

ALTERNATIVE ACCESS AND LOCATIONS FOR AIR CARGO

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DISCLAIMER

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ABSTRACT

In recent years, air cargo has been the fastest growing segment of the goods movement industry in the United States, placing increasing demands both on airports and ground transportation to/from airports. This project documents and analyzes issues confronting air cargo movements in Southern California (the Los Angeles and San Diego areas), develops strategies for accommodating growth in air cargo, and assesses the impacts of these strategies on carrier operations. The emphasis is on the operation of the cargo carriers themselves, rather than on the governmental entities that serve these carriers. Particular emphasis is given to operation of integrated carriers.

Within Southern California, LAX is the dominant cargo airport, trailed by Ontario and San Diego. LAX acts as an international gateway between North America and Asia. It is also the location for the FedEx “Metroplex” (min-hub). The majority of the freight traffic through LAX travels on passenger/freight airlines. Ontario is dominated by UPS’ regional hub, which serves 78% of the airport’s freight volume. San Diego provides a mixture of domestic and international service. Other airports serve domestic hub traffic of integrated airlines, within local areas. This report describes the roles of these airports with respect to the operational concerns of air cargo carriers.

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DISCLOSURE

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1. INTRODUCTION

In recent years, air cargo has been the fastest growing segment of the goods movement industry in the United States. The growth has been especially strong in the overnight parcel movement segment, led by Federal Express, but also including such companies as United Parcel Service, Airborne Express, DHL, Emery, along with services offered by the United States Postal Service. A consequence has been increased demands on airports to accommodate both ground access movements of trucks feeding into cargo flights.

Unlike some segments of the freight industry, much of the ground movements for air cargo occur during peak travel periods in the morning and evening. To meet east coast delivery commitments, aircraft depart from west coast airports in the period around 6:30 to 7:30 p.m. Because pickup operations end around 5:00 p.m., at close of business, very little time is available to move shipments to the airport, sort the shipments, load air containers, and load the containers on aircraft. Small amounts of delay can impose tremendous cost, and possibly force late deliveries all around the country (due to late connections at hub airports). Due to time zone differences, west coast flights are the last to arrive at the hubs (Hall, 1989); Southern California flights account for a huge percentage of these west coast flights.

Due to a west coast time zone advantage (3 hours behind east coast), the time pressure is lessened during the a.m. period in California. Nevertheless, trucks are on the road during peak periods to meet start-of-day delivery commitments.

Both Federal Express and United Parcel Service have major operations centers in Southern California. UPS operates a regional hub out of the Ontario airport, and Federal Express operates a "Metroplex" (mini-hub) out of LAX. Both companies offer flights to major hubs out of other airports, including San Diego, Burbank, Long Beach and Orange County. And both companies operate an extensive network of terminals, from which pickup and delivery vehicles are dispatched, and trucks are routed to airports.

UPS and Federal Express use two methods for transporting shipments to the airports. One method is to fill air containers at the local pickup/delivery terminals, and move these on tractor-trailers. The air containers are typically pre-sorted, so that they can be moved directly to the aircraft. The alternative is to use smaller shuttle trucks, which are bulk loaded. Bulk loads must be sorted and loaded into containers at the airport. One advantage of the shuttle trucks is that they are eligible to use HOV lanes, provided that two people ride in the vehicle.

It should be mentioned that whereas air cargo is a fast growing industry segment, it is associated with only a small portion of truck movements in the region and in the country. Shippers pay a substantial premium for the service relative to all-ground or water service, so they only utilize air for their most critical and highest value freight. Future growth in overnight freight is unlikely to drastically change the balance between air and ground shipments. Nevertheless, air cargo is vitally important to the economy, because of its

high-value shipments, and because late deliveries can delay projects, shut down production lines, and miss time critical deadlines.

Air shipments are inherently intermodal, as few shippers and receivers are directly served by aircraft. Intermodal transportation has received increased attention since the passage of the Intermodal Surface Transportation Efficiency Act (ISTEA). All levels of government have since paid closer attention to planning for intermodal freight facilities (FHWA, 1994; California DOT, 1995; GAO, 1996; Eberts, 1998; TRB, 2001). Nevertheless, much better information is available on the design of aircraft ground access facilities for passengers (e.g., Bellomo-McGee, 1996; Leigh Fisher, 1998), than for freight. And even though intermodal freight is a much-studied subject (e.g., Muller, 1995; Wegmann, 1995), intermodal rail and ship have received much more attention than intermodal air.

A number of issues are critical to air cargo ground operations in Southern California, which will be the focus of this paper:

- LAX is the third largest airport in the nation, measured in enplanements, and largest as measured in passengers originating/terminating within the region. LAX is under pressure to expand its passenger facilities to better serve the current traffic, as well as to accommodate future growth. This growth, along with expanding freight traffic, places a premium on airport property, along with property surrounding the airport. (LAX currently has the second highest commercial lease rates in the country, behind only JFK in New York; Riggins, 2002). Other airports in the region also face land pressures. Though freight cargo facilities at LAX are currently separated from passenger facilities, the competition for space will certainly grow in the future.
- Truck movements experience significant roadway congestion on the way to, and in the vicinity of, the region's airports, especially LAX. Unlike conventional freight, air cargo is often on the roads during peak periods. The hub operations of the major air cargo carriers depend on meeting departure schedules in Southern California to keep their entire U.S. delivery network on schedule.
- Changes in regional congestion, property constraints and constraints on aircraft landings/departures may force carriers to adopt new operational strategies for moving freight in the region. Examples of these changes could be: (1) changing the location at which shipments are sorted, (2) changing the number of "splits" (i.e., groupings) into which shipments are categorized, (3) offering direct flights from more or different airports, (4) connecting pickup/delivery terminals to different airports. The LAX Master Plan is still in flux, and it is unclear whether the airport will be expanded to accommodate future growth in freight, though expansion has been proposed.
- The region is currently contemplating a variety of changes in its air system. This includes opening or expanding airports (e.g., March, Palmdale, El Toro, Victorville), some with a specific focus on freight. In addition, the region faces competitive

pressure from other west-coast airports, such as San Francisco, Oakland and Seattle-Tacoma (Thuermer, 1997; Parezo, 2002).

Other changes being studied include truck-only-lanes, Maglev/high-speed rail access to airports (possibly accommodating freight), and conventional rail transportation.

2. INDUSTRY STRUCTURE

The air freight industry can be segmented into five categories: (1) integrated freight carriers, (2) non-integrated freight carriers, (3) passenger/freight carriers, (4) postal services and (5) freight forwarders. To put these categories in perspective, Table 1 provides the total ton-kilometers of freight carried by the 15 largest carriers in the world.

Federal Express	10,809
Lufthansa	7,115
Korean Air	6,491
UPS	6,318
Singapore Airlines	6,020
Air France	4,980
Japan Airlines	4,607
British Airways	4,564
Cathay Pacific	4,108
KLM	3,964
United Airlines	3,694
Cargolux	3,523
Northwest Airlines	3,234
American Airlines	2,780
Nippon Cargo	2,186

Source: International Air Transportation Association

Of the top 15 cargo carriers, 11 also carry passengers (some, such as United, do not even operate all-cargo aircraft). These passenger airlines depend on freight forwarders and postal systems to generate traffic. The list is dominated by carriers with strong international passenger operations, reflecting the importance of trans-oceanic shipments in the air cargo industry. Similarly, strong international airports also play a major role in freight transportation. The number 1 and number 4 cargo carriers (FedEx and UPS) are the only integrated carriers on the list. The only non-integrated freight carriers, Cargolux and Nippon Cargo, rank 12 and 15.

We discuss each category in this section.

Integrated Carriers

Federal Express (FedEx) and United Parcel Service (UPS) are the dominant companies in domestic air freight (Pagano, 2001). Both provide an integrated door-to-door service, merging four principal elements: (1) ground fleet of pickup/delivery trucks, (2) terminals for sorting and processing freight, (2) long-haul truck fleet for moving freight between

terminals, and (4) an air fleet for moving freight between airports. Both companies operate internationally, and operate a network of hub airports for processing freight. Comparing the two, FedEx is somewhat stronger in the overnight air segment of the business, whereas UPS is stronger in ground transportation. Total revenues for the major American integrated carriers (including all business segments) follow in Table 2.

United Parcel Service	\$29,771 (2000)
Federal Express	\$19,629 (2001)
DHL	\$ 5,100 (1999)
Airborne	\$ 3,276 (2000)
CNF (Emery Parent)	\$ 5,572 (2000)
BAX Global	\$ 2,097 (2000)

Source: Hoovers Online for all financial statistics in report.

Due to their smaller size, DHL, Airborne, Emery and BAX operate somewhat differently than UPS and FedEx. For instance, DHL has specialized in international freight and, therefore, it provides less extensive service domestically (for instance, fewer service options). The German Post Office recently acquired a majority stake in DHL, apparently to gain a foothold in the American market. BAX Global, the smallest carrier shown, is a hybrid between an air carrier and a freight forwarder: it utilizes passenger airlines for much of its freight. BAX, along with Emery, focuses on heavier shipments than UPS and FedEx. Airborne offers similar services as UPS and FedEx, but has focused on negotiated arrangements with major shippers, with more limited service for the general public. Airborne, BAX and Emery are all financially weak. Emery in particular suffered in the last year, due to the temporary grounding of its fleet (a consequence of maintenance concerns), and the loss of a major US Postal Service contract to FedEx.

Non-Integrated Freight Carriers

The non-integrated carriers are considerably smaller than the integrated carriers. They are differentiated from integrated carriers by: (1) serving narrower geographic markets, (2) focus on larger and more specialized shipments, and (3) emphasis on acting as a sub-contractor to other carriers. The largest non-integrated carriers are Cargolux (Luxemborg) and Nippon Cargo (Japan), based on kilometer-tons carried. Within the United States, Evergreen International (\$550 million revenue in 2001) and Atlas Air (\$790 million revenue in 2001) are the largest. Kitty Hawk, Gemini and Polar (recently acquired by Atlas) are other major cargo airlines.

The non-integrated carriers serve two basic functions. First, carriers like Cargolux, Nippon and Evergreen provide scheduled service on major traffic lanes, which can be utilized by shippers or freight forwarders as needed. Second, carriers like Atlas and Gemini provide outsourcing, carrying contracted freight for freight forwarders and other airlines. This can either be a long-term contract (either for an entire aircraft or a portion

of an aircraft), or a one-time charter. Within the outsourcing category, some carriers provide specialized services, such as small feeder aircraft (e.g., Ameriflight), or large military-styled aircraft designed to carry oversized loads (e.g., Volga-Dnepr).

Because the freight airlines generally do not provide a complete transportation service (e.g., they do not operate ground transportation), and because their shipments tend to be large, they are much less capital-intensive than integrated carriers. That is, they have fewer assets because they can operate their fleets without investing in terminals for sorting and processing freight. They also do not require extensive staffing, because terminal operations are limited, truck drivers are not needed and fewer customers are served. As a consequence, they are much smaller businesses than the leading integrated carriers (FedEx and UPS).

Combination Passenger/Freight Carriers

In addition to transporting passengers, most airlines also provide freight and mail services. Usually this entails selling excess space in the belly of passenger aircraft (especially 747, DC10 or other larger aircraft). Some passenger carriers (such as Korean Air and Northwest Airlines) also operate all-freight aircraft – most commonly on trans-Pacific and trans-Atlantic routes. However, some major carriers of freight -- United, American and Delta -- rely entirely on passenger aircraft. According to Dahl (2000), “more than half of the world’s freight moves on passenger flights.” Overall, as indicated in Table 1, 11 out of the top 15 cargo airlines are also passenger airlines. These airlines carry well over half of the world’s freight.

To service freight, passenger/freight airlines typically form partnering arrangements with freight forwarders, trucking companies, postal services and couriers. The airlines typically do not operate their own fleets for pickup and delivery, and do not operate local terminals for sorting and processing shipments. Instead, they rely on third-parties to assemble shipments, which are then delivered to airport terminals. The passenger carriers focus on providing the air transport portion of the service.

Postal Services

Postal services are usually owned by national governments, though there has been some move toward privatization. The US Postal Services is the largest in the world, with \$64,540 million revenue in 2000 (more than twice the revenue of UPS). Although USPS is still part of the US government, it operates without subsidy.

The largest European postal service is Deutsche Post AG (German Post Office), with \$30,798 million revenue in 2000. Though the German government holds a majority stake in Deutche Post AG, the company is increasingly focused on private markets, and international expansion through investments in companies like DHL. TNT Post Group in the Netherlands was the first publicly traded postal system. It has expanded into express markets (including the US), and reached sales of \$9,358 million in 2000.

Although the US Postal Service (USPS) has offered overnight mail services for some time, it has never operated its own airline. Instead, it has relied on private carriers (Emery and Kitty Hawk, and more recently FedEx), and passenger airlines to provide its air services. In this sense, the USPS functions more like a freight forwarder than an integrated freight carrier. USPS is also noted for its extensive pickup and delivery services. It is the only transportation company that visits almost every US address on a daily basis.

Although the USPS is the largest transportation organization in the world, it only accounts for a modest fraction of the air freight shipped in this country (about 10% of weight). This is because their air shipments tend to be very small (envelopes and documents), and because much of the mail shipped in the US travels in ground vehicles.

Freight Forwarders

Freight forwarders do not ordinarily operate airlines. Instead, they are wholesale purchasers of airline capacity. By providing ground feeder services and specialized support services (e.g., assistance in clearing customs and inspections), forwarders are able to resell airline capacity to shippers. Freight forwarders also frequently assist their customers through warehousing, order fulfillment and other types of logistical support. They are especially prominent in the vicinity of the major international gateway airports, such as LAX, Miami and John F. Kennedy (New York), and in the vicinity of major sea ports. According to Clancy and Hoppin (2001), forwarders serve 80% of international cargo traffic. Forwarders frequently serve both ocean and air shipments.

The largest freight forwarders operate internationally and operate pickup and delivery services, though many companies work on a small scale in a single location, utilizing partnerships with foreign counterparts. Danzas Group (subsidiary of Deutsche Post) is the largest in the air forwarder market, with \$7,805 million revenue in 2000. Some large freight forwarders, such as Eagle Global Logistics (\$1,861 million in revenue), have contracted for dedicated air routes and pickup and delivery, to provide a coordinated door-to-door transportation service. Traditional freight forwarding is strongest in large shipments (bigger than typical packages), and international shipments.

In another class, some freight forwarders specialize in very urgent “next-flight-out” service. Here the emphasis is on domestic shipments for which next-day service is inadequate. This class of forwarder has developed partnerships with airlines and couriers for door-to-door service, especially within the United States. Examples include UPS’ Sonic Air subsidiary, FedEx “SameDay” service, and “NextJet”.

Freight Airports in the United States

Table 2 lists the 15 largest freight airports in the United States, measured in total metric tonnage. The largest airport (Memphis) and the sixth largest airport (Louisville), owe their size to hub operations of FedEx and UPS. Neither airport resides in a highly

populated region, and neither is positioned as an international gateway. They were selected by UPS and FedEx as hubs because of their central location relative to US population, minimal snowfall, and attractive labor environments.

Table 2. US Airports with Largest Cargo Volumes+

Airport	Total Metric Tons	Hub Operation
Memphis	2,489,070	Federal Express
Los Angeles	2,054,212	DHL
Anchorage*	1,883,825	Federal Express
New York-JFK	1,825,906	
Miami	1,642,484	DHL
Louisville	1,519,558	UPS
Chicago	1,463,941	
Indianapolis	1,173,967	Federal Express
Newark	1,082,668	Fed Ex Regional
Dallas	904,994	UPS-Regional
Atlanta	871,602	
San Francisco	870,113	
Dayton	832,205	Emery
Oakland	703,043	Fed Ex Regional
Philadelphia	562,752	UPS-Regional

Other Hubs

BAX: Toledo, Ohio
 Airborne: Wilmington, Ohio
 DHL: Cincinnati
 Federal Express: Fort Worth Alliance Field

* Includes transit freight
 + Source: Airports Council International

The second largest airport (LAX), fourth largest airport (JFK) and fifth largest airport (Miami) are all major international gateways (Asia, Europe and South America, respectively). Their size is not so much due to FedEx and UPS traffic as it is due to international airlines – especially passenger airlines that also carry freight.

The third largest airport – Anchorage – is a special case. Its size is largely due to its ability to serve as a refueling stop for Asian/North American traffic. The remaining airports (numbers 7 through 15) are large for either of two reasons: (1) location of a domestic freight hub, or (2) location within a highly populated region.

To put these data in perspective, Figure 1 shows the locations of the largest freight airports in the US along with the locations of major passenger airports. Circles, representing freight airports, are graduated in size to represent freight volume. Flags, also graduated in size, represent passenger enplanements. As indicated, the major freight airports tend to be either coastal (serving international traffic), or in the center of the country (acting as domestic hubs). Major passenger airports are more evenly distributed.

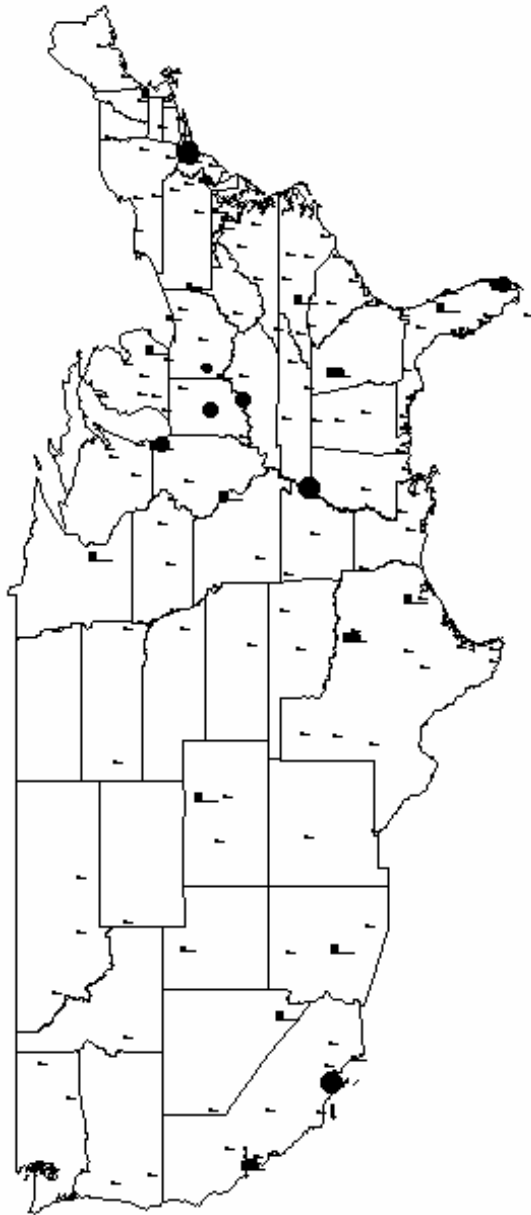


Figure 1. Locations of Largest Freight Airports in the United States (graduated circles represent passenger traffic; graduated flags represent freight traffic)

Services in Southern California

Freight service is available through all of the region's major airports – LAX, San Diego, Orange County, Ontario, Burbank and Long Beach. However, LAX dominates the market, with Ontario and San Diego well behind (Orange County, Burbank and Long Beach serve a small fraction of LAX' volume). In 2000, LAX served 2.25 million tons of freight, a factor of 4 larger than Ontario and San Diego (sources: LA World Airports, Port of San Diego).

FedEx has its largest Southern California operation at LAX, with direct flight service to about 10 cities across the United States. Despite its size, FedEx accounts for just 18.2% of the regular freight at LAX (even less if mail is factored). UPS operates its west coast hub out of Ontario, where it accounts for 78% of the airport's freight traffic (not counting mail). Despite this high percentage, traffic volumes for UPS' Ontario hub and FedEx' LAX Metropolex are similar. Both carriers provide limited service out of the other four major airports (principally connected to the carriers' hub airports).

Table 3 lists the top 10 LAX carriers by tonage. Similar to the international ranking in Table 1, the list is dominated by passenger carriers, with just three all-freight carriers (Federal Express, Emery and Atlas) appearing in the top 10. Major domestic passenger airlines – United, American, Northwest and Delta – rank 2, 4, 5 and 6. Three major foreign passenger carriers also rank high: Korea Air (3), Asiana (8) and Singapore (10). The list is reflective of the international strength of LAX.

Table 4 provides the top 10 all-freight carriers, which are dominated by FedEx. The five largest integrated carriers all appear on the list (FedEx, 1; Emery, 2; DHL, 4; Airborne, 6; and UPS, 10). Collectively, the top 10 all-freight carriers only account for 33% of the total freight volume at the airport (the remainder being predominantly passenger airlines).

Table 5 shows the dominance of UPS among the top 10 carriers at Ontario. Other integrated carriers – FedEx, BAX, Emery and Airborne – also operate from Ontario, and are ranked 2 to 5. DHL, with its international focus, does not. Collectively, the integrated carriers account for nearly 98% of the freight tonnage. The remaining 2% is roughly evenly divided between small non-integrated freight carriers (Ameriflight and Ryan) and passenger carriers. It is clear from these statistics that Ontario is almost exclusively focused on the domestic freight market.

Elsewhere in the region, Burbank, Long Beach and Orange County provide limited freight service, principally FedEx and UPS flights to domestic hub airports. San Diego's freight volume is similar to Ontario's, but it is not concentrated with a single carrier. In addition to UPS and FedEx, San Diego is served by BAX, Emery, Evergreen and Ryan, as well as a large number of passenger airlines. Other smaller airports (such as Palmdale, Palm Springs, Oxnard) are largely limited to feeder service to the larger airports in the region.

Table 3. Largest Air Freight Carriers at LAX (2000)

Carrier	Freight Tons	% of Freight Market	Mail Tons	% of Mail Market	Passengers
Federal Express	364,313	18.2%	0	0.0%	N/A
United	168,092	8.4%	53,694	21.8%	15,200,000
Korea Air	127,118	6.3%	974	0.4%	830,000
American Airlines	80,920	4.0%	27,651	11.2%	8,000,000
Northwest Airlines	76,455	3.8%	15,603	6.3%	2,600,000
Delta Airlines	71,606	3.6%	26,601	10.8%	5,200,000
Emery	42,280	2.1%	25,394	10.3%	N/A
Asiana	58,840	2.9%	467	0.2%	340,000
Atlas	55,953	2.8%	0	0.0%	N/A
Singapore Airlines	53,752	2.7%	142	0.1%	410,000
Total Top 10 Airlines	1,099,329	54.9%	150,526	61.1%	
Total All Airlines	2,002,614		246,538		

Table 4. Largest All Freight Airlines at LAX (2000)

Carrier	Freight Tons	% of Freight Market	Mail Tons	% of Mail Market
Federal Express	364,313	18.2%	0	0.0%
Emery	42,280	2.1%	25,394	10.3%
Atlas	55,953	2.8%	0	0.0%
DHL	39,522	2.0%	43	0.0%
Evergreen	38,868	1.9%	0	0.0%
Gemini	16,850	0.8%	18,310	7.4%
Airborne	34,967	1.7%	0	0.0%
Nippon	27,456	1.4%	467	0.2%
Cargolux	25,459	1.3%	17	0.0%
UPS	22,852	1.1%	142	0.1%
Total Top 10 Cargo	668,520	33.4%	44,373	18.0%
Total All Airlines	2,002,614		246,538	

Table 5. Largest Freight Carriers at Ontario

Carrier	Freight Tons*	% of Freight Market	Mail Tons	% of Mail Market
UPS	390,000	77.7%	0	0.0%
Federal Express	64,000	12.7%	0	0.0%
BAX	14,000	2.8%	0	0.0%
Emery	14,000	2.6%	0	0.0%
Airborne	10,000	2.0%	0	0.0%
Southwest	2,000	0.4%	4,000	28.6%
Delta	1,000	0.2%	3,000	21.4%
Ameriflight	4,000	0.7%	0	0.0%
United	1,000	0.1%	3,000	21.4%
Ryan	2,000	0.4%	0	0.0%
Total Top 7 Airlines	502,000	99.6%	10,000	71.4%

* Approximation

Source: Los Angeles World Airports

Tsao (1998) recently completed a comprehensive survey of air cargo in California, and provides an extensive data set on air cargo freight movements, and Mercer (1995) provides additional data on air cargo facilities in Southern California (along with other modes of cargo transportation). An extensive study of truck transportation in Southern California was completed in 1988. Though the study is now dated, it provides useful information regarding the distribution of trip ends throughout the region and the distribution of truck travel by time of day. Wilbur Smith (1990) studied truck traffic in the vicinity of LAX in particular, and found that it was a relatively small contributor to overall congestion in the vicinity of the airport. Lastly, Hall and Partyka (1991) provide information on the linkage between economic activity and truck traffic in the region, including traffic related to air-express shipments.

Industry Interviews

A series of interviews was completed with trucking companies, freight forwarders and airlines, including the three largest airlines serving LAX and the largest serving Ontario (Appendix). Interviewees were asked to cite the advantages and disadvantages of utilizing LAX for freight cargo, and to offer their suggestions to improve ground transportation of freight. We summarize the findings here, and provide more details on integrated carriers in the following chapter.

From the carrier perspective, LAX offers numerous advantages. First, carriers such as United and Korean Air, offer both passenger and freight services. Because LAX is the focal point for international passenger traffic in the region, and because LAX is also a major passenger hub for United, it would be very difficult to operate anywhere else. Secondly, LAX has a strong infrastructure to support cargo operations, including air freight terminals, runways for larger aircraft, freight forwarders, trucking companies, customs, and Department of Agriculture inspections. Third, LAX is the most centrally located airport relative to the region's population and employment. Last, one carrier believed that it was easier to retain employees at LAX, due to its location.

From the perspective of ground carriers and forwarders serving the airport, LAX offers similar advantages, most importantly an ability to accommodate larger aircraft, a central location relative to customers and flight connections to many destinations. Customs facilities, an ability to accommodate larger aircraft and on-time performance were also cited.

Interviewees seemed satisfied with on-time performance at LAX, in most cases citing it as neither an advantage nor disadvantage.

The biggest disadvantages of LAX are the costs of leases, crowding and traffic congestion. These disadvantages are a byproduct of LAX' central location, which has limited room for constructing new facilities. It is also a byproduct of delays in implementing a master plan for airport expansion. In general, interviewees were dissatisfied with the state of the facilities at LAX, citing difficulties in adding to their warehouses, and lack of planning in separating freight from passengers.

Interviewees were very concerned about traffic in the vicinity of LAX, which is among the worst in the LA region. Despite these disadvantages, the interviewees did not view Palmdale to be a viable alternative: the reduction in congestion, crowding and cost of operation do not adequately compensate for its remoteness. And although the Palmdale airport is located in a less congested area, trucks would need to pass through considerable congestion in the LA region in order to reach Palmdale.

Freight Forwarders

As an illustration of the how freight forwarders are tied to freight-serving airports, Figures 2 and 3 plot their Southern California locations (based on the Air Cargo World forwarder directory). The great majority of these are located in the immediate vicinity of LAX, to the south and the northeast. In strong contrast to integrated carriers, forwarders do not spread their facilities throughout the region. This can be attributed to the relatively large size of their shipments (making it less important to consolidate loads close to the shipper/receiver), and due to forwarders' reliance on trucking companies for providing ground transportation service (which operate their own distinct terminals). The forwarders themselves are not positioned to serve airports other than LAX.

To put this further in perspective, Figure 4 provides site plans for the LAX operational area, as it exists today. Freight operations fall in two general areas: along Imperial highway on the south of the property (Figure 4a, including FedEx and the Imperial Cargo Complex), and along Century Boulevard in the north-east corner of the property (including United, Figure 4b). Fortunately, the southern facilities are largely isolated from passenger terminals, minimizing car/truck conflicts. The Century Boulevard facilities are more problematic, because the street is a main access route to passenger terminals, and because of their proximity to hotels and offices. Attention needs to be placed on facilitating truck traffic along Century Boulevard, and moving as much freight traffic as possible to the south side of the airport property. The LAX Master Plan proposed four concepts, all of which include expansion of cargo facilities along Imperial Boulevard. Two of the concepts also provide expansion along Century Boulevard.

In planning for expansion, consideration should be given to accommodating forwarders, which are generally located off of the airport property. In particular, it would be beneficial to develop strategies by which forwarders and air cargo terminals are located in close proximity, away from passenger traffic. This may include development of off-airport property to the south of Imperial Boulevard.

Figure 2. Freight Forwarders in Los Angeles Basin

Figure 3. Freight Forwarders Near LAX

Figure 4a. LAX Plan in Vicinity of Imperial Boulevard

Figure 4b. LAX Plan in Vicinity of Century Boulevard

3. INTEGRATED CARRIER OPERATIONS

FedEx and UPS are similar in that they provide an integrated, door-to-door, service, meaning that they own and operate fleets of ground vehicles, fleets of aircraft, and terminals for consolidating and sorting shipments. They are also similar in that they have focused on the document/package business, carrying shipments up to 150 pounds. DHL, Airborne, and Emery provide similar services and operations, on a smaller scale, and within market niche's.

Integrated Carrier Operations

Integrated carriers price their services according to delivery commitment, ranging from premium (early-morning) delivery, to delivery several days in the future. Depending on the distance from origin to destination, the day shipped and the service selected, a shipment may or may not travel by aircraft. Because the cost of ground transport is substantially less than the cost of air transport, trucks are preferred whenever sufficient time is available. For instance, an early morning delivery could be handled entirely by truck if the origin and destination are sufficiently close. Even a coast-to-coast 2-day shipment can travel by truck if shipped on a Friday. These choices are generally invisible to the customer, who is unaware of the routing.

Despite this flexibility, much of the system design is driven by the next-day, morning (generally 10:30), segment of the business. Meeting this deadline is especially challenging for shipments that originate in the west coast and terminate in the east coast. With a typical drop-off time of 5:00 p.m., just 14 ½ hours are available from pick-up to delivery. Within this time, the following activities take place.

Pickup: Packages/documents are collected from shippers in four ways: (1) at customer locations, (2) from drop-boxes, (3) from authorized service centers (e.g., a Kinkos store), or (4) from carrier staffed centers. A customer pickup can either be on a regular schedule, or be “on-call” (phoned in on the day the service is requested). A carrier staffed center can either be an office or a terminal (thus, eliminating one step in transportation).

As with an ordinary mailbox, drop-boxes have posted pick-up times, which vary depending on distance from the airport and anticipated truck routing. Service centers additionally have specified hours of operation, though their pick-up times tend to be later than drop-box times. Service centers located at airports have the latest pick-up times, because the customer handles transportation to the airport.

Stations/Terminals: Within larger regions carriers operate multiple stations/terminals, each of which serves a local territory. Each of these local terminals is the base for a fleet of pickup/delivery vehicles, and each terminal provides facilities for sorting and processing shipments. Some terminals are served by a single airport, while others are served by two airports (a smaller nearby airport and a more distant major airport, with more extensive service).

Depending on the location, pickups may be sorted prior to leaving the terminal, according to airport, destination or class of service. As shipments are sorted, they are either transferred in bulk into larger trucks or, alternately, loaded into air containers and then loaded into trucks. Trucks generally travel non-stop to their airport. In some cases the terminal is adjacent to the airport, eliminating the need for this transportation step.

Airports: We distinguish between five types of airports in our discussion. A *national hub* is the highest class of airports, serving aircraft from multiple origins and destinations located throughout the country. It provides connectivity between most domestic origins and destinations with a single cargo transfer. A *regional hub* also serves aircraft from multiple origins and destinations, but is limited to a section of the country (e.g., the west coast). A *major airport* is the largest airport within a large metropolitan area, potentially providing direct service to other major airports in addition to hubs (a major airport could also be a hub). A *local airport* is a secondary airport within a larger metropolitan area, or the only airport within a smaller metropolitan area. It provides jet service to hub airports only. Last, a *rural airport* is served by small aircraft (often prop planes), which provide a feeder service to other airports. Within the LA region, LAX is a major airport for FedEx and Ontario is a regional hub for UPS. Burbank, Long Beach and Orange County also act as local airports. Memphis is a national hub for FedEx and Louisville is a national hub for UPS.

Air shipments normally pass through two or three airports on their journey: one near the origin, one near the destination and possibly a hub airport. In sparsely developed areas, a shipment may also be served by a rural airport.

Bulk loaded trucks are frequently re-sorted at the airport according to destination, with varying levels of granularity. At a minimum, shipments must be sorted by airport-destination if flights are scheduled to multiple destinations. In some cases shipments are sorted into finer categories. This could entail separating lower classes of services (especially 2-day or 3-day), which could be transported by truck or by later aircraft, or this may entail sorting shipments by final destination. Ultimately, shipments must be loaded into aircraft containers, which are subsequently loaded onto aircraft (occasionally, depending on aircraft, shipments are also bulk-loaded in the aircraft).

Hub Airport: The hub airport receives aircraft from multiple origins, and loads shipments onto aircraft for multiple destinations. To accomplish these tasks, some containers must be opened so that individual shipments can be sorted. These are then reloaded into containers and transferred onto outbound aircraft. Some containers arrive pre-sorted by destination, so they do not need to be opened at the hub.

The transportation process from hub airport to location terminal/station mirrors the process from local terminal to hub airport.

Delivery: Deliveries occur at the ultimate destination, and not through service centers or drop boxes. This means that more locations are served for delivery than pickup, that

locations are more spread out, and that deliveries are more time consuming. Whereas most pickups occur late in the day, deliveries tend to be spread from 8:00 a.m. until about 3:00 p.m. The driver's day is approximately divided by class of service: prior to 8:00 a.m. for premium, 8:00-10:30 for regular next day, 10:30 – 3:00 for discounted next day, and 10:30 – 4:30 for 2-day or 3-day service.

Effects of Service Classes

By having multiple service classes, carriers can better utilize their aircraft, truck and personnel resources. For instance, aircraft can make multiple roundtrips each day, with separate trips for next-day and 2-day/3-day service. Delivery trucks can also be more productive throughout the day, keeping drivers busy in the 10:30 to 3:00 time period, handling shipments that do not require early delivery.

Multiple service classes also add considerable complexity to scheduling drivers and aircraft and sorting shipments. A driver may need to repeatedly visit a building or an area to accommodate the different classes of shipments delivered. And shipments must be sorted into more categories and sometimes stored for later departing aircraft. Aircraft schedules become more complex because they are used for multiple trips each day (daytime trips are used to accommodate 2-day service).

Routing

The routing defines the sequence of terminals and airports visited by a shipment. The routing depends on the origin, destination and service class, along with strategic design decisions.

Figure 5 illustrates basic options for routing air freight within and around a major metropolitan area. Three airport classes are shown: major, local and rural. Locations served in the immediate vicinity of the major airport are served entirely by the major airport, independent of destination. Locations in the vicinity of the rural airport are served by the rural airport, in combination with the major airport via feeder aircraft. Locations in the vicinity of the local airports can be served in either of two ways. For in-between locations, freight is served by a combination of major airport and local airport. The local airport is used for freight that must pass through a hub. The major airport is used for traffic that can be routed direct. More distant locations may be served entirely by the local airport, due to their greater distance from the major airport. In addition to the options shown, some freight may be routed direct, by truck, from station to station, or airport to airport, if there is sufficient traffic.

Figure 6 illustrates basic options on a national scale. Local airports have three options: air routes to the closest regional hub, air route to a national hub, or truck routes to nearby airports (e.g., if volume and time permits). Major airports have two additional options: air routes to other major airports, or air routes to more distant regional hubs. These options are viable because the major airport can draw sufficient traffic to fill aircraft to smaller destinations, whereas local airports cannot. This can reduce the cost of hub

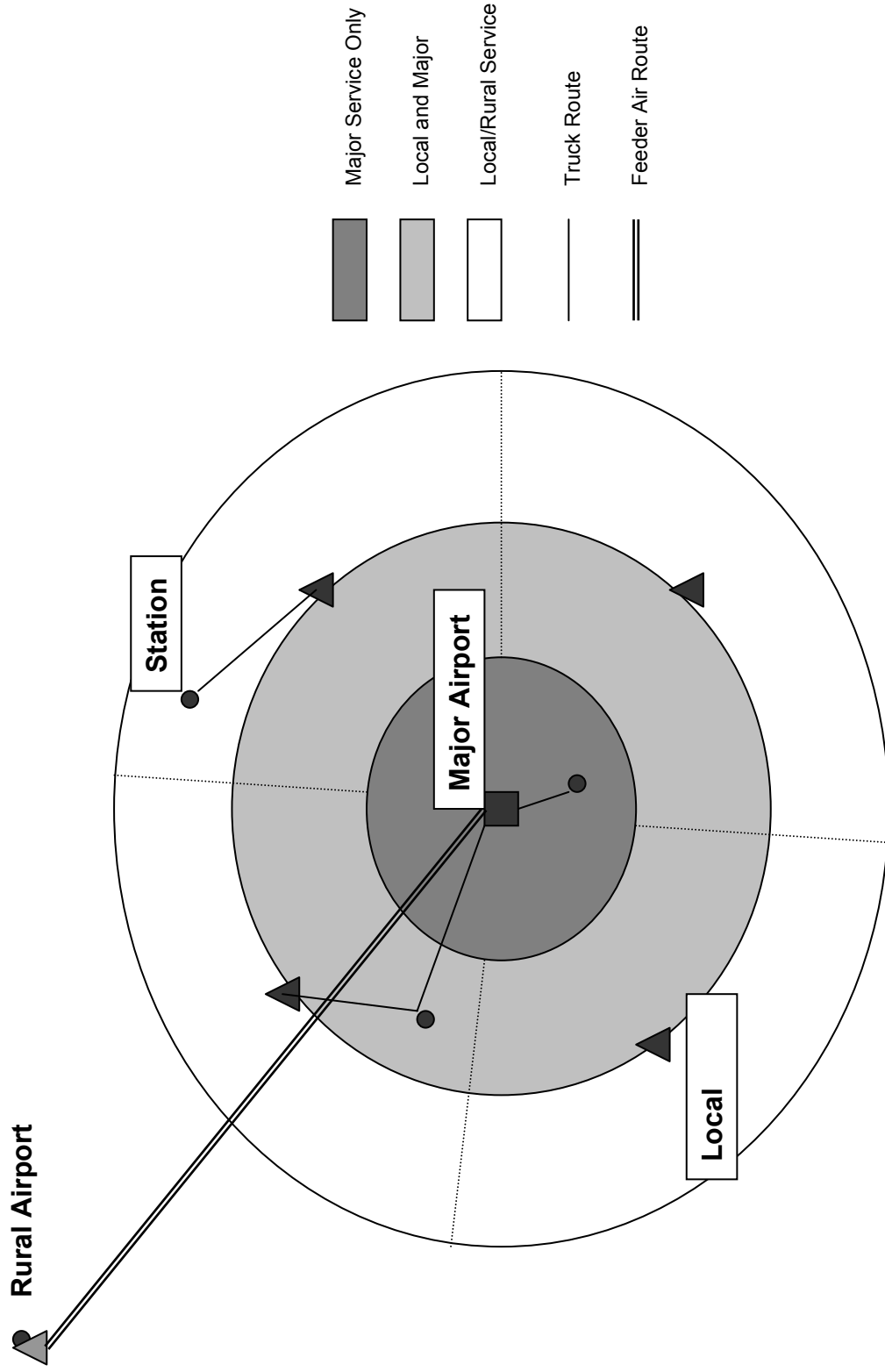


Figure 5. Conceptualized Routing Options within Major Metropolitan Area

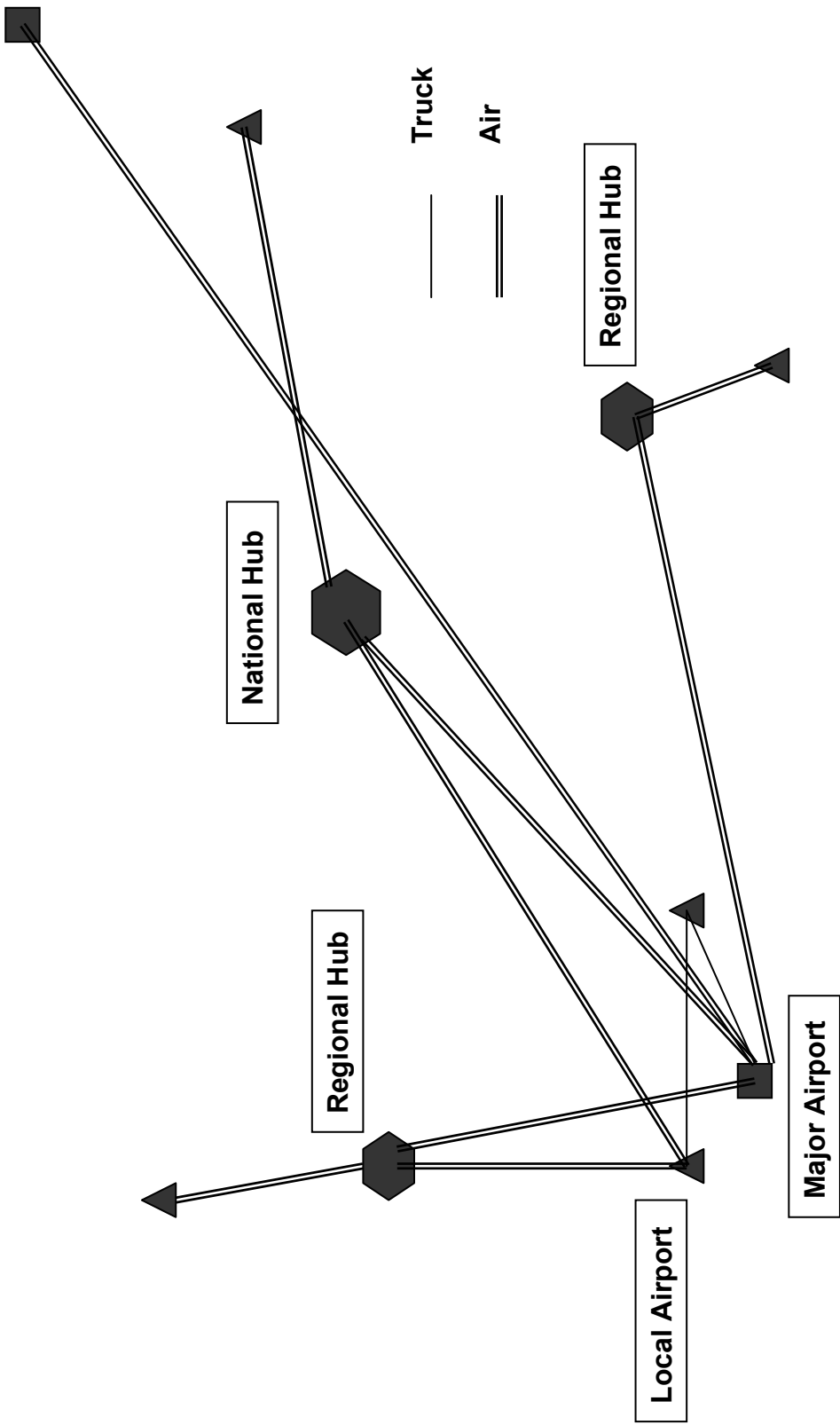


Figure 6. Routing Options from Local and Major Airports

sorting, and reduce the flying distance for cargo. For major-major routes, time is also saved, which allows aircraft to depart later, and allows the sorting facility at the originating airport to be utilized over more hours. Because these major-major routes have later departures, it is feasible for trucks to travel greater distances to reach the airport, enabling major airports to serve large regions for some destinations.

By routing some traffic through local airports, local truck mileage is reduced within large metropolitan areas. However, because the major airport provides better flight connectivity, trucks may still travel from locations throughout the region to reach the airport. In Southern California, this means that FedEx trucks travel from throughout the region to LAX, and UPS trucks travel from throughout the region to Ontario.

Station/Terminal Locations

Figures 7-9 show station/terminal locations for FedEx, UPS and DHL within the Los Angeles region. FedEx provides the most uniform coverage, placing most locations within 10 miles of a station. This means that local pickup/delivery trucks do not have to travel far to reach their bases. It also means that shipments are quickly consolidated into truckloads for transport to airports. UPS terminals are less spread-out, with some concentration in the vicinity of downtown Los Angeles. This is a product of UPS' historical strength in ground shipments. Their terminals tend to be larger facilities, with considerable dependence on investments in shipment sorting equipment. DHL has the fewest terminals, because it processes the smallest freight volume.

Route Construction

We now consider processes by which shipment routes are constructed and optimized. We consider the inter-terminal portion of a route, which begins and ends at a local station. A route can be characterized by a sequence of arcs, each representing a transportation movement by truck or aircraft. A transportation movement is defined by the assignment of a shipment to (1) geographical path, (2) aircraft/flight time, and (3) container. With respect to path, four basic alternatives follow.

Figure 7. Federal Express Terminal Locations in Los Angeles County

Figure 8. UPS Terminal Locations in Los Angeles County

Figure 9. DHL Terminal Locations in Los Angeles County

<p><u>Via National Hub</u></p> <p>Truck from origin station to local airport Aircraft from local airport to national hub Aircraft from national hub to local airport Truck to destination station</p> <p><u>Direct, Via Major Airport</u></p> <p>Truck from origin station to major airport Aircraft from major airport to major airport Truck to destination station</p>	<p><u>Via Nearby Regional Hub</u></p> <p>Truck from origin station to local airport Aircraft from local airport to regional hub Aircraft from regional hub to local airport Truck to destination station</p> <p><u>Via Distant Regional Hub</u></p> <p>Truck from origin station to major airport Aircraft from major airport to distant regional hub Aircraft from regional hub to local airport Truck to destination station</p>
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With regard to aircraft, there may be multiple aircraft scheduled to fly a particular path on a given day. The assignment to aircraft is determined in part by the sort time, as follows: (1) early evening for flights to national hub for next-day delivery (about 7:00 p.m.), (2) late evening, direct and nearby regional hub (about 10:00 p.m.), (3) morning, for 2-day service. Typically, no more than one aircraft is scheduled for a given route and sort, though a few high volume routes may require multiple aircraft. Thus, the combination of service priority and destination determines both the aircraft and route assignments.

Most shipments are containerized to facilitate easy loading and unloading, and in some cases to save effort in sorting shipments. At any terminal/airport along a path, shipments may be pre-sorted into categories corresponding to distant destinations, or intermixed among all destinations. Pre-sorting eliminates the need to sort shipments at an intermediate terminal, permitting an entire container to be transferred directly from one aircraft to another. Intermixing forces the container to be opened at an intermediate terminal and re-sorted. However, intermixing improves capacity utilization. Several containers that would otherwise be only partly full can be combined into a smaller number of totally full containers (Figure 10).

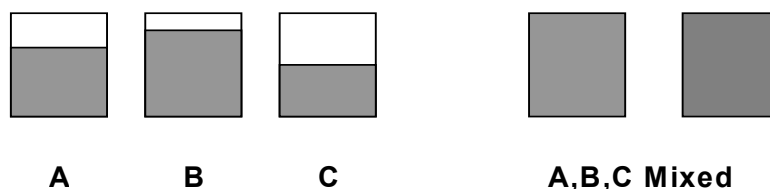


Figure 10. Intermixed Containers Reduce Container Requirements.

Combining all factors, a shipment route can be characterized as a sequence of the following type:

$$\{(t_1, a_1, c_1), (t_2, a_2, c_2), \dots\}$$

where

- t_i is the i 'th terminal visited
- a_i is the i 'th vehicle utilized
- c_i is the i 'th container utilized

Cost Structures

Transportation networks generally exhibit strong scale economies, and integrated air/truck networks are no exception. The cost of operating a vehicle or a terminal only increases marginally as freight is added, until reaching capacity. Once capacity is exceeded, a larger vehicle or facility may be substituted, leading to a cost function of the type in Figure 11. Even as larger resources are substituted, the trend is for decreasing average cost.

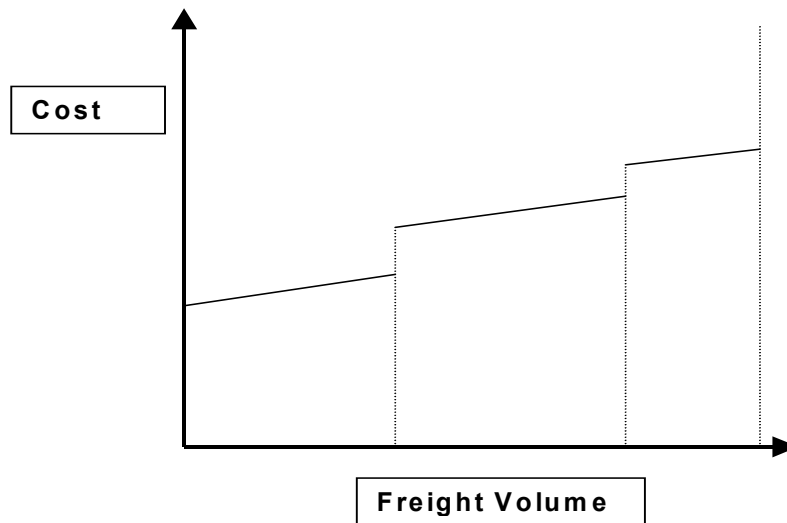


Figure 11. Cost Versus Volume Trend for an Aircraft Route

As shown in Figure 11, costs are highly non-linear, which creates a natural interdependency in the decisions made among origin-destination pairs. It takes the combined freight of many o-d pairs to justify operating a flight, or opening a terminal. Moreover, once an aircraft is scheduled or a terminal is opened, it is advantageous to route freight in a manner that maximizes utilization of the available capacity.

Network costs can be divided into three components, as described in the following.

Terminal Costs: Associated with sorting, processing and handling shipments. These costs are strongly dependent of the design capacity of the facility, measured in units of freight per hour. When freight is added to a terminal, either the sorting period must be extended, or the capacity must be increased. While the former is less expensive, it may be impossible to meet deadlines without also adding capacity. When a container is pre-sorted, so that an intermediate terminal is bypassed, capacity increases, and costs decline, at the intermediate terminal.

Local Transportation Costs: This is the cost of transporting freight from stations to airports or other major terminals. These costs depend on the timing of shipments, route lengths and freight volumes. Transporting freight to a more distant major airport ordinarily adds to the local transportation cost. However, some of the added cost may be offset if it is possible to delay travel beyond the rush hour, because direct routes out of major airports have later departure times.

Terminal Transportation Costs: This is the cost of transporting shipments between airports or major terminals, either by aircraft or truck. Generally the least expensive mode that meets time commitments is used (i.e., truck is preferred to air if feasible). The costs of terminal routes increase with distance, and decrease per unit weight when freight can be moved in larger, and more full, aircraft.

The optimal strategy for any given region depends on a complex set of trade-offs, which are not independent of the decisions made for other regions. The cost of utilizing a national hub depends on the freight already assigned to vehicles traveling in and out of the hub. If additional traffic can be accommodated without changing the aircraft assignment or adding sorting capacity, then the marginal cost will be small and the terminal route attractive. If facilities and vehicles are operating close to capacity, then the marginal cost can be large and alternate routes may be preferred.

One of the critical decisions in network design is whether a station should be connected to the major airport, or solely to a closer local airport. We assume that the local airport is only connected to the national hub, and that the following information is available:

- D = set of destination airports that have direct service from the major airport
- λ_j = shipment volume from the station to destination airport j , $j = 1, \dots, J$
- f_{kl} = shipment volume already utilizing arc (k, l) – other than traffic from the station under consideration
- $C_{kl}(f)$ = cost of transporting freight volume f on arc (k, l)
- α = added unit cost of sorting shipments at the station
- γ = average unit cost of transporting freight between stations and local airport
- γ' = average unit cost of transporting freight between stations and major airports
- h = index used to represent the national hub
- 1 = index used to represent the local airport nearest to the station
- 2 = index used to represent the major airport nearest to the station

Then the incremental cost change due to providing direct service from the station, through the major airport, is as follows:

$$\begin{aligned} \Delta &= \{\text{sort cost}\} + \{\text{local transportation cost}\} + \{\text{direct air cost}\} + \{\text{hub air cost}\} \\ &= \left\{ \alpha \left(\sum_{j=1}^J \lambda_j \right) \right\} + \left\{ (\gamma' - \gamma) \left(\sum_{j \in D} \lambda_j \right) \right\} + \left\{ \sum_{j \in D} [C_{2j} (f_{2j} + \lambda_j) - C_{2l} (f_{2l})] \right\} + \\ &\quad + \left\{ [C_{1h} (f_{1h}) + \sum_{j \in D} C_{hj} (f_{hj})] - [C_{1h} (f_{1h} + \sum_{j \in D} \lambda_j) + \sum_{j \in D} C_{hj} (f_{hj} + \lambda_j)] \right\} \end{aligned}$$

Once a station provides service through the major airport, all of its shipments must be sorted into at least two categories at the station, corresponding to major or local airport. Thus, the sort cost applies to all shipments generated in the station. The location transportation cost is a function of the distance from the station to the local airport, relative to the major airport distance, along with the relative distances at destination stations. γ' and γ represent an averaging of these values. The direct air cost is computed as an incremental function, which depends on the amount of freight sent to each direct destination from the station, along with the amount of freight already sent direct to these destinations. Lastly, the hub air cost is also computed incrementally, depending on the amount of freight that traveling to the non-direct destinations, and the amount of freight is diverted to the major airport.

Taking all factors into account, the major airport becomes more attractive when:

- Freight can be sorted quickly and efficiently at the station.
- Added distance from the station to the major airport, relative to the local airport, is small.
- The major airport provides direct service to many cities, each of which offers cost savings. That is, the direct routes do have excess capacity, meaning the incremental cost due to adding direct traffic is small.
- The local airport to hub route does not have excess capacity, meaning there are true savings when traffic is diverted from the local airport to the hub.

As indicated, the cost function only accounts for a single station, and is dependent on several other strategic decisions:

- The set of cities that receive direct service from the major airport.
- Type of aircraft flown on each route.
- Whether local airports are used at all, and where they are located.
- Locations of stations within the region.

Because Southern California is such a large region, UPS and Federal Express have both found it attractive to establish a major facility along with many local facilities. By utilizing many local airports, ground transportation has been reduced. On the other hand, provision of direct routes increases ground transportation for some destinations, though the trips tend to be more outside of the peak period.

Looking to the future, growth in highway congestion may have the effect of increasing traffic through the major airports (LAX in the case of Federal Express and Ontario in the case of UPS). Direct flights can cut several hours from the transportation time between LAX and other large cities, which can more than compensate for the added ground travel distance to LAX from outlying areas. In addition, as air shipments increase, it becomes more economical to add direct flights, which can divert traffic away from the local airports and add to ground travel. These trends are not all that different from passenger traffic in the region. Although smaller airports are generally more convenient from the perspective of ground transportation, the much larger number of flights through LAX continues to draw the large majority of passenger traffic.

5. CONCLUSIONS AND RECOMMENDATIONS

Southern California is served by a system of airports, including LAX, Ontario, San Diego, Orange County, Burbank and Long Beach, as well as many smaller airports. Freight traffic, like passenger traffic, is dominated by LAX. This is because LAX is the only airport that has the facilities and schedules to serve international traffic (*Murphy et al.*, 1989, present criteria). It is a major gateway connecting Asia to the United States. Ontario also serves significant traffic because UPS uses the airport as its regional hub. San Diego serves significant traffic because it serves a large region. All other airports have minimal freight traffic, largely limited to integrator traffic to domestic hubs.

Although Palmdale, March Air Force Base and Victorville have been proposed as freight airports, they are not well positioned to accept a large portion of the traffic that currently uses LAX. Over half of the freight traffic through LAX travels via passenger airlines. Much of this traffic also travels via international airlines. These freight operations could not be relocated unless passenger operations are also relocated. Even for domestic operations, these sites are far from optimal, due to their remote locations. Their use as a ground/air hub would inevitably increase trip lengths, leading to more truck traffic and increased difficulty in hitting time commitments.

Because LAX, and the west side of Los Angeles, have become very congested, it would still be attractive to shift some of the freight traffic to other airports. This might be accomplished by:

- 1) Redirecting domestic freight traffic to local airports, or creating major integrator operations at other airports, such as Long Beach or Ontario. Domestic shipments are less dependent on proximity to passenger airlines, and are the most easily relocated.
- 2) Increasing international passenger and freight operations at a second airport in Southern California. At the moment, San Diego is the closest to filling this role, though it far smaller than LAX. By further developing San Diego, traffic that would otherwise travel from San Diego to LAX could stay in the San Diego region. Ontario is also a potential candidate for the future, as it currently has the best facilities for accepting additional traffic, and because it is located in the vicinity of a growing number of freight distributors.

Despite these possibilities, LAX will likely attract the majority of the region's freight traffic far into the future. No other airport is comparable in terms of the scope of facilities, scheduled service and central location. Therefore, considerable attention should be placed on roadway access, and possibly the separation of freight and passenger facilities for smooth traffic flow. Because of its special features, international traffic is the least likely to move to an alternate airport. Because passenger and freight are interdependent in International travel, LAX will likely retain its current position as the focus for freight.

Fortunately, LAX segregates much of its freight facilities from its passenger facilities. Focusing developing on the south side of the property will meet this objective.

6. IMPLEMENTATION

To reduce ground freight traffic, economic incentives should be provided to encourage integrated airlines to serve as much freight as possible from local airports. This may include governmental financing for ground access infrastructure, and provide facilities at attractive rents. Facilitating off-airport development of forwarder facilities on the south side of LAX and in the vicinity of Ontario and San Diego airports could also be advantageous. In planning for a regional air system, consideration should be given to promoting a second international airport, with a combination of freight and passenger services, either at Ontario or San Diego.

Appendix
Interview Guide

Research Project for LAX

‘Alternative Access and Locations for Air Cargo’

at

University of Southern California

Airline Carrier:

Contact:Survey Topics

1.0 Systemwide Operations/Strategy

- 1.1 Which destinations/origins do you serve from Southern California? (core geographic business area?)
- Direct

 - With additional transshipments/same carrier

 - Additional transshipments/different carrier
- 1.2.1 Have you formed strategic alliances with other carriers? If yes, who are they and for which destinations?
- 1.3 What types of shipments do you regularly carry
- USPS
 - Small package/letter
 - Large sized/specialized
 - Palletized
 - Containerized
- 1.4 Do you specialize in particular commodities? Do you prohibit particular commodities?
- 1.5 In terms of delivery time commitments, what levels of service are offered?
- 1.6 Does cargo operations operate as a separate business unit?
- 1.7 How are cargo and passenger operations integrated?
- 1.8 What types of aircraft do you operate from Southern California (how many flights)?
- 1.9 Does Southern California operate as a hub or major transshipment point? If so, have you contemplated moving the hub elsewhere?

2.0 Local Operations/Strategy

- 2.1 Which Southern California airports do you utilize? And which destinations are served from each airport?
- 2.2 Why did you select the airports that you use? What are their advantages?
- 2.3 Have you contemplated use of other airports, or used other airports in the past?
- 2.4 Do you own or contract out warehousing facilities? (if so, where)
- 2.5 Do you own or contract for a ground transportation fleet?
- 2.7 Describe your fleet (number of vehicles, size of vehicles, etc.)

- 2.8 Do you offer pickup/delivery at customer site?
- 2.9 Do you operate local terminals within the region?
- 2.10 Do you regularly work with freight forwarders? If yes, describe their function?

3.0 The Ground Transportation Process

- 3.1 Describe the process followed by a shipment from pickup to airplane
 - Requesting pickup
 - Assignment of pickup to airport
 - Scheduling pickup driver
 - Sorting operations at local terminal
 - Transportation from local terminal to airport
 - Sorting operations at airport
 - Loading operations
- 3.2 Describe the process followed by a shipment for delivery from airplane to customer.
 - Unloading operations
 - Sorting operations at airport
 - Transportation from airport to local terminal/customer
 - Sorting operations at local terminal
 - Scheduling delivery driver
 - Assignment of airport to delivery
 - Actual delivery
- 3.3 How is ground transportation scheduled?
- 3.4 What are the critical deadlines affecting your scheduling of ground transportation?
- 3.5 To what degree do shippers/receivers arrange their own ground transportation?
- 3.6 What proportion of shipments are delivered/picked up?
- 3.7 How do they arrange their ground transportation?
- 3.8 What additional space requirements are imposed on your operations for warehousing?
- 3.9 How are operations affected by congestion?

4.0 Feedback

- 4.1 In what ways could LA World Airports better serve its airlines? (in terms of facilities, operations, etc.)
- 4.2 What types of facilities are most needed on or near the airport?
- 4.3 Tell us some of the major issues faced by ground transportation. What remedial actions were taken?
- 4.4 Can you provide us with some statistical data which you think might be useful to us for this project.

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