.63	2.48	3.44
Valuables	8.25	4.24	4.95
Miscellaneous	2.44	2.01	2.37
News photos	4.42	.79	1.73
Drugs	1.46	1.08	1.20
Transcription records, radio parts	4.53	2.04	2.80
Freight manifests	4.36	1.61	2.15
Jewelry	2.60	.75	1.39
Food and raw samples	1.78	1.02	1.36
Optical goods, cameras	1.85	1.14	1.44
Personal baggage	2.19	4.52	3.91
Liquor	.30	.21	.29
	100.00	100.00	100.00

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Navy Air Forces totaled about 3 million men. The Army Air Transport Command is staffed by more than 85,000 officers and men and during recent months has averaged over 12 million plane-miles flown monthly in air transport.

Air Cargo Rates

Present Rates

Most of the operating experience of the airlines has been obtained by the use of the airplane on scheduled passenger routes. As the hauling of cargo before the war was of minor importance, the best basis on which to estimate possible air-cargo rates in the postwar period is found in the operating costs of the airlines in the prewar period and during the war. According to the Civil Aeronautics Board, costs per plane-mile increased from about 50 cents in 1920 to about 70 cents in 1936. However, because of the increased size of the planes, the cost per ton-mile at full capacity decreased from about $1.60 in 1920 to about 30 cents in 1936.

The comparative summary of operating expenses for the airlines for the calendar years 1939 and 1942 are given in table 3.

TABLE 3.—*Comparative summary of operating expenses for calendar years 1939 and 1942 (3, p. 77)*

Type of expense	Comparison by cents per mile on basis of total miles flown, year ended Dec. 31	
	1939	*1942*
	Cents	*Cents*
Aircraft operating expenses:		
Flying operations:		
Captains and senior pilots	5.93	5.99
First officers and copilots	1.98	2.30
Aircraft engine fuels	5.86	6.56
Aircraft engine fuel taxes	.95	1.44
Aircraft engine oils (including tax)	.34	.37
Flight equipment insurance and injuries, loss and damages	.87	.95
Flying liability and compensation insurance	1.52	.15
Other expenses	.82	1.13
Total flying operations expenses	18.27	18.89
Flight equipment maintenance—direct:		
Aircraft repairs	2.80	3.11
Aircraft engine repairs	2.96	3.50
Other expenses	.77	.87
Total flight-equipment maintenance—direct expenses	6.53	7.48
Depreciation—flight equipment:		
Aircraft depreciation	3.92	3.07
Aircraft-engine depreciation	1.38	1.29
Other flight-equipment depreciation	.29	.70
Total flight-equipment depreciation expenses	5.59	5.06
Total aircraft operating expenses	30.39	31.43

TABLE 3.—*Comparative summary of operating expenses for calendar years 1939 and 1942 (3, p. 77)*—Continued

Type of expense	Comparison by cents per mile on basis of total miles flown, year ended Dec. 31	
	1939	*1942*
	Cents	*Cents*
Ground and indirect expenses:		
Ground operations:		
Salaries of superintendents, airport and hangar employees, etc.	7.20	9.63
Rents of fields, buildings, and offices	1.13	.98
Other expenses	2.04	2.73
Total ground-operations expenses	10.37	13.34
Ground-equipment maintenance—direct (total)	.68	.89
Equipment maintenance—indirect (total)	2.36	3.76
Depreciation—ground equipment (total)	1.07	1.09
Passenger service:		
Stewards and stewardesses	.78	1.15
Passenger supplies and food expense	1.35	1.91
Passenger liability insurance	------	1.25
Other expenses	------	1.32
Total passenger-service expenses	2.13	5.63
Traffic and sales:		
Salaries of superintendents, traffic managers, agents, etc.	2.31	4.16
Other expenses	2.37	2.94
Total traffic and sales expenses	4.68	7.10
Advertising and publicity (total)	2.54	2.75
General and administrative:		
Salaries of general officers	.62	.58
General office employees	.89	1.74
Legal salaries, fees, and expenses	.42	.35
Special, professional and technical services	.11	.16
Regulatory proceeding expenses	.11	.12
Pensions and welfare	.08	.86
General taxes (excludes income taxes)	1.26	1.45
Other expenses	1.22	1.62
Total general and administrative expenses	4.71	6.88
Total ground and indirect expenses	28.54	41.44
Total	[1] 59.40	72.87
Deduct: profit on retirement or sale of operating property	------	2.39
Operating expenses after retirement gains and losses	[1] 59.40	70.48

[1] Includes the total operating expenses for Colonial Airlines for 1939 and 1940. for which the distribution by type of expense was not available. Hence the detail distribution of expenses for these years does not add to the totals set forth.

Total operating expenses per mile were 59.40 cents in 1939 and 70.48 cents in 1942. The higher cost in 1942 was due largely to higher costs caused by the war. In 1939 individual domestic airline costs ranged from a low of 36.03 cents *(3, p. 84)* to a high of 64.87 cents *(3, p. 79)* per plane-mile. In 1942, the range was from a low of 48.35 cents *(3, p. 78)* to a high of 112.54 cents per plane-mile. There appears to be a considerable variation in costs of the individual companies.

The base rate for air express is 3½ cents per pound per 100 miles, or 70 cents per ton-mile. This was a reduction in base rates in force before July 15, 1943, from 4 cents per pound per 100 miles or 80 cents per ton-mile. In 1942, the average ton-mile rate charged for railway express was about 9 cents.

Ton-mile costs for rail freight are considerably cheaper than for rail express. A similar relationship exists between ton-mile costs for air freight and air express. The first air-freight tariff was filed by the American Airlines, Inc., and went into effect October 15, 1944. The rate structure for the American Airlines' tariff is built around four freight classes for the transportation of commodities in less than plane-load lots. Rates per 100 pounds for shipping freight from Detroit to Los Angeles are $51.70 for Class A, $44.70 for Class B, $37.70 for Class C, and $30.70 for Class D freight.

In addition to these four classes, rates were established for perishables in minimum-weight shipments of 5,000 pounds. From Los Angeles to Detroit the rate is $24.80 per 100 pounds. This rate is based on charges of approximately 21 cents per ton-mile.

Estimates of Future Rates

The cost per ton-mile of carrying air freight has been declining during the last 20 years. Because of the importance of the airplane during the war, the attention of many scientists has been focused on improving the plane's performance. Many of these improvements will tend to lower the operating costs of planes.

Aviation authorities have predicted airport-to-airport air-cargo costs in the immediate postwar period as low as 5 cents per ton-mile. For example, Douglas Aircraft Company's market research department has estimated postwar air-cargo costs this low. The National Resources Planning Board *(2, p. 28)*, Charles I. Stanton, United States Deputy Administrator of Civil Aeronautics, Edward P. Warner, Vice Chairman of the United States Civil Aeronautics Board, and Grover Loening, Aircraft Consultant to the War Production Board, have estimated an immediate postwar air-cargo cost as low as 10 cents per ton-mile.[3] None of the predictions stated the load factor upon which they were based. As the idea of regular operations hauling agricultural perishables with a 100-percent load factor is a relatively new concept, it seems safe to assume that most of the predictions were based on operations with load factors of around 65 or 75 percent.

Estimates of Rates Based on Contract-Carrier Operation

The present airlines and railroads and some trucking firms operate as "common carriers." The common carrier is under a duty to serve the general public, without unjust discrimination or undue preference, at reasonable rates which must be published and filed with proper regulatory bodies. Usually the common carrier travels designated routes, makes scheduled stops, and accepts all traffic offered by shippers, in conformity with published tariffs and within the carrier's capacity to serve.

The term "contract carrier" or the term "nonscheduled flights" is applied to all other carriers that transport in interstate or foreign commerce for

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[3] American Aviation Daily. 30: 215–219. 1943. (See p. 216); 34: 68–73. 1944. (See p. 68) Washington. [Processed.]

compensation. A contract carrier does not undertake to transport for all who apply but limits its service to specific shippers under special and individual contracts. In the case of motor carriers, where this type of operation is commonly found, the carriers are required to publish and file with the Interstate Commerce Commission schedules of minimum rates and charges. The contract-carrier type of air-transport operation makes possible certain economies in handling air-freight shipments that may result in lower costs of operation than for common carriers.

The Bureau of Agricultural Economics and the Edward S. Evans Transportation Research (a fund established for this purpose) have cooperatively made studies *(6, 8)* for the purpose of investigating the economies of the "contract-carrier" operation. Estimated costs were based on hypothetical operations with the assumptions that: (1) Surplus war transport planes and pilots would be utilized, (2) the fleet of planes used would be relatively small, (3) there would be an interchange of agricultural perishables with industrial commodities, (4) the planes would link by a direct route metropolitan centers with an important southern fruit and vegetable production area at least 750 miles distant, (5) the agricultural area would be located close to a sizable export city, (6) agricultural perishables would be available in the producing areas most of the year, and (7) fast schedules would be maintained. These assumptions are elaborated further in the report, "The Use of Surplus War Cargo Planes to Transport Agricultural Perishables." [4]

In the study Postwar Air Transportation of Fresh Strawberries and Tomatoes from Florida to Detroit, Mich., the average cost per ton-mile for transporting tomatoes and strawberries was estimated to be approximately 9 cents for shipment in C–47 airplanes purchased at 25 cents on the dollar, 10 cents in planes purchased at 50 cents on the dollar, and 11 cents in planes purchased at 75 cents on the dollar.

In the study Post-War Air-Transport Costs and Markets for Lettuce the average cost per ton-mile for transporting lettuce from California to Detroit was estimated to be approximately 6.8 cents. The ton-mile cost was reduced to 6.5 cents by the use of airways that use the shortest possible routes.

The principal reason there is a difference in ton-mile costs in the two reports is that C–47 airplanes were used in the strawberry and tomato report while C–54A airplanes were used for the lettuce report.

A spokesman for the Consolidated-Vultee Aircraft Corporation stated that planes they have built could be used in contract-carrier operation at an operating cost as low as 5½ cents per ton-mile.[5]

Engineers for the Douglas Aircraft Company estimate that present DC–4 planes could be operated as contract carriers as low as 6.75 cents per ton-mile *(4, pp. 7–8)*.

These estimates are based on the assumption that certain limiting governmental regulations affecting the hauling of air freight will be modified. Most of these regulations were adopted for the protection of passengers when airplanes were primarily used for passenger transportation.

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[4] Hoecker, R. W., Waldo, R. K., and Brittin, L. H. THE USE OF SURPLUS WAR CARGO PLANES TO TRANSPORT AGRICULTURAL PERISHABLES. Bur. Agr. Econ. and Edward S. Evans Transp. Res. 17 pp., illus. 1945. [Processed.]

[5] Wold, W. C. THE AIR FREIGHTER—NOW AND THEN. Unpublished address before the United Fresh Fruit and Vegetable Convention, Jan. 24, 1945.

New Developments in Air Transportation

The airplane has reached its present stage of development in an extremely short time. Further development no doubt will take place when it is possible to adapt to peacetime uses many of the innovations formerly used solely for war purposes. Little information is made public regarding new improvements but the effect undoubtedly will be to continue the downward trend in cost of air transportation.

Specially Designed Cargo Planes

Although no actual estimate will be made of potential savings, it is obvious that air-transport costs for cargo could be lowered (although not necessarily below costs computed, as above, using surplus war planes at greatly reduced first cost) by the use of planes specifically designed to haul commercial cargo. Most of the plane manufacturers that intend to manufacture cargo planes in the postwar period are engaged in engineering work on special cargo planes. Some of the cargo planes will be redesigned or modified military transport planes. Others will be built "from the drawing board up." The new planes probably will aid in the achievement of superior performance at lower cost of operation. Compared with prewar equipment, new planes will undoubtedly have less drag, have superior wing airfoil sections, and have improved high-lift devices. Other contemplated improvement are a reduction in weight of structure and equipment, improvement in power plants, and reductions in fuel consumption *(11)*. Much research is being done to improve take-off devices for heavily loaded aircraft.

Helicopters

The helicopter is the only aircraft that can move up or down, forward or backward, or sideways under its own power and under control. The helicopter was first tested in 1939 and first quantity orders were placed by the Army in December 1942. Grover Loening, Chairman of the Helicopter Committee, National Advisory Committee for Aeronautics, predicts that helicopters will not be available for general use for 5 or 10 years *(10, p. 24)*. At present they are more difficult to fly than airplanes. They probably will not become important as long-distance cargo carriers unless new developments make them relatively more efficient than at present. The airplane can fly almost twice as fast and can haul much heavier loads more economically. Helicopters probably will be used for flights of relatively short distances and for special purposes.

Gliders

Gliders have about the same pay-load capacity but are less expensive to build than power-driven airplanes. Because the engines, propeller, fuel and fuel tanks, and some of the instruments are not required, construction of the glider is simple, weight is decreased, and the proportion of pay load to gross empty weight is greatly increased. This is not a net saving, however, as more power is required on the tow plane to pull the glider and with a given load distributed between tow plane and glider the cost per ton-mile is greater than if the entire load is carried in the airplane without the glider.

Gliders probably will not become important as cargo carriers until the tow planes are improved. Tow planes should be designed which have the proper gear ratio in engines, suitable wing design, and the proper center of gravity. Automatic pilots must be installed in gliders which will prevent the gliders from flying out of the right place behind the tow plane. When these problems and others not mentioned are solved, trains of five or six gliders may be possible.

Predictions are that if airplanes can carry freight profitably for 10 cents per ton-mile, a tow plane pulling its own weight in gliders under similar conditions could transport freight for 5 cents or less per ton-mile *(5, p. 11)*. It is thought that gliders probably will not become important as cargo carriers for 5 or 10 years.

Facilities for Handling Air Cargo

Airports

In the immediate postwar period there may be sufficient equipment to fly the air cargo that is offered, but the potential volume may be greater than could be handled at the available airports. Inadequate ground facilities could be a serious handicap to the development of air transportation.

Use of airways and airports is limited to the number of planes that can be landed when weather conditions necessitate instrument flight operation. Present techniques permit an airport that has a single runway to handle in instrument weather from 8 to 15 take-offs and landings per hour. This figure may be increased to 30 an hour almost immediately upon adoption of new techniques, and it may ultimately be raised to 75 per hour after the adoption of radar and other electrical equipment. These new appliances probably will not be in general use for at least 5 years.[6]

In 1939 the Civil Aeronautical Administration estimated that 4,000 airports were needed in the United States. At present, there are about 3,000 airports but only 1,000 of them have runways sufficiently long to accommodate primary and secondary trunk-route planes. Many airports are for military use and not suitable for the handling of cargo. The CAA is making an upward revision in the estimated number of airports needed.[7] The airport cities and certificated airlines as of October 1943 are shown in figure 3.

When planning new airports, special attention should be given to the design of the runway, passenger facilities, cargo handling, general administration, maintenance, safety control, capacity of air lanes approaching the airport, and the capacity of communications systems between the airport and centers of population. The type of problem now encountered in handling passengers and one which will apply to cargo handling is illustrated in the following example. For the flight from the New York airport to the Boston airport, the proposed fare of 4 cents per mile for 220 miles would be $8.80 and the flight would take approximately 1 hour. In contrast, the limousine charges to the airport and from the airport at present

[6] Civil Aeronautics Administration, Traffic Control Division. [Unpublished report.]
[7] Donaldson, C. B. THE AIRPORT SITUATION. Unpublished address, Oct. 26, 1943.

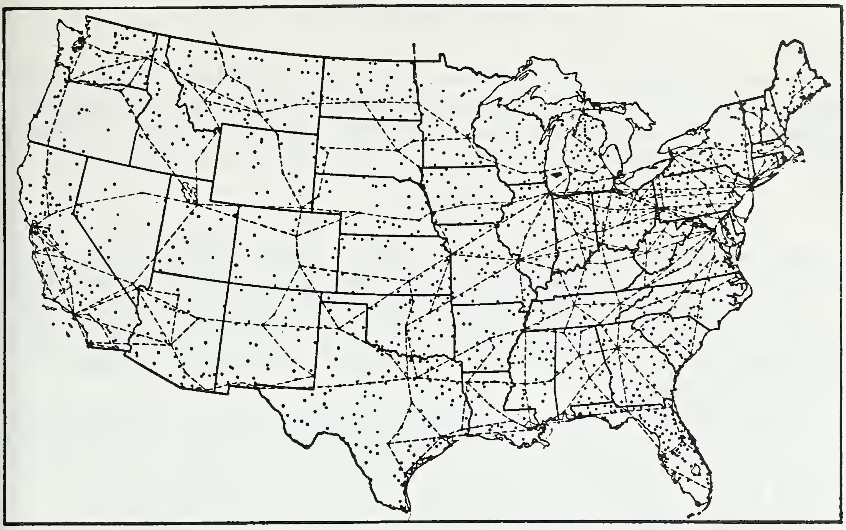

FIGURE 3.—Airport cities and certificated airlines, October 1943.

total $2.20 or an additional 25 percent and as much time is consumed at each end as the flight.[8]

Although produce probably will arrive at airports in cities in the early hours of the morning when highways are not congested, the delivery of the produce to wholesale markets and retail stores should be expedited. It may be desirable to establish a separate airport to speed the handling of cargo. A fresh fruit and vegetable wholesale market at the airport may prove advantageous but probably the best procedure will be to handle the perishables through existing wholesale channels.

Ground Handling

Ground handling involves the pick-up and delivery of freight to the airport by motortruck; terminal operations such as weighing, billing, sorting, and dispatching; loading and unloading trucks and aircraft; and tying down cargo in the aircraft. Present air-express shipments are handled exclusively by one agency. The ground cost for the average shipment was estimated at $1.04.[9] This figure does not include loading and unloading the airplanes. The principal reasons for the high cost were the small average size of shipment and the speed with which the shipments were handled. In 1941 the average shipment weighed 8 pounds and the average length of haul was about 1,000 miles. Deliveries are usually made the same day the express shipments arrive at the airport. Handling costs per ton-mile were about 26 cents.

In one study it was etimated that, in the postwar period, air-express handling costs could be reduced to about 8 cents per ton-mile *(11, p. 67)*. This reduction would be possible primarily because of an estimated increase

[8] VARKER, W. M. AIRPORTS AND COMMUNITY PLANNING. Unpublished address before the National Air Cargo Conference, Detroit, Mich., March 23, 1944.

[9] Based on an unpublished paper presented before the Institute of Aeronautical Sciences by C. G. Peterson, Jan. 30, 1942.

in the average size of shipment and some economies in pick-up and delivery service.

Ground handling costs for planeloads of perishables probably will average much lower than 8 cents per ton-mile. Average size of shipments probably will be measured in tons. Handling costs for air-borne produce will probably be little different from those for surface-borne produce.

Stowage

Firm anchorage of air cargo is a necessity. When cargo is not securely anchored in surface transportation usually the cargo only is damaged, but in air transportation a shift of the cargo might wreck the plane. The weight of the load in a plane must always be properly distributed and the cargo must be shifted each time the weight in the plane is changed by loading or unloading.

Light but efficient tie-down equipment is highly desirable. A lightweight strong bag with open mesh in front has been developed for securing small packages. Heavy articles may be secured in several ways, one tie-down method being a series of clamps fastened to the ribbing of the plane.

Large lightweight containers have been patented. The cargo is packed in them and then they are loaded and securely fastened to the plane. It is possible to pack freight into the containers and then haul them to the plane. The large container helps to avoid overpacking and reduces ground handling. Its use probably would be more advantageous in shipping industrial products than in the transportation of perishables. Agricultural perishable shipments probably would originate in a limited number of areas and packing would probably be similar for any one load, with not more than three of four sizes of containers in each load. The containers for perishables probably could be fastened directly to the plane without the necessity of an outside container. The principal objection to the large container is its additional weight.

A large shipping container has been developed by one company to include a refrigerating unit and a heating unit. The container can be used for truck, air, or rail shipment. Deterring factors in the adoption of this container for air shipment probably will be its weight and the necessity for special handling equipment.

One proposed design for an airplane that is expected to eliminate some weight and take advantage of the large-container principle is called the "flying boxcar." This general principle is comparable with that of the present trailer truck, the tractor or motor of which is detachable from the trailer. The fuselage of the plane would be detachable so that it could be replaced quickly. The principal advantage claimed for this type of handling is the saving of time for the flight crew. The plane's structural strength, however, probably would be weakened and probably little tie-down equipment would be eliminated.

Economies of Air Transportation

Air shipment offers certain cost-offsetting economies. Economies—such as the use of lighter containers, elimination of ice, and the elimination of some packing costs—may be substantial. In handling perishables, economies such as smaller interest charges, more efficient use of working capital, and reduced inventories will usually be relatively unimportant.

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Packaging Economies

Correct packaging for air shipment may be the difference between success and failure in shipping a wide variety of commodities. Containers for use in air shipment will stress the following new developments: (1) Reduction in tare weight, (2) insulation for shipment of perishables, and (3) resistance to the elements.

Lighter weight packages for air shipment than for surface shipments are possible because the air shipments are not subjected to as severe shocks in transit as are rail-borne shipments. This advantage is partly offset, however, by the fact that the product must still be protected from rough handling before it is loaded and after it is unloaded from the plane. Another principal reason air cargo can use a light container is that ice is not needed for most shipments by air. If necessary, the plane usually can fly high enough to make use of the high altitudes for refrigeration and as the product is in air transit only a fraction of the time that it is in rail transit, the perishable does not have the same need for refrigeration. High air-transportation cost per pound increases the importance of lightweight containers and undoubtedly will justify more careful handling on the ground.

Assuming a rate of 10 cents per ton-mile, the cost of transporting products over a 2,000 mile haul would be 10 cents per pound. At this rate, reducing the weight of the containers one half would result in a saving in transportation costs of 1.4 cents per pound for strawberries, 0.5 cent per pound for lettuce, and 0.6 cent per pound for tomatoes. The lower transportation charge, as a result of reducing the weight of the container one half, is about equivalent to the current cost of standard containers.

Containers that will afford some protection against changes of temperature will be particularly useful for perishable shipments. Planes encounter a wide difference in temperature between the ground temperature and cruising temperature as well as between originating point and terminal point. For example, a shipment of perishables from Florida may experience a ground temperature of 80 degrees Fahrenheit in Florida; a cruising height temperature of 40 degrees in Florida and 10 degrees below zero in the North; and a ground temperature of 30 degrees Fahrenheit in New York City.

Consumer package requirements essential to the proper protection and merchandising of fruit and vegetable shipments by air, according to a commission merchant, are several. (1) The consumer package must be designed and constructed to allow for compact packing, despite varied sizes of the items, so that movement within the individual package is eliminated. (2) It must have extended edges or some similar feature to permit distribution of weight and so give needed protection to bottom of packages. (3) The small package must be protected from being crushed by other cargo by being packed in strong containers. (4) Identification, provided by means of a brand or trademark, is an important basis for effective advertising and sales promotion; for perishables, dating the package could emphasize the element of freshness. (5) The package should allow for convenient inspection of the product by consumers, with a minimum of handling—as through a transparent window. (6) The package should contain the quantity of produce commonly purchased by consumers *(12, p. 84)*.

Describing new developments in packaging, K. N. Merritt *(12, p. 86)* states:

> . . . The war has developed many strikingly new container materials. So-called "weatherproof" or V-board corrugated and solid fibre boxes, lighter than wood, will

withstand prolonged contact with water without disintegrating. New wax treatments have resulted in paperboard packages that are already being successfully used for carrying fresh fish surrounded with water ice in place of the former tin boxes. Other familiar examples of this new development are the Ration K boxes, the various dehydrated food packages, the small arms ammunition container, cylindrical paper shell tubes and many other lightweight paperboard packages developed under the high pressure of military requirements to reduce weight and substitute paperboard for critical wood and metal. Many of these new developments undoubtedly will remain after the war and be adapted to civilian air-cargo requirements.

It is important to remember, however, that in addition to having light weight, the container must be strong, rigid and have adequate cushion protection against outside shocks and impacts. It should also have a surface which permits it to be handled without fear of nails or splinters. Other air-cargo requirements include low-cost insulation against heat and cold, ease of efficient sealing, ability to take multi-colored printing and minimum of bulk. The corrugated box is one answer to all these requirements.

Difficulty was experienced in shipping certain flowers by air because of the changes in atmospheric pressure until it was observed that the flowers were not properly packaged. Failure to puncture the containers caused the containers to expand and lose pressure when the plane was at high altitudes and then, upon the plane's descent, the increased outside pressure caused the packages to crush the flowers.

Changes in atmospheric pressure are not expected to limit air transportation. First, the probable cruising level of 8,000 to 10,000 feet is not expected to damage seriously many of the perishables, and, second, if it should be found desirable to fly higher than this, pressurized cargo compartments probably could be used, if necessary.

Elimination of Part of the Usual Marketing Costs

Shipment by air makes possible the elimination of some of the usual marketing costs for some commodities. The extent to which these costs can be lowered will tend to offset the higher air-transportation charges. Commodities must be examined individually to determine the costs that can be decreased or eliminated.

Inventories may be decreased if replacements can be obtained within 1 day instead of within 3 or 4 days. There would be a small saving in interest, but this would make only a slight difference in cost. Air express is about 3 days faster than rail express from New York to Los Angeles. At 6 percent interest on a $100 shipment, the shorter time would represent a saving of only 5 mills. The reduction of risk in carrying a large inventory would be more important as a saving than the saving in interest costs.

More substantial savings are of the type represented in the shipment of tomatoes and lettuce by airplane. The usual method of handling tomatoes during the winter is to pick them green and ripen them after they reach northern markets. By picking the tomatoes when vine-ripened and transporting them overnight to the northern markets, the ripening cost of 2 cents to 3 cents per pound may be eliminated. Because lettuce is packed with ice for rail shipment, it cannot be packed directly into containers in the field but must go to packing sheds. Air transportation of lettuce would make it feasible to dry-pack the lettuce in the field and eliminate the expense of going through the packing shed. This would save an estimated 1 cent per pound in handling lettuce.

Elimination of Some Waste

Spoilage of fruits and vegetables, including necessary mark-downs, accounts for a large percentage of the retailer's and wholesaler's gross margin.

The rate of spoilage varies considerably from one product to another as well as from one lot of produce to another. The weather and shipping conditions affect the rate of spoilage more than do any other factors. For example, during August 1940 the percentage of loss, including mark-downs, for spinach ranged from an average of 17.7 percent for 1 week to an average low of 2.9 percent for the following week.[10] The variation in average percentage of loss from one product to another for any 1 week was even greater. The wholesaler's waste and spoilage is not nearly so high nor is the range so great as for the retailer.

As only small quantities of perishable commodities have been shipped by air, no data are available on which to base a reliable estimate of the reduction in waste and spoilage, but it probably would be substantial. Even though the commodities are harvested vine-ripened and therefore are more susceptible to bruising while being transported than if transported in less mature condition, the gentler transportation will prevent some bruising and it is likely that any bruised air-transported produce could be sold and consumed before noticeable deterioration takes place.

Sorting and cleaning produce before it is shipped is one method of decreasing waste at wholesale and retail levels. If commodities are shipped by air, the rapid rate of transportation and their relatively higher costs make the sorting and cleaning of the produce at the shipping point more feasible than when similar commodities are shipped by rail. Air shipment of spinach has recently demonstrated what could be done to decrease waste by special packaging and handling. The spinach had been washed, sorted, and packed in 10-ounce bags. About 50 percent of the weight of spinach that is usually shipped was discarded in California. If lima beans were shelled in California and shipped by air in special bags, about 68 percent of their usual rail shipping weight would be saved. Additional costs of sorting and cleaning are incurred, but the saving in weight tends to reduce substantially the difference between the cost of transportation by rail and by air.

Savings in Refrigeration Costs

Many vegetables and some fruits require artificial refrigeration in transit. Lettuce moving east by rail in carload lots from California requires 10,000 to 20,000 pounds of top ice, and in addition about 30 pounds of ice is packed in the lettuce crate which would amount to 9,600 additional pounds of ice in a car of 320 crates.

Spinach from California to eastern markets requires about 10,000 pounds of top ice and 40,000 pounds for re-icing the bunkers in transit. Snap beans from Florida require about 10,000 pounds of initial bunker ice and at least 10,000 pounds for re-icing the bunkers. Tomatoes do not require so much icing as lettuce, spinach, or snap beans. The quantity required differs, depending on the degree of ripeness of the tomatoes when they are shipped.

The shipper pays for icing costs and the freight charges on the ice. The cost of refrigerating lettuce, exclusive of crate ice, is about 40 cents per crate. Crate ice costs 13 cents. The packing-shed charge for icing and packing the lettuce is also additional.

There would be a substantial saving in refrigeration costs if perishables

[10] Stolting, W. H., and Meyers, A. L. FOOD WASTE AND SPOILAGE IN WASHINGTON, D. C., JULY 29 TO SEPTEMBER 14, 1940. U. S. Bur. Agr. Econ. 19 pp., illus. (See p. 10.) [Processed.]

can be transported by plane without artificial refrigeration and it appears as though the use of artificial refrigeration in cargo planes will be unnecessary. Precooling the commodities and the use of insulated containers and insulating blankets should be adequate protection from usual temperature changes en route.

Temperatures encountered by airplanes are relatively more extreme than temperatures encountered by surface transportation. Readings made on one flight from San Francisco, Calif., to Dayton, Ohio, are given in table 4.

TABLE 4.—*Outside temperature (°F.) readings of plane ascending and descending on TWA Flight 6 from San Francisco, Calif., to Dayton, Ohio, June 15 and 16, 1944 (8, p. 27)*

Altitude (feet)	San Francisco	Burbank	Boulder City	Winslow	Albuquerque	Amarillo	Wichita	Kansas City	St. Louis	Cincinnati	Dayton
ASCENDING											
1,000	50.0	62.6	----	----	----	----	----	80.6	73.4	77.0	----
2,000	50.0	55.4	----	----	----	----	78.8	78.8	77.0	77.0	----
3,000	45.5	51.8	73.4	----	----	----	77.0	73.4	75.2	71.6	----
4,000	44.6	46.4	69.8	----	----	84.2	73.4	69.8	71.6	----	----
5,000	41.0	42.8	64.4	----	----	80.6	69.8	68.0	68.0	----	----
6,000	37.4	39.2	57.2	73.4	82.4	75.2	----	----	----	----	----
7,000	36.5	35.6	53.6	68.0	78.8	71.6	----	----	----	----	----
8,000	32.0	35.6	50.0	64.4	73.4	68.0	----	----	----	----	----
9,000	28.4	33.8	44.6	57.2	68.0	64.4	----	----	----	----	----
10,000	25.7	28.4	41.0	53.6	----	----	----	----	----	----	----
11,000	----	26.6	35.6	46.4	----	----	----	----	----	----	----
DESCENDING											
11,000	----	----	32.0	42.8	53.6	----	----	----	----	----	----
10,000	----	26.6	35.6	50.0	60.8	----	----	----	----	----	----
9,000	----	30.2	39.2	55.4	69.8	68.0	64.4	----	----	----	----
8,000	----	33.8	42.8	60.8	73.4	73.4	71.6	----	----	----	----
7,000	----	36.5	48.2	68.0	77.0	77.0	73.4	----	----	----	----
6,000	----	41.0	55.4	75.2	----	80.6	69.8	----	----	----	----
5,000	----	41.0	62.6	----	----	82.4	71.6	71.6	71.6	68.0	----
4,000	----	42.8	68.0	----	----	86.0	73.4	73.4	75.2	71.6	----
3,000	----	----	71.6	----	----	----	----	75.2	78.8	77.0	71.6
2,000	----	----	----	----	----	----	----	77.0	80.6	77.0	77.0
1,000	----	----	----	----	----	----	----	77.0	80.6	78.8	73.4
Surface	----	59.9	78.8	78.8	----	82.4	----	78.8	71.6	78.8	69.8

Temperatures on trial shipments of lettuce from San Francisco, Calif., to Detroit, Mich., are shown in table 5.

On the trial shipments the quality of the lettuce on arrival probably would have been better had the temperature of the lettuce been lower in transit. Larg shipments in special cargo planes would help to keep the temperature low. It may also be desirable to precool the lettuce before shipment.

Case Studies of Possible Economies in the Transportation of Perishables

The Bureau of Agricultural Economics in cooperation with the Edward S. Evans Transportation Research has made two studies of the economies of transporting fruits and vegetables by air.

Strawberries and Tomatoes *(6)*

The airport-to-airport transportation costs were estimated to be $2.39 per

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TABLE 5.—*Altitude and temperature (°F.) record on trial shipments of lettuce by air from San Francisco, Calif., to Detroit, Mich., June 1944. TWA via Los Angeles, Albuquerque, Amarillo, Wichita, Kansas City, Cincinnati, and Dayton. Tail compartment C–47 (unheated and uninsulated) (8, p. 28)*

Altitude, temperature, and humidity	Overnight storage [1]				In flight [2]														
	June 14							June 15						June 16					
	4pm	8pm	12	4am	8am	10am	12	2pm	4pm	6pm	8pm	10pm	12	2am	4am	6am	8am	10am	12
	Salinas				San Francisco		Los Angeles			Albuquerque	Amarillo	Wichita	Kansas City		Cincinnati	Dayton	Detroit		
Altitude (thousand feet)	----	----	----	----	----	10	11	11	11	11	9	9	5	5	5	3	----	----	----
Temperature:																			
Air outside °F.	70	70	50	48	----	24	27	36	43	54	68	64	72	72	68	72	----	----	----
Air at floor °F.	----	----	----	----	60	55	60	62	64	66	79	78	77	75	78	78	78	----	----
Air 10 inches above floor °F.	----	----	----	----	60	52	70	58	65	73	74	75	74	73	74	80	88	----	----
Lettuce, center of crate, °F.	68	67	67	67	65	65	65	65	65	60	66	67	68	69	70	71	72	----	----
Humidity near crate, percent	----	----	----	----	50	65	40	25	20	20	45	70	40	60	80	50	35	----	----
	June 21							June 22						June 23					
Temperature:																			
Air at floor °F.	----	----	----	----	----	58	61	62	64	70	77	76	72	76	76	75	74	----	----
Lettuce, center of crate, °F.	65	66	66	65	62	61	60	59	59	60	60	61	62	64	66	66	66	----	----
	June 28							June 29						June 30					
Temperature:																			
Air outside °F.	47	47	46	46	64	----	----												
Air at floor °F.	----	----	----	----	----	64	70	70	70	72	73	72	71	70	75	77	74	70	70
Air 10 inches above floor °F.	----	----	----	----	65	65	78	66	70	75	75	74	72	70	72	----	74	71	80
Lettuce, center of crate, °F.	60	60	58	57	56	56	56	57	58	59	60	61	62	63	65	67	68	69	69
Humidity near crate, percent	----	----	----	----	65	80	50	30	25	40	45	65	52	52	65	----	65	35	40

[1] Lettuce held in cold room overnight and trucked to San Francisco early next morning.
[2] Plane left San Francisco 9:30 a.m.

crate or 6.6 cents per pound of content for strawberries from Lakeland, Fla., to Detroit, Mich., and $2.15 per lug or 7.2 cents per pound of content for tomatoes from Miami to Detroit. When these costs are adjusted by adding the cost of hauling the produce to the airport and from the airport to the wholesale market they are 7.5 cents per pound or 11.3 cents per quart of strawberries and 8 cents per pound of tomatoes.

Air transportation charges are about 6½ cents higher than rail or truck charges and 6 cents higher than rail-express charges per quart of strawberries and 6 cents higher per pound of tomatoes.

By the use of a 7-pound cardboard container instead of the 10-pound wooden container for strawberries, the air-transportation cost would be about 5½ cents per quart higher than for rail or truck transportation and 5 cents higher than for rail-express shipment. The substitution of a 2-pound cardboard container for tomatoes in place of the 30-pound lug box now in use results in an air-transportation cost 5 cents higher per pound of tomatoes.

Air transportation of vine-ripened tomatoes would eliminate the need for tomato ripening rooms. This cost was estimated to be about 3 cents per pound, thus reducing the net difference between the cost of transporting by air and the cost of transporting by surface methods to 2 cents per pound.

The probable elimination of some waste would tend to reduce further the net difference in cost between the air-transported and surface-transported strawberries and tomatoes.

Lettuce *(8)*

The airport-to-airport transportation costs were estimated to be 9.33 cents per pound for lettuce from Salinas, Calif., to Detroit, Mich. The air-transportation cost is estimated to be about 6.37 cents per pound more than the rail transportation cost. These costs are estimates, assuming the use of the present-type wooden shipping container and flying existing planes over established airways.

The cost of transporting a pound of lettuce could be reduced from 9.33 to 8.57 cents by the use of lighter and more efficient shipping containers. By flying the shortest distance between major refueling stops, mileage flown between Salinas and Detroit could be reduced 7.3 percent and the cost of transporting lettuce per pound would be further reduced to 8.23 cents.

The use of airplanes for the transportation of lettuce makes possible the elimination of packing-shed costs because the lettuce can be dry packed in the field. A field from which the lettuce is dry packed tends to yield more salable heads than a field from which the lettuce is ice packed. There are additional costs of hauling the lettuce to the airport and from the destination airport to the terminal market. The net difference between expected savings and additional costs would reduce the cost of air transportation of lettuce to 7.23 cents.

Information obtained from the test flights of lettuce and from other sources indicates that waste probably could be reduced from about 12 percent to about 6 percent. If these estimates are correct, the air transportation cost would be reduced by an additional ½ cent per pound. If estimated savings from all sources should be realized, the net difference between costs by air and by rail transportation would be reduced from about 6.37 cents to about 3.75 cents per pound of lettuce.

Greater Retention of Food Value by Fast Air Shipment

No data are available by which an adequate estimate can be made to indicate how much air shipment of perishables can be expected to help preserve vitamin content. The Bureau of Human Nutrition and Home Economics prepared the following unpublished statement regarding vitamins.

A number of studies have shown that vegetables, especially asparagus, string beans, kidney beans, lima beans, cabbage, corn, kale, lettuce, peas, spinach, and tomatoes, lose from twenty to seventy-five percent of their ascorbic acid when held after picking from three to seventeen days, at temperatures as low as 33–34° F. Losses not as extreme but amounting to twenty to thirty percent have been observed for thiamine. Certain enzyme changes may also take place which spoil the "fresh" flavor. These studies also show that when properly refrigerated, losses may be held at a minimum in the first 24–48 hours so that the foods are practically garden fresh. Any method of transportation which cuts down the time period of transit so that fresh foods may reach the consumer in forty-eight hours will do much toward conserving the vitamin value of foods.

Recent experiments [11] designed to measure the effects of time and handling upon the quality of fresh produce have been conducted. The vitamin C content of air-borne, rail-borne, and hothouse tomatoes were compared. The average of six samples showed 25.45 milligrams of vitamin C per 100 grams of sample for the air-borne tomatoes as compared with an average of 14.43 and 13.18 milligrams, respectively, for the rail-borne and hothouse samples. The air-borne tomatoes had ripened on the vine before being shipped.

Use of the Airplane for Quick-Freezing Foods

Thought has been given by individuals who are interested in aviation to the quick-freezing of fruits and vegetables in the plane while the produce is en route to market. Produce from the fields or from plants where it had been prepared for freezing would be loaded, the plane would ascend immediately to a zero or sub-zero temperature level and fly at this level until it had reached destination. The frozen products would then be unloaded and stored at a low temperature until sold.

Many unfavorable factors probably would make the freezing of foods in the plane uneconomical. Fruits or vegetables should be frozen as quickly as possible after being harvested to retain the quality and flavor of the fresh product. Fruits and vegetables must be cleaned, graded, and prepared before they can be frozen. The cost of actually freezing the product is only a small part of the total expense. The produce to be frozen while en route would have to be transported and handled at an assembly point then rehandled and loaded in the plane. The time between harvesting and freezing probably would be increased at least 2 hours and the additional handling would be a considerable expense.

The plane would require special and difficult engineering features to freeze the product properly. About the only feasible method would be to bulk freeze the product in large containers. Advantageous stowage of family-size containers for freezing would be difficult and probably greatly reduce carrying capacity of the plane. Freezing in transit would also present the problem of suitable packaging.

The economical cruising height of cargo planes at present is between 8,000 and 10,000 feet. This usually is below the altitude necessary for the quick freezing of products. It would add considerably to the cost to take the plane up to the substratosphere for the necessary below-zero temperature for quick freezing.

The quality at destination of frozen foods shipped by air probably would

[11] Reported in an unpublished address by S. A. Larsen, Wayne University, Detroit, Mich., at the Convention of the United Fresh Fruit & Vegetable Association, Jan. 24, 1945.

not be superior to the quality of frozen foods shipped by rail. Speed in transit is not an advantage since the quality of properly refrigerated frozen foods is not affected by time in transit.

Freezing in air transit probably could not save more than the freezing and storing expenses. The rail-transportation cost of not more than 2 cents per pound would be saved. Based on the costs shown in table 6, a maximum of about 2.5 cents per pound for frozen fruits and vegetables could be saved.

TABLE 6.—*Average processor costs per pound for freezing fruits and vegetables, 1942* [1]

Item	Fruits	Vegetables	Fruits and vegetables
	Cents	*Cents*	*Cents*
Cost of raw materials	0.0606	0.0583	0.0592
Sugar	.0088	.0003	.0038
Container and wrapper	.0086	.0098	.0093
Direct labor	.0113	.0184	.0155
Freezing and storing	.0041	.0046	.0044
Shipping cases	.0009	.0020	.0015
Indirect costs	.0107	.0201	.0162
Warehouse and shipping expense	.0029	.0041	.0036
Selling expense	.0038	.0039	.0039
Administrative and general expense	.0040	.0068	.0057
Total cost and expense	.1157	.1283	.1231
	Number	*Number*	*Number*
Pounds	70,813,000	102,284,000	173,097,000

[1] Office of Price Administration unpublished data.

The cost of freezing and transporting fruits and vegetables by the use of the airplane would be higher than the cost of about 8 cents per pound for transporting lettuce by air from California to Detroit. It is estimated that products frozen en route would cost at least 6 cents per pound more than those frozen in ground plants and transported by rail.

If the quality at destination of air-borne frozen foods is not superior to that of surface-borne frozen foods and if it costs more to freeze and transport frozen foods by the use of the airplane than by the conventional method, there appears to be no reason for using the airplane in handling frozen foods.

Potential Domestic Cargo of Agricultural Perishables

In spite of low ton-mile costs and economies in handling, most air-transported produce must be sold at premium prices to cover the higher air-transportation costs. Before conclusions regarding potential air freight can be made, a much larger quantity of merchandise must be transported and sold to consumers.

Potential Air Cargo of Fruits and Vegetables

An estimate was made of the air-cargo potential in fruits and vegetables before any shipments were made by air *(9)*. The analysis was based on rail shipments of fresh produce which moved more than 250 miles to metropolitan areas in the United States and upon dealers' opinions of what part of this traffic might move by air at different rates.

Ten sample cities, for which carlot unload data were available, were selected for analysis. The traffic figures for these cities were adjusted to obtain an estimate of the total fresh produce traffic for the regions in which the cities are located. For estimating the extent to which each of 43 fresh fruits and vegetables would respond to air shipment, the composite judgment of 10 large wholesale and retail merchants was ascertained. To obtain the air-cargo potential, a statistical measure of this judgment was applied to the gross ton-miles of actual traffic involved in the movement of each of these commodities. The actual gross traffic in ton-miles, which served as the basis for the calculation of the potential traffic, was developed from the number of carlot unloads as reported in 1941 by the local representatives of the United States Department of Agriculture for each of the 10 sample cities. To assist the 10 merchants in making quantity estimates of individual produce items which they believed could be shipped advantageously by air, an analysis was made of the manner in which increased rates build up transportation charges which become an integral part of wholesale prices.

The air-cargo potentials estimated by Spencer A. Larsen to become available at rates ranging from 3 cents to 15 cents per air-ton-mile are shown for fruits in table 7 and for vegetables in table 8.

The study shows the total ton-mile potential of fruit and vegetable traffic at an air-cargo rate of 15 cents per ton-mile would be 24,419,000 ton-miles, at 10 cents 63,714,000, at 7 cents 333,127,000, at 5 cents 967,711,000, and at 3 cents 4,018,743,000 ton-miles of traffic. At 15 cents per ton-mile it shows that 0.15 percent of the total gross traffic in fruits and vegetables would be potential traffic, whereas at 3 cents per ton-mile the potential would be 24.89 percent.

On September 15, 1944, one of the leading airlines transported its first planeload of specially packaged spinach from California to three midwestern cities. It was retailed at a price high enough to cover the estimated 26 cents per ton-mile cost of air transportation. The spinach was prepared for shipment by removing the stems, bad leaves, and sand. It was then cleaned and wrapped in cellophane and a special label was attached designating it as having been transported by air. The retail price of 29 cents for a 10-ounce bag of spinach was divided—about 10 cents to the grower who trimmed, washed, and packaged the product; about 17 cents to the airline which transported the product; and about 2 cents for distribution costs. After the trial shipment an airline official said, "The demand for this commodity already is tremendous. We have had requests to transport a minimum of ten planeloads of this spinach a week." [12] This airline has made subsequent shipments of a variety of commodities to other cities at special rates lower than 26 cents per ton-mile.

Trial shipments of strawberries, lettuce, and other perishables are being made from California to Chicago, Detroit, and New York by another leading airline. Results of these shipments have not been made public.

Results of the study on the postwar air transportation of strawberries and tomatoes *(6)* indicate that a very substantial portion of the strawberries sold during the winter and spring months might move by air to Detroit. The results also indicated that all the tomatoes now moving to Detroit, or even a substantially larger quantity, may be transported by air. If one-half the strawberries and all the tomatoes now being transported to Detroit from a distance of more than 1,000 miles were to move by air, the total movement would require 2,537 DC–3 planeloads during a 6-month period, an average of 14 DC–3 planeloads a day.

A more distinct indication of the quantity of perishables that could be

[12] Wooten, J. H. Unpublished address before the Texas Citrus and Vegetable Growers and Shippers Convention, Sept. 19, 1944, Dallas, Tex.

TABLE 7.—*Estimated potential air traffic in fresh fruits to metropolitan areas* [1] *in the United States at ton-mile rates indicated (9, p. 44)*

[In thousands of ton-miles]

Commodity	Estimated ton-miles of gross-traffic	Estimated air-traffic potential at ton-mile [2] rates of—									
		15 cents		10 cents		7 cents		5 cents		3 cents	
		Percent [3]	*Ton-miles*	*Percent* [3]	*Ton-miles*	*Percent* [3]	*Ton-miles*	*Percent* [3]	*Ton-miles*	*Percent* [3]	*Ton-miles*
Apples	753,517	0	0	0	0	0	0	0	0	0	0
Apricots	25,685	0	0	0	0	2	514	8	2,055	38	9,761
Avocados	33,916	0	0	0	0	3	1,017	18	6,105	55	18,653
Bananas	1,738,978	0	0	0	0	0	0	0	0	65	1,130,336
Cantaloupes	318,966	0	0	0	0	2	6,379	8	25,517	46	146,724
Cherries	69,680	0	0	1	697	9	6,271	30	20,904	75	52,259
Cranberries	9,198	0	0	0	0	0	0	0	0	6	552
Figs, fresh	3,934	0	0	3	118	9	354	21	826	51	2,009
Grapefruit	598,990	0	0	0	0	0	0	0	0	5	29,950
Grapes	1,022,748	0	0	0	0	1	10,227	5	51,137	20	204,550
Honeydews	147,498	0	0	0	0	0	0	2	2,950	20	29,500
Lemons	695,216	0	0	0	0	0	0	0	0	2	13,904
Oranges	3,032,234	0	0	0	0	0	0	0	0	1	30,322
Peaches	114,971	0	0	2	2,299	7	8,048	23	26,444	78	89,678
Pears	326,004	0	0	0	0	0	0	2	6,520	7	22,820
Pineapples	111,469	0	0	0	0	4	4,459	21	23,408	79	88,061
Plums, prunes	210,955	0	0	0	0	1	2,110	13	27,424	53	111,806
Raspberries	2,105	5	105	28	589	65	1,368	95	2,000	100	2,105
Strawberries	73,151	5	3,658	28	20,483	65	47,549	95	69,494	100	73,152
Tangarines	77,650	0	0	0	0	0	0	3	2,330	9	6,988
Watermelons	135,796	0	0	0	0	0	0	0	0	0	0
1–2 day fruits [4]	20,645	0	0	3	619	9	1,858	21	4,335	51	10,529
3–4 day fruits [5]	80,993	0	0	0	0	0	0	1	810	5	4,050
5–6 day fruits [6]	14,152	0	0	0	0	0	0	0	0	3	425
Total	9,618,451		3,763		24,805		90,154		272,259		2,078,134

[1] Includes all metropolitan districts containing one or more central cities of 50,000 or more inhabitants.
[2] Short hauls of 250 miles or less eliminated.
[3] Berries, nectarines, and persimmons.
[4] Melons.
[5] Limes, pomegranates, cocoanuts, crabapples, and dates.
[6] Percent of gross traffic.

Limes, pomegranates, cocoanuts, crabapples, and dates.

TABLE 8.—*Estimated potential air traffic in fresh vegetables to metropolitan areas*[1] *in the United States at ton-mile rates indicated (9, p. 52)*

[In thousands of ton-miles]

Commodity	Estimated ton-miles of gross-traffic	Estimated air-traffic potential at ton-mile[2] rates of—									
		15 cents		10 cents		7 cents		5 cents		3 cents	
		Percent[3]	*Ton-miles*	*Percent*[3]	*Ton-miles*	*Percent*[3]	*Ton-miles*	*Percent*[3]	*Ton-miles*	*Percent*[3]	*Ton-miles*
Asparagus	84,892	0	0	0	0	15	12,734	28	23,770	62	52,633
Beans (snap)	122,310	0	0	1	1,223	10	12,2[illegible]1	50	61,155	86	105,187
Beets	24,382	0	0	0	0	3	[illegible]1	20	4,876	60	14,629
Broccoli	66,814	0	0	0	0	0	0	5	3,341	40	26,726
Brussels sprouts	15,639	0	0	0	0	2	[illegible]13	10	1,564	40	6,256
Cabbage	324,444	0	0	0	0	2	6,489	7	22,711	28	90,844
Carrots	354,729	0	0	0	0	0	0	0	0	6	21,284
Cauliflower	192,814	0	0	0	0	0	0	6	11,569	35	67,485
Celery	353,427	0	0	0	0	0	0	7	24,740	33	116,631
Corn	18,343	0	0	2	367	14	2,568	39	7,154	83	15,225
Cucumbers	71,311	0	0	0	0	2	1,426	13	9,270	50	35,656
Endive	18,966	0	0	0	0	7	1,328	28	5,310	87	16,500
Lettuce	1,133,513	0	0	0	0	6	68,011	18	204,032	47	532,751
Mixed vegetables	283,778	0	0	0	0	0	0	6	17,027	39	110,673
Onions	348,256	0	0	0	0	0	0	0	0	4	13,930
Peas	153,361	0	0	0	0	3	4,601	17	26,071	75	115,021
Peppers	79,491	0	0	0	0	5	3,975	14	11,129	53	42,130
Potatoes	2,050,014	0	0	0	0	0	0	0	0	0	0
Radishes	16,235	0	0	0	0	3	487	12	1,948	55	8,929
Shallots	11,854	0	0	0	0	2	237	11	1,304	35	4,149
Spinach	80,195	0	0	0	0	4	3,208	15	12,029	63	50,523
Sweet potatoes	64,348	0	0	0	0	0	0	0	0	3	1,930
Tomatoes	516,396	4	20,656	7	36,148	23	118,771	43	222,050	81	418,281
Turnips (with tops)	23,377	0	0	0	0	0	0	14	3,273	42	9,818
1–2 day vegetables[4]	117,133	0	0	1	1,171	5	5,857	18	21,084	54	63,252
3–4 day vegetables[5]	639	0	0	0	0	1	6	7	45	26	166
Total	6,526,661		20,656		38,909		242,973		695,452		1,940,609

[1] Includes all metropolitan districts containing one or more central cities of 50,000 or more inhabitants. [2] Short hauls of 250 miles or less eliminated.
[3] Artichokes, lima beans, eggplant, escarole, green onions, various greens, mushrooms,okra, parsley, rhubarb, squash, watercress.
[4] Horse radish, parsnips, and turnips (without tops). [5] Percent of gross traffic.

expected to move by air was obtained by shipping small quantities of lettuce from California to Detroit and selling it in retail stores in competition with surface-transported lettuce *(8)*. Conditions of the sale of the two products were kept as nearly comparable as practicable, except that most of the air-borne lettuce was priced at 16 cents per head while most of the surface-borne lettuce was priced at 11 cents per head. The experiment was conducted on four consecutive Fridays in three Detroit Kroger Grocery and Baking Company stores. The results of the store sales are shown in table 9.

TABLE 9.—*Heads of rail-borne and air-borne lettuce sold in competition in 4 Detroit retail stores, 1944 (8, p. 31)*

Date	Store A (Lettuce unidentified)			Store B (Lettuce unidentified)			Store C (Lettuce identified)			Store D [1] (Lettuce identified)		
	Differential per hd.	Rail	Air	Differential per hd.	Rail	Air	Differential per hd.	Rail	Air	Differential per hd.	Rail	Air
	Cents	*No.*	*No.*	*Cents*	*No.*	*No.*	*Cents*	*No.*	*No.*	*Cents*	*No.*	*No.*
June 16	5	([2])	([2])	4	[3] 61	52	------	------	------	5	([4])	([4])
23	5	38	51	4	[5] 16	54	------	------	------	5	50	40
30	5	([6])	([6])	3	25	24	5	18	19	------	------	------
July 7	5	41	43	5	53	54	5	37	25	------	------	------
	Heads of air-borne lettuce sold for every 10 heads of rail-borne lettuce											
June 16	5	------	------	4	10.0	8.5	------	------	------	5	------	------
23	5	10.0	13.4	4	10.0	33.7	------	------	------	5	10.0	8.0
30	5	------	------	3	10.0	9.6	5	10.0	10.6	------	------	------
July 7	5	10.0	10.5	5	10.0	10.2	5	10.0	6.8	------	------	------

[1] Experiment transferred to store C on June 30 where it could be conducted more conveniently. Store D is a large supermarket while store C is a smaller neighborhood type of store.

[2] 2 crates of rail-borne lettuce were displayed whereas only 1 crate of air-borne lettuce was displayed.

[3] 10 heads of rail-borne lettuce were added to the display.

[4] Lettuce from 7 crates of rail-borne lettuce was displayed while only 1 crate of air-borne was displayed.

[5] The quality of the rail-borne lettuce was below average.

[6] Air-borne lettuce arrived at 1:00 p.m. after all rail-borne lettuce had been sold.

On the average, as much air-borne lettuce was sold at 16 cents as was sold of the surface-borne lettuce at 11 cents. In only one of the three stores the air-borne lettuce was advertised as such; in the other stores it was bought apparently because of appearance alone. Advertising appeared to have little effect. Variation in the results shown in table 9 result from the differences between stores and the difference in quality of the lettuce from week to week.

If these results are directly applied to the quantity of lettuce shipped by rail from Arizona and California to Detroit, a total of about 900 carloads, or 1,001 C–54A planeloads, of lettuce would be sold in Detroit annually. The direct application of the results may be misleading, and in the report cited some qualifications are stated. These qualifications, however, do not vitiate the principal conclusion—that air-transported lettuce can be sold in considerable quantities at a sufficient difference in price to cover the estimated extra costs of air transport.

The map shown in figure 4, The United States winter garden-industrial area, interchange of products by contract aircraft operation, illustrates the application of the principle of the interchange of agricultural perishables with manufactured products.[13]

[13] See footnote 4, p. 14.

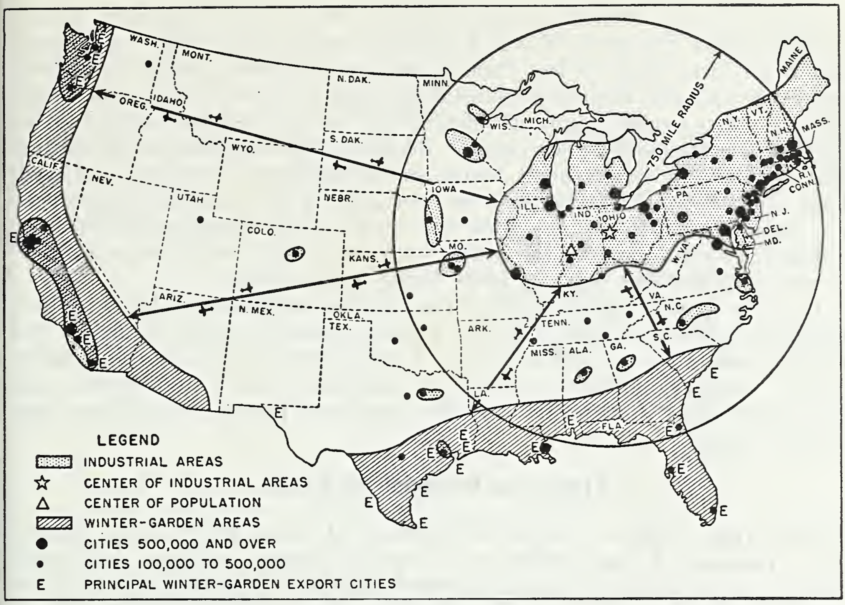

FIGURE 4.—The United States winter garden-industrial area, interchange of products by contract aircraft operation.

Fruit and vegetable shipments from the "winter garden" areas to the northeastern industrial areas of the United States, which are potential cargo for air transportation, are estimated at 5 billion ton-miles. The 5 billion ton-miles are net, after eliminating shipments which originated within 750 miles of their point of consumption and after eliminating fruits and vegetables, such as potatoes, carrots, oranges, and grapefruit, which for various reasons probably would not be shipped by air in any quantity under postwar conditions.

This estimated movement of perishables does not consider the possible development of new business in fruit and vegetable shipments. If fruits and vegetables are transported in such a way as to retain much of their original palatability, a larger quantity will be consumed. For example, a larger total consumption of tomatoes probably will result if top-quality tomatoes are offered to consumers during the entire year.

Tropical fruits may be another large potential source of air shipments. Most of these fruits are too perishable for shipment by present transportation methods. Florida, Texas, and California produce substantial quantities of subtropical fruits. South America and the Caribbean Islands are other sources of tropical-fruit shipments for the United States market.

Bulky fresh staple products that can be processed or concentrated in the producing area may move in relatively large quantities even at relatively high air-freight costs. Products in this category are peas, shelled before shipment; spinach, cleaned, washed, and packed ready to cook; and citrus juices, extracted and possibly condensed in the producing area. Members of a growers and shippers association are considering the installation near airports of processing and chilling plants to extract the juice from oranges and possibly from grapefruit for shipment by air transport. The juice, in paper containers, would move overnight to northern metropolitan centers for doorstep delivery, possibly in conjunction with milk deliveries.

Research by the Bureau of Agricultural Economics, the Edward S. Evans Transportation Research, Wayne University, and various airlines indicates that if air-cargo rates of less than 10 cents per ton-mile should be offered fruit and vegetable shippers, a substantial portion of the 5 billion ton-miles of fruit and vegetable shipments originating from the "winter garden" areas probably would move by air cargo. Because of the difficulty in estimating new business in semitropical fruits, in concentrated, consumer-packaged foods and the probable increase in consumption of high-quality produce, no separate estimate of ton-miles was made. This potential freight was weighted in the final estimate of the total ton-miles of fruit and vegetable shipments which may move by plane in the postwar era.

If it is assumed that one third of the 5 billion ton-miles, or 1,667 million ton-miles, will be air cargo in the postwar period, a fleet of about 380 C–54A's would be required or a fleet of about 830 of the C–47's (a smaller plane). The availability of the planes and their relative suitability to the work to be done would determine the number of planes of each type that would be used.

Flowers as Potential Air Cargo

Many types of flowers are in the category of commodities which are not being transported long distances at present because of their perishable nature. If air-freight service at expected rates is established, a tremendous increase in the flower buiness of the West coast and of the extreme Southeast may materialize. Some expensive flowers, such as orchids and carnations, have already moved at high air-express rates.

Robert L. Smith, President of Mission Nurseries & Florists, Inc., of Los Angeles, stated in part:

> Just as surely as the tremendous progress made in air transportation during the war period will open up new markets and redistribute old ones will Southern California, by virtue of "stepped up" postwar air transportation facilities, become the "flower basket" of America. Here a whole new industry is being created by technological means. From the transportation phase markets heretofore inaccessible to Southern California flower growers are now a matter of hours away by air freight, while from the packaging phase technological developments have produced streamlined, stronger, lighter, pre-cooled cartons which make it possible to deliver flowers halfway around the globe as fresh as the hour they were picked.[14]

Some of the flowers which may be among the first to move in quantity by air are chrysanthemums, asters, gladioli, camellias, orchids, roses, carnations, and gardenias. Many of these flowers can be grown in the open, whereas in the northern competitive regions most of them must be grown under glass. Their lower production costs and generally superior quality will put southern flower growers in a favorable competitive position with northern and eastern greenhouses even though charges for air transportation are relatively high. Cut flowers average 6 pounds per cubic foot, whereas the capacity of the DC–3 is 4 pounds per cubic foot.[15] Thus it is possible to overload a DC–3 with a cargo of flowers.

The eastern market, compared with the existing California and Florida markets, is very much undersupplied. Flower purchases per capita in the Northeast are substantially below per capita purchases in the West.

Transportation of Livestock and Poultry Products by Air

The transportation of livestock products and poultry products by air

[14] In an unpublished address before the Aviation Section of the Society of Automotive Engineers, Los Angeles, Calif., Jan. 1945.

[15] See footnote 14, p. 32.

in the continental United States and to Latin American countries has been negligible. The only reported movement has been for emergency uses or under very unusual circumstances. It is not believed that there is much likelihood of either livestock products or poultry products moving in appreciable quantities in the postwar period.

The only reported movement by air of poultry and egg products has been the very limited transportation of eggs for hatching purposes and in the forwarding of baby chicks. It is necessary that temperatures be thermostatically controlled and adequate air pressure maintained in the forwarding of these two commodities. The movement by air of this type of product is still in an experimental stage. It is possible that it may develop to the point where air transportation will prove to be satisfactory.

The artificial-insemination method of breeding dairy cattle has increased in the United States in recent years. The practice is now being adopted throughout the livestock and poultry industries. While no actual figures are available on the number of calves secured through artificial breeding in 1944 among the Nation's dairy herds, estimates of the number of calves which will be produced by this method in 1945 run as high as half a million. The Bureau of Dairy Industry, United States Department of Agriculture, reports 95 cooperative artificial-breeding associations with 28,627 members in existence on January 1, 1944. These associations maintained 657 bulls and bred annually 218,070 cows.

The transportation of the semen by air under controlled temperatures should make possible the mating of superior animals even though it is necessary that it be transported long distances. The transportation of this product by air is expected to have possibilities in the postwar period.

Seasonal Factor in Air Transportation of Perishables

The seasonal factor in air transportation is important. Maximum economy can be attained only by keeping the plane in operation during the entire year. Production of industrial commodities is much less seasonal than the production of most agricultural perishables. If a service during the entire year can be maintained between an industrial city and a principal producing center of perishable products, much better possibilities for maintaining a substantial backhaul of industrial products would exist.

Seasonal production of seven vegetables for the fresh market is shown in table 10. The production of the seven is not nearly as seasonal as the production of any one of the vegetables in a particular production area. To maximize the air-freight tonnage, it probably will be necessary to select many products that are harvested at different times and in this way make shipments available over a long period. In some regions practically no fruit, vegetable, or flower shipments are available for several months.

California has less seasonal variation in its production of perishables than do Florida and Texas. California and Arizona combined have a year-round production of lettuce. The quantities of lettuce shipped in 1943 and the seasonal distribution of the shipments to four Northeast cities are shown in table 11. Shipments of lettuce from California and Arizona during the year fluctuate less than the shipments of any other major fruit or vegetable. During the harvesting seasons of other vegetables, fruits, or flowers, these products may be more profitable as air freight than lettuce. The carriers may transport these more profitable items during their harvesting seasons, depending on lettuce shipments to fill their planes when more profitable freight is not available.

TABLE 10.—*Seven vegetables: Production for market (fresh), October 1941–September 1942 (in terms of acres)*

Item	Total	1941			1942								
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Total 7 vegetables	727,105	60,853	38,564	42,521	38,596	52,630	48,551	80,251	101,648	80,384	73,376	60,683	49,048
Lima beans	22,312	566	-------	-------	910	910	910	910	910	5,450	5,280	4,905	1,561
Snap beans	164,110	17,825	13,967	7,633	3,818	11,454	5,728	25,408	26,387	16,655	10,706	13,217	11,312
Beets	11,495	263	-------	1,560	1,420	1,420	1,820	2,075	415	292	972	971	287
Cabbage	169,311	26,460	7,151	11,678	19,753	19,175	17,456	20,407	13,670	6,024	6,081	9,181	12,275
Green peas	76,972	3,281	4,631	2,850	3,817	7,492	6,583	11,160	10,800	3,006	10,383	11,051	1,918
Spinach	64,350	1,658	5,365	11,800	8,878	8,879	9,454	6,191	3,966	1,667	2,917	1,800	1,775
Tomatoes	218,555	10,800	7,450	7,000	-------	3,300	6,600	14,100	45,500	47,290	37,037	19,558	19,920

Reproduced from Fruit and Vegetable Production and Consumption, Geographic and Seasonal Patterns by Alva H. Benton, Principal Social Scientist, and Arnold R. Frank, Assistant Agricultural Economist, Bur. Agr. Econ., July 1943, Washington, D. C. [Processed.]

TABLE 11.—*Carloads of lettuce shipped and the seasonal distribution of the shipments from California and Arizona to four Northeast cities, 1943 (8, p. 32–33)*

Month	Chicago	Detroit	Pittsburgh	Cleveland	Total	Index (average 725 = 100)
	Number	*Number*	*Number*	*Number*	*Number*	*Percent*
Jan.	316	161	130	102	709	98
Feb.	325	163	119	99	706	97
Mar.	398	194	142	139	873	120
Apr.	365	195	174	103	837	115
May	435	192	181	133	941	130
June	292	157	87	87	623	86
July	375	156	90	108	729	101
Aug.	353	140	108	90	691	95
Sept.	320	99	104	87	610	84
Oct.	274	98	110	81	563	78
Nov.	276	108	113	88	585	81
Dec.	388	173	150	123	834	115
Total	4,117	1,836	1,508	1,240	8,701	100

The seasonal production of vegetables in Florida is shown in table 12. In the 1942–43 season about 82 percent of the total tonnage was harvested during December to May, inclusive. However, the tonnage of perishables harvested during the remaining 6 months was of such a character that possibly a substantial portion of it may be moved by air.

Production of perishable agricultural products in Florida is particularly small during July, August, September, and October when less than 3 percent of the total tonnage is harvested. The lowest operating costs for an air-freight line probably would be obtained through adjusting operations during the period of seasonal low supply of agricultural perishables by: (1) Haul northward other perishable commodities such as sea food from Florida or the Caribbean Sea area. (2) Reduce the number of flights made so that as nearly as possible a full load may be hauled northward. The reduction in number of flights would be governed partly by trade demands and partly by the quantity and nature of the south-bound load. (3) Encourage production of perishables that are harvested and sold during the season of usual short supply.

The seasonal production problem might be solved by flying perishable products to destination, the plane carrying no cargo on the return flight. This would almost double the ton-mile cost of operations so only commodities could be hauled for which the shippers could pay a high ton-mile rate.

Potential Domestic Cargo of Industrial Products

As this publication is primarily concerned with the air transportation of agricultural perishables, only brief reference can be made to the air transportation of products other than perishables. As indicated in several sections of the report, it is practically impossible to segregate one phase of air transportation entirely without making certain assumptions regarding other phases of the problem. One of the basic assumptions in the research work on costs of the Bureau of Agricultural Economics and the Edward S. Evans Transportation Research was that there would be a 75-percent pay load of industrial products from Detroit to Florida in the strawberry and

TABLE 12.—*Seasonal production of vegetables, Florida, 1942–43* [1] *(7, p. 12)*

Item	Year beginning August												Total	Per cu. ft.
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July		
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Pounds*
Cabbage				55	4,512	12,489	14,122	32,173	16,652	3,818	329		84,150	26.1
Celery					8,769	18,607	24,044	31,163	24,999	23,899	2,759		134,240	
Cucumbers			1,746	1,518	555	178		21	1,970	5,155	89		11,232	38.6
Cantaloupes											780		780	32.7
Eggplant			82	349	311	593	955	751	1,433	1,685	2,099	207	8,465	26.5
Potatoes (Irish)					2,479	11,112	9,706	14,594	7,019	35,960	17,292	13	98,175	48.2
English peas					194	777	250	114	26	4			1,365	
Peppers			85	1,520	2,644	2,873	2,598	1,697	2,629	4,675	2,031	173	20,925	20.1
Strawberries					123	490	932	558	609	96			2,808	38.6
Tomatoes			13	3,375	6,571	6,131	9,547	5,119	5,371	30,179	2,530		68,836	43.4
Watermelons									138	3,478	38,546	6,848	49,010	
Lima beans			57	365	360	294	300	54	721	1,177	232		3,560	25.7
Snap beans			2,597	17,773	19,761	16,236	10,569	3,445	22,067	25,303	2,085		119,836	24.1
All lettuce				568	2,796	3,166	1,563	3,866	649	55			12,663	23.9
Escarole				539	2,260	1,984	1,095	1,501	1,565	445			9,389	19.3
Sweet corn				682						1,264	3,787		5,733	28.1
Field peas	255									17	286	792	1,350	
Okra										447	854		1,301	
Squash			312	344	101	397	495	1,012	1,285	431			4,377	
Beets							129	130	66				325	[2] 23.9; [3] 41.8
Chinese cabbage							91	119	90				300	
Mustard				92	52	40	4	40		122			350	
Turnips				339	284	417	65	489		156			1,750	[2] 23.5; [3] 43.4
Onions						24	62	64	50	50			250	[4] 43.0; [5] 18.0
Broccoli					55			130					185	
Cauliflower					81	42	247						370	19.8
Collards						64	130	162	64				420	
Radishes				376	500	500	624	500					2,500	
Spinach					29	106	107	60					302	14.5
Carrots								1,453	71	405	71		2,000	[2] 25.6; [3] 40.2
Total	255		4,892	27,895	52,437	76,520	77,635	99,215	87,474	138,821	73,770	8,033	646,947	

tomato report *(6)* and from Detroit to San Francisco in the lettuce report *(8)*.

To test the validity of the assumption of a 75-percent west-bound load from Detroit to San Francisco, Detroit manufacturers were surveyed personally and by mail by representatives of the Edward S. Evans Transportation Research. Questionnaires were mailed to 1,434 manufacturers selected by the Detroit Board of Commerce to be most likely to use the projected service. Replies were received from 436 manufacturers.

The questionnaire was worded as follows:

If a reliable daily all-air freight service were provided that would leave Detroit at the close of every business day, and arrive at San Francisco early next morning, at a rate of $10.00 per hundred, or ten cents per pound, airport to airport, how much poundage would your company be likely to ship in an average month by such service, for redistribution to Pacific Coast points and for export from San Francisco?

Two hundred manufacturers stated they would use the projected air-freight service. Their estimated shipments for an average month totaled 350,058 pounds, slightly more than the 333,450 pounds which would provide a 75-percent load for one cargo plane leaving Detroit at the close of business every day, for early next-morning arrival in San Francisco, 26 working days each month.

The principal reasons given by the 200 manufacturers for using the proposed air-freight service were: (1) For emergency shipments, (2) to support reduced West coast inventories, and (3) to cut transit time to the coast in order to compete with newly developed California industries.

The principal reasons given by the 236 manufacturers for not using the proposed air-freight service were: (1) Their customers decide how the article is to be shipped and usually pay the freight, (2) nonsuitability of products for air shipment because of low value per pound, and (3) existence of a local rather than a long-distance market.

An analysis of the replies of the 200 manufacturers who stated they would use the air-freight service showed that 34 percent, or 68 individual manufacturers, would have shipments aggregating 97 percent of the weight of all shipments made in an average month. Six of the 68 leading manufacturers accounted for 55 percent of the total estimated poundage. This concentration of traffic in the hands of a relatively few manufacturers would be desirable if the service would be operated by a contract air carrier, since the fewer shippers with whom the airline officials would have to deal, the more economical would be its operation.

The 200 prospective users of the air-freight service fell within 5 Detroit industries. The industries and their percentages of the total estimated monthly shipments by weight were as follows:

	Percent
The small-tool and die industry	35
The automobile and automobile-parts industry	30
The pharmaceutical industry and collateral products	30
The cutting-tool industry and allied lines	4.5
The forging and casting industry	.5

Industrial cargoes from other cities to San Francisco or to Miami, Fla., would be different from cargoes from Detroit. For example, one of the important commodities which probably would move by plane from New York City would be women's dresses. At least one of the airlines has concluded that a substantial quantity of dresses probably would be so shipped. Much more work needs to be done before a satisfactory appraisal of back-haul potentialities can be made.

Air Transport in Foreign Trade—Fruits, Vegetables, and Cut Flowers

A number of fruits and vegetables that are now imported into the United States from foreign countries probably could be transported by air.

The west coast of Mexico, Cuba, and Puerto Rico are important sources for United States imports of fresh vegetables during the winter. Tomatoes are the most important from the standpoint of volume, but peppers, peas, eggplant, okra, and snap and lima beans are also imported from these areas in sizable quantities. The original quality of all of these imports would be retained better if the elapsed marketing time were shortened through the use of air transport. The bulk of the fresh vegetables imported from Mexico is now transported by rail and finds a market in the midwestern cities of the United States from December through May while those vegetables imported from Cuba and Puerto Rico are normally shipped by boat to New York City. In each case the elapsed time in transit is about 10 days and thus the quality of the product is somewhat impaired. It is necessary to harvest tomatoes in these areas in a green condition and ripen and repack them on arrival in the terminal markets. Refrigeration and elaborate packaging are required to prevent spoilage in transit. Air transport would eliminate a large part of these costs.

Table 13 includes rail-transport cost for shipments from the west coast of Mexico to Chicago.

TABLE 13.—*Cost per 100 pounds of specified items for shipment from west coast of Mexico to Chicago, Ill.*[1]

Cost item	Tomatoes	Peppers	Peas
	Dollars	*Dollars*	*Dollars*
Ice	0.0447	0.0544	0.0750
Freight	1.4991	1.4783	1.4893
Miscellaneous (spotting car, demurrage, etc.)	.0201	.0239	.0250
Total	1.5639	1.5566	1.5893

[1] Office of Foreign Agricultural Relations unpublished data.

The volume of vegetables imported from these areas generally depends on the market situation in the United States. Not infrequently more is produced than can be marketed at profitable prices. During the war years the scarcity of shipping resulted in decreases in output in Cuba and Puerto Rico. Coupled with the increased demand, this stimulated Mexican output to record high levels. Shortages of labor and equipment prevented domestic production from expanding greatly. In the 1943-44 season Mexico shipped 177 million pounds of fresh vegetables to the United States while Cuba and Puerto Rico sent only 23.5 million and 0.1 million pounds, respectively. In normal seasons, Mexico supplied 50 million pounds; Cuba, 80 million; and Puerto Rico, 6 million. The distances over which these shipments moved are well over 1,000 miles and, therefore, the trade would qualify for air transport on this score.

Two other areas of even greater distance from the United States markets (Chile and Argentina) supply fruits and melons during the late winter. Both of these countries are rapidly developing a fruit industry which will be able to supply the United States and European markets with highly perishable fruits if a rapid transport can be developed. Even during the war years, pears and grapes continued to move by refrigerated boats from Argentina to the United States, but the deficiency of shipping practically halted the imports of fruits and melons from Chile. In normal times 11 million pounds of pears and 9 million pounds of grapes were imported from Argentina with the trend before the war rapidly upward. From Chile, the United States received 3 million pounds of melons and 2.5 million pounds of soft fruits. The situation is such that, with rapid transportation, both a greater volume and variety of highly perishable fruits would be available for shipment from both countries. It is believed that the rapid transport would result in a great improvement in quality on arrival which would offset at least in part the increased cost.

Many different kinds of tropical fruits could be produced in considerable volume and shipped to the United States if transportation facilities were improved. Most of these fruits are highly perishable and some are restricted by quarantine regulations. A partial list of some of the more important kinds, together with the quantities imported in 1939-40, are given in table 14.

TABLE 14.—*Imports of tropical fruit into the United States, by country of origin, 1939–40*

Fruit	Country of origin	Total
		1,000 pounds
Avocado	Cuba, 6,483	6,483
Banana [1]	Country of origin not shown	53,643
Plantain	British Honduras, 77; Cuba, 5,577; Haiti, 10; Dominican Republic, 231; Honduras, 228; Panama, 253.	6,376
Balsam apple	Cuba, 38; Mexico, 5	43
Chayote	Cuba, 19; Mexico, 1	20
Grapefruit	Cuba, 4,675; Haiti, 232	4,907
Lemon	Cuba, 1	1
Lime (sour)	Cuba, 160; Dominica, 579; Dominican Republic, 7; Haiti, 2; Honduras, 2; Jamaica, 255; Mexico, 8,388; Montserrat, 2; St. Lucia, 67.	9,462
Melon	Argentina, 43; Chile, 3,174; Mexico, 7; Portugal, 291; Others, 2.	3,517
Nectarine (fresh)	Chile, 724	724
Orange	Cuba, 2; Haiti, 9	11
Orange (Mandarin):		
Frozen	Japan, 14	14
Natural	Japan, 1,996	1,996
Papaya:		
Frozen	Philippines, 4	4
Natural	Cuba, 748; Mexico, 10	758
Pineapple [2]	Azores, 2; Cuba, 960; Dominican Republic, 1; Mexico, 286.	1,249

[1] Bunches.
[2] Crates.

From Office of Foreign Agricultural Relations. United States Imports of Fruits and Vegetables under Quarantine—July–June 1939–40. [Processed.] Figures are compiled from official records of the Bureau of Entomology and Plant Quarantine.

Cut flowers for the winter trade is another perishable item. These can be grown at rather low cost in many of the Latin American countries and with rapid transport could be exported to the United States in considerable volume. It is believed that this category would be well suited for the air-transport trade. Cut flowers are of comparatively light weight and of high value, but are highly perishable. Value of imports of cut flowers by country of origin for the calendar year 1941 is given in table 15.

Table 15.—*Cut flowers, fresh, dried, prepared, or preserved: Value of imports into United States, calendar year 1941 (13, p. 79, item 2945.1)*

Country of origin	Value	Country of origin	Value
	Dollars		*Dollars*
Canada	5,285	Haiti	58
Panama Canal Zone	184	Brazil	41,421
Panama, Republic of	44	Colombia	1,530
Bermuda	10,815	Ecuador	3
Jamaica	100	Peru	10
Trinidad and Tobago	170	Venezuela	655
Other British West Indies	63	Union of South Africa	504
Cuba	74		
		Total	60,916

The production of most of the perishable commodities is seasonal and therefore no one commodity will provide cargo for a very long period.

There probably will be air shipment of fruits and vegetables from the United States to Central and South American countries. These shipments probably will consist of high-quality standard perishables. Persons with high incomes, especially those from the United States, probably will be the principal consumers of these perishables.

Competitive Position of the Air-Freight Carrier

The volume of postwar air cargo probably will be only a small percentage of the total surface-carrier traffic. Until air-cargo rates are reduced to nearly the same level as rail and truck rates, air cargo will be limited to a relatively small tonnage of commodities which possess special characteristics. Unless substantial value is added to the product by the airplane's speed, the product will be hauled by the cheaper surface carrier. The volume carried by air, though only a small percentage of total traffic, probably will be a large increase over that now so transported.

Many minor and some major commodities now being transported by surface carriers might be better carried by the airplane under present conditions, but if the railroads and motor carriers improve their equipment and handling methods the tendency for some of this traffic to leave the surface carriers would be retarded. Technological improvements made during the war and the quantity of worn-out and obsolete equipment in the hands of the railroads and truck lines at the close of the war probably would cause the railroad and truck line officials, in any event, to add much new and improved equipment to their lines. Surface carriers will be inclined to rush improvements and make more far-reaching changes if they believe a substantial quantity of their traffic volume is threatened by the airplane. Thus air transport after the war may benefit producers and consumers indirectly even more than directly.

The railroads may put into service a greater number of lightweight improved refrigerator cars which are equipped with circulation fans, half-stage-icing grates, collapsible bunkers, load dividers, distant reading thermometers, and better insulation for the cars. The wider adoption of an improved coupling will contribute toward more gentle handling. The use of Diesel-operated locomotives and the more efficient handling of perishable freight in the terminal and switching yards will help to reduce the time in transit of rail-borne freight. Mechanically operated, thermostatically controlled refrigerating units have been tested and, although opinions differ regarding their practicability for rail cars at the present stage of development, under the stimulus of increased competition such equipment may be widely adopted.

Motor carrier operators are expected to continue to increase their tonnage of perishables hauled. They probably will have the benefit of improved highway systems, more efficient motors operating on low-cost fuel, and mechanical refrigeration systems thermostatically controlled.

Insofar as improvements are adopted by surface carriers, their costs of transportation will be reduced or the quality of the produce hauled will be better preserved than it now is. Either of these factors will tend to decrease the desirability of air carriers in relation to surface carriers.

Previous sections have dealt with air-freight rates. These rates translated into a comparison between present charges per package of perishables shipped by rail freight between two points versus the same commodity content shipped by air transport indicate the difference in the cost per package at destination caused directly by transportation.

Air mileages between two cities are often significantly less than rail mileages between the same two points (table 16). Thus the rail mileage between Denver, Colo., and Wenatchee, Wash., is 1,648 miles, whereas the great-circle mileage (shortest air mileage) is 930 miles or only 56 percent as great as rail mileage. Direct comparison of air-freight ton-mile costs with rail-freight ton-mile costs is therefore often misleading. If rail-freight costs are estimated at 2 cents per ton-mile and air-freight costs at 10 cents per ton-mile, the cost of shipping freight between Denver, Colo., and Wenatchee, Wash., by air will not necessarliy be 5 times as great as shipping by rail. Rather it would be only about 2.8 times as great provided there were no other differences except distance.

From Stockton, Calif., to New York City, the ton-mile freight revenue, including refrigeration, is 1.3 cents on shipments of asparagus. The ton-mile rate via air routes on the same product between the same points at double the present rail-express rate is 5.97 cents. Translated on a basis of dollars and cents per 100 pounds between the two points, the rail-freight rate, including standard refrigeration service, is $2.19 per 100 pounds and the air-freight rate at double the rail-express rate is $7.50 per 100 pounds. The airline rate at 10 cents per ton-mile would be $12.56 per 100 pounds and the rate at 20 cents per ton-mile would be $25.11 per 100 pounds.

Similar comparisons of transportation charges for cherries, peaches, strawberries, and tomatoes are made in table 17.

As pointed out in the section on economies of air transportation, the difference between surface- and air-transportation charges may be reduced by taking advantage of possible economies in packaging, refrigeration, marketing, and the elimination of much of the waste. Commodities transported by air freight probably will be of the best quality and usually will be those commodities with relatively high value per pound. When the commodity is shipped by air the cost as well as the value per pound of the product will be increased considerably over its original value. As the perishables are transported by air to retain as much as possible their garden-fresh quality and as they are relatively expensive per pound, good merchandising of air-borne fruits and vegetables is even more important than good merchandising of surface-borne perishables.

New techniques of packaging and the use of lightweight containers and transparent overwraps made of newly developed materials probably will be developed. Packaging in the production areas of only the best quality edible portions of the fruits and vegetables and retailing air-borne produce in refrigerated open display cabinets may also be developments. However,

TABLE 16.—*Comparison of the great-circle mileage versus rail mileage*

Origin	Destination	Rail mileage	Great-circle mileage
		Miles	*Miles*
Wenatchee, Wash.	Denver, Colo.	1,648	930
	Kansas City, Mo.	1,969	1,408
	Chicago, Ill.	2,040	1,644
	Pittsburgh, Pa.	2,508	2,045
	New York City, N. Y.	3,093	2,315
Los Angeles, Calif.	Denver, Colo.	1,619	830
	Kansas City, Mo.	1,756	1,361
	Chicago, Ill.	2,269	1,746
	Pittsburgh, Pa.	2,737	2,139
	New York City, N. Y.	3,321	2,451
Buhl, Idaho	Denver, Colo.	777	442
	Kansas City, Mo.	1,308	963
	Chicago, Ill.	1,669	1,262
	Pittsburgh, Pa.	2,137	1,677
	New York City, N. Y.	2,721	1,977
Grand Junction, Colo.	Denver, Colo.	274	256
	Kansas City, Mo.	956	786
	Chicago, Ill.	1,408	1,106
	Pittsburgh, Pa.	1,876	1,524
	New York City, N. Y.	2,460	1,827
Hammond, La.	Denver, Colo.	1,515	1,006
	Kansas City, Mo.	881	626
	Chicago, Ill.	807	803
	Pittsburgh, Pa.	1,144	931
	New York City, N. Y.	1,576	1,199
Weslaco, Tex.	Denver, Colo.	1,425	1,034
	Kansas City, Mo.	1,135	924
	Chicago, Ill.	1,416	1,233
	Pittsburgh, Pa.	1,793	1,416
	New York City, N. Y.	2,225	1,700
Orlando, Fla.	Denver, Colo.	1,764	1,551
	Kansas City, Mo.	1,381	1,049
	Chicago, Ill.	1,238	981
	Pittsburgh, Pa.	1,300	822
	New York City, N. Y.	1,153	944

all of these developments, although very important to air-borne produce, also may lend themselves to the marketing of surface-borne produce. For some perishables the application of better marketing techniques will so preserve their garden-fresh character as to offer no justification for using air freight.

There probably is a type of transportation best fitted for every type of commodity. Coordinated transportation makes the maximum economical use of all types of carriers. Speed is the principal advantage the airlines have to offer shippers. Find the situation in which speed adds considerable value to the commodity, and probably the commodity can be transported to advantage by air freight.

TABLE 17.—*Comparisons of rail freight, rail express, and proposed air-freight transportation charges*

CHERRIES FROM WENATCHEE, WASH., TO NEW YORK CITY, N. Y.

Item	Via rail freight	Via rail express	Via air freight at double the present rail-express rate	Via air freight at 10 cents per ton-mile	Via air freight at 20 cents per ton-mile
Packages per carload—number	1,576	1,576	1,576	1,576	1,576
Billing weight per package—pounds	17.5	17.5	17.5	17.5	17.5
Gross weight per carload—pounds	27,580	27,580	27,580	27,580	27,580
Freight rate per 100 pounds—dollars	1.63	3.55	7.10	11.58	23.15
Freight charges per carload—dollars	449.55	979.09	1,958.18	3,193.74	6,384.77
Refrigeration charges per carload—dollars	95.00	83.16			
Freight and refrigeration charges per carload—dollars	544.55	1,062.25			
Cost per package at destination—dollars	.35	.67	1.24	2.03	4.05
Mileage	[1] 3,092	[1] 3,092	[2] 2,315	[2] 2,315	[2] 2,315
Ton-mile revenue—cents	1.28	2.49	6.13	10.00	20.00

PEACHES FROM HANFORD, CALIF., TO CHICAGO, ILL.

?ackages per carload—number	1,211	1,211	1,211	1,211	1,211
3illing weight per package—pounds	22	22	22	22	22
;ross weight per carload—pounds	26,642	26,642	26,642	26,642	26,642
'reight rate per 100 pounds—dollars	1.50	3.03	6.06	8.72	17.43
'reight charges per carload—dollars	399.63	801.19	1,614.51	2,323.62	4,644.57
{efrigeration charges per car-load—dollars	79.00	69.30			
'reight and refrigeration charges per carload—dollars	478.63	870.49			
:ost per package at destination—dollars	.40	.72	1.33	1.92	3.84
{ileage	[1] 2,280	[1] 2,280	[2] 1,743	[2] 1,743	[2] 1,743
'on-mile revenue—cents	1.58	2.87	6.95	10.00	20.00

STRAWBERRIES FROM HAMMOND, LA., TO NEW YORK CITY, N. Y.

ackages per carload—number	736	736	736	736	736
illing weight per package—pounds	25	25	25	25	25
ross weight per carload—pounds	18,400	18,400	18,400	18,400	18,400
reight rate per 100 pounds—dollars	1.93	2.45	4.90	6.00	11.99
eight charges per carload—dollars	355.12	450.80	901.60	1,116.00	2,206.16
efrigeration charges per car-load—dollars	70.00	62.37			
eight and refrigeration charges per carload—dollars	425.12	513.17			
›st per package at destination—dollars	.58	.70	1.23	1.52	3.00
ileage	[1] 1,576	[1] 1,576	[2] 1,199	[2] 1,199	[2] 1,199
n-mile revenue—cents	2.93	3.54	8.17	10.00	20.00

See footnotes at end of table.

TABLE 17.—*Comparisons of rail freight, rail express, and proposed air-freight transportation charges.—Continued.*

TOMATOES FROM VENTURA, CALIF., TO NEW YORK CITY, N. Y.

Item	Via rail freight	Via rail express	Via air freight at double the present rail-express rate	Via air freight at 10 cents per ton-mile	Via air freight at 20 cents per ton-mile
Packages per carload—number	630	630	630	630	630
Billing weight per package—pounds	34	34	34	34	34
Gross weight per carload—pounds	21,420	21,420	21,420	21,420	21,420
Freight rate per 100 pounds—dollars	1.84	3.75	7.50	12.55	25.10
Freight charges per carload—dollars	394.13	803.25	1,606.50	2,688.21	5,376.42
Refrigeration charges per carload—dollars	34.30	32.18	------	------	------
Freight and refrigeration charges per carload—dollars	428.43	835.43	------	------	------
Cost per package at destination—dollars	.68	1.33	2.55	4.27	8.53
Mileage	[1] 3,395	[1] 3,395	[2] 2,510	[2] 2,510	[2] 2,510
Ton-mile revenue—cents	1.18	2.30	5.98	10.00	20.00

[1] Mileage via direct customarily used routes. [2] Via great-circle mileage.

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