INTERMODAL AIR-SURFACE MOVEMENT
OF CARGO

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Seaboard World Airlines

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Seminar
July 14, 1980
to
Summer Course,
"Air Transportation -- Management, Economics and Planning"
sponsored by
Flight Transportation Laboratory/
Center for Advanced Engineering Study
Massachusetts Institute of Technology

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INTERMODAL AIR-SURFACE MOVEMENT OF CARGO

Presented at:
Massachusetts Institute of Technology
By: John H. Mahoney
On: 14 July 1980
Someone who told me he was a friend asked me to talk to you about "any single important aspect of air cargo" and the booby trap I suddenly stumbled into was the difficulty of sticking to a single subject from the many delectable debates currently raging in the airline industry.

I would be delighted to loose a torrent of thoughts on a palletload of air cargo topics -- such as a participant's critique of air cargo deregulation, a swimmer's eye-view of the cargo wave of the future, and a dirty-picture candid-camera snapshot of the love-hate relationship of those strange bedfellows, cargo wholesalers and retailers. It also would be fun to turn over rocks in the snake-infested field of air cargo marketing, and bounce around among the various rubbery definitions of market elasticity. But, unfortunately, time won't permit the pleasure of serving up a melange of these tidbits, because each ought to be stewed separately in its own juice over a slow fire and presented to you with the proper condiments in order to be savored fully, in justice to it, and to you. So, I'm forced to select a single subject in spite of the great temptation to wander these various enticing realms, mixing metaphors as I go.

The single subject I've selected is intermodal air-surface movement of cargo. The major question involved is whether it is economically efficient to utilize special 8x8x20-ft intermodal containers in the airplane and over the road. You may say, "how dull can you get!", because this may sound to you like a pretty dull subject. But, I trust you'll find such is not the case. This subject involves plenty of controversy and strong opinions. Furthermore, it will give you a real live air cargo problem that is still being worked out in the field, to which you can apply your own
judgment. The inputs to its economic analysis, such as labor, fuel costs, and customer perceptions, are constantly changing and assuming differing proportions in the equation, so your analysis and recommendation can be just as valid and effective as one being done by someone who gets paid for doing it.

If you begin to get the feeling that I'm about to present you with a "case history", eschew the thought. The boys in the Business School up the street at Harvard Yard have a patent on the "case history method" upon which they deeply meditate to the exclusion of all else. By contrast, this is a live and throbbing issue, not a time-worn fossil.

Why is the Question Important?

Why should the intermodal container question be an important one? One of the reasons is that the use of intermodal containers has revolutionized the US maritime industry, and it's logical to wonder if the same facility will spark a similar revolution in air cargo. Seagoing containerships accommodating intermodal cargo containers for interchange with trucklines and railroads have built a twenty-billion-dollar-a-year industry from scratch in the span of twenty years. We may ask ourselves to what extent customer needs and carrier economics parallel each other, or diverge, in the two transportation modes, to get a clue as to whether maritime history will be repeated in airfreight.

Another reason the question is important is that it involves transportation generally, not just air transportation. The intermodal container is a common denominator, binding together air-sea-rail-truck into a single system. The Federal Departments of Transportation and Defense have long supported the establishment of a single integrated national transportation system on national commercial and defense grounds.
Illustration 1

Intermodal 8\times 8\times 20 \text{ Ft Container}

A side transfer of a 20-foot container from the loader to an over-the-road truck trailer

Two 20-foot truck trailers and containers joined to form a 40-foot over-the-road trailer

Five 8\times 8\text{-by}-2\text{-foot} structural containers inside Seaboard T41RF
DEDICATED INTERMODULE DISTRIBUTION SYSTEM

OPTIMIZED FREIGHTER DESIGN OBJECTIVES

<table>
<thead>
<tr>
<th>Objective</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck Height</td>
<td>54 inches (truck bed height)</td>
</tr>
<tr>
<td>Cargo Environment</td>
<td>Unpressurized; temperature controlled</td>
</tr>
<tr>
<td>Field Length</td>
<td>7000 feet</td>
</tr>
<tr>
<td>Service Life</td>
<td>20 years at 15 hours per day</td>
</tr>
</tbody>
</table>

Most projections of futuristic cargo aircraft encompass an intermodal concept using intermodal containers. The illustration shown above was prepared by Boeing.
However, the real test is day-to-day commercial use.

The third reason the question is important is the very fact that airlines generally (as well as shippers) seem not yet to have made up their minds as to whether the air-surface intermodal container is the answer to their prayers, or just a specialized gimmick for occasional use.

The Importance of (Your Speaker) Being Neutral

As for me, I'll be the very soul of neutrality. I'll present you with the problem, and give you all the facts, as I see them. But I'll do my best not to give you a clue as to what I think any of the answers should be. My posture is not simply a didactic one, but reflects a certain measure of caution, discretion (and, shall we say, survivability?) in light of my business affiliations. Seaboard World Airlines, for which I have worked many years, has been a major sponsor and promoter of intermodal air-surface containers; whereas Flying Tiger, which is about to take over Seaboard in a merger, has been much more cautious in its approach. My attitude at this time is akin to that of Pierre Salinger when he was White House press secretary and unofficial court jester for President Kennedy. The president's brother, Bobby, was about to embark with a group of young people on a vigorous 50-mile cross-country hike to publicize National Fitness Day, and a reporter asked Pudgy Pierre if he was planning to hike the 50 miles. He protected himself very well with his reply which was along the lines of, "I may be patriotic, but I'm not stupid." I hope to protect myself as effectively in the comments which follow.

Definition of Intermodal Container

The 8x8x20-ft air-surface intermodal container is an oblong box which can be carried as an integral part of the equipment in a Boeing 747 airfreighter, or on a truck chassis,
or by rail car, or in a sea containership. Thus, it is truly intermodal. This is not to say that other air containers cannot be carried by truck, rail or ship, because they can, and are. The difference is that the intermodal container is of a size and shape which is compatible with each of the various transport modes, whereas other types of airplane containers are awkwardly and inefficiently carried by surface modes of transport. It is the compatibility of this and similar boxes among various transport modes which has spawned intermodality in transportation.

**Advantages to the Customer**

If the customer has an air shipment of the proper size to be accommodated in the intermodal container, he may gain certain advantages from its use. He may get door-to-door service, thus avoiding multiple handlings of his goods resulting in less exposure to damage, loss, or pilferage. He can utilize the same loading and/or unloading facilities for his air shipments as for surface shipments. He can stack his cargo more efficiently in its relatively capacious interior and vertical sides as compared with other containers which are smaller or with rounded contours. He can get more cargo into the container than into any other air container because it has more capacity. He may be able to clear customs more quickly. He can ship on a closer schedule based on a later closeout time by the airline because his goods will not have to be rehandled when the truck gets to the origin airport. He may also get faster delivery from the airline at destination airport. He may be able to achieve lower overall transportation costs by using surface transport for a larger portion of the journey without losing a great deal of time in transit. He may get all of these advantages, or just some of them, depending on the circumstances.
The only disadvantage to the customer is more in the category of lack of advantage, if his shipment size or shape happens to be wrong for the box, or if handling facilities or local regulations anywhere along the route won't permit its accommodation.

Possible Advantages & Disadvantages to the Airlines
There are four possible advantages to the airlines of using the intermodal containers, and three possible disadvantages. We refer to these as "possible" advantages or disadvantages because part of our purpose is to analyze them to determine their validity. They are as follow.

**Possible Advantages**

1. Savings in ground handling costs
2. Savings in airport terminal costs
3. More cargo per flight
4. Marketing advantages

**Possible Disadvantages**

1. Container ownership costs
2. Cost of carriage in flight
3. Cost of rate incentives

It is these possible advantages and disadvantages to the airlines which we must consider and weigh in order to get an indication of whether or not the intermodal container is an economical unit from the airline's view point, and if it is, under what circumstances. This is where the debate is taking place in the industry, and it is where we have to cope with the shifting proportions of expenses -- as fuel, labor and other costs spiral upward at varying rates.

Possible Advantages to Airlines

Possible Advantage No. 1

**Savings in Ground Handling Costs**

When the customer offers his shipment to the carrier documented and ready for carriage, and containerized in a container that is compatible with the aircraft, there are ground-handling cost savings to the carrier as compared to the cost of
Main Deck 747 Containers

8x8x20 ft. Intermodal Container

ATA Type: M-2
IATA Type: 1

8x8x10 ft. Container

ATA Type: M-1
IATA Type: 2

10 ft. High Container

ATA Type: M-1H
IATA Type: 2-H
Igloos and Pallets

**Structural Igloo**

ATA Type: M2 Pallet
IATA Type: 1 Pallet

ATA Type: A3
IATA Type: 3

**Non-Structural Igloo**

ATA Type: M1 Pallet
IATA Type: 2 Pallet

ATA Type: A3
IATA Type: 3

ATA Type: M4 Pallet
IATA Type: 2A Pallet
Lower Deck 747 Containers

ATA Type: LD 7
IATA Type: 5

ATA Type: LD 3
IATA Type: 8
International Standards Organization (ISO)

I.S.O. 8' X 8' X 20' CRITERIA

1. Top lift corner fittings
2. External dimensions:
   \[ W \times H \times L = 8' \times 8' \times 19'10.5" \]
3. Capacities: Mgw 25,000 lbs
   / Tare 2,600 lbs / Vol \( \frac{1135}{cu\ ft} \)
4. Weather proof door seals
5. Door locks
6. All panel strengths
7.bottom lift and mounting corner fittings
8. Forklift tyneways

The International Standards Organization (I.S.O.) is an organization (headquartered in Geneva, Switzerland) whose stated purpose is to develop and foster international trade through universally accepted standards. Members are composed of nations around the world who voluntarily participate in the development and promulgation of universally accepted criteria concerning such areas as sizes, weights, measures and handling methods in all modes of transportation.

U.S. participation in I.S.O. affairs is through the American National Standards Institute which receives input from various industry study groups such as the Aerospace Industries Association of America and the Society of Automotive Engineers (Aerospace Division), all of which have contributed to the basic design criteria adopted by I.S.O. members.
handling the same shipment if it were delivered loose consisting of a multitude of small packages which had to be counted, labeled and loaded into a container or onto a pallet. There are also savings in tracing, accounting for, and security.

Now that we have enunciated this axiom, let us recognize that it applies not just to intermodal containers, but to shipper-loaded containers generally. It is necessary not only to evaluate the pros and cons of the intermodal containers per se, but constantly ask the question, "compared to what?". Compared to loose cargo or to cargo in airline-loaded containers or on pallets, containerization savings of intermodal cargo are a factor, but compared to cargo in other shipper-loaded containers only the relative cost-effective characteristics of the containers themselves are relevant. It is necessary to make multi-faceted comparisons because this is a multi-faceted problem.

Getting back to containerization, the increasing percentage over the years of cargo delivered to the airline at origin containerized, and picked up from the airline at destination containerized, not only has reduced handling costs, but actually has permitted major airline cargo terminals physically to cope with rapidly increasing throughput. Without containerization some major terminals -- especially international terminals -- would have been unable to function with a very high degree of effectiveness.

Ground handling costs for an all-cargo airline currently represent roughly about 16% of total costs, including only cargo-handling labor and equipment, but not terminal buildings and upkeep. Several caveats have to be attached to this estimate. Firstly, the assignment of functions and facilities for cost allocation purposes necessarily is
arbitrary, and it is a matter on which reasonable men frequently differ. Secondly, these ratios consist of a snapshot in time in which the majority of tonnage (about 65%) already was containerized by the customer, which means further efficiency will be hard to come by. And, thirdly, being ratios they are subject to variation by inflationary cost increases on either side of the equation.

Another approach is to ask what is the cost per pound of filling or breaking down the container, because this is the cost avoided by the airline when it is performed by the customer. The incremental cost to the airline currently is only something around 1.5¢ per pound, but it would be much more than double this amount on a fully-allocated basis, which is why it is important to know that containerization has saved some major terminals from being overwhelmed with large volumes of small packages. Still another approach is to ask what price non-airline handling agents charge to fill or break down containers, and this currently seems to be in the neighborhood of 6¢ per pound for each function -- filling and breaking down. The customer who lacks facilities for containerization, and who would use the services of non-airline handling agents, would need at least to offset non-airline handling costs as an incentive to containerize.

To summarize, containerization is part of intermodality, but containerization also exists apart from intermodality. Therefore it is useful to know about the economics of containerization with the recognition that it applies both in connection with intermodality and separately from it.

Possible Advantage No. 2
Savings in Airport Terminal Costs

There is an extra efficiency of the intermodal container which is not applicable to the others to the same extent, and that is its ability to bypass the terminal. Terminal costs and administration represent roughly about 8% of the total cargo airline costs.
The intermodal container can be delivered by the shipper at planeside, and picked up by the consignee at planeside, thus obviating the need for a terminal building in which to process and handle the cargo. Additionally, with airport space at a premium, the containers on chassis can be stored at off-airport parking facilities during waiting time at either origin or destination airport.

Now someone is sure to challenge this, and allege that other containers can also bypass the terminal, and this is true under specially-managed circumstances. But no other container has as great an adaptability as the intermodal container has in this respect.

However, most cost savings of terminal bypass efficiencies will not be realized by the airline until all, or almost all, the traffic is handled via intermodal containers, as in the case of marine containership operation. In the meantime, regular common-carriage air terminals have to be versatile in order to be able to accept a wide range of shipments, large and small, containerized and non-containerized.

The customer may have another point of view, especially if he uses intermodal containers exclusively. His question may be why he shouldn't be relieved of terminal costs in the rate charged by the airline, since his business bypasses the terminal.

We may hold these two points of view in abeyance as we proceed to review other aspects of air-surface intermodality.

Possible Advantage No. 3
More Cargo Per Flight

The aircraft which made air-surface intermodality a practical reality is the Boeing 747 airfreighter. Initial 747 design was influenced by the requirement that the airplane carry cargo as well as passengers, and specifically that the airplane carry two
8x8-ft containers side-by-side on the main deck.

The economics of this large heavy-lift freighter also urgently require large cargo loads in order to turn a profit. The importance to the airline of stuffing every last bit of cargo into the cubic capacity of the airplane cannot be overemphasized. Every extra pound loaded on a flight that is operating "anyway" can be considered as an incremental contribution toward profit. Transcending even that is the fact that if each flight in a series can accommodate extra cargo, it might make unnecessary the operation of the last flight or flights in the series.

**Evolution of Two Schools of Thought**

With the passage of time several versions of this aircraft have been developed. The first ones had less powerful engines with less payload and range than later models. Some airlines used 747's which were converted from passenger operation, and these also had less payload capability and range than those constructed from scratch as freighters. The airlines operating the airplanes with less payload capability and range had a greater incentive to keep tare weight to a minimum in order to conserve payload capability and range for paying cargo. These airlines preferred to stack cargo on pallets or in high-rise low-tare containers themselves, rather than to have the customer deliver it to them already containerized, because they felt they could avoid the extra tare weight of the container in which the customer would have loaded the cargo. Furthermore, line-haul costs hold at least a four-to-one ratio to handling costs, and consequently savings in stackability on board the airplane could potentially far exceed containerization savings.

On the other hand, the airlines with 747's built from scratch as freighters had a greater weight-carrying capability to work with, and they found they could carry the
extra tare weight of intermodal containers without interfering with the payload capability of the airplane. Furthermore, the intermodal container at that time carried more payload per square foot of 747 main-deck space than any other shipper-loaded container. For example, the intermodal container uses the same floor space as two igloos, but it will accommodate 40% more cargo, even though it uses twice as much tare weight. Keep in mind also the very important point that jet fuel in those days cost less than one-tenth of what it costs today, and therefore the cost of hauling around the extra tare was relatively much less.

There’s one other factor which may have had an influence although it is speculative, and its effect somewhat psychological. That is that the airplanes converted from passenger operation had no nose door, but only a side door. The intermodal container is somewhat more difficult to handle through the side door, but the more ample measurements of the side door concentrate attention on the possibility of stacking cargo higher than the 8-ft height of the intermodal container. The factory-built freighter has both nose and side doors. The nose-door opening height is just inches greater than eight feet, but it permits straight-in loading of intermodal containers.

Thus it is understandable why two schools of thought should have grown up regarding the advisability of intermodal air-surface container operations. Airlines operating airplanes with less payload capability had a strong incentive to reduce tare in order to improve payload; whereas the airlines with heavy-lift freighters looked to the intermodal containers as a means of improving payload, and they had little concern about the extra tare weight required. The former felt that by stacking the cargo themselves onto pallets or in lightweight frames to a height greater than the 8-ft height of the 20-ft intermodal container, they could get more paying freight onto
Boeing 747 Freighter Family

B-747 100SF Special Freighter Modification Side Door Loading Only

Maximum Load: 222,500
Takeoff Wt: 750,000

Converted from passenger operation
Built to operate as either
a-passenger-or-a-cargo
airplane
Main cabin only 8'2" high
throughout its length, unless
a major modification is
undertaken.

B-747 200F Freighter Nose and Side Door Loading 70A Engine

Maximum Load: 248,000
Takeoff Wt: 820,000

Built from "scratch"
as a freighter.
Boeing 747 Freighter Family

B-747 200F Freighter
Nose and Side Door Loading
7Q Engine

Maximum Load: 279,600
Takeoff Wt: 833,000

(Built from "scratch"
as a freighter)

B-747 200C Convertible
Nose Door Loading Only

Maximum Load: 250,000
Takeoff Wt: 775,000

(Built to operate as either a passenger or a cargo airplane)
(Converted from passenger operation)
the same deck space as that occupied by the 20-footer. However, the latter preferred shipper-loaded to airline-loaded containers, and concluded that the 20-footer provided the best economics of the shipper-loaded containers of that day. The former made a tradeoff against ground-handling costs, and the latter against extra tare weight, both with the same objective -- to carry more cargo per flight.

Now, that's a tidy little formula, and it would be just lovely if we could depend on it wholeheartedly as a firm platform from which to proceed without having to look back. But there are aberrations in both philosophies, and there are constant changes in basic elements which deny us the luxury of a fixed platform from which to work.

Igloos - "Losers"

One of the aberrations found equally in both philosophies is that igloos and other types of containers compatible with smaller airplanes but not with 747's continue to be accepted for carriage on the 747 -- and at a discount! The igloo when used on a 747 is a real "loser" because the cubic limitations of the igloo in relation to the square footage of main-deck space occupied by the igloo limits severely the volume of cargo that can be carried. The most efficient thing to do technically would be to eliminate igloos and similar inefficient containers for 747 flights; but this would make 747 operators non-competitive for igloo-sized containerized shipments, and it would pose a difficult question of what to do about online and interline container connections between 707's/DC8's and the 747.

"Well-Stacked"

The second loose plank in our moving platform is the airline's ability to stack efficiently in the airplane whatever loose (non-containerized) cargo is offered to it by shippers, to achieve optimum weight per square foot on the main deck. This requires quite a lengthy learning curve for the airplane's loaders because the 747 is so different
**Container and Pallet Information**

<table>
<thead>
<tr>
<th></th>
<th>TARE WEIGHT (lbs)</th>
<th>CAPACITY CUBIC FOOT</th>
<th>CURRENT PURCHASE COST $'s</th>
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</thead>
<tbody>
<tr>
<td>20 ft. container</td>
<td>2,600</td>
<td>1,138</td>
<td>1,272</td>
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<tr>
<td>10 ft. container</td>
<td>970</td>
<td>580</td>
<td>628</td>
</tr>
<tr>
<td>2-H container</td>
<td>705</td>
<td>773</td>
<td>819</td>
</tr>
<tr>
<td>structural igloo</td>
<td>650</td>
<td>449</td>
<td>460</td>
</tr>
<tr>
<td>non-structural igloo</td>
<td>500</td>
<td>448</td>
<td>460</td>
</tr>
<tr>
<td>96 x 125 in. pallet plus net 120 in. high</td>
<td>300</td>
<td>773</td>
<td>773</td>
</tr>
<tr>
<td>88 x 125 in. pallet plus net 120 in. high</td>
<td>275</td>
<td>655</td>
<td>655</td>
</tr>
<tr>
<td>LD-7</td>
<td>500</td>
<td>355</td>
<td>400</td>
</tr>
</tbody>
</table>

1/ Subject to slight variation depending on model.

I.D. - Interior dimensions.
O.D. - Outside Dimensions.
The 747F main-deck has 29 "positions" measuring about 3 x 10 ft. One "position" can be filled by a single pallet or an igloo. Since a "10 ft. container" is slightly less than ten feet, 31 of these units can be carried on a 747F. The 20 ft. intermodal container takes up two "positions". The maximum number of intermodal containers that can be accommodated on a single flight is 13, as illustrated at the top. Sometimes it is not possible to utilize all main-deck "positions". The average number of main-deck "positions" utilized is 29. The number of belly "positions" is 9. The table at the bottom of the page shows various combinations of pallets and containers which may be accommodated on the main-deck and in the belly of the 747 freighter.

### Cargo Configurations

<table>
<thead>
<tr>
<th>MAIN DECK</th>
<th>QUANTITY</th>
<th>VOLUMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITEM NO.</td>
<td>LOAD ITEMS</td>
<td>CUBIC FT.</td>
</tr>
<tr>
<td>BASIC CAPABILITIES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>96&quot;x125&quot;x96&quot; Pallet</td>
<td>29</td>
</tr>
<tr>
<td>2</td>
<td>96&quot;x125&quot;x96&quot; Pallet</td>
<td>29</td>
</tr>
<tr>
<td>3</td>
<td>96&quot;x108&quot;x96&quot; Pallet (Com)</td>
<td>33</td>
</tr>
<tr>
<td>4</td>
<td>96&quot;x108&quot;x96&quot; Pallet (M1)</td>
<td>37</td>
</tr>
<tr>
<td>5</td>
<td>96&quot;x117.75&quot;x96&quot; Pallet</td>
<td>31</td>
</tr>
<tr>
<td>6</td>
<td>96&quot;x117.75&quot;x96&quot; Container</td>
<td>31</td>
</tr>
<tr>
<td>OPTIONAL CAPABILITIES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>8'x8'x10' Container</td>
<td>5</td>
</tr>
<tr>
<td>11</td>
<td>8'x8'x10' Container</td>
<td>10</td>
</tr>
<tr>
<td>12</td>
<td>8'x8'x30' Container</td>
<td>7</td>
</tr>
<tr>
<td>13</td>
<td>96&quot;x117.75&quot;x96&quot; Pallet</td>
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</table>

<table>
<thead>
<tr>
<th>FORE &amp; AFT LOWER HOLDS</th>
<th>QUANTITY</th>
<th>VOLUMES</th>
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<tr>
<td>ITEM NO.</td>
<td>LOAD ITEMS</td>
<td>CUBIC FT.</td>
</tr>
<tr>
<td>7</td>
<td>IATA - A1 (LD-3) (Half-Width Container)</td>
<td>30</td>
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<tr>
<td>8</td>
<td>IATA - A2 (LD-1) (Half-Width Container)</td>
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<td>9</td>
<td>Full Width Container</td>
<td>15</td>
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<tr>
<td>14</td>
<td>96&quot;x108&quot;x96&quot; Pallet</td>
<td>5</td>
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<tr>
<td>15</td>
<td>96&quot;x125&quot;x96&quot; Pallet</td>
<td>5</td>
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<tr>
<td>16</td>
<td>96&quot;x125&quot;x96&quot; (Lower Hold Igloo)</td>
<td>5</td>
</tr>
<tr>
<td>17</td>
<td>96&quot;x1125&quot; Pallet and LD-1 Half-Width Containers</td>
<td>5</td>
</tr>
<tr>
<td>18</td>
<td>Main-Deck Baggage-Full Width</td>
<td>12</td>
</tr>
<tr>
<td>19</td>
<td>Main-Deck Baggage-Half Width</td>
<td>24</td>
</tr>
</tbody>
</table>
from all other airplanes in this respect. Height has been a limiting factor up until the advent of the 747 airfreighter, but it is the expandable element with this airplane.

The DC8 and 707 main decks are limited by the igloo-shape contour, the maximum height of which is 86 inches just at the very peak, and their bellies are limited to a maximum height of 52 inches. Even the 747 belly permits cargo to a maximum height of only 64 inches. However, by contrast, optimum weight utilization of the main deck of the 747 involves stacking cargo 8 to 10 feet high. This is an extremely important consideration with regard to the economy of use of intermodal containers, because if the payload weight limit of the airplane can be achieved through better stacking, and if there is a sufficient flow of cargo to fill the flights on a consistent basis and if, as a result, container tare weight displaces revenue cargo, the intermodal container would become a mighty expensive proposition for the airlines.

That's putting a lot of "ifs" together, however. So far, experience indicates that the payload weight limit is reached only occasionally on regular flights of heavy-lift 747 airfreighters -- where there is an exceptionally long hop and consistently high load factors. However, the revenue cargo weight carried per flight is improving with concentration on, and experience with, cargo stacking, and we may eventually reach that point -- except that improvements in airplane payload capabilities may outrun our learning curve on stacking.

2H Container Superior

The objective of having cargo stacked as high and as densely as possible is also a very desirable one in relation to shipper-loaded containers. In this connection, Flying Tiger Line has developed the 2H container, and has begun to use it as a shipper-loaded, as well as an airline-loaded container. This now unquestionably is the most efficient main-deck 747F container that has been developed so far, from the viewpoint of high cubic capacity, low-tare weight and low purchase price.
The above drawing indicates the desirability of stacking cargo on the main deck as high as possible to achieve maximum weight payload. Relative height of intermodal container (96"), igloo (86"), and 2-H (118") container are indicated in the drawing.

The height of 123" can be achieved in the aft 21 positions, where the 2-H container would be effective. The forward section of the airplane, consisting of 10 positions, restricts height of the load to 8' for most of its length. Cargo stacked higher than 8' can be accommodated through the side (main deck) door, while cargo that is to be accommodated through the nose door must not exceed 8' in height.

The above drawing shows a cross-section of the 747F aft of the crew compartment, where the ceiling height is maximum. It indicates that the 8 X 8-ft. cross-section of the intermodal container achieves optimum utilization of main-deck capacity based on vertical sides and horizontal top; but that the 2-H airline-loaded container achieves greater capacity with a contoured top.
The only combination giving a better high-cube/low tare ratio is the pallet-and-net, and this does not provide the advantages of a container in security, stacking, support, etc. The 2H is superior to the intermodal container in terms of tare, capacity and cost, and these are key elements in line-haul economics, which is of extreme importance to an airline in freighter operation. The 2H is inferior to the intermodal container in terms of over-the-road capability, which means that the 2H can be used as a shipper-loaded container by forwarders and other customers at or very near the airport, but that it is awkward when trucked very far from the airport. Its advantage of low tare also implies the reciprocal disadvantage of easy damage; and its plain-pallet base and light construction give it some disadvantages in terms of handling with forklifts and on-airport storage. Nevertheless, given all these factors, the 2H container currently is best suited of any container to take advantage of the tremendous carriage capability of the 747F.

A side-view plan of the 747F interior shows that cargo in the forward 10 positions cannot be stacked to the same height as in the aft section. The most efficient containers (excluding pallets) for 8 of the 10 forward positions would be 8x8 containers, whereas the 2H provides maximum container capability in the 21 aft positions (except in the 747-200C convertible. See Table 11).

Airplane Weight Capabilities Change

The third loose plank in our moving platform is the fact that airplane weight payload capabilities change with time. Aircraft and engine manufacturers are constantly bringing forth improvements in the form of increased thrust, greater efficiency, or improved structure which increase payload or range or both. In new 747 airfreighters greater structural strength can be included which will raise payload capability by about 31,000 to 36000 lbs, but this differential starts to fade at about 2700 miles, and it disappears at about 3600 miles. (Some part of the differential can be made to
Dimensions of Nose Door and Side Door (Main Deck) of 747F

Nose Cargo Door

Side (main deck) Cargo Door

CARGO MODULES CAPABLE OF CONTAINING CARGO HEIGHTS OVER 12 FEET WHEN LOADED THROUGH SIDE DOOR PROVIDING APPROXIMATELY 2,500 CU FT OF ADDITIONAL CARGO VOLUME.
apply to longer ranges through another engineering change.) The significance of this added payload capability is that it makes it much less likely that container tare weight will detract from cargo weight capacity on such an airplane for stage lengths up to 3600 miles.

"Less likely", however, doesn't mean "invariably", and in a 3-cornered calculation involving airplane capabilities, cargo density, and length of hop, an imbalance in one of these three factors can cause an exception to the general rule. There are two closely-related examples I know of in which the cargo is not of average density but consistently, day-after-day, is of very high density. In one, VIASA, the Venezuelan airline, carries full loads on a regular basis of very dense General Motors automotive components from Toronto to Caracas for an assembly plant near that city. The other example is that of UTA, the French airline, which also carries automotive components from the Peugeot plant near Lyon, France to an assembly plant at Kadena in Nigeria. The cargo on both these routes is so dense that it doesn't fill the cubic capacity of the airplane before reaching its weight limit even on the high-payload 747 freighter on these hops of 2406 miles and 2335 miles respectively. This means that every effort has to be made to hold down tare weight to conserve weight carrying capability for more cargo. Only pallets and nets are used on these flights, and we can say without qualification that the extra tare weight of containers would encroach on the amount of cargo that could be carried in these exceptional instances. Would that all of our examples were as clearcut!

In sum, the 2H container and properly-stacked cargo to a 10-ft height in the aft 21 positions of the 747 main deck, will permit approximately 15% more cargo of average density per flight to be carried than with intermodal containers in the same positions. Likewise, the intermodal container accommodates more cargo than the
Results on Payload/Range of Increasing Structural Load of a 747 Freighter

- Structural Load: 278,600 Lbs
- Structural Load: 247,600 Lbs

Load (Payload & Tare Wt., 000's Pounds) vs. Range in Statute Miles

- New York - Los Angeles: 2467 st.m.
- New York - London: 3440 st.m.
igloos and other similar containers.

Also to be considered are the type of 747 airplane, the length of hop, the experience and success of the cargo handlers in stacking freight, and the volume and density of cargo to be flown on the route segment in question, among others. These factors are constantly in the process of change.

Possible Advantage No. 4
Marketing Advantages

There exists today preference on the part of certain customers for the intermodal 20-ft container. Seaboard World Airlines has marketed the intermodal air-surface transportation system by raising the consciousness of direct shippers and air freight forwarders to its advantages, and Seaboard has been successful in having some of them specify this shipping method. Seaboard's 747's carry the word "Containership" painted in 2-ft-high letters alongside the company's name on the fuselage in an effort to develop the containership concept in air-surface transport. Many regular customers have been attracted to Seaboard, and continue to use its services, because they have been sold on the advantages of this system. Other airlines have followed Seaboard, and the airline industry inventory of intermodal containers is growing, as indicated by the number of intermodal containers owned or leased by major airlines as of April 15, 1980:

<table>
<thead>
<tr>
<th>Airline</th>
<th>Containers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seaboard</td>
<td>295</td>
</tr>
<tr>
<td>American</td>
<td>100</td>
</tr>
<tr>
<td>Pan Am</td>
<td>78</td>
</tr>
<tr>
<td>Lufthansa</td>
<td>30</td>
</tr>
<tr>
<td>Northwest</td>
<td>20</td>
</tr>
<tr>
<td>Flying Tiger</td>
<td>15</td>
</tr>
<tr>
<td>Air France</td>
<td>5</td>
</tr>
</tbody>
</table>

(29)
A study by Boeing Aircraft Company* indicates the growth curve in use of intermodal air containers so far has almost exactly paralleled the early stages of the growth curve of maritime intermodal containers, which eventually built a whole new transport system.

Possible Disadvantages to Airlines

Possible Disadvantage No. 1
Container Ownership Costs

Like everything else, the purchase prices for intermodal containers are going up daily. There are several types produced by various manufacturers, but the current cost for a high-grade intermodal air-surface box is in the neighborhood of $12,000. If you long-term lease it, or amortize it, it costs you about $9.00 per day. Repairs run about $1.50 per day. Then you need chassis' on which to park or move it on the ground in the ratio of about 1 chassis to every 3 containers (other containers being in the hands of customers, or in flight). A chassis costs about $4.45 per day, including repairs (or $1.48 per container). This adds up to a daily cost per intermodal container of $11.98. On the transatlantic route, where the cycle time is 14 days, the cost per one-way trip is $83.86. On the domestic route, where the cycle time is 4 days**, the cost per one-way trip is $23.96. Adding 20% to cover peak seasons, peak days, directional imbalance and containers out of service for repair, the one-way trip costs will be $100.63 New York-London and $28.75 New York-Los Angeles.


**A 4-day cycle time based on 5 trips per week is equivalent to 5.6 day cycle time for a 7-day week. However, since the in-flight need is for 5 days a week, the 4-day cycle time is used for this calculation.
Possible Disadvantage No. 2
Cost of Carriage

At the beginning we asked ourselves if intermodal containers will spark an air-land revolution as they have a sea-land revolution. One major difference between air and surface transport is that everything carried by air literally has to be lifted off the ground and carried through the air at a much larger expenditure of energy. The 2600-lb tare weight of the intermodal container related to its 1138 cubic-foot capacity results in a tare ratio of 2.28 lbs per cubic foot. If the revenue cargo carried is of the standard density of 8.9 lbs per cubic foot, it means that the tare weight of the container equals 20% of the gross load.

On a New York-London hop it takes approximately 25 lbs of fuel to carry 100 lbs of cargo or tare weight -- a 25% ratio. Therefore 650 lbs, or 97 gallons* of fuel is required to carry the 2600-lb tare weight of the intermodal container, which at the current international fuel price of $1.09 per gallon costs $105.73 per trip. Adding the ownership costs, the total cost per trip is $206.36. At 10,128 lbs of cargo per container (8.9 lbs per cubic foot x 1138 cubic foot interior) the tare cost is 2.04c per lb, amounting to 3% of the average New York-London rate of 65c per lb.

On a New York-Los Angeles hop 18 lbs of fuel are needed to carry 100 lbs of load, which means 468 lbs of fuel, or 70 gallons at a domestic price of 95c per gallon for a per-trip fuel cost of $66.50 for intermodal container tare weight. Added to ownership costs the total per-trip cost is $95.25, or 1.15c per lb, or 2% of the New York-Los Angeles pivot** rate of 58c per lb.

* Fuel weighs 6.7 lbs per gallon at 80°F at sea level.

**The domestic container pivot weight permits lower density than the international pivot weight and so the domestic pivot is used more. Therefore the domestic example is based on the New York-Los Angeles pivot charge of $4785 for the intermodal container divided by the pivot weight of 8250 lbs. The international example is based on the loose cargo density limitation.
Approximate Additional Weight of Fuel Consumption

For Each 10,000 Pounds of Freight and Tare Weight

Lbs. of fuel needed to carry each 10,000 lbs. of freight and/or tare weight.

Percentages indicate fuel as a percentage of load carried.

Statute miles.

No consideration for wind component/direction.

Standard degree day/sea level.
These per-trip costs of intermodal container ownership and carriage bring us back to our principle of "compared to what", since some sort of pallet or container is needed to carry cargo in each position. The net extra cost of the intermodal container versus other pallets or containers can be obtained by taking the purchase price and tare weight of the comparable pallet or container as shown in Table 9, and then applying the same formula according to relative cubic capacities. The resulting extra cost of the intermodal container compared to other pallets and containers on this basis is approximately as follows:

<table>
<thead>
<tr>
<th>Compared to:</th>
<th>New York-London</th>
<th>New York-Los Angeles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two Pallets</td>
<td>2.7</td>
<td>1.01</td>
</tr>
<tr>
<td>Two 2H Containers</td>
<td>2.0</td>
<td>.81</td>
</tr>
<tr>
<td>Two Non Struct. Igloos</td>
<td>1.8</td>
<td>.74</td>
</tr>
<tr>
<td>Two Structural Igloos</td>
<td>1.4</td>
<td>.61</td>
</tr>
<tr>
<td>Two 10-Ft Containers</td>
<td>.9</td>
<td>.48</td>
</tr>
</tbody>
</table>

Possible Disadvantage No. 3
Cost of Rate Incentive

Cargo of the same density between the same points is charged for at approximately the same rate in the various shipper-loaded containers. This rule is not without its numerous exceptions and variations, and it should not be interpreted to mean that there is great uniformity or design in airline container ratings. However, it is generally applicable, which means that the airline receives about the same per-pound revenue regardless of the type of container used by the customer. Thus there is no appreciable difference in cost to the airline of rate discounts of the intermodal
container versus any other. Containerization discounts were in effect before the advent of intermodal containers, and there was no major change in the system with the new containers, which would indicate that the containerization discount system exists without regard to the intermodal facility. This would seem to eliminate the cost of the rate incentives as a disadvantage to intermodal containers.

**Airline to Itself**

In all of the previous examples an airline-customer relationship has been assumed. But is there a potential for the intermodal container within the framework of the airline's routes, to serve points not served by aircraft?

The 747F is a most efficient cargo-carrying aircraft, but to be profitable it has to carry a large load, which means, conversely, it would be relatively unprofitable serving smaller cities. This leaves the choice of serving these smaller cities either by connection to smaller aircraft, or to truck. It is much less expensive to truck than to fly cargo, and the service is comparable at least up to a 500-to-700-mile range. The intermodal container possibly could facilitate such online aircraft-truck transfers.

Air-truck online carriage becomes a much more relevant consideration as a result of the comprehensive trucking deregulation legislation passed by Congress just last month. The legislation does two things in this regard.

Firstly it exempts from I.C.C. regulation and substantially broadens the section of the law concerning truck movements incidental to air carriage by eliminating all mileage limits and by authorizing trucking by airlines of all goods that have had a prior or subsequent movement by air and are part of a continuous movement. Not
coincidentally, the CAB at the same time issued Notice of Proposed Rulemaking EDR-403/ODR 22 which grants virtually the identical authority to airlines. In that Notice the Board reverses all of the restrictive rulings limiting intermodal transport that it has issued in the past several years. Comments on this Rulemaking are due August 22.

Secondly, the legislation authorizes the same freedom of air-truck transport in the USA to foreign airlines, but provided they apply to the CAB for it and get permission. This proviso is an interesting current move in a political battle which has raged for several years. Some countries had attempted to limit freedom of US airlines to truck freight in those countries, which would have severely restricted market access of the US airlines. Also, some US domestic airlines had wanted the CAB to restrict trucking by foreign airlines within the USA, so as to force connecting cargo to move by air on domestic routes, and not by truck. The new proviso in the law hopefully will give the US government the clout to enforce intermodal freedom of movement on all traffic to and from the USA.

The significance of this battle is the importance it demonstrates of air-surface intermodal carriage. But intermodal carriage does not necessarily mean the use of the intermodal container. Use of the intermodal container would require volumes of cargo to a single destination large enough to fill the container, and all of the other considerations listed herein would have to be given due weight.

Findings

"Findings" is a favorite word used by consultants in reports, when they want to restate the obvious but don't want to be tagged for having made an outright recommendation. The word also serves as a sort of half-pregnancy, heading up the section
of the report coming between the investigation and the recommendations, the latter of which always is less specific than the findings. In all these respects it fits my needs, so here are my findings:

1. The major advantage of the intermodal container is its over-the-road capability, and its major disadvantage is its cost/capacity ratio as compared to pallets and nets, or the 2H container. This suggests the possibility of marketing it only to customers with real over-the-road need.

2. Further reductions in ground costs are harder to obtain the greater the degree of containerization and intermodality already achieved.

3. The cost of owning and carrying intermodal containers depends on a multitude of factors, such as cycle time, traffic demand, aircraft capability on the route, and fuel costs, among others.

4. Marketing is an esoteric term at best, so it's up to you to balance the marketing value of a facility which makes it easier for some customers to do business with you, against your cost of providing the facility. An important question, requiring you to weigh intangible benefits against tangible costs.

5. All of the elements necessary to a solution are in the process of constant change, but in a real-life situation, which this is, a long-term point of view sometimes helps one to cope with the short-term fluctuations.

Recommendations

The pros and cons of air-surface intermodal container use have been presented herein as they might appear to someone working in the industry, even to the extent of listing some considerations not directly pertinent to intermodality, but bearing indirectly on it. This was done in order to "put you in the driver's seat" so to speak, to let you decide how you would solve the problem.
The Massachusetts Institute of Technology is a prestigious institution with almost unlimited resources at the service of its students. Computer capabilities and an understanding of macro- and micro-economics and linear programming are just a few of the advantages available. You have here before you an air cargo industry problem, and the tools and techniques with which to solve it.

Over to you.