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The Role of Air Cargo in California's Goods Movement

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Preface and Acknowledgments

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List of Acronyms and Abbreviations

AAS	Airport Activity Statistics of Certified Route Carrier
ACAIS	Air Carrier Activity Information System
ACI	Airports Council International
AIP	Airport Improvement Program
ATR	Airport Traffic Report, published by individual airports
BEA	Business Economic Area
BTS	Bureau of Transportation Statistics, U.S. DOT
CFR	Code of Federal Regulations
CFS	Commodity Flow Survey
FAA	Federal Aviation Administration
FedEx	Federal Express
FHWA	Federal Highway Administration, U.S. DOT
GDP	Gross Domestic Product
IATA	International Air Transport Association
ITMS	(California) Intermodal Transportation Management System
ITS	Intelligent Transportation Systems
LAX	Los Angeles International Airport
MPO	Metropolitan Planning Organization
NARA	National Archives and Records Administration
NAS	National Airspace System
NTACS	Nationwide Truck Activity and Commodity Survey
NTAR	National Transportation Analysis Region
OAI	Office of Airline Information, Bureau of Transportation Statistics
OAK	Oakland International Airport
RSPA	Research and Special Program Administration, US DOT
RTK	Revenue Ton-Kilometer
SFO	San Francisco International Airport
T-3	Schedule T-100, Research and Special Programs Administration (RSPA) Form 41, Uniform Systems of Accounts and Reports for Large Certified Air Carriers
T-100	Schedule T-100, Research & Special Programs Administration (RSPA) Form 41, Uniform Systems of Accounts and Reports for Large Certified Air Carriers
TIUS	Truck Inventory and Use Survey
UPS	United Parcel Service
USIA	U.S. International Air Passenger and Freight Statistics
USPS	United States Postal Service
VNTSC	Volpe National Transportation Systems Center
WATR	Worldwide Airport Traffic Report, published by ACI

Executive Summary

Motivation of the Study

California would be the seventh largest economy in the world, if it were a nation. Efficient goods movement is crucial to California's economy. To support continued growth of the State's economy, Caltrans is leading the development of a Statewide Goods Movement Strategy. This strategy is being prepared as a response to a recommendation of the 1993 California Transportation Plan. It serves as one element, together with the Transportation System Performance Measures report being prepared in parallel by Caltrans, of the 1998 California Transportation Plan update.

Air cargo consists predominantly of high-value, time-sensitive or time-definite goods, e.g., electronic equipment, emergency shipments, overnight packages, etc. Timely delivery of these goods has been an important element of many manufacturing and service operations in California. Therefore, the air cargo industry is a vital part of the State's economy. Continued ability of the State's air cargo industry to serve the other industries in the State and the State's ability to capitalize on the forecast growth of air cargo routes between Pacific-Rim countries in Asia and North America are essential to the prosperity of California. However, future demand on California's air cargo system may continue to outpace the future supply of the system's capacity.

Faced with these challenges, Caltrans began a systematic investigation into the role of air cargo in California's goods movement, as part of the larger development effort for a statewide goods movement strategy, and funded a research project in 1997 for the Institute of Transportation Studies at U.C. Berkeley to (i) gain a broader understanding of the State's air cargo industry and the role of air cargo in California's goods movement, (ii) assess the importance of air cargo to the State's economy, (iii) begin identification of issues hindering efficient air cargo movement in the State, and (iv) explore possible State roles for resolving the issues. This "white paper" documents the findings of that research and serves as an input to the development of the Statewide Goods Movement Strategy.

Fast Growth of Air Cargo in California

To gain a basic understanding of the State's air cargo industry, we focused on three basic air cargo traffic measures for major California airports:

- Total Weight of Air Cargo Enplaned or Deplaned,
- Weight of Air Cargo Enplaned,
- Weight of Air Cargo Deplaned.

Although data inconsistencies exist for some major California airports, accurate estimation is achievable. With a comprehensive data fusion and processing effort, one can monitor the evolution of total, enplaned and deplaned air cargo tonnage at all major California airports. Our estimation shows that the growth of air cargo at the top ten airports in California has been very

fast. Seven out of the ten airports experienced a growth rate higher than 50% in the five years between 1991 and 1996; four out of the seven experienced more than doubling of the total air cargo tonnage. The ten airports had a combined growth rate of higher than 50% in those 5 years.

The State's Heavy and Valuable Air Cargo Traffic and Its Role in Exporting

Los Angeles International Airport was ranked as the second largest cargo airport in the World in 1996 by Airports Council International, outranked by only Memphis - the biggest hub for Federal Express. The total amount of air cargo enplaned or deplaned at the Los Angeles International Airport in 1996 was estimated by Airports Council International to be 1,719,449 tons. (Its Memphis counterpart is 1,933,846 tons.) Three out of the top twelve air cargo airports in the U.S. are in California, with a combined tonnage of more than 3 million in 1996. The 1993 Commodity Flow Survey (of primarily the manufacturing industries) estimated that, in 1992, 21.4% (\$30 billion) of the non-parcel domestic air cargo, in value, originating in the U.S. originated in California. (Parcel refers to a small package and typically weighs less than 100 lbs.)

According to the California World Trade Commission's estimates of the value of the merchandise exported by California manufacturers in 1986, close to 70% (\$16.7 billion) of the exports, in value, was shipped by air. Although accurate estimates of such percentages for recent years are not available, percentages higher than 70% have been reported. In addition, six of the twenty top U.S. exporting metropolitan areas in 1996 are in California, with the San Jose metropolitan area ranked the first. The high percentages and the high export value achieved by the six California metropolitan areas attest undoubtedly to the critical role of air cargo for California's economy.

Significance of Passenger and Aircraft Traffic in the State's Aviation System

Much air cargo is carried by passenger aircraft or small aircraft, and therefore it is important to understand passenger traffic and the amount of (landing and take-off) operations at California airports. Los Angeles and San Francisco International Airports were ranked as the fourth and the seventh largest passenger airports in the world, respectively. In terms of the total number of operations, Los Angeles International Airport was ranked number three in the world. Perhaps quite surprisingly, although Oakland, Long Beach and Orange County Airports have not been considered to be major passenger airports in the State, they are actually ranked number 10, 12 and 14 in the world in terms of the number of operations (resulting partially from general aviation and cargo operations). In each of the three categories (air cargo, air passengers and aircraft operations), California has by far the busiest traffic among all fifty states of the U.S.

Measuring the Role of Air Cargo with Respect to Other Modes of Goods Movement

To gain an understanding of California's air cargo movement with respect to other modes of goods movement, we focused on the following four types of mode-comparison measures:

- **Trucking-for-Air-Cargo Percentage:** the percentage, by value and weight, of goods (across all commodity categories) moved via air-truck combination with respect to all goods whose movement involves trucking,

- Commodity-Weight-Moved-by-Air Percentage: percentage of commodity weight, for individual commodity categories, that is moved by air,
- Commodity-Value-Moved-by-Air Percentage: percentage of commodity value, for individual commodity categories, that is moved by air, and
- Commodity-Movement-Mode Distribution: the distribution of modes of transportation for each of the commodity categories for which air cargo plays a significant role.

Based on the 1993 Commodity Flow Survey (CFS), we were able to develop plausible lower and upper bounds for the first quantity type and obtain lower bounds for the last three with broad commodity categorization. Note, however, that the Survey focused on the manufacturing and whole-sale industries and ignored several other industries, e.g., the service industries. Therefore, the percentages developed are valid only when the scope is limited to those industries surveyed.

Relative Value of Air Cargo with Respect to All Trucked Goods

Our estimation is that, for the first type of quantities, the percentages by value and weight are approximately 6.6% and 0.18%, respectively. These percentages suggest that, in California, air cargo is on average approximately 37 times as valuable as trucked goods. The estimated percentages can be significantly higher because the 1993 CFS focused only on domestic flow of commodities and could significantly underestimate the role of air cargo in the State's goods movement. This is because international air cargo has accounted for approximately 40% and 50% of the total air cargo at the Los Angeles and San Francisco International Airports, respectively, in the past few years, and the 1993 CFS considers the exports portion of the air cargo movement as domestic shipments ending at the airports. In other words, such exporting air shipments are not considered at all by the 1993 CFS as goods movement involving air transportation.

Commodity categories whose movement involves air transportation significantly (5% or more in value) are electrical machinery, equipment, or supplies; machine, excluding electrical; instruments, photographic goods, optical goods, watches, or clocks; and apparel or other finished textile products. Because the 1993 CFS treated "Parcel, U.S. Postal Service, or Courier" as a single transportation mode and it is difficult to estimate the proportion of commodity weight or value moved by this mode (for individual commodity categories) whose movement also involves air transportation, we developed the percentages based on only the air-truck and air (i.e., air-only) modes. Consequently, the percentages are actually lower bounds for the industries surveyed by the 1993 CFS.

Role of Air Cargo in Goods Movement: Much More Important to California than to the Nation

The 1993 Commodity Flow Survey estimated that 10.4% (\$639 billion) of the goods, in value, originating in the U.S. actually originated in California. It also estimated that 21.4% (\$30 billion) of the non-parcel air cargo, in value, originating in the U.S. originated in California. Note that the air-cargo percentage is more than double the overall percentage. This indicates the higher importance of air cargo for California relative to that for the nation, in terms of goods' value. In fact, the relative importance is even higher in terms of goods' weight. The 1993 CFS estimated

that total weight of commodity originating in California accounted for 5.8% (707 million tons) of the total weight of commodity originating in all fifty states of the U.S. However, total weight of non-parcel air cargo originating in the State accounted for 22.3% (701 thousand tons) of its U.S. counterpart. Note that the air-cargo percentage is almost four times the overall percentage. This further attests to the importance of air cargo relative to other modes of goods movement in California.

Issues in Movement of Air Cargo

With a description of air cargo activities, this paper summarizes and places major issues regarding air cargo movement in California in the context of the activities. Major issues that Caltrans or the State may not play any significant role are also included so that the relative importance of those issues (with respect to all the major issues) that Caltrans and the State may indeed play a significant role can be better assessed. Important issues include (i) the difficulty to understand California's air cargo industry, its interaction with the State's transportation system and economy, and the relative importance of issues facing the industry and (ii) traffic congestion in the State's air and ground transportation systems. Possible State roles range from a proactive leader in improving the State's air cargo system, to a promoter of State's air cargo industry, to a facilitator/co-provider of efficient ground access to airports, to a provider of integrated traffic information to air-cargo-carrying trucks. In California's aviation system capacity planning, a basic but crucial role for Caltrans is system coordinator and advisor.

A Multitude of Research Needs

Little is known about the role of air cargo in California's goods movement, and, hence, much future research is needed for understanding this role and for developing State strategies and action plans to facilitate efficient air cargo. Although many specific research needs have been identified in this white paper, they barely begin to "scratch the surface." Major categories of research needs include:

- Improve the understanding of air cargo operations and planning.
- Better understand the shipper's mode choice between air cargo and other modes of transportation in California's goods movement.
- Better understand the status of California's air cargo industry, the industry's planning/operational issues, the shipper's concerns, and the relative importance of the issues.
- Develop metrics of activity for California's air cargo industry, e.g., research into the amount of transfer traffic (i.e., connecting cargo) and transit traffic (i.e., through cargo) at cargo hubs or gateway airports in the State and factors that influence the growth of this segment of industry.

- Develop metrics of performance for California’s air cargo operations.
- Improve the understanding of the interaction between air cargo movement and the State’s surface transportation system, economy and environment. Develop metrics of such interaction. (These metrics can be used as an important input to the tasks of optimizing the operations of the overall transportation system in the State and promoting the State’s economy. They can also be used to perform trade-off analyses.)
- Improve access to existing data sources, develop data fusion methods, identify data deficiencies, and develop data collection methods to measure the three types of metrics defined in the previous three bullet items.
- Develop a methodology for forecasting future air cargo activities at individual California airports.
- Develop strategies for resolving the industry’s planning/operational issues and the shipper’s concerns and for improving air cargo planning and operations in California.
- Identify appropriate State, regional and local governments’ roles in the pursuit defined in the previous bullet item.

The severe lack of understanding of the role of air cargo in California’s goods movement can be illustrated with the following data and model deficiencies.

- Lack of (Public-Domain) Data and Models for Estimating Weights of Air Cargo Originating from, Transferring at, Passing Through or Destined for California Airports
- Lack of (Public-Domain) Data and Models for Understanding Commodity Flow via Individual California Airports.

1.0 Introduction

The Importance of Goods Movement in California

California, if it were a nation, would be the seventh largest economy in the world. Efficient goods movement is an integral part of the State's economy. Total State goods movement volume is estimated to have been approximately one billion tons in 1995 while the combined volume of interstate and international goods movement is estimated at approximately 365 million tons in the same year [16]. To support continued growth of the State's economy, Caltrans is leading the development of a Statewide Goods Movement Strategy. This strategy is being prepared as a response to a recommendation of the 1993 California Transportation Plan. It serves as one element, together with the Transportation System Performance Measures report being prepared in parallel by Caltrans, of the 1998 California Transportation Plan update. Many issue papers regarding statewide goods movement [e.g., 16 - 20] have been drafted as an input to this development effort.

The Importance of Air Cargo in the State's Goods Movement and Economy

The air cargo industry is a vital part of California's economy. Air cargo carries high-value, time-sensitive, or time-definite goods, e.g., electronic equipment, emergency shipments, overnight packages, etc. Timely delivery of these goods has been an important element of many manufacturing and service operations. Although the weight of air cargo originating in California accounts for only a negligible fraction of the total weight of goods originating in the State, its value has been estimated to be well above 4.7 percent of the total value of goods originating in California in 1992 [11]. According to the California World Trade Commission's estimates of the value of the merchandise exported by California manufacturers in 1986, close to 70% (\$16.7 billion) of the exports, in value, was shipped by air. Although accurate estimates of such percentages for recent years are not available, percentages higher than 70% have been reported. Movement of low-weight high-value goods such as computers and electronic components is very important to California's economy. Various researchers and organizations have forecast fast and steady growth of air cargo demand in the world, in the US and in California. Efficient air cargo movement, including the movement in the air, movement on the ground and the intermodal transfer, is therefore essential to California.

In addition to the air cargo originating from or destined for California, a significant amount of air cargo is transferred at or passes through California's airports in transit. Some reports [2,36] pointed out that congestion at some of the California's gateway airports (with respect to the Pacific Rim) had driven some would-be transfer or through traffic to airports in neighboring states or countries. This may or may not have significantly adverse impact on the State's economy and employment. If so, then this adds to the importance of efficient air cargo movement in California. World air cargo is expected to triple by the year 2010, and the highest growth of air cargo market is expected to occur on the Pacific Rim to North America routes [18]. California is in a prime location to capitalize on the growth of the traffic, much of which will not originate in or be destined for California.

The continued ability of the State's air cargo industry to serve the other industries in the State and the State's ability to capitalize on the forecast growth of air cargo routes between Pacific Rim countries in Asia and North-America are essential to the well-being of California. However, future demand on California's air cargo transportation system is expected to outpace the future supply of the system's capacity unless critical capacity and efficiency issues are pinpointed, the corresponding cost-efficient system improvements are identified, their implementation is carefully planned, and the improvements are eventually implemented.

Motivation of This Research

Faced with these challenges, Caltrans initiated several studies on the role of air cargo in California's goods movement, as part of the larger development effort for the Statewide Goods Movement Strategy mentioned earlier, and funded the Institute of Transportation Studies at U.C. Berkeley to (i) gain a broader understanding of the State's air cargo industry and the role of air cargo in California's goods movement, (ii) assess the importance of air cargo to the State's economy, (iii) begin identification of issues hindering efficient air cargo movement in the State, and (iv) explore possible State roles for resolving the issues. This "white paper" documents the findings of that research and serves as an input to the development of the Statewide Goods Movement Strategy.

Three Categories of Air Cargo Traffic Statistics

The following three categories of traffic statistics have been selected during the research to describe air cargo movement at California airports:

- Total Weight (at airport): Total weight of Air Cargo Enplaned or Deplaned at Major California Airports,
- Enplaned Weight (at airport): Weight of Air Cargo Enplaned at California's Airports,
- Deplaned Weight (at airport): Weight of Air Cargo Deplaned at California's Airports.

These categories of quantities are fundamental for understanding the movement of air cargo in the State. Note that part of the air cargo deplaned at an airport may be loaded (i.e., enplaned) on other aircraft at the airport and then transported to other airports. We refer to such air cargo as transfer air cargo. Also note that some air cargo carried by an aircraft arriving at an airport may not be deplaned at the airport and may remain on the aircraft for transportation to the cargo's final destination. We refer to such cargo as transit or through air cargo. Although estimating the amount of these two types of air cargo at California airports is beyond the scope of this research, it is clearly an important issue that needs to be addressed in the future. With an accurate estimate of the amount of transfer cargo, the amounts of air cargo originating from or ultimately destined for an airport can be estimated.

Four Types of Mode-Comparison Measures

The following four types of mode-comparison quantities have been developed for understanding the role of air cargo with respect to other primary modes of goods movement in the State:

- **Trucking-for-Air-Cargo Percentage:** the percentage, by value and weight, of goods (across all commodity categories) moved via air-truck combination with respect to all goods whose movement involves trucking,
- **Commodity-Weight-Moved-by-Air Percentage:** percentage of commodity weight, for individual commodity categories, that is moved by air,
- **Commodity-Value-Moved-by-Air Percentage:** percentage of commodity value, for individual commodity categories, that is moved by air, and
- **Commodity-Movement-Mode Distribution:** the distribution of modes of transportation for each of the commodity categories for which air cargo plays a significant role.

Note that it would be interesting to have a sense of how much the ground portion of air cargo movement accounts for the State's truck traffic. It turns out that such a percentage is difficult to estimate using currently available data. The trucking-for-air-cargo percentage can be used as a surrogate. The commodity-weight-moved-by-air percentages and their value counterparts reveal the major commodity types for which air transportation plays a significant role. The commodity-movement-mode distributions reveal the relative importance of air transportation with respect to other modes of transportation for moving the corresponding commodity types.

Organization of this Paper

This paper is organized as follows: Section 2.0 briefly describes the air cargo industry, the world air cargo market, and the U.S. air cargo market. It also contains a short discussion on the primary data sources used for estimating the four traffic statistics and the four mode-comparison quantities discussed in Sections 3.0 and 4.0, with a particular emphasis on their relevance to the estimation processes. Data fusion or integration, including the component data sources and the "fusion methods," and the resulting estimates for the eight quantities will be presented in Sections 3.0 and 4.0. (General information about all the data sources discussed in this paper and other useful data sources for other possible quantities pertaining to further understanding of the role of air cargo in California's goods movement can be found in the Appendix.) More precisely, based on existing data sources and their fusion, Section 3.0 describes the current air cargo market in California. Section 4.0 discusses air cargo movement with respect to other modes of goods movement, particularly the truck mode.

With a basic understanding of the air cargo market and its role relative to other modes of goods movement, we discuss in Section 5.0 major issues faced by the air cargo operators and the public agencies that support air cargo movement. These issues have been identified mostly through literature survey, and hence the list should be regarded as preliminary. To better understand the air cargo industry and the issues facing the industry and to better assess the relative importance of the issues, particularly those that the State may play a role in their resolution, we also discuss various dimensions of air cargo activities and their interaction with the broader context of the State's transportation systems, economy and environment. Each issue is given an identification number for citation in later discussion. We pinpoint where those issues occur in the broader context by citing the issue identification numbers at appropriate places. A preliminary

identification of those issues that the State government, particularly the Department of Transportation (Caltrans), may play a role will be attempted in Section 5.0. Prioritization of those issues according to their relative importance is deferred until a more systematic study of the air cargo industry has been performed. Section 6.0 discusses future research needs. Since this paper is a “white paper” and we have just begun the process of understanding the role of air cargo in the State’s goods movement, we will list broad categories of research needs. Many specific research needs will be discussed in earlier sections. Finally, the Appendix discusses twenty different data sources.

2.0 The Air Cargo Industry

This section provides an overview of the nature of the air cargo industry, the world air cargo market, the U.S. air cargo market, and primary data sources.

2.1 Air Cargo and Operators

Before discussing the air cargo markets, it is necessary to clarify several key terms regarding air cargo services. Air cargo has been broadly classified into three categories: air mail, air express and air freight. These terms have had different meanings in the past, but we will address only the definitions commonly accepted in the industry at the present time. Air mail refers to the letters and packages transported by air by the world's governmental postal services. Note that such letters and packages include those that are sent through the overnight express services offered by the US Postal Services. The rest of the goods carried by aircraft is referred to as either air express or air freight. The distinction between them is not as clear as the distinction between them and air mail. Today, air express refers to small packages that usually have a higher priority of carriage than air freight. These small packages typically weigh less than 100 lbs, and the higher priority is typically manifested by a delivery deadline, e.g., 10AM tomorrow morning or 8:00 AM on Thursday. Services whose delivery is guaranteed by a specific time has been referred to as time-definite services. Overnight air express is an important part of air express. For a detailed historical account of these terms and their current meanings, the reader is referred to [21]. For a concise glossary, see[38]. Overnight express services are typically operated by integrated operators, i.e., those operators who use primarily their own trucks and aircraft to pick up, transport through air, and deliver goods.

In this paper, air cargo is broadly defined to be freight that is transported in part or in full via air transportation. An air cargo operator is therefore broadly defined as an entity that transports air cargo, i.e., an entity that transports goods whose transportation from the origin to the destination includes air transportation. A shipper is a person or an organization who desires to send some material to a recipient through a transportation network but is not involved in the actual transportation of the material (except for the possible transportation needed to drop the material off at a transportation service provider.) With this broad definition of air cargo, the operator of a truck that delivers electronic equipment from a manufacturing plant to an airport for a passenger airliner to fulfill the air portion of the transportation is considered an air cargo operator. (An alternative definition of air cargo would be cargo that is transported in full via air transportation, and the companion definition of air cargo operator would be an entity that transports cargo through air. Note that we adopt the broad definition because otherwise many major issues, particularly those that concern Caltrans, will be beyond the scope of this paper. Moreover, with this narrower definition, the freight forwarders, who handle local pick-up, consolidation, and delivery of air cargo, may not be considered as an air cargo operator.)

Air cargo operators include integrated carriers (i.e., those operators who use primarily their own trucks and aircraft to pick up and deliver air cargo) and non-integrated carriers. Those non-integrated carriers may operate any portion of the entire process between pick-up at the goods'

origin and delivery at the goods destination, and include all-cargo air carriers, passenger airlines, relevant truck operators, air freight forwarders, etc.

Major stakeholders in air cargo activities include: the shippers, air freight forwarders, air carriers, trucking firms, airports (intermodal goods transfer provider), State DOTs, MPOs, the FAA, policy makers, etc.

The amount of air cargo activities has been measured in several different units, including

- annual operating revenue
- cargo weight (ton; lb.)
- cargo value
- cargo weight * distance moved (ton-kilometer; ton-mile)
- number of shipments.

Note that different data sources may use different units of measurement.

2.2 World Air Cargo Market

In 1995, air cargo was a \$40 billion per-year business, and accounts for 13% of the overall annual revenue of the world's air transportation industry. World's passenger airlines generate on average approximately 11% of their overall revenue and 16% of their international revenue from air cargo. For major U.S. passenger airlines, e.g., United, American and Delta, air cargo contributed to only approximately 5% of their annual revenues[33].

In 1995, the total air cargo traffic was estimated to have been 110.1 billion (revenue) ton-kilometers (RTK), which grew 9.8% from its 1994 volume. Table 2.1 below summarizes the percentage of scheduled cargo, charter cargo and mail and also the corresponding U.S. market shares [4]. Throughout Section 2.2, the unit of measurement is RTK, and the growth rate is calculated accordingly.

Table 2.1. 1995 World Air Cargo Traffic (110.1 B Ton-Km) and U.S. Market Shares

Type of Air Cargo	% of 110.1 B ton-km	U.S. Market Share of \$110.1 B ton-km
Scheduled Cargo	85.1%	25.3%
Charter Cargo	9.7%	3.2%
Mail	5.2%	3.2%

Source: Boeing Commercial Airplane Group, 1996/1997 World Air Cargo Forecast

In 1995, the growth rate of world air cargo decreased from the 1994 growth rate of 12.5%. The average growth rate since 1970 has been estimated at approximately 8% per year. It has also been observed that world Gross Domestic Product (GDP) has been a good predictor for the growth rate of air cargo, and the latter has been consistently 2.5 times the former since 1970.

It has been predicted by Boeing [4] that long-term air cargo growth will average 6.6% per year (up to 2015) while the world's economy grows at 3%. Since the growth rate of air cargo is

higher than the growth rate of passenger services, which has averaged at 4.9%, air cargo business has received renewed attention from the management of air carriers.

Among the three basic classes of air cargo services, the international air express has enjoyed a much faster growth rate than the other service categories. The international air express market now accounts for 5% of the total air cargo market, in terms of revenue-ton-kilometers, and has grown more than 22% from its 1994 volume. Some predict that the growth of international air express will mirror what has occurred in the U.S. air cargo market. Beginning with a 4% share of the U.S. market in 1977, air express has enjoyed an average growth rate of 25% per year and now has close to 60% of the air cargo market.

Another major trend is that the air cargo industry is becoming an air logistics industry in the sense that the air transportation of goods is becoming only a component of the larger activities of logistics and even manufacturing. It has been estimated that the \$40 billion revenue generated for the air transportation of air cargo (from airport to airport) in the world accounts for only 20% of the revenue generated by the movement of the goods from their origins to their destinations. The integration of air transportation of goods is not only being integrated into intermodal transportation but also into the logistics and even manufacturing activities, e.g., warehousing, customs processing and product assembly. Integration of air cargo transportation into manufacturing activities is a promising concept worthy of further research. For a detailed discussion of the world's air cargo market, the reader is referred to [4,33].

2.3 U.S. Air Cargo Market

The U.S. air cargo market grew by 5.5% in 1995 from 1994, nearly double the growth rate of 2.8 for the U.S. economy. In addition to the fact that manufacturers are using time-dependent air cargo services as an integral part of their end-to-end logistics solutions, air transportation is also becoming a more important logistic element of direct retail distribution.

The air express carriers enjoyed a growth of 9.7% in 1995 and accounted for 59.4% of the total air cargo market. Since 1990, the market share has increased by 15%. The market share has been forecast to continue to grow as manufacturers and shippers integrate more time-dependent shipments into their operations [4,33].

Among the carriers offering overnight air express services, Federal Express is the largest. It was started by Frederick W. Smith in 1973; it acquired the Flying Tigers recently. It now has 137,000 employees, a 38,500 fleet of ground vehicles, and 596 aircraft. Its 1997 annual revenue was approximately \$11.5 billion, and the annual revenue has increased by approximately \$1 billion per year since 1993. Morgan [29] stated that three factors have contributed to the fast growth: growth of high-value-added technology-based commerce, increasing globalization of international economy, and fast production and distribution cycle (e.g., just-in-time methodology). This sector of the industry is expected to continue to grow at a fast pace.

Table 2.2 below tabulates the total air cargo tonnage, including enplaned and deplaned, at the top 12 U.S. cargo airports for the year of 1996. Note that Memphis and Louisville are central hubs for Federal Express and United Parcel Service, respectively.

Table 2.2. Total Air Cargo Tonnage at 12 Top U.S. Cargo Airports in 1996

U.S. Airports	Total Tonnage	Rank in the World	Rank in the U.S.
Memphis	1,933,846	1	1
Los Angeles	1,719,449	2	2
Miami	1,709,906	3	3
New York (JFK)	1,636,497	4	4
Louisville	1,368,520	8	5
Chicago	1,259,858	10	6
Newark	958,267	15	7
Atlanta	800,181	16	8
Dallas/Fort Worth	774,947	19	9
Dayton	767,255	20	10
San Francisco	711,877	21	11
Oakland	615,298	23	12

Source: Airports Council International, Worldwide Airport Traffic Report

Los Angeles International Airport was ranked as the second largest cargo airport in the World in 1996 by Airports Council International, outranked by only Memphis - the biggest hub for Federal Express. The total amount of air cargo enplaned or deplaned at the Los Angeles International Airport in 1996 was estimated by Airports Council International to be 1,719,449 tons. (Its Memphis counterpart is 1,933,846 tons.) Three out of the top twelve air cargo airports in the U.S. are in California, with a combined tonnage of more than 3 million in 1996.

Air cargo movement occurs in the bigger context of passenger movement and aircraft movement, and they may play complementary or competing roles. It is therefore informative to understand the bigger context. Tables 2.3 and 2.4 below tabulate, respectively, the amounts of passenger and aircraft movement at top US airports. These data [1], together with the relative ranking of California airports with respect to air cargo, also show the extreme importance of aviation to the State.

Note that although Oakland, Long Beach and Orange County Airports have not been considered major passenger airports in the State, they are actually ranked number 10, 12 and 14 in the world in terms of the number of landing and take-off operations.

In each of the three categories (air cargo, air passengers and aircraft operations), California has by far the busiest traffic among all fifty states of the U.S.

Table 2.3. Passenger Traffic at Five Top US Passenger Airports in 1996

Airport	Total # of Passengers	Rank in the World	Rank in the U.S.
Chicago	69,153,528	1	1
Atlanta	63,303,171	2	2
Dallas/Fort Worth	58,034,503	3	3
Los Angeles	57,974,559	4	4
San Francisco	39,251,942	7	5

Source: Airports Council International, Worldwide Airport Traffic Report

Table 2.4. Aircraft Operations at Selected Top US Airports in 1996

Airport	Aircraft Operations	Rank in the World	Rank in U.S.
Chicago	909,593	1	1
Dallas/Fort Worth	848,028	2	2
Los Angeles	763,866	3	3
Atlanta	761,011	4	4
Oakland	487,844	10	9
Long Beach	477,364	12	11
Orange County (J.W.)	468,811	14	13
San Francisco	427,449	21	19

Source: Airports Council International, Worldwide Airport Traffic Report

In addition, six of the 20 top exporting metropolitan areas in 1996 are in California, with the San Jose metropolitan area ranked the first in the U.S. Table 2.5 below tabulates selected metropolitan areas and their export values in 1996 dollar value [40]. Note that the value of export refers to the merchandise sales made by businesses located in the corresponding metropolitan areas and that the location from which exports are sold is not always the same as the production location. Therefore, the percentage of the value of the merchandise produced in the State and exported from the State is unclear. For ease of discussion, we refer to this percentage as manufacturing-to-exporting-value ratio in this paper.

As will become clear later, there is little literature about the value or weight of international air cargo. As also mentioned earlier, close to 70% (\$16.7 billion) of the goods manufactured in and exported from California in 1986, in value, was shipped by air, according to the California World Trade Commission's estimates of the value of the merchandise exported by California manufacturers in 1986. (The Commission estimated that, out of the 32.8 billion in exports leaving California's three Customs Districts in 1986, approximately 24 billion worth of the commodities was manufactured in the State. In addition, 16.7 billion (i.e., 50.9%) out of the 32.8 billion went by air, and the Commission concluded that the 16.7 billion is a "reasonably close approximation of airborne export shipments made by California manufacturers and growers.") For ease of discussion, we refer to such a percentage as air-cargo-for-manufacturing-and-export ratio. One way to approximate the value of international air cargo enplaned at California airports is to multiply the total value of California exports, as estimated in the Exporter Location series by the U.S. Bureau of the Census and partially quoted in Table 2.5, by the two ratios.

It is well known that, due to the gateway nature of California, a large proportion of the air cargo handled at major California airports is international air cargo. (See Table 4.1 and the related discussion in Section 4.1.) However, lack of knowledge about the two ratios about exports and the absence of key information about imports has impeded accurate estimation of the value of the international air cargo. This is a worthy topic for future research.

Table 2.5. Selected Top Metro Area Exporters in 1996, Ranked by 1996 Dollars

Metro Area	\$ Billions (1996)	Rank in the U.S.	Rank in CA
San Jose	29.3	1	1
New York	28.0	2	
Detroit	27.5	3	
LA-Long Beach	24.4	4	2
Chicago	22.0	5	
Seattle-Bellevue-Everett	21.4	6	
Houston	16.5	7	
Minneapolis-St. Paul	12.4	8	
Miami	10.7	9	
Portland-Vancouver (OR-WA)	9.2	10	
Boston	8.7	11	
San Francisco	8.6	12	3
Orange County	8.3	13	4
Oakland	7.3	17	5
San Diego	6.7	19	6

Source: U.S. Bureau of the Census, Exporter Location Series

2.4 Primary Data Sources

The following eight primary data sources were used for understanding the air cargo market and the role of air cargo in the State's goods movement. This section briefly describes the eight data sources. How these data sources were used in our estimation process will be discussed in Sections 3 and 4.

- Worldwide Airport Traffic Report (WATR) published by Airports Council International (ACI)
- Airport Traffic Reports (ATRs) published by airport authorities
- Form 41 T-100 Data Banks (T-100) collected and compiled by the US DOT (on 6250 reel-to-reel magnetic tapes)
- Form 41 T-3 Database (T-3) collected and compiled by the US DOT (on 6250 reel-to-reel magnetic tapes)
- Airport Activity Statistics of Certified Route Air Carrier (AAS) published by the US DOT
- U.S. International Air Passenger and Freight Statistics (USIA) published by the US DOT
- ONBOARD: an information product (CD-ROM) based on US DOT's Form 41 T-100 and T-3 Data Banks and marketed by Data Base Products, Inc.
- The 1993 Commodity Flow Survey (1993 CFS) by Bureau of the Census

2.4.1 Worldwide Airport Traffic Report (WATR) by Airports Council International (ACI)

Airports Council International publishes annual Worldwide Airport Traffic Report (abbreviated as WATR reports) [1], which provides data about cargo tonnage loaded and unloaded at large California airports. Distinction is made in the Report between domestic operations and international operations, and the tonnage information is reported for each of the two sets of operations. Data collected for the current year is contrasted with those collected in the previous year so as to reveal the percentage change. The information is based on a survey of large airports in the world by the Airports Council International. For the year of 1991, 370 airports responded to the survey.

In addition to air cargo, two other types of information are reported: aircraft movements and commercial passengers. The aircraft movements section includes data by type of aircraft for commercial transport operations: passenger and combi-aircraft, all-cargo aircraft, and general aviation and other aircraft. Commercial passenger information includes domestic, international passengers, and in-transit passengers. The domestic and the international passenger data reveal the sum of enplaned and deplaned passengers.

The annual report costs CHF 250; back issues of the annual report series cost CHF 150. (CHF is Swiss Frank; Current exchange rate is approximately CHF 1.5 for 1 U.S. Dollar. This translates the costs of a current issue and a back issue into approximately \$166 and \$100, respectively.) Airport Council International maintains an internet website and publishes on the website statistics about passenger, cargo and aircraft movement for the busiest airports in the world. Only aggregate statistics are provided. For the previous full year, total weights of cargo (enplaned and deplaned) are ranked and tabulated. For example, currently the website provides total tonnage data for 551 airports. For the previous month as well as for the calendar year up to the previous month, the website provides total cargo weights for 30 top ACI airports, together with the percentage from their counterparts of the previous year.

2.4.2 Airport Traffic Reports (ATR) by Airport Authorities

Many California airport authorities publish reports summarizing the air cargo activities at the corresponding airports. For example, the Los Angeles International Airport - Traffic Comparison [27] is compiled from over one hundred airline traffic reports, U.S. Customs and the FAA and is published monthly. San Francisco International Airport: Air Traffic Report [34] provides a summary as well as detailed accounts for the air cargo activities at the airport. San Francisco International Airport: Comparative Traffic Report [35] provides summaries of air cargo activities for consecutive periods for comparison purposes. Oakland International Airport Monthly Activity Report summarizes the air cargo activities at the airport. These reports in general provide the most detailed data regarding airport activities, when compared to all other data sources, e.g., the Worldwide Airport Traffic Reports (WATR reports). However, not all major California airport authorities publish such reports for external distribution, and the estimation procedures are generally unclear and could vary with the airport. The reported data need to be cross-verified with other data sources.

Compared to WATR reports, these Airport Traffic Reports tend to provide more information. For example, unlike the WATR reports, which provide only the combined tonnage of enplaned and deplaned air cargo, these reports generally provide separate estimates for enplaned air cargo and deplaned air cargo.

2.4.3 T-100 Data Banks (T-100) by the US DOT

The T-100 Data Banks consist of the following four separate databases:

- T-100 Data Bank 28DM Domestic Market Data
- T-100 Data Bank 28DS Domestic Segment Data
- T-100 Data Bank 28IM International Market Data
- T-100 Data Bank 28IS International Segment Data

The data contained in these data banks are derived from data filed by U.S. carriers and non-U.S. carriers and are published by the Office of Airline Information of US DOT Bureau of Transportation Statistics. The U.S. carriers are required by Code of Federal Regulations 14 CFR 241.25 to file Form 41 Schedule T-100 while non-U.S. carriers are required by the same regulation to file Form 41 Schedule T-100(f). The FAA processes the data filed by the air carriers and prepares four different data files on magnetic tapes. The processed data are not separated with respect to flag of carriers. Rather, they are separated along two dimensions: (i) domestic versus international operations and (ii) “market” (i.e., airport) versus Segment. It helps to clarify the data reported on Schedule T-100 and Schedule T-100(f).

Schedule T-100 is filed monthly by each large certified U.S. air carrier except for a charter air carrier or an all-cargo carrier with only domestic operations. Domestic scheduled passenger/cargo operations and all international operations of scheduled and non-scheduled passenger/cargo and all-cargo services are reported on Schedule T-100, except international military charters.

Schedule T-100 contains detailed “on-flight market data” as well as detailed segment data. More precisely, it contains (i) the weights of air mail and air freight enplaned at the origin airport (i.e., “market” data) as well as (ii) the weights of air mail and air freight transported from the origin to the destination of the segment (i.e., segment data).

Schedule T-100(f) contains similar information but is filed by non-U.S. carriers.

Market (airport) data are reported by all reporting U.S. carriers as defined earlier in this section and by all international carriers, and the data are derived from air carriers’ international operations (segments). An international operation (segment) is defined as follows. For U.S. carriers, at least one end-point has to be outside the U.S. or in one of its territories. For all foreign carriers, at least one end-point must be in the U.S. or in one of its territories.

T-100 Data Bank 28DM contains domestic “market” data derived from the data reported by both the U.S. and non-U.S. carriers. T-100 Data Bank contains detailed non-stop segment data for all

reported domestic operations. T-100 Data Bank 28IM contains airport data for all reported international operations. T-100 Data Bank 28IS contains segment data for all reported international operations.

2.4.4 T-3 Database by the US DOT

Schedule T-3 supplements the detailed Schedule T-100 data and collects supplementary airport activity statistics as follows: The domestic-entity report covers summary statistics on domestic all-cargo operations and both civilian and military charters. The international-entity report covers summary information on military charter operations only.

Note that Schedule T-3 reports only “market” (i.e., airport) data and not segment data. Therefore, it supplements only the “market” portion of the Schedule T-100 data, not the segment portion. This lack of supplement to Schedule T-100 segment data leads to difficulty in estimating the weight of air cargo passing through an airport and consequently in estimating the weight of air cargo deplaned at the airport. Moreover, the accuracy of those estimation methods that require segment data depends on the amount of traffic contributed by the non-reporting air carriers of Schedule T-100 and by the non-reporting operations. It is useful to estimate the amount of such traffic, particularly its relative magnitude with respect to the total traffic reported on Schedule T-100. A particular application will be to estimate the contribution of such carriers and such non-reporting operations to the weight of through air cargo.

Both Schedules T-100 and T-3 are reported as parts of the Research & Special Programs Administration (RSPA) Form 41, Uniform Systems of Accounts and Reports for Large Certified Air Carriers.

2.4.5 Airport Activity Statistics of Certified Route Air Carrier (AAS) by the US DOT

The data summarized in this report are compiled from information reported to the US DOT by large certified air carriers on Schedules T-100 and T-3. This report will be abbreviated as AAS. It contains 7 tables, five of which are summary tables and the other two are detailed tables. Three summary tables are particularly useful for our purposes because they contain information about enplaned air cargo tonnage at air transportation hubs of different sizes. They are (i) Table 3: (Scheduled and Performed) Aircraft Departures, Enplaned Revenue Passengers, and Enplaned Revenue Tons of Cargo and Mail in total operations (Percent of Total Enplaned Passengers), All Services at Large Air Traffic Hubs, (ii) Table 4: (Scheduled and Performed) Aircraft Departures, Enplaned Revenue Passengers, and Enplaned Revenue Tons of Cargo and Mail in total operations (Percent of Total Enplaned Passengers), All Services at Medium Air Traffic Hubs, and (iii) Table 5: (Scheduled and Performed) Aircraft Departures, Enplaned Revenue Passengers, and Enplaned Revenue Tons of Cargo and Mail in total operations (Percentage of Total Enplaned Passengers), All Services at Small Air Traffic Hubs.

Caution is important when interpreting the data reported in this series of reports. Data for commuter, intrastate, and foreign-flag air carriers are not included.

2.4.6 U.S. International Air Passenger and Freight Statistics by the US DOT

The statistics reported are based on the T-100 databanks. The report contains 12 tables. Particularly useful for our purposes are (i) Table 11: Top 15 US International Freight Gateways (Arrivals and Departures Combined; Scheduled and Non-Scheduled Combined) for a Particular Month of a Particular Year and the Previous Year by Flag (US vs. non-US), and (ii) Table 12: Top 15 US International Freight Gateways (Arrivals and Departures Combined; Scheduled and Non-Scheduled Combined) for Year-to-Date of a Particular Year and the Previous Year by Flag (US versus non-US).

Note that freight tonnage does not include that of air mail. However, air mail accounts for a small fraction of air cargo.

2.4.7 ONBOARD by Data Base Products, Inc.

This is a collection of four databases produced by an information vendor Data Base Products based on the data collected through Schedule T-100 and Schedule T-3. The four databases are: T-100 Segment, T-100 Market Monthly, T-3 Data, and Commuter. Similar information products are available from other vendors, e.g., BACK Associates. Information products like ONBOARD not only provides the data but also allows customized data analysis and report generation.

The T-100 Segment database contains data reported for each non-stop domestic U.S. flight segment by each reporting carrier on a monthly basis and includes a breakdown by equipment type. The data include onboard passengers, freight and mail, number of departures, segment distance, available seats and freight capacity, block time (time elapsed from when an aircraft leaves the gate at its origin airport until parking at the gate at the destination airport), and airborne time. T-100 Market Monthly contains information on enplaned passengers, enplaned freight, and enplaned mail for each origin airport. The T-3 Data is based on Schedule T-3 reported by air carriers and contains number of departures performed, enplaned passengers, enplaned tons of freight (express and regular), enplaned tons of mail. The information is reported on a quarterly basis, rather than the monthly basis upon which T-100 Segment and T-100 Market Monthly are reported and published, and is broken down by equipment type. The Commuter database is based on Schedule 198CT-1 and results from 100% reporting of enplaned passengers, freight and mail by all commuter air carriers.

Although ONBOARD or similar information products provide user-friendly interface, particularly in the form of menu-driven report specification and generation, for some selected database queries, this interface can actually limit the kinds of queries that can be performed on the databases. The T-100 and T-3 Data Banks, whose direct use requires some programming effort, contain all the data collected through the corresponding reporting processes.

2.4.8 The 1993 Commodity Flow Survey by the US Department of Commerce

The 1993 Commodity Flow Survey provides data on the movement of freight by type of commodity shipped and by mode of transportation. It is a continuation of statistics collected in

the Commodity Transportation Survey (CFS) from 1963 through 1977. Its scope is larger than the Nationwide Truck Activity and Commodity Survey (NTACS), and therefore NTACS is no longer conducted. The CFS is to be conducted every five years. A sample of 200,000 domestic establishments randomly selected from a universe of approximately 800,000 establishments engaged in manufacturing, mining, wholesale, and some selected activities in retail and service was used. Each establishment reported a sample of approximately 30 outbound shipments for a two-week period in each of the four calendar quarters of 1992. This produced a total sample of approximately 13 million shipments.

For each shipment, major data elements include: zip codes of domestic origin and destination, 5-digit Standard Transportation Commodity Classification Code, weight, value, modes of transportation for the domestic portion of the shipment. Information on whether the commodity is shipped in a container, a hazardous material, or an export. Results are reported at the aggregate level of National Transportation Analysis Regions (NTAR), which are combinations of Business Economic Areas (BEAs). (The nation is partitioned into 89 NTARs.) Only aggregated data were released, in the forms of 2 CD-ROMs, printed reports and tables posted on Internet website. Printed reports include State Freight Transportation Profiles. (No public-use data files are available.) CFS is sponsored by Bureau of Transportation Statistics and FHWA of US DOT and Bureau of the Census of US Department of Commerce, and is performed by Bureau of the Census of US Department of Commerce and Oak Ridge National Laboratory.

2.5 Generic Cautionary Notes about the Data Sources

In discussing air cargo and its impact, weight and value have most often been used as the two fundamental units for measurement. Due to the fact that weight plays a pivotal role in the cost and safety of air transportation, information about the weight of air cargo is much more available than that about air cargo value. Moreover, most air carriers are required to report the weight of air cargo transported by or enplaned onto their aircraft to the US DOT, but not value. Value information is made available through the reporting process associated with exporting goods to other countries. Value of goods depends on the commodity type. The process of surveying and estimating commodity flow produces estimates about the value of air cargo.

Air transportation is a complex industry. Statistics are gathered through two different means: mandatory reporting and voluntary reporting. Examples of voluntary reporting include reporting of air cargo volume (in terms of weight) by airport authorities for disclosing their air cargo activities to the communities they serve or as members of Airports Council International. This voluntary reporting results in the publication of Airport Traffic Reports by some airport authorities and the Worldwide Airport Traffic Report by Airports Council International. Since the data processing resulting in the data reported in Airport Traffic Reports varies with the airport authority and there exist many major airports in California, we did not attempt to document the different data processing procedures used by the individual airports. However, in what follows, we will cross-verify data from different sources.

Many statistics are gathered through mandatory reporting as required by federal law [25]. There exist different classes of services and the companion different classes of carriers, which for

different purposes are subject to different reporting requirements. When interpreting reported data and their derivatives, e.g., published reports and “public-use files,” one needs to understand at least two important attributes of the reporting process, as well as the data processing performed on the raw data reported that leads to the derivatives.

The two important attributes of the mandatory reporting processes are (i) which carriers should file what reports and (ii) which operations and attributes should be reported. To illustrate (i), consider the following example. An important source of air cargo information is the Schedule T-100. “This schedule shall be filed monthly by each large certified U.S. air carrier except for a charter air carrier or an all-cargo carrier with only domestic operations.” (See Section 2.4 above or Code of Federal Regulations, 14 CFR 241.25 [25].) A common misperception is that all all-cargo air carriers are exempted from reporting this schedule. Note that only those all-cargo air carriers that offer only domestic operations are exempted. To illustrate (ii), we expand on the previous example. “Domestic scheduled passenger/cargo operations and all international operations of scheduled and non-scheduled passenger/cargo and all cargo services shall be reported on Schedule T-100, except that international military charters shall not be reported on Schedule T-100 [25].” Note that non-scheduled domestic cargo services need not be reported, not even by those all-cargo carriers that offer international cargo services. (Those all-cargo carriers offering only domestic operations do not need to report for Schedule T-100.) However, the non-reporting carriers can voluntarily report their air cargo activities to the US DOT. Moreover, all air carriers can voluntarily report their non-reportable operations to the US DOT. To interpret the reported data, it would be good to know the size of all reportable operations, the size of all non-reportable operations, as well as how much of the non-reportable operations have been voluntarily reported to the US DOT.

Absence of any information about such sizes introduces uncertainty and error into the estimation processes. In the Airport Activity Statistics of Certified Route Air Carriers (AAS) covering 12 months ending December 1994, it was stated that “Beginning with the publication ending calendar year 1993, all scheduled and non-scheduled service traffic statistics performed by large certified U.S. air carriers are presented”. This change in data presentation certainly makes the estimates more accurate, and is enabled by combining the data reported on Schedule T-3. Note however that, as pointed out earlier, Schedule T-3 is a supplement to Schedule T-100, collects enplanement data for individual airports (i.e., the weight of air cargo loaded onto aircraft at the airports), and does not have the concept of origin-destination segment (i.e., does not contain any information about the weight of air cargo being transported from the origin to the destination). Therefore, unless all non-reportable operations have been voluntarily reported by the air carriers (including reporting carriers and non-reporting carriers capturing a significant market size), the accuracy of the AAS data could be questionable.

In interpreting the reports published based on the data reported to the U.S. DOT, e.g., T-100, one needs to understand what has been included or ignored in the corresponding data processing. Again, we use the ASS reports as an example. The AAS does not consider services offered by foreign-flag carriers, although such data are indeed collected as part of the T-100(f) (of Form 41).

Also, distinction needs to be made among the raw data reported by the air carriers, the processed data files provided by the FAA, value-added information products offered by private vendors, and reports published by the FAA or other public or private entities. Caution is needed when interpreting the data to be provided in the following section. We will point out possible pitfalls.

3.0 California’s Air Cargo Market

There exists little published literature on the current air cargo market at the state level. There seems to have been no systematic effort in forecasting future air cargo market in California, although some air cargo forecasts are available at the world, world-region-to-world-region or country-to-country levels. Given the increasing importance of air cargo to California’s economy, it is imperative to begin to understand the role of air cargo in California. There are many important and interesting aspects of the California’s air cargo market that deserve research attention. This paper begins the exploration by focusing on the following three fundamental quantities regarding the movement of air cargo at top ten airports of the State.

- Total Weight (at airport): Total weight of Air Cargo Enplaned or Deplaned at Major California Airports,
- Enplaned Weight (at airport): Weight of Air Cargo Enplaned at California’s Airports,
- Deplaned Weight (at airport): Weight of Air Cargo Deplaned at California’s Airports.

By integrating the existing data sources and analyses, this section estimates or proposes methods for estimating these quantities. Many of the estimates will be presented in the form of tables.

Note that estimating the amounts of transfer (i.e., connecting) and transit (i.e., through) air cargo at California’s airports is important. Transfer cargo enplaned at an airport has been deplaned at the same airport from another flight for transportation to another airport. Therefore, the amount of transfer cargo at an airport is needed for estimating the amounts of air cargo originating from and ultimately destined for the airport. Also, the amount of transfer cargo determines the amount of air cargo redistribution performed at California’s airports and the associated employment opportunities. The Los Angeles International Airport and the San Francisco International Airport are important air cargo hubs due to its locations as natural gateways to the Pacific-Rim countries in Asia. Understanding the annual amount of transfer air cargo and its trend at California airports as well as at airports in neighboring states is important in assessing the relative competitiveness in attracting transfer air cargo at competing airports. Due to lack of data, no estimates regarding transfer or transit air cargo will be provided in this paper. However, as mentioned earlier, lack of such data is a critical issue that needs to be resolved in the future.

Table 3.1 below summarizes the data sources for the three types of air cargo traffic measures and indicates the availability of data fusion or other estimation methods to be proposed in this paper. We list at most two direct data sources and at most two data fusion or estimation methods for each of the four air cargo traffic statistics.

Table 3.1. Data Sources and Data Fusion Methods for Air Cargo Traffic Statistics

Traf. Statistics	Dir. Source 1	Dir. Source 2	Data Fusion 1	Data Fusion 2
Total (on + off)	WATR	ATRs		
Enplaned (on)	ATRs	ONB. (T-100&3)		
Deplaned (off)	ATRs		T-100, above	T-100, above

The data to be presented in this section are intended to demonstrate the kinds of information that can be either obtained or derived from available data sources, and are not intended to be complete for the purpose of understanding California's air cargo market (based on the available data sources). When comparison is made across different California airports, we consider only the top ten airports, particularly those airports considered in Table 3.2 below. When trends of air cargo activities are studied and demonstrated, we illustrate the trends with data about a small number of major California airports.

The rest of this section is organized in three subsections, each of which addresses one of the three traffic statistics defined earlier in this section. Only cargo weight will be discussed in this section. In the next section, we discuss air cargo movement in the context of goods movement in California, with attention to other transportation modes and the commodity type. Value of air cargo will be discussed there.

3.1 Total Weight of Cargo Enplaned and Deplaned at California Airports

The Worldwide Airport Traffic Report, to be abbreviated as WATR report, includes air cargo data for the following California airports: Burbank-Glendale-Pasadena, Orange County (John Wayne), Long Beach, Los Angeles International, Oakland International, Ontario, Sacramento Metro, San Diego International-Lindbergh Field, San Francisco International, and San Jose International. The reader is referred to Section 2.4.1 for details about WATR reports. The most recent full WATR report owned by the UC system, Stanford, and State libraries is the 1991 report. (Each current issue of the report costs 250 and each back issue of the report costs CHF 150 plus shipping and handling charges, where CHF stands for Swiss Frank. Current exchange rate is approximately 1.5 CHF for 1 US Dollar. This translates the costs of a current issue and a back issue into approximately \$166 and \$100, respectively. The Airports Council International's website on the World Wide Web provides some high-level summary information about its member airports' operation during the current and the previous years free-of-charge. Some such website information regarding 1996 will be used later.) Table 3.2 below contains the total weight of air cargo enplaned and deplaned at these airports in 1991. Reports published in subsequent years can be purchased.

The current website of Airports Council International on the World Wide Web provides the total weights of air cargo enplaned and deplaned at the above airports during 1996 and the change in percentage from their 1995 counterparts. (The most recent full WATR report owned by the UC system, Stanford, and State libraries is the 1991 report. But, the 1996 and 1995 information was obtained from the website.) Table 3.3 below lists the weights according to the order defined in Table 3.2.

It is clear from the Table 3.3 that the growth of air cargo at the top ten airports in California has been very fast. Seven out of the ten airports enjoyed a growth rate higher than 50% in the five years between 1991 and 1996; four out of the seven experienced more than doubling of the total air cargo tonnage. The ten airports had a combined growth rate of higher than 50% in those 5

years. Depending on Caltrans needs, we can try to obtain the most recent reports of consecutive years so as to provide trend charts for the airports.

Table 3.2: Total Weight of Cargo Enplaned and Deplaned at CA Airports

CA Airports	91 Domestic	91 International	91 Total Tons	Change from 90
Los Angeles	718,627	422,569	1,141,196	-2.0%
San Francisco	372,411	233,597	606,008	6.8%
Ontario			256,280	3.6%
Oakland	251,410	1,445	252,855	18.9%
San Jose			77,229	-7.1%
San Diego	47,604	573	48,177	-8.8%
Sacramento			31,017	5.0%
Long Beach			24,886	37.1%
Burbank			17,640	-11.8%
Orange County			2,515	33.5%
Total			2,457,803	2.5%

Source: Airports Council International, Worldwide Airport Traffic Report

Table 3.3: Total Weight of Cargo Enplaned and Deplaned at CA Airports

CA Airports	96 Total Tons	Change from 95	Change from 91
Los Angeles	1,719,449	7.7%	50.6%
San Francisco	711,877	2.2 %	17.5%
Ontario	396,485	13.0%	54.7%
Oakland	615,298	11.7%	143.3%
San Jose	91,798	-0.5%	18.9%
San Diego	92,980	5.0%	93.0%
Sacramento	65,426	-4.6%	110.9%
Long Beach	27,392	12.6%	10.1%
Burbank	37,751	10.8%	114.0%
Orange County	19,822	22.1%	688.2%
Total	3,778,278	8.6%	53.7%

Source: Airports Council International, Worldwide Airport Traffic Report

Another way to obtain the combined enplanement and deplanement data is to use the Air Traffic Reports, to be abbreviated as ATR reports, published by the airport authorities directly. Table 3.4 below summarizes the information regarding enplaned, deplaned and total air cargo at the San Francisco International Airport and illustrates the available information about enplaned and enplaned air cargo for most major California airports.

Table 3.4. Trend of Air Cargo Activities at SFO (Tons)

Year	Enplaned Cargo	Deplaned Cargo	Total Cargo	% Change
1996	362,306	349,374	711,680	2.2%
1995	351,797	344,332	696,129	2.6%
1994	347,901	330,264	678,165	10.3%
1993	307,212	307,812	615,024	3.9%
1992	297,223	294,695	591,918	-0.2.%
1991	290,337	302,594	592,931	3.8%
1990	287,239	284,189	571,428	2.4%

Source: San Francisco International Airport, Airport Traffic Report

The data reported in WATR reports may not be the same as what are reported in the Airport Traffic Reports or the Annual Reports published by the individual airport authorities. For example, Ontario International Airport Volume of Air Traffic reported a total of 437,139 tons of air cargo enplaned or deplaned at the airport, which is 10.3% higher than its WATR counterpart. The deviation varies. For example, the San Francisco International Airport 1996 Annual Report reported total annual air cargo of 697,000 Tons while WATR reported 711,877 (which is virtually identical to what is reported in the Airport Traffic report). The difference is only 2%.

Although the Airport Traffic Reports tend to contain more information than the WATR reports, not all airports publish such reports, and the detail level varies widely. For example, a typical issue of the Air Traffic Report published by the San Francisco International Airport has 46 pages while the corresponding issue of the Monthly Activity Report published by the Oakland International Airport has only one page. For those airports that do not publish Air Traffic Reports for external distribution, we expect to be able to solicit such data directly from the airport authorities. Currently, all but the Long Beach and Burbank Airports among the top ten California airports either publish regularly the Airport Traffic Reports or have responded to the author's request for cargo information. The WATR reports are based on their survey of the member airport authorities anyway.

Another possible issue associated with using the Airport Traffic Reports is that the procedure for reaching the estimates is unknown and is subject to airport-specific variation. The procedures for calculating the estimates for the purpose of filing reports to the federal government or to Airports Council International tend to be well specified.

To cross-verify the validity and accuracy of the data reported in WATR or Airport Traffic Reports, it is desirable to compare their data with data from other sources, e.g., U.S. International Air Passenger and Freight Statistics (to be abbreviated as USIA). (For more information about USIA, the reader is referred to Section 2.4.6.) USIA contains tonnage information about air cargo between major U.S. international gateway airports and the rest of the world. Since WATR distinguishes international cargo from the domestic cargo, these two sources of data regarding international cargo at several California airports can be used to systematically cross-verify the accuracy of the respective information, which can be an interesting exercise in the future.

3.2 Weight of Cargo Enplaned at California Airports

Besides using Airport Traffic Reports directly, one way to estimate the weight of air cargo enplaned at California airports is to use the data provided in an information product named ONBOARD, which has been developed by the vendor Data Base Products. (See Section 2.4.7 and the Appendix for more information about ONBOARD. Tables 3.5 and 3.6 below summarize the result of querying the ONBOARD database for the calendar years of 1993 and 1994.

Table 3.5: Cargo in Tons Enplaned at CA Airports (ONBOARD (1/93 - 12/93))

CA Airports	Enplaned Freight	Enplaned Mail	Enplaned Total
Los Angeles	368,225	74,587	442,812
San Francisco	194,305	65,135	259,440
Ontario	24,650	12,424	37,074
Oakland	144,911	9,783	154,694
San Jose	27,191	5,004	32,195
San Diego	24,046	8,398	32,444
Sacramento	12,754	8,154	20,908
Long Beach	12,759	710	13,469
Burbank	7,142	2,086	9,228
Orange County	3,698	161	3,859

Source: Data Base Products, Inc., ONBOARD (1/93 - 12/93)

Table 3.6: Cargo Enplaned at CA Airports (ONBOARD (1/94 - 12/94))

CA Airports	Enplaned Freight	Enplaned Mail	Enplaned Total
Los Angeles	409,552	84,062	493,614
San Francisco	207,155	93,197	300,352
Ontario	25,538	10,953	36,491
Oakland	150,855	18,990	169,845
San Jose	33,250	5,098	38,348
San Diego	23,312	9,354	32,666
Sacramento	14,671	8,438	23,109
Long Beach	9,512	241	9,753
Burbank	8,008	1,427	9,435
Orange County	4,237	441	4,678

Source: Data Base Products, Inc., ONBOARD (1/94 - 12/94)

Note that the weights of cargo enplaned at San Francisco during the two years according to ONBOARD are 259,440 and 300,352 tons, respectively, while those according to the Airport Traffic Reports published by the San Francisco International Airport are 306,942 and 347,596 [34 (Dec. 1993 and Dec. 1994)], which are 18.3% and 15.7% higher than their ONBOARD counterparts. This raises the consistency issue across different databases and reports. This could be a worthy subject for future research.

These data sources reveal a particularly disturbing inconsistency in tonnage of enplaned cargo at the Ontario International Airport. Table 3.7 below contrasts the enplaned tonnage reported in three different data sources for three different years. Note that the AAS data contain not only the amount of air cargo loaded at an airport but also that of the through air cargo.

Table 3.7: Contrast for Enplaned Tonnage at Ontario among Three Data Sources

Sources	1990	1991	1992	1993	1994	1995	1996
ATR	157,896	153,230	177,496	193,027	203,185	208,612	229,232
ONB.	176,133	103,752	24,197	37,074	36,491	44,739	57,126
AAS	19,156	23,018	23,003	37,646	36,489	N/A	N/A

Sources: Ontario Airport, Air Traffic Report; Data Base Products, Inc., ONBOARD; FAA, Airport Activity Statistics of Certified Route Air Carrier

The inconsistency is clearly drastic. Ontario Airport's personnel stated during a telephone inquiry that the AAS data are incorrect and pointed out that Ontario is the hub for UPS operations in the Southwest. Note that although both Airport Activity Statistics (AAS) and ONBOARD are based on data reported on Schedule T-100 and Schedule T-3, AAS and ONBOARD data differ drastically for the years of 1990 and 1991. However, for the years of 1992, 1993 and 1994, the two data sources seem consistent. (According to the Government and Social Science Information Library of UC Berkeley, the most current AAS report is the 1994 report, which was published in Oct. 1996.) We also observed that both the Airport Traffic Report and the Worldwide Airport Traffic Report (WATR) are based on data reported by the airport authorities and that their data seem consistent. (Although WATR does not report enplanement data, our observation reveals that the amounts of enplaned and deplaned cargo at Ontario are quite close to each other. We can therefore approximate the enplaned tonnage by dividing the total tonnage by two.) This issue of data inconsistency may be a worthy subject for future research.

Table 3.8: Contrast of Enplaned Tonnage at CA Airports from Three Sources: 1993

CA Airports	ONBOARD	ATR.	ATR/ONB.	AAS
Los Angeles	442,812			449,197
San Francisco	259,440	307,212	118%	263,153
Ontario	37,074	193,027	521%	37,646
Oakland	154,694	207,046	134%	154,800
San Jose	32,195			32,195
San Diego	32,444			32,443
Sacramento	20,908			21,655
Long Beach	13,469			13,469
Burbank	9,228			9,228
Orange County	3,859			3,859

Sources: LAX, SFO and OAK Air Traffic Reports; Data Base Products, Inc., ONBOARD; FAA, Airport Activity Statistics of Certified Route Air Carrier

Finally, we compare the 1993 data from the three sources for all ten major California airports in Table 3.8. The percentages stated in the ATR/AAS column indicate the ratio of the ATR data over the AAS data. Note that the ATR data reported in Table 3.7 are consistently higher than their AAS and ONBOARD counterparts. Note particularly the disparity between the ATR and AAS data for the Ontario Airport.

3.3 Weight of Cargo Deplaned at California Airports

A direct way of estimating the weight of cargo deplaned at California's airports is to use the Airport Traffic Reports published by the corresponding airport authorities. Table 3.9 below illustrates the kind of data that is available for the largest airports in California, for example LAX and SFO.

Again not all major airports in California, particularly those ten that were addressed in Table 3.2, publish or would provide such data. Even if all of them do publish or provide such data, it is still desirable to be able to cross-verify the data with other data sources. Therefore, we now describe an additional method for the estimation task.

Table 3.9: Tons of Cargo Deplaned at SFO from 10/96 through 9/97 and from 10/95 through 9/96 (Example for CA Airports)

Period	Deplaned Freight	Deplaned Mail	Total Deplaned Cargo
10/95 - 9/96	272,197	72,119	344,316
10/96 - 9/97	303,367	79,476	382,843

Source: San Francisco International Airport, Airport Traffic Report

Since the on-board cargo tonnage reveals not only the amount of cargo leaving the origin airport but also the tonnage of cargo arriving at the destination airport. Therefore, the T100 schedule and T-100(f) Schedules reveal the tonnage of cargo arriving at an airport as well as that of cargo departing an airport. If we also know the tonnage of the transit (i.e. through) cargo, then we can infer the tonnage of deplaned cargo by simply subtracting the through tonnage from the arriving tonnage. The rest of this subsection describes briefly the significance of transit cargo and a method for estimating the amount of transit cargo at an airport.

Transit (i.e., through) air cargo is defined to be the cargo that arrives at an airport, remains on the aircraft and, departs for another airport on the same aircraft. There exists very little information about the tonnage of through air cargo. The amount of through air cargo is interesting also because it can reveal its relative magnitude with respect to the deplaned cargo at California's international gateway airports. Through air cargo does not seem to offer much economic value to California but may actually consume precious landing and take-off resources at busy California airports and contribute to environmental concerns. (The opportunity cost is not clear because landings and take-offs are necessary also for California-bound air cargo.)

One way to approximate the weight of through air cargo is as follows. We discuss the general method with some complications ignored first and then address the complications. Due to the complications, no reliable estimates can be provided in this paper.

We now discuss an additional estimation method, which is similar to the method just described but relies directly on the databases upon which the AAS and USIA are based. Limitations of this method will be discussed after the general steps of the method is described. Schedule T-100 contains both enplanement and on-board data for all domestic segments; the T-100(f) schedule contains both enplanement and on-board data for all international segments. In both cases, what is known includes both the tonnage of air cargo loaded onto aircraft of a carrier at an airport and the tonnage of air cargo that is actually on-board the aircraft at take-off time, including the through cargo. Therefore, by subtracting the enplaned tonnage from the on-board tonnage, one obtains the transfer tonnage.

One complication comes from the fact that Schedule T-100 and Schedule T-100(f) data do not reflect air cargo carried by all flights. Another complication is that no published reports provide the kind of information required for implementing the above method, and an implementation requires both acquisition of T-100 and T-100(f) data tapes prepared by the US DOT and custom-developed data processing. (The information product Onboard marketed by Data Base Products carries only the enplanement information but not the on-board information for cargo, although it does carry both kinds of information for passenger traffic.) This is also a worthy subject for future research.

4.0 Air Cargo and California Goods Movement

Research into goods movement at the state level, particularly such research based on the 1993 Commodity Flow Survey, has received some attention recently, e.g., [23,3]. Study of air transportation at the state level, including passengers and cargo, has also received some attention lately, e.g., [6]. This section focuses on the comparison between air cargo and other modes of goods movement, particularly goods movement by trucks. We use the 1993 Commodity Flow survey (1993 CFS) as the primary data source. (For details about 1993 CFS, the reader is referred to Section 2.4.8 and the Appendix.) As will become clear later, 1993 CFS alone cannot provide a clear picture for the comparison, and other data sources and additional data processing are required. Since agriculture is a vital component of the State's economy, this section also discusses briefly some important air cargo activities at the Stockton Airport regarding export of San Joaquin County's fruits and vegetables.

Of particular interest is the question of how much truck traffic is for the purpose of fulfilling the ground portion of the movement of air cargo. The 1993 CFS and the data sources that we are aware of are not sufficient for answering this question. Therefore, we seek to answer a surrogate question: what are the percentages of the value and tonnage of goods that are carried first by trucks (originating in California and destined for a California airport) and then transported through air with respect to those of goods whose movement involves trucking. We will refer to these two percentages as (value and tonnage) trucking-for-air-cargo percentages. As will become clear later, the 1993 CFS focuses on domestic commodity flow. Therefore, little can be inferred about the international air cargo based on the 1993 CFS, and we limited our attention to domestic air cargo and hence trucking-for-domestic-air-cargo percentages. Although the 1993 CFS data cannot even provide an accurate trucking-for-domestic-air-cargo percentages, we managed to provide plausible lower and upper bounds of the percentages. We will propose two methods to obtain better estimates for the percentages.

Air cargo and California goods movement has also been studied by other efforts, most notably the development of California Intermodal Transportation Management System (ITMS). California ITMS used TRANSEARCH data to estimate the weight of goods moved in California by mode and by import/export/interstate-commerce, for the year of 1992 (the same year in which the 1993 CFS data were collected). Details can be found in ITMS Basic Documentation [5] and the references cited therein. TRANSEARCH is a commercial information product and its database is beyond the scope of this study. However, it is worth pointing out several deficiencies of the air cargo portion of the ITMS database.

California ITMS Basic Documentation has only a very limited discussion about air cargo (three short paragraphs on page 4-10). Its primary data source is the FAA's Airport Activity Statistics (AAS), and it is likely that the FAA AAS data have been misused. A key input to the ITMS air cargo data is the weight of the air cargo originating in the State. It is stated in ITMS Basic Documentation that "The FAA data reports the total tonnage originating at each airport." Actually, the "enplaned revenue tons of freight and mail" was defined as "The number of revenue tons of freight and mail loaded on an aircraft including originating and transfer tons." See Glossary of AAS. More precisely, the "enplaned tonnage" includes not only the originating but

also transfer cargo. (Because of this definition, the Anchorage International Airport of Alaska “enplaned” reportedly in AAS more air cargo than the San Francisco International Airport, and was ranked as the second largest international gateway for air cargo in the U.S..) This misuse of the AAS data may significantly adversely affect the validity of the inferences made by ITMS about air cargo. To correct this error, the weight of transfer air cargo needs to be estimated. This is a worthy subject for future research.

A major processing step employed by ITMS is “The origin tonnage is then disaggregated into commodity classifications based on prior-year TRANSEARCH air cargo flow data and our annual updating of commodity volumes at the 4-digit STCC level.” The validity of current-year air cargo flow depends on prior-year air cargo flow, but how the prior-year air cargo flow or that of the “initial year” was estimated was not discussed. Another major step is “Prior -year TRANSEARCH flows establish the destination patterns.” It appears that the destination pattern would remain the same from year to year. Cross-verification of the results provided by ITMS and those provided in this section, integration of the data, and analyses based on the integrated data set can be worthy future research.

It is well known that air cargo is typically high-value and time-sensitive. Therefore, it would be interesting to get a sense of what commodity types that use air-truck mode movement significantly and the distribution of mode types involved in moving those commodity types.

The four major quantities to be estimated in this section are:

- Trucking-for-Air-Cargo Percentage: the percentage, by value and weight, of goods moved via air-truck combination with respect to all goods whose movement involves trucking,
- Commodity-Weight-Moved-by-Air Percentage: percentage of commodity weight, for individual commodity categories, that is moved by air,
- Commodity-Value-Moved-by-Air Percentage: percentage of commodity value, for individual commodity categories, that is moved by air, and
- Commodity-Movement-Mode Distribution: the distribution of transportation modes for each of the commodity categories for which air cargo plays an important role.

This section is organized as follows. Section 4.1 discusses the limitations of 1993 Commodity Flow Survey (CFS) for our purposes. Section 4.2 summarizes, according to 1993 CFS, the total amount of freight movement originating in California that is related to air cargo. Section 4.3 provides plausible lower and upper bounds for the trucking-for-air-cargo percentages based on 1993 CFS. Section 4.4 proposes two methods for obtaining better estimates for the percentages. Section 4.5 identifies those commodity types whose movement involves the air mode in a significant way, where the qualifier “significant” is defined as 5% or higher in value. Section 4.6 is similar to Section 4.5 but the qualifier “significant” is defined as 1% or higher in weight. Section 4.7 summarizes the distribution of transportation modes used to move those commodities whose movement involves air transportation significantly. Section 4.8 summarizes the composition of air cargo originating in California and moved via the Air-Truck Mode. Section 4.9 discusses recent air cargo activities at the Stockton Airport regarding export of San Joaquin County’s fruits and vegetables.

4.1 The Limitations of the 1993 CFS

A brief introduction to the 1993 Commodity Flow survey can be found in Section 2.4.8; further information can be found in the Appendix. For complete details, the reader is referred to [7,8,9,10]. This subsection addresses two major limitations for our study. Further research to overcome the limitations will also be discussed.

The first major limitation is that the 1993 CFS focuses on domestic transportation of goods. Although information about whether a shipment is being exported to another country is requested on the survey form, it is not used to reveal the amount of transportation activities involved beyond the port of exit. In fact, the port of exit is effectively considered as final the destination for an exporting shipment. Although a primary purpose of the 1993 CFS is to gather information about the modes of transportation used in moving goods, the survey asks only the modes used in moving goods within the U.S.. For example, if a shipment is destined for a foreign country via air, the survey asks only the mode of transportation used for shipping the goods from the establishment to the airport. Therefore, although two modes are involved in the shipment, only one mode is revealed from the questionnaire. (However, if the shipment is destined for a domestic location and both trucking and air modes are involved, two modes are revealed in the questionnaire about the shipment.) This imposes a major limitation on studying the role of air cargo in goods movement in California because of the international-gateway nature of several of the California's airports. Table 4.1 below tabulates the tonnage of international air cargo and its percentage with respect to that of total air cargo enplaned or deplaned at the Los Angeles International Airport. Note that international air cargo accounted for approximately 40% of the total air cargo in the past few years.

Table 4.1. Percentage of International Air cargo at LAX

Year	International Cargo (Tons)	Total Cargo (Tons)	Percentage
1997	866,142	2,064,897	42%
1996	783,989	1,895,754	41%
1991	422,569	1,141,196	37%

Source: Los Angeles International Airport, Airport Traffic Report

International air cargo accounted for approximately 50% of total air cargo at the San Francisco International Airport in 1996, which is even higher than its LAX counterpart. Two ways of circumventing this limitation will be discussed in Section 4.3.

Ten possible modes of transportation were defined in the 1993 CFS, including the mode named Parcel, U.S. Postal Service, or Courier. We will refer to this mode as the Parcel mode. The Parcel mode is multi-modal by nature, and this results in the second major limitation of the 1993 CFS for our study. We are not aware of any statistics regarding the proportion of goods shipped through the Parcel mode whose movement involves air transportation. For California, 14.2% of the value and 0.4% of the weight of the goods moved during 1992 was moved via this mode. The transportation mode for 7.6% of the value and 6.0% of the weight of the goods moved in

1992 was either unknown or not provided. It is likely that at least a small portion of the Parcels was also moved via air, and a large proportion of the goods whose transportation mode was unknown actually involved trucking. We will make certain assumptions in developing plausible lower and upper bounds in the next subsection.

Other limitations exist. Some examples are briefly discussed below. The 1993 CFS sampled establishments in mining, manufacturing and whole-sale trade, and selected retail and service industries. It also covered selected auxiliary establishments (e.g., warehouses) of in-scope multi-unit and retail companies. However, the survey coverage excluded establishments classified as farms, forestry, fisheries, oil and gas extraction, government, construction, transportation, households, foreign establishments, and most establishments in retail and services. The 1993 CFS was conducted as part of the census of Transportation, Communications, and Utilities, which is in turn a component of the Economic Census. In addition to the Census of Transportation, Communications, and Utilities, the Economic Census consists of seven other censuses: Retail Trade, Wholesale Trade, Service Industries, Financial, Insurance, and Real Estate Industries, Manufacturers, Mineral Industries, and Construction Industries. A more complete picture about goods movement and the companion traffic in California can be obtained by combining the CFS results with the other Census results. Also, the 1993 CFS California [8] reports only data about commodity movements originating from California establishments, not those movements destined for California. Therefore, no import activities are reported in the survey findings.

U.S. exports and imports data collected by the U.S. Department of Commerce International Trade Administration can and should be used to compensate for the domestic nature of CFS, both in terms of its lack of data on exports and imports. Private air cargo operators should be approached and relevant proprietary data solicited. These are important subjects for future research.

4.2 Value and Weight of Air Cargo Originating in California, Based on 1993 CFS

According to the 1993 CFS, the value and weight of air cargo and related modes of goods movement originating in California is summarized in Table 4.2 below. The Air mode is defined as “movements using commercial or private aircraft, and all air service for shipments that typically weigh more than 100 pounds.” It “includes air freight and air express.” [7,8] The Air-Truck mode refers to those shipments for which both truck (including Private Truck and For-Hire Truck modes) and air modes were used.

As will be discussed in more detail in the next subsection, a significant amount of goods moved by the Parcel mode was transported by air. It is also possible that some of the goods whose transportation mode was “unknown” was moved partially by air. However, judging by the miles per shipment, it is likely that such goods accounts for a small percentage of all the goods moved via the “unknown” mode. It is not clear how much of the goods reportedly moved by the single mode of Air was actually moved by the single mode of Air. It is also possible that the shipments were aircraft that were manufactured in California airports and were flown to their customers from the airports. However, the commodity type of Transportation Equipment accounted for only \$140 million out of the \$1,162 million worth of goods reportedly moved by the single mode

of Air, and not all of the \$140 M would have been associated with aircraft manufacturing. 1993 CFS Data also show that \$461 million worth of Electrical Machinery, Equipment or Supplies was shipped by the single mode of Air. The author is not aware of any significant amount of non-aircraft manufacturing that took place in California airports in that year. It is possible that some surveyees misreported the mode, and their goods was actually moved by Air-Truck mode, perhaps with a short ride from the manufacturing facilities to the nearby airports.

Table 4.2. Goods Movement Originating in CA: Air, Air-related, and Other Modes

Mode	Value - \$M (%)	1,000 Tons (%)	Mil. Ton-Miles (%)	miles/ship.
All	638,523 (100.0)	706,554 (100.0)	136,682 (100.0)	644
Air-Truck	28,594 (4.5)	681 (0.1)	1,213 (0.9)	1,803
Air (only)	1,162 (0.2)	20 (-)	S (-)	S
Parcel	90,882 (14.2)	2,520 (0.4)	2,763 (2.0)	1,008
For-hire Truck	247,920 (38.8)	215,406 (30.5)	56,637 (41.4)	785
Private Truck	182,844 (28.6)	305,085 (43.2)	18,056 (13.2)	57
Rail	11,019 (1.7)	15,225 (2.2)	19,483 (14.3)	1,497
Truck-Rail	4,389 (.7)	1,675 (.2)	3,739 (2.7)	1,690
Pipeline*	17,191 (2.7)	100,825 (14.3)	S (S)	S
Unknown	48,361 (7.6)	42,484 (6.0)	11,678 (8.5)	353

Source: 1993 Commodity Flow Survey

* 1993 CFS data for pipelines exclude most shipments of crude oil.

“S” indicates that data do not meet 1993 CFS publication standards due to sampling variability or other reasons. “-” represents zero or less than 1 unit of measure.

Tables 4.3 and 4.4 below show that air cargo is particularly important in California. While the total value of commodity originating from California accounted for 10.4% of the total value of commodity originating in the U.S., total value of air cargo originating in the State accounted for 21.4% of its U.S. counterpart. Note that the air cargo percentage is more than double the overall percentage. The weight counterparts of these two percentages are 5.8% and 22.3%. Note that the air cargo percentage is almost four times the overall percentage.

Table 4.3. Importance of Air Cargo Relative to Other Modes in CA: Value

Mode	CA Value - \$M	U.S. Value - \$M	CA value/U.S. Value
All	638,523	6,123,832	10.4%
Air-Truck & Air	29,756	139,087	21.4%

Table 4.4. Importance of Air Cargo Relative to Other Modes in CA: Weight

Mode	CA Weight - K Tons	U.S. Weight - K Tons	CA Weight/U.S. Weight
All	706,554	12,157,105	5.8%
Air-Truck & Air	701	3,139	22.4%

The importance of aviation in general to California was discussed in Section 2.3.

4.3 Plausible Lower and Upper Bounds for Value and Weight of Air Cargo and Relative Value of Air Cargo with Respect to Trucked Goods, Based on the 1993 CFS

Due to the domestic nature of the 1993 CFS (i.e., the first limitation discussed in the previous subsection), we focus on only the air cargo moved from California establishments to domestic destinations. In other words, we ignore the air cargo moved abroad and hence the truck traffic fulfilling the ground movement. Due to the limitations caused by (i) the ambiguity of the Parcel mode and (ii) the fact that a significant amount of goods moved via unknown transportation mode, we can provide only lower and upper bounds for the trucking-for-air-cargo percentage at best. All the calculations in this subsection are based on the 1993 CFS California [8] unless explicitly stated otherwise.

The goods moved via the air-truck mode accounted for 4.5% of the total value of goods originating in California. For developing lower and upper bounds, we assume that 0% and 20% of the goods (in value) moved through the Parcel mode involved air transportation, respectively. We assume that none of the goods moved by the Unknown mode was actually moved by air. Also, the fraction 20% is an assumption that needs to be validated in the future. Out of the major parcel carriers, e.g., USPS, FedEx, etc., we use operations of UPS, a \$23 billion annual-revenue company (twice that of FedEx), as a guide for estimating the fraction. UPS delivers approximately 12 million packages a day, of which approximately 1.5 million are shipped under one-day, two-day or three-day time-definite services. The exact percentage of these 1.5 millions shipments that are actually shipped by air is unknown, although a UPS headquarters operations manager indicated that the majority of the 1.5 million shipments are transported by air.)

Since 14.2% of the value of all goods moved in 1992 was moved via the Parcel mode, the assumption leads to 0% and 2.8% as the bounds for the percentage of the value of the parcels moved via air with respect to the total value of goods originating in California in 1992. This leads to 4.5% and 7.3% as the lower and upper bounds for the percentage of value of the goods moved via air with respect to the total value of goods originating in California in 1992, respectively. For convenience, we use the mean value of 5.9% as a point estimate.

The value of trucked goods, including those whose movement involved Private Truck, For-Hire Truck, Private-Truck and For-Hire Truck, Truck and Air, Truck and Rail, and Truck and Water, accounted for 72.7% of the total value. (Other modes include Inland Water, Great Lakes, Deep Sea Water, Pipeline, Rail, and Air.) For developing bounds, we assume that 80% and 100%, as lower and upper bounds respectively, of the goods (in value) moved through the Parcel mode involved trucking and that 0% and 100% of the goods moved via the Unknown mode involves trucking. (The percentages of value moved via these two modes are 14.2% and 7.6%, as mentioned earlier.) These two assumptions lead to 83.6% and 94.5% as the lower and the upper bounds. For convenience, we use the mean value 89% as a point estimate. Table 4.5 contrasts the percentages of value of goods moved by air and trucking.

Table 4.5: % of Value of Goods(Originating in CA) Whose Movement Involves Air-Truck Combination or Truck, Based on 1993 CFS

Mode	Lower Bound	Upper Bound	Point Estimate
Air-Truck	4.5%	7.3%	5.9%
All Modes Involving Truck	83.6%	94.5%	89.0%

Source: Based on 1993 Commodity Flow Survey

Goods moved via the combined mode of air-truck accounted for 0.1% of the total weight of the goods originating in California. For developing lower and upper bounds, we assume that 0% and 20%, as lower and upper bounds respectively, of the goods (in weight) moved through the Parcel mode involves air transportation. Since 0.4% of the value of all goods originating in 1992 was moved via the Parcel mode, the two percentages lead to 0% and 0.08% with respect to the total weight moved in 1992, according to our assumption. This leads to 0.1% and 0.18% as the lower and upper bounds, respectively, for the percentage of the weight of goods moved via air with respect to the total weight originating in California in 1992. For convenience, we use the mean value of 0.14% as a point estimate.

The weight of trucked goods, including those whose movement involved Private Truck, For-Hire Truck, Private-Truck and For-Hire Truck, Truck and Air, Truck and Rail, and Truck and Water accounted for 74% of the total weight. For developing lower and upper bounds, we assume that 80% and 100%, as lower and upper bounds respectively, of the goods (in weight) moved through the Parcel mode involved trucking and that 0% and 100% of the goods moved via the Unknown mode involved trucking. (The percentages of weight moved via these two modes are 0.4% and 6.0%, as mentioned earlier.) These two assumptions lead to 74.3% and 80.4% as the lower and the upper bounds. For convenience, we use the mean value 77.4% as a point estimate. Table 4.6 contrasts the percentages of weight of goods moved by air and trucking.

Table 4.6: % of Weight of Goods (Originating in CA) Whose Movement Involves Air-Truck Combination or Truck, Based on 1993 CFS

Mode	Lower Bound	Upper Bound	Point Estimate
Air-Truck	0.10%	0.18%	0.14%
Truck	74.30%	80.40%	77.40%

Source: Based on 1993 Commodity Flow Survey

According to these assumptions and the resulting calculations, approximately 5.4% and 7.7% are the lower and upper bounds for the percentage of value of trucked goods that are air cargo, with a point estimate of 6.6%. (Note that the point estimate is based on the two point estimates developed for the value of air cargo and the value of all trucked goods discussed above.) Similarly, approximately 0.135% and 0.224% are the lower and upper bounds for the percentage of weight of trucked goods that are air cargo, with a point estimate of 0.18%.

These percentages indicate that a minute amount of tonnage moved by trucks actually is air cargo (0.18%), although the value of trucked air cargo accounted for a disproportionately high

percentage (6.6%) with respect to that of the trucked goods in general. The actual percentages should be higher because the truck traffic generated by the international air cargo would add to their values, perhaps significantly. According to this calculation, the value of the air cargo whose movement also involves trucking is on average 37 times higher than that of trucked goods in general. Table 4.7 below summarizes the value and weight of air cargo with respect to trucked cargo based on 1993 CFS California.

Table 4.7. Proportion (%) of All Trucked Goods That Was Moved via Air-Truck: in Value or Weight, Based on 1993 CFS

Criterion	Lower Bound	Upper Bound	Point Estimate
% in Value	5.4 %	7.7 %	6.6 %
% in Weight	0.135%	0.224%	0.180%
% in Value / % in Weight	40	34.7	36.7

Source: Based on 1993 Commodity Flow Survey

4.4 Two Methods for Developing Better Estimates through Estimation of International Cargo Activities

One method for overcoming the limitation of the 1993 CFS about its domestic focus is to use the relative magnitudes of domestic and international cargo activities as a guide to estimate the amount of international air cargo that use the air-truck mode as the means of transportation. The Worldwide Airport Traffic Report (WATR) and the Airport Traffic Reports (ATR) published by California airports provide the relative magnitude of domestic and international air cargo. ATR reports publish enplanement and deplanement data separately, but WATR reports aggregate enplanement and deplanement data. However, note that both data sources do not distinguish among the modes of Parcel, Air (no trucking) and Air-Truck. Therefore, if US Customs tracks also the weight and value of exporting parcels or at least tracks the percentages of value and weight of exported parcels with respect to the overall exported cargo, then better estimates are possible. (Parcels, in this context, mean those packages moved by USPS, international integrated carriers and international couriers. Whether US Customs indeed tracks the desired quantities is yet to be determined.)

T-100 and T-3 Schedules combined can provide a complete weight data set for all domestic air cargo originating from each of the major California airports. Subtracting the combined amount of tonnage for the Air-Truck mode and the Air (no truck) mode estimated by the 1993 CFS from the data estimated from the T-100 and T-3 Schedules would produce an estimate of the amount of the goods moved by the Parcel mode that actually was moved via air transportation too. (We have so far assumed that none of the goods moved through the Unknown mode was actually moved via air. This assumption can be relaxed, and new estimates obtained.) Note that the 1993 CFS was a sample survey that focused on manufacturing and whole-sale activities and ignored several important industries, e.g., the service industries, while Schedules T-100 and T-3 are total counts. This raises the issue of how to factor up the CFS data. To obtain accurate estimates this way, data from other economic censuses, e.g., the Census of Service Industries, may be required.

The two methods discussed above can improve our understanding of the contribution of international air cargo and the Parcel mode of goods movement to air cargo movement and hence improve the estimates provided earlier. This could be a worthy subject for future research.

4.5 Commodity Types Moved by Air: Percentage of Value

Table 6 of the 1993 CFS California tabulates Shipment Characteristics by Commodity and Mode of Transportation. This subsection identifies the commodity types whose movement involves air transportation significantly, where the qualifier “significantly” means that “higher than 5% of the total value of goods of a particular commodity type is moved by air.” The commodity types moved significantly by air and the percentages of commodity (of the corresponding types) whose movement involves air transportation with respect to the total value of goods of the corresponding types are tabulated in Table 4.8 below.

Table 4.8: Commodities Moved Significantly in Value by Air

Commodity Category	Value Percentage
Electrical Machinery, Equipment, or Supplies	13.2%
Machine, Excluding Electrical	9.5%
Instruments, Photographic Goods, Optical Goods Watches, or Clocks	9.4%
Apparel or Other Finished Textile Products	5.9%

Source: 1993 Commodity Flow Survey

4.6 Commodity Types Moved by Air: Percentage of Weight

This subsection identifies the commodity types whose movement involves significantly air transportation, where the qualifier “significantly” is defined as higher than 1% of the total weight of goods of a particular type moved in 1992. The commodity types and the corresponding percentages are tabulated in Table 4.9 below.

Table 4.9: Commodities Moved Significantly in Weight by Air

Commodity Category	Weight Percent.
Machine, Excluding Electrical	3.7%
Instruments, Photographic Goods, Optical Goods Watches, or Clocks	2.1%
Apparel or Other Finished Textile Products	1.8%
Electrical Machinery, Equipment, or Supplies	1.6%
Fresh Fish or Other Marine Products	1.6%

Source: 1993 Commodity Flow Survey

Electrical machinery, Equipment, or Supplies include electronic equipment.

4.7 Mode Distribution for Major Commodity Types Moved by Air

This subsection describes the distributions of transportation mode for the five commodity types identified in Table 4.9. Note that the four commodity types identified in Table 4.8 are a subset of those identified in Table 4.9. The five distributions of transportation modes are tabulated in Tables 4.10 - 4.14. In these tables, the symbol “-” indicates that the corresponding quantity is negligible, and the symbol “S” indicates that the estimate of the corresponding quantity is omitted because the estimate is not reliable enough.

Table 4.10: Mode Distribution for Electrical Machinery, Equipment, or Supplies

Mode(s)	Value (Mil \$)	Value %	Weight (1000 tons)	Weight %
All Modes	81,196	100.0	2,547	100.0
Parcel, USPS, Courier	22,705	28.0	154	6.1
Private Truck	12,050	14.8	800	31.4
For-Hire Truck	24,902	30.7	1,096	43.0
Air	461	0.6	2	0.1
Rail	521	0.6	69	2.7
Private & For-Hire Truck	S	-	S	S
Truck & Air	10,680	13.2	40	1.6
Truck & Rail	S	-	S	-
Truck & Water	S	-	S	S
Other & Unknown	9,806	12.1	S	S

Source: 1993 Commodity Flow Survey

Table 4.11: Mode Distribution for Machine, Excluding Electrical

Mode(s)	Value (Mil \$)	Value %	Weight (1000 tons)	Weight %
All Modes	61,794	100.0	2,056	100.0
Parcel, USPS, Courier	15,470	25.0	221	10.8
Private Truck	5,374	8.7	440	21.4
For-Hire Truck	29,855	48.3	1,166	56.7
Air	66	0.1	S	-
Rail	S	S	14	0.7
Private & For-Hire Truck	S	-	-	-
Truck & Air	5,896	9.5	77	3.7
Truck & Rail	S	S	S	S
Truck & Water	S	S	1	-
Inland Water & Deep Sea	S	-	-	-
Other & Unknown	4,874	7.9	131	6.4

Source: 1993 Commodity Flow Survey

Table 4.12: Mode Distribution for Instruments, Photographic Goods, Optical Goods Watches, or Clocks

Mode(s)	Value (Mil \$)	Value %	Weight (1000 tons)	Weight %
All Modes	24,754	100.0	568	100.0
Parcel, USPS, Courier	8,181	33.1	91	16.0
Private Truck	2,943	11.9	79	13.8
For-Hire Truck	9,072	36.6	348	61.2
Air	67	0.3	1	0.1
Truck & Air	2,319	9.4	12	2.1
Truck & Water	S	S	S	S
Other & Unknown	2,152	8.7	37	6.5

Source: 1993 Commodity Flow Survey

Table 4.13: Mode Distribution for Apparel or Other Finished Textile Products

Mode(s)	Value (Mil \$)	Value %	Weight (1000 tons)	Weight %
All Modes	37,308	100.0	1,546	100.0
Parcel, USPS, Courier	6,426	17.2	165	10.7
Private Truck	6,021	16.1	364	23.5
For-Hire Truck	20,752	55.6	872	56.4
Air	S	S	S	S
Rail	S	S	S	S
Private & For-Hire Truck	S	-	-	-
Truck & Air	2,183	5.9	28	1.8
Truck & Rail	S	S	41	2.7
Truck & Water	S	S	S	S
Inland Water & Deep Sea	S	-	-	-
Other & Unknown	1,029	2.8	48	3.1

Source: 1993 Commodity Flow Survey

Table 4.14: Mode Distribution for Fresh Fish or Other Marine Products

Mode(s)	Value (Mil \$)	Value %	Weight (1000 tons)	Weight %
All Modes	1,540	100.0	S	S
Parcel, USPS, Courier	S	S	S	S
Private Truck	1,167	75.8	S	S
For-Hire Truck	272	17.7	96	22.6
Rail	S	S	S	S
Private & For-Hire Truck	S	-	-	-
Truck & Air	42	2.7	7	1.6
Truck & Rail	S	-	S	S
Other & Unknown	4	0.2	1	0.2

Source: 1993 Commodity Flow Survey

4.8 Composition of Air Cargo Originating in California and Moved by Air-Truck

Table 4.15 below summarizes the composition of air cargo that originated in California and was moved by the Air-Truck mode, according to 1993 CFS. Note that the percentages associated with the weights of individual modes do not add up to 100%. Also note that the weight data for Chemical products and Pulp, Paper or Allied products are missing because they “do not meet publication standards due to high sampling variability or other reasons.” It could be that these two types of products are relatively heavy and the missing data are the primary cause of the problem of “missing percentage.” This, nevertheless, exemplifies a serious problem with some of the existing data sources.

Table 4.15. Composition of air cargo originating in CA: Air-Truck Only (1993 CFS)

Commodity	Value - \$M (%)	Weight -K Tons (%)
Total	28,594 (100.0%)	681 (100.0%)
Electrical Machinery	10,680 (37.4%)	40 (5.9%)
Machinery, Excl. Electrical	5,896 (20.6%)	77 (11.3%)
Instruments, Photo., Optical, etc.	2,319 (8.1%)	12 (1.8%)
Apparel	2,183 (7.6%)	28 (4.0%)
Chemical	1,302 (4.6%)	S
Fabricated Metal	337 (1.2%)	6 (0.9%)
Farm Products	175 (0.6%)	48 (7.0%)
Pulp, Paper or Allied	48	S
Clay, Conc., Glass or Stone	118	1
Fresh Fish or Other Marine	42	7
Food or Kindred	33	6
Leather or Leather Products	30	1
Misc. Manufactured	580 (2.0%)	5 (0.7%)
Misc. Freight Shipment	140 (0.5%)	1 (0.1%)

Source: 1993 Commodity Flow Survey

4.9 The Role of Stockton Airport in Exporting San Joaquin County’s Agricultural Products

The importance of air cargo for shipping California’s agricultural products to domestic or international destinations has long been recognized. See, e.g., [39]. So far, air shipments of San Joaquin’s fruits and vegetables to domestic or international destinations have been mostly by way of large airports in neighboring counties, e.g., the San Francisco International Airport. Major disadvantages of this arrangement exist. For example, trucking the products to those airports is often delayed by the congested bridges, highways and surface streets. It is well known that air cargo receives lower priority than passengers on passenger airlines. In addition, when air cargo is “bumped” for accommodating passengers and their luggage, fruits and vegetables tend to get lower priority than commodities like computers and machinery. Fruits and vegetables are particularly vulnerable to such disadvantages due to their perishable nature.

Farmington Fresh Inc., a farmer co-op, has been established recently and uses the Stockton Airport as the principal consolidation point for different types of fruits and vegetables produced in the San Joaquin County. Fresh produce, including cherries, is routinely shipped to Japan and other destinations. Fresh-cut beef is also trucked in to the Stockton airport from Kansas and then shipped to foreign countries. The airport will receive import of fresh-cut lamb from Australia in the near future.

For promoting efficient export of San Joaquin County's agricultural products, the County supervisors have been supporting the development of air cargo facilities at the Stockton Airport. Officials at the Airport claim that their 50,000 square-foot cold-storage facility is the largest in the country and can be expanded to 108,000 square-feet in same building. The Airport has 1,549 acres of land, of which 650 acres can be converted for new usage (400 acres are currently unused land). Currently, only 100 acres have been devoted to air cargo activities, of which 40 acres are being used by Farmington Fresh. The County and the airport authority are trying to promote the Airport as a better choice for shipping the County's produce by air, and are planning to launch a marketing campaign this summer.

5.0 Issues in California's Air Cargo Movement and the State Role in Development of California's Air Cargo System

This section consists of four subsections. Section 5.1 discusses issues that may be of critical concern to either the State's air cargo industry or the State of California as a whole. These issues have been identified mainly through a literature survey, and hence the list should be considered as preliminary and non-comprehensive. Caltrans [16] discussed many issues related to the goods movement in California in general. Issues identified there that pertain to air cargo are integrated with other issues in Section 5.1. Each issue is given an identification number for citation in later discussion. To better understand the air cargo industry and the issues facing the industry and to better assess the relative importance of the issues, particularly those that the State may play a role in their resolution, we then discuss various dimensions of air cargo activities in Section 5.2 and their interaction with the broader context of the State's transportation systems, economy and environment in Section 5.3. We pinpoint where those issues discussed in Section 5.1 occur in the context by citing the issue identification numbers at appropriate places. A preliminary identification of those issues that the State government, particularly the Department of Transportation (Caltrans), may play a role will be attempted in Section 5.4.

5.1 Issues in California's Air Cargo Movement

The issues to be discussed in this section include those directly related to the operations of the State's air cargo industry, e.g., efficient intermodal transfer of goods between the air and ground transportation modes, efficient air and ground movement, efficient customs clearance for international air cargo. They also include those that relate to the interaction between the State's air cargo operations and the State's transportation systems and economy, e.g., issues related to the competitiveness of the State with respect to its neighboring states or countries in attracting transfer air cargo to California airports. Note that the State government, particular the Department of Transportation (Caltrans), may not play any role in some critical issues faced by the State's air cargo industry. Such issues are included nevertheless so that the relative importance of those issues that the State can play a role can be assessed.

Many issues beyond the scope of this subsection exist. For example, Frederick Smith, the founder of Federal Express, recently called for attention to the constraints on international trade and international distribution services imposed by the current postal, customs and transportation laws [42]. For an example regarding inter-jurisdiction coordination, see the first bullet item in Section 5.4.

This section is organized as follows. Section 5.1.1 discusses issues regarding air cargo operations. Section 5.1.2 takes the perspective of the State and discusses pertinent issues

5.1.1 Air Cargo Operational Issues:

This subsection is partitioned into three parts. Sections 5.1.1.1 through 5.1.1.3 list and discuss issues regarding (i) airport (terminal) operations, (ii) airport capacity and congestion, and (iii)

ground access to airports and ground movement of air cargo. Other issues are collected in Section 5.1.1.4.

5.1.1.1 Airport (Terminal) Operational Issues:

Murphy et al. [31] identified and studied ten air cargo operational attributes mainly regarding terminal operations. The attributes are as follows, listed in descending importance perceived by the air cargo operators. The relative importance perceived by airport operators is somewhat different.

- (I1) Capacity of loading and unloading equipment,
- (I2) Frequency and extent of cargo loss and damage,
- (I3) airport location,
- (I4) Accommodation of large shipments,
- (I5) Convenience of pickup and delivery times,
- (I6) Availability of information concerning shipments,
- (I7) Availability of loading and unloading facilities for large and/or odd-sized freight,
- (I8) Flexibility in meeting special handling requirements, e.g., refrigeration,
- (I9) Freight handling charges, and
- (I10) Assistance in claims handling.

Item (I1) is a key consideration for air cargo operators because air shipments are time sensitive. Equipment availability may be a proxy for the number of flights into and out of the shared cargo area of an airport. Item (I1) can be interpreted as airport having sufficient air cargo handling capacity. Due to the geographical limitations of some busy airports, off-site “cargo cities” and container stations have been created to facilitate air cargo handling [30]. Therefore, Item (I1) can be generalized to the following:

- (I11) Airport has sufficient cargo handling capacity, e.g., warehousing and refrigerating capacity, or has an off-site cargo processing station (i.e., cargo station) in proximity that provides sufficient supplemental capacity.

Note that since selecting locations for cargo stations beyond the territories of existing airports is not completely within the jurisdiction of airport authorities, Caltrans may play a significant advisory role in site selection, traffic planning, construction planning, and their operations. Items (I3), (I5) and (I6) are also related to the time-sensitivity of air cargo.

Operations associated with international air cargo involves customs clearance, which has often caused much delay to air cargo movement. Therefore, the following is an important attribute of air cargo operations at an airport.

(I12) Expeditious customs clearance.

Much of the cargo dwell time is simply spent on waiting for some action to take place. Metcalf [28] provided a set of data depicting the relative magnitude of required service time and the delay associated with a number of standard within-terminal operations for conventional air freight. Although he did not provide absolute measures of average delays, he estimated that 40% of the total average delay occurs during the wait for customs clearance and another 40% occurs while the air cargo waits for consignment movement. He stated that “Dwell time within the terminal continues to be a major constraint to expeditious traditional freight movements. The express carriers have virtually negated the problem by manpower/automation/mechanization and simplified customs clearance procedures.”

Containerization has made intermodal transfer of goods much more efficient between different modes of transportation, e.g., between trucking and rail. However, it has not been very popular between the modes of air and trucking. Muller [30] discussed the reasons why air-surface container has not be widely used in air-surface intermodal air cargo transportation. Primary reasons include the excessive weight of such containers, the difficulty to fit such containers to space-limited cargo space on different aircraft, etc.

5.1.1.2 Airport Capacity and Congestion Issues:

These issues apply to air transportation in general. Details about these issues can be found in [16]. Currently over 64% of air cargo is moved by all-cargo freighters [18]. Whether the impact of airport capacity and environmental concerns on the operations of these all-cargo freighters is different from that on the operations of passenger aircraft is unclear. A possibility is that many all-cargo freighters fly at night. Although there may be less concern for congestion, noise restrictions may have more adverse impact on their operations. This issue is a worthy subject for future research.

(I13) Airside and landside congestion at major airports limits operations.

Many airports have exceeded their original design capacity and lack room for airport expansion. Considerable interest has occurred in using former military bases for air cargo operations.

(I14) Local airport noise restrictions and environmental regulations limit operations at many airports.

(I15) Existing airports need to be modified in order to accommodate next generation of large aircraft.

5.1.1.3 Ground Access and Ground Movement Issues:

By the intermodal nature of air cargo, issues regarding trucking on surface transportation systems apply to air cargo movement. Details can be found in [16].

By the time-sensitive nature of air cargo, the following general issues are particularly important.

(I16) Recurrent congestion on surface transportation systems, including main access routes to the airport, other highways and city streets, hinders the ground portion of air cargo movement.

To combat ground access deficiencies, some airports like the JFK International Airport in New York City has made improvements to better integrate trucking and air cargo [30]. For example, new and improved landside directional signing (both on and off the airport), updated and easy-to-read maps, establishment of information centers and state-of-the-art truck stops have been put in place, are being put in place, or is being planned for implementation. Access and egress points to the airport and individual terminals have been examined for improvements, including a close look at the entire on-airport roadway system in terms of roadway configuration and geometry. Caltrans, together with relevant regional planning agencies, play a pivotal role in improving the ground access to airports, not to mention the highway systems.

(I17) Non-recurrent congestion on highways and surface streets and lack of comprehensive and consistent incident and roadway condition information also hinder the ground portion of air cargo movement.

The impact of non-recurrent congestion on the ground portion of air cargo movement is higher than that on general freight movement by truck because of the time-sensitivity of air cargo pick-up and delivery.

A closely related issue is as follows:

(I18) Need for measures of impact of traffic congestion on air cargo pick-up and delivery, particularly the delivery and pick-up of time-definite parcels.

5.1.1.4 Other Operational Issues:

(I19) Many airports and airlines give priority to passengers over air cargo operations.

To accommodate passenger movement, some passenger airlines would “bump” air cargo off flights to make room for excess passenger luggage. The loading priority for passenger aircraft is passenger, luggage, human remains, human organs for transplant, emergency medical shipments, parts for down aircraft, mail and finally freight.

(I20) Security rules negatively impact air cargo operations on passenger aircraft.

Air cargo carried in the “belly” of passenger aircraft is subject to more stringent security regulations than their all-cargo counterpart. Negative impact includes, among other things, limitation on the type of commodity that can be carried on passenger aircraft and lengthened inspection during loading.

5.1.2 Issues from the State’s Perspective:

The State may be concerned about the following additional issues:

(I21) Air cargo carriers choose non-California airports as gateways for overseas operations or as hubs for domestic operations to avoid delays at busy California airports [36,16].

Currently 64% of air cargo is carried by all-cargo freighters, from 40% several years ago. The impact of separation of air cargo from passengers on air cargo routing is unclear. It has also been observed that air cargo forwarders have started to cooperate with airlines more closely to more efficiently use the cargo space on passenger airliners [18]. Air cargo originating from or destined for the State, at least the cargo originating or destined for California’s metropolitan areas, can be considered captured by the State’s airports. However, transfer cargo can be shifted to other states by the air cargo operators. The effect of the two trends mentioned above on the amount of transshipment business the State can secure is unclear.

When cargo operations are limited by airport capacity or environmental concerns, priority may need to be given to improving air cargo operations for cargo originating from or destined for California. Transfer or through cargo may be less critical to the well-being of the State. The absolute and relative importance of these different categories of air cargo to the State’s economic well-being could be a worthy subject for future study.

(I22) State and local decision makers are unfamiliar with critical issues and needs of the air cargo industry [16].

This issue leads to the apparent need for continuing, cooperative and comprehensive issue identification process.

(I23) Unclear value of the air cargo industry and that of the freight industry in general to the society.

(I24) Lack of performance measures and lack of knowledge of trade-off among the different performance measures.

Example questions include the relative importance of goods movement, people movement and car movement to the State.

(I25) Lack of understanding of the behavior of various players in the air cargo industry.

(I26) Need for more initiatives and leadership by the public-sector agencies to develop strategies for leading the industry toward the state desired by the society.

Such strategies would define roles of the public-sector players and those of the private-sector players. Public-sector players include the State Government, particularly Caltrans. Possible Caltrans' roles include a leadership role, in terms of providing technical and financial assistance to local players in the State [20,12,15,37,26]. The state of the industry desired by the society is unclear at this point, as mentioned earlier.

(I27) Lack of data and analytical tools for understanding the current state of the air cargo industry, e.g., air cargo composition and origin-destination, and for understanding the impact, e.g., cost and benefit, of possible solutions to air cargo industry's needs (e.g., possible impact of preferential treatment like dedication of truck lanes near airport cargo terminals).

This and future studies would help determine the proper roles of the State and Caltrans. The issues discussed in this subsection (i.e., Section 5.1) are summarized in the following list, with categorization.

- Air Cargo Operational Issues
 - Airport (Terminal) Operational Issues:
 - (I1) Capacity of loading and unloading equipment,
 - (I2) Frequency and extent of cargo loss and damage,
 - (I3) Airport location,
 - (I4) Accommodation of large shipments,
 - (I5) Convenience of pickup and delivery times,
 - (I6) Availability of information concerning shipments,
 - (I7) Availability of loading and unloading facilities for large and/or odd-sized freight,
 - (I8) Flexibility in meeting special handling requirements, e.g., refrigeration,
 - (I9) Freight handling charges, and
 - (I10) Assistance in claims handling.
 - (I11) Airport has sufficient cargo handling capacity, e.g., warehousing and refrigerating capacity, or has an off-site cargo processing station (i.e., cargo station) in proximity that provides sufficient supplemental capacity.
 - (I12) Expedient customs clearance.
 - Airport Capacity and Congestion Issues:
 - (I13) Airside and landside congestion at major airports limits operations.
 - (I14) Local airport noise restrictions and environmental regulations limit operations at many airports.

- (I15) Existing airports need to be modified in order to accommodate next generation of large aircraft.
- Ground Access and Ground Movement Issues:
 - (I16) Recurrent congestion on surface transportation systems, including main access routes to the airport, other highways and city streets, hinders the ground portion of air cargo movement.
 - (I17) Non-recurrent congestion on highways and surface streets and lack of comprehensive and consistent incident and roadway condition information also hinder the ground portion of air cargo movement.
 - (I18) Need for measures of impact of traffic congestion on air cargo pick-up and delivery, particularly the delivery and pick-up of time-definite parcels.
- Other Operational Issues:
 - (I19) Many airports and airlines give priority to passengers over air cargo operations.
 - (I20) Security rules negatively impact air cargo operations on passenger aircraft.
- Issues from the State's Perspective:
 - (I21) Air cargo carriers choose non-California airports as gateways for overseas operations or as hubs for domestic operations to avoid delays at busy California airports [36,16].
 - (I22) State and local decision makers lack knowledge of critical issues and needs of the air cargo industry [16].
 - (I23) Unclear value of the air cargo industry and that of the freight industry in general to the society.
 - (I24) Lack of performance measures and lack of knowledge of trade-off among the different performance measures.
 - (I25) Lack of understanding of the behavior of various players in the air cargo industry.
 - (I26) Lack of public-sector strategies for leading the industry toward the state desired by the society.
 - (I27) Lack of data and analytical tools for understanding the current state of the air cargo industry, e.g., air cargo composition and origin-destination, and for understanding the impact, e.g., cost and benefit, of possible solutions to air cargo industry's needs (e.g., possible impact of preferential treatment like dedication of truck lanes near airport cargo terminals).

5.2 Dimensions of Air Cargo Activities

This section discusses briefly the activities peculiar to air cargo movement. Air cargo activities take place among and interact with many other activities of a society. In this section, we first discuss the societal environment in which air cargo activities occur and their interaction with the other activities. We then focus on shippers' and air cargo operators' activities. A shipper is a person or an organization who desires to send some material to a recipient through a transportation network but is not involved in the actual transportation of the material (except for the possible transportation needed to drop the material off at a transportation service provider.)

Given the shipper's goods movement needs (particularly possible demand for air cargo service) and the operators' service types and the companion charges, the shipper determines which needs are to be satisfied by what air cargo services and by which air cargo operators. Airports provide not only the physical connection between the two primary transportation modes but also provide facilities for intermodal goods transfer, e.g., loading/unloading facilities, storage facilities, refrigeration facilities, etc. Freighters as well as passenger aircraft carrying freight are subject to the rules and control of the National Airspace System. They share the NAS resources with the other NAS users. Similarly, trucks fulfilling the ground portion of air cargo movement also interact with the operators and users of the surface transportation system. Air cargo movement is subject to many rules, whether it is the air or the ground portion of the movement. Therefore, policies and their makers may significantly impact air cargo movement.

We now focus on shippers' and air cargo operators' activities. We also point out where the air cargo operational issues summarized in Section 5.1.1 occur in the activities. Placement of those issues identified in Section 5.1.2 from the State's perspective will be made in the Section 5.3.

The rest of this subsection is partitioned into three parts: Sections 5.2.1 and 5.2.2 address the shipper's and the air cargo operator's activities. Section 5.2.3 addresses the quality of the service provided by the operator, i.e., the degree to which the air cargo operator's activities are able to satisfy the expectation of the shipper. Labels defined by issue numbers, delimited by parentheses, and placed at the end of an activity indicate the corresponding issues discussed in Section 5.1.

5.2.1 Shipper's Activities:

Given the shipper's goods movement needs (particularly possible demand for air cargo service) and the operators' service types and the companion charges, the shipper determines which needs are to be satisfied by what air cargo services and by which air cargo operators.

Shippers' Transportation needs can be characterized as follows:

- Commodity
 - commodity classification
 - size (I7)
 - weight

- density
- special handling required (I8)
 - fragile
 - perishable
- Origin and destination
- Degree of time sensitivity
- Desired departure and arrival times
- Preferred shipping modes and routes
- Commodity security

Supply information includes:

- service types
- operators
- charges

Considering the needs and the supply information, shippers' determine which service types and which operators to use.

5.2.2 Air Cargo Operator's Activities:

An air cargo operator's activities may include some or all of the following depending on the portions of the air cargo movement that the operator serves.

Air Cargo Operators' planning

- forecasting
 - economy, etc.
 - air cargo market
 - competition
- long-range planning (strategic planning)
 - network
 - air hubbing
 - ground hubbing
 - fleet
 - aircraft
 - ground vehicle
 - business strategies
- mid-range (tactical planning)
 - route
 - schedule
 - crew & personnel
 - etc.

Air cargo operator's interaction with the shippers:

- selling services
- negotiating prices
- taking orders

Air cargo operator's interaction with the providers of the intermodal goods transfer facilities: (I9)

- long-term lease of facilities from the airport (e.g., FedEx)
- short-term facility rental

Air cargo operations:

- normal movement operations:
 - domestic
 - movement planning (short-range planning)
 - aggregating demand from different customers
 - routing and scheduling (onto carrier, i.e., aircraft and possibly ground vehicles)
 - modes/phases of movement execution according to plan: (note the close interaction between the air cargo operator and the airport)
 - ground transportation outside airport (I16, I17)
 - ground access to airport (I16, I17)
 - landside movement within airport (I13, I15)
 - unloading (I1, I7, I8, I11)
 - storage/sorting (I4, I8, I11)
 - security inspection (I11, I20)
 - loading onto aircraft (I1, I7, I8, I11)
 - airside movement in airport (I13, I15)
 - movement in airspace (I13)
 - international:
 - operations applicable to domestic
 - customs clearance (I12)
- exception handling
 - unplanned unavailability of carrier or cargo space (I19)
 - exogenous events, e.g., weather
 - etc.

Air cargo movement is intermodal by nature. The intermodal-transfer operations, particularly those involved in overnight delivery conducted by integrated carriers are well known to be “seamless” by design. Those conducted by other air cargo carriers may not be as efficient. However, a recent trend in the air cargo industry is that many air carriers and forwarders form alliances to provide logistics services to the shippers, i.e., moving away from the conventional role of transportation providers to the role of shippers' business partners in manufacturing and product distribution. Some air carriers even contracted with some larger shippers directly for more efficiently meeting the shippers' freight movement needs, bypassing the forwarders all together. This trend can be viewed as a manifestation of the importance of efficient intermodal

transportation. Intermodalism in air cargo movement is a subject of a pending research project sponsored by the New Technology and Research Program of Caltrans.

5.2.3 Service Quality:

Service quality can be measured according to the following criteria:

- delivery to the destination or loss (I2, I10)
- goods integrity upon delivery or damage (I2, I10)
- timely delivery or delay (I3, I5, I6, I10)

5.3 Interaction between California's Air Cargo Activities and Its Economy, Transportation Systems and Environment

Important mutual impact between air cargo movement in the State and the State's transportation system include:

- mutual impact between air cargo and aviation system
 - delays
 - travel time variability
- impact of ground transportation system on air cargo (I18)
 - delays
 - travel time variability

Measures of such mutual impact are needed before the mutual impact can be assessed. Methodology is needed; data can then be collected accordingly.

Important mutual impact between air cargo movement in the State and the State's economy include:

- impact of air cargo movement in CA on the State's economy (I21, I22, I23, I24, I25, I26, I27)
 - effect of air cargo movement on the current economy
 - sensitivity of economy to changes in current air cargo movement
- impact of the State's economy on the State's air cargo movement
 - sensitivity of air cargo demand to the State's economy
 - sensitivity of supply and service quality to the State's economy

Measures of such mutual impact are needed before the mutual impact can be assessed. Methodology is needed; data can then be collected accordingly.

Important mutual impact between air cargo movement in the State and the State's natural environment

- impact of air cargo movement on the State's environment
 - noise
 - air pollution
 - toxic and hazardous material

- impact of the State's environmental policies and regulations on air cargo movement (I14)
 - hours of operations
 - number of operations
 - airspace capacity

Similar to the discussion above, measures of such mutual impact are needed before the mutual impact can be assessed. Also, methodology is needed, and data can then be collected accordingly.

Important mutual impact between air cargo movement in the State and the State's land use. Similar to the discussion above, measures of such mutual impact are needed before the mutual impact can be assessed. Also, methodology is needed, and data can then be collected accordingly.

5.4 Possible State Roles in the Development of State's Air Cargo System

Traditionally, state and local governments have deferred to the federal government on most issues related to the National Airspace System (NAS). Although the Federal Aviation Administration is responsible for the overall regulation and safety of NAS, it has limited or no control over many crucial aspects of air transportation, e.g., airport capacity, land use compatibility planning, ground access to airports, etc. Recently, several attempts have been made to identify proper state roles in addressing air transportation issues. For example, a 1986 California State Senate Hearing sought to identify proper state roles in aviation safety; a 1989 California State Senate Hearing sought to identify the state role in commercialization of space and promotion of California's aerospace industry. The fact that the FAA issued an Advisory Circular on the subject of Planning the State Aviation System [24] demonstrates the need for an active State role in ensuring the health of California's aviation system. Other efforts on the subject of state aviation planning includes [26,37]. The California Commission on Aviation and Airports was formed in January 1987 to advise the State Legislature and the appropriate federal agencies on matters related to aviation and aeronautics.

The Commission (i) identified, reviewed, monitored and evaluated major issues facing the air transportation system in California, (ii) assessed and emphasized the benefits of aviation to the California economy, (iii) addressed land use and environmental issues, as well as the opportunities and challenges presented by military base closures, and (iv) proposed proper federal, state, local, and private sector roles in aviation. The findings have been documented in four annual reports [12-15]. The importance of air transportation for the State economy was outlined at length in [13], and much of the importance comes from the contribution of efficient air cargo movement.

Proper identification of state roles in air cargo movement requires understanding and monitoring of the air cargo movement in the State. Earlier sections presented initial findings. This section briefly summarizes several possible state roles in facilitating air cargo movement within the state. Much more research is needed for developing a comprehensive list of possible state roles. A closer examination of the references cited earlier in this section would be a first step toward a better understanding of possible state roles in air cargo movement. For an accurate assessment of how the State can best serve the air cargo industry, the State needs to fully understand the issues faced by the air cargo industry in the State and the relative importance of the issues. To do so requires a full understanding of air cargo operators' planning and operational processes.

The following roles have been identified through the preliminary analyses reported in previous sections or in existing literature.

- Ensure continued ability of the State's transportation system to support economic growth of the State by taking a "systems" perspective in assessing and satisfying the capacity needs of the State's aviation system (passengers and goods) as well as the capacity needs of the rest of the State's transportation systems that interfaces with the State's aviation system.

The systems perspective is different from institutional or stakeholder perspectives. Since the FAA has jurisdiction over the airspace and has little control over construction of new runways or new airports, it tends to seek to increase only the capacity of the airspace, particularly the terminal airspace, by applying advanced technologies. Although it is clear that the dominant bottlenecks in the current National Airspace System are at or near the terminal airspace, it is not clear at all whether the bottlenecks would quickly move elsewhere in NAS after small improvements in the capacity of the terminal airspace have been made.

It is well known that, when all of the runways at the Chicago O'Hare International Airport are in full operation, the ground portion of the airport, including the gates, the taxiways, etc., is also approaching saturation. Therefore, any significant improvements to the capacity of the terminal airspace alone at Chicago O'Hare would quickly shift the current bottleneck from the terminal airspace to the ground or elsewhere (e.g., the metering fixes) and would lead to little actual capacity gain at the airport. Therefore, such "latent bottlenecks" must be identified and their capacity expanded if the capacity of NAS is to be expanded. Note that many existing airports are approaching the saturation level currently experienced at Chicago O'Hare, and that it is the prevention or delay of such possible saturation levels at many existing airports that has motivated the recent surge of interest in increasing NAS capacity by using advanced technologies. Focusing on the airspace alone due to limitation on institutional authority is inadequate in addressing the pressing issue of NAS capacity improvement and may lead to inefficient or even wasteful spending of public funds.

The State of California, by its very nature, would want to improve the capacity of the system (not just the airspace), at least the California portion of NAS. Many stakeholders for or against particular NAS changes exist, e.g., communities adjacent to airports, air traffic controllers, avionics vendors, airlines, the FAA, etc. The State, by its very nature, needs to consider the preferences of all stakeholders and deals with the related issues all the time.

Transportation of goods or people plays a vital role in the State's economic health, and it is incumbent upon the State to advocate for efficient goods and people movement. Goods and people movement involves multiple modes, including air and surface. The State, particularly Caltrans, has the mandate and is in a unique position to ensure efficient goods and people movement from the origins to the destinations across all California regions and across all modes. These and many other reasons suggest a proactive role of transportation system coordinator and advisor for the State and Caltrans.

In the area of aviation system capacity planning, Caltrans' "systems" perspective and the absence of a strong institutional stake point to at least a basic but important role of capacity planning advisor. Such a system capacity planning advisor needs to identify the "latent bottlenecks" of the California aviation system.

These roles seem only natural, and no other institution seems to be able to fulfill the roles. Identification of "latent bottlenecks" in the current NAS, particularly the current California aviation system, could be a worthy subject for future research.

- Facilitate efficient ground portion of air cargo movement through adoption of intelligent transportation systems (ITS) technologies.

If no preferential treatment is given to the ground portion of air cargo movement, then, given the time-sensitive or time-definite nature of air cargo, air-cargo-carrying trucks can benefit much from the availability of accurate and timely dynamic traffic information about highways and city streets.

Caltrans, in cooperation with municipal traffic operations centers can provide such valuable information to air-cargo-carrying truck drivers or dispatchers. Note that many of such trucks, e.g., UPS and FedEx ground vehicles, are already equipped with communication and display devices and can receive such information without additional equipment. The State can also entice air-cargo-carrying trucks to adopt Intelligent Transportation Systems (ITS) or other technologies to improve efficiency.

- Facilitate efficient ground access to airports.

Given the low percentage of trucks carrying goods from its origin to the airport with respect to the total truck traffic on highways or city streets, the only logical place where preferential treatment to the ground portion of air cargo movement can be considered is near or at airports, particularly those locations near the freight entrances to airports. Note that such preferential treatment may not require construction of new roads. For example, it may take the form of preferential signaling at intersections near the freight entrances to airports.

- Develop measures of performance of the State’s air cargo industry, measures of its relationship with the rest of the transportation system, the economy, the environment and other relevant aspects of the society, as well as measures of competitiveness with respect to its neighboring states.

An example of the latter is California’s market share of transfer cargo with respect to other international gateway airports on the West Coast and Alaska. To do so, monitoring performance of the air cargo industries in the corresponding states (at a lesser detail level) may be needed.

- Promote California air cargo business.

The FAA plays the role of a promoter of the nation’s aviation industry, although this role has generated much controversy because of the FAA’s role in ensuring aviation safety. The State naturally plays the role of a promoter of the State’s aviation industry, including the air cargo industry.

- Coordinate activities among California airport authorities.

This role may overlap with current roles of the MPOs. Coordination may be needed for many different reasons, e.g., advocating system performance rather than individual airport performance in possible airspace redesign for clusters of airports, migration of cargo or passenger services to reliever airports, etc.

- Initiate and coordinate the development of new airports or related infrastructure.

As stated in [15], “Airport siting or expansion is often extremely controversial at the local level . The diversity of issues and intensity of debate have consistently led to inaction. The commission, therefore, recommended that the State become actively involved in the discussion surrounding airport capacity enhancement and ground access decisions.” This includes “accepting the responsibility and the authority for making a decision which is in the best interest of the State as a whole in those circumstances when the local authorities are politically paralyzed with indecision. Types of development include those for:

- new airports, on closed military bases or elsewhere,
- new runways on existing airports,
- airports for tiltrotors and helicopters, including those intended to be placed in downtown areas for both cargo and passenger movement,
- off-airport cargo stations or passenger terminals,

- “superhubs” or “wayports” for cargo and passenger operations.

6.0 Future Research Needs

Little is known about the role of air cargo in California's goods movement, and, hence, much future research is needed for understanding this role and for developing State strategies and action plans to facilitate efficient air cargo. Although many specific research needs have been identified in earlier sections of this white paper, they barely begin to "scratch the surface." In this section, we first state important categories of research needs and then illustrate the severe lack of understanding with some specific research needs.

6.1 Categories of Research Needs

Major categories of research needs include:

- Improve the understanding of air cargo operations and planning.
- Better understand the shipper's mode choice between air cargo and other modes of transportation in California's goods movement.
- Better understand the status of California's air cargo industry, the industry's planning/operational issues, the shipper's concerns, and the relative importance of the issues.
- Develop metrics of activity for California's air cargo industry, e.g., research into the amount of transfer traffic (i.e., connecting cargo) and transit traffic (i.e., through cargo) at cargo hubs or gateway airports in the State and factors that influence the growth of this segment of industry.
- Develop metrics of performance for California's air cargo operations.
- Improve the understanding of the interaction between air cargo movement and the State's surface transportation system, economy and environment. Develop metrics of such interaction. (These metrics can be used as an important input to the tasks of optimizing the operations of the overall transportation system in the State and promoting the State's economy. They can also be used to perform trade-off analyses.)
- Improve access to existing data sources, develop data fusion methods, identify data deficiencies, and develop data collection methods to measure the three types of metrics defined in the previous three bullet items.
- Develop a methodology for forecasting future air cargo activities at individual California airports.
- Develop strategies for resolving the industry's planning/operational issues and the shipper's concerns and for improving air cargo planning and operations in California.

- Identify appropriate State, regional and local governments' roles in the pursuit defined in the previous bullet item.

6.2 Illustration of Severe Lack of Understanding with Specific Research Needs

This subsection illustrates the severe lack of understanding of the role of air cargo in California's goods movement with some specific research needs.

- Lack of (Public-Domain) Data and Models for Estimating Weights of Air Cargo Originating from, Transferring at, Passing Through or Destined for California Airports

Fundamental to understanding the role of air cargo in the State's goods movement is the knowledge about key attributes, e.g., the weight, value, number of pieces, etc., of cargo traffic (i) originating from, (ii) transferring at, (iii) passing through or (iv) destined for a given California airport. Currently, only weigh information is available. More importantly, none of the four fundamental types of information is available. What are available are (i) the weight of cargo enplaned at an airport and (ii) the weight of cargo deplaned at an airport. Note that none of the four fundamental types of traffic information can be accurately inferred from these two available data types.

In fact, deplanement cargo data have been lacking. For example, the Schedule T-100 data do not include the weight of cargo deplaned at the destination of a "reportable flight." (our data sources for such deplanement data are Airport Traffic Reports and Worldwide Airport Traffic Reports published by individual airport authorities and the Airports Council International, respectively. But, these reports contain only highly aggregated data.) However, the Schedule T-100 data do include the weight of cargo enplaned onto a reportable flight at an airport and that of cargo transported (i.e., on board) the flight. The difference between the two weights is the weight of cargo passing through the airport on the aircraft. However, reporting of such weights is not required of certain types of air carriers and a significant number of flights, and the amount of under-reporting is unclear.

Although reporting of Schedule T-3 data was required of those air carriers or flights that were exempted from reporting Schedule T-100 data (as a supplement to Schedule T-100 reporting), only the weight of cargo enplaned on a flight is required by Schedule T-3 (and reporting of the weight of on-board cargo is not required). Therefore, weight of transit or through cargo cannot be accurately inferred, not to mention the weight of transfer cargo.

Since the air cargo deplaned at an airport may be loaded (enplaned) onto another aircraft at the airport for transportation to another airport for transfer (i.e., connection), it is not possible to estimate the amount of air cargo originating from or destined for a given airport without the knowledge of the amount of the transfer cargo.

- Lack of (Public-Domain) Data and Models for Understanding Commodity Flow via Individual California Airports

In addition to weight information, also fundamental to understanding the role of air cargo in the State's goods movement is the composition and value of the commodity shipped by air. One data source does provide information about commodity type, value and even weight, and that is the Commodity Flow Survey (CFS), which is performed every five years and the previous survey took place in 1993. However, its geographical unit of reporting is not airport or metropolitan area/region but a much larger aggregate. This is a major limitation for studying the role of air cargo in the State's goods movement.

Another limitation of the 1993 CFS is that it focuses on domestic transportation of goods. Although information about whether a shipment is being exported to another country is requested on the survey form, it is not used to reveal the amount of transportation activities involved beyond the port of exit. In fact, the port of exit is effectively considered by the survey as the final destination for an exporting shipment. This imposes a major limitation on studying the role of air cargo in goods movement in California because of the international-gateway nature of several of the California's airports. Note that international air cargo accounted for approximately 50% and 40% of total air cargo at the San Francisco and Los Angeles International Airports in 1996, respectively.

There are other limitations. Ten possible modes of transportation were defined in the 1993 CFS, including the mode named Parcel, U.S. Postal Service, or Courier. The Parcel mode is multi-modal by nature, and this results in another major limitation of the 1993 CFS for the study. It is not clear how much of the goods shipped through the Parcel mode involves air transportation. The 1993 CFS sampled primarily establishments in mining, manufacturing and whole-sale trade, and selected retail industries. However, the survey coverage excluded most service industries. Also, the 1993 CFS reports only data about commodity movements originating from California establishments, not those movements destined for California. As a result, no import activities (from abroad) are reported by the survey findings.

U.S. exports and imports data collected by the U.S. Department of Commerce International Trade Administration can and should be used to compensate for the domestic nature of CFS, in terms of its lack of data on both exports and imports. Private air cargo operators should be approached and relevant proprietary data solicited. These are important subjects for future research.

Based on the illustration given above, the severe lack of knowledge about the role of air cargo in the State's goods movement and the resulting urgency of the companion research needs should be abundantly clear.

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Appendix: Sources for Air Cargo and Related Traffic Data and Analyses

This appendix summarizes the following twenty different data sources:

- (A.1) Commodity Flow Survey (1993)
- (A.2) Nationwide Truck Activity and Commodity Survey (NTACS;1990)
- (A.3) T-100 Data Bank 28DM Domestic Market Data
- (A.4) T-100 Data Bank 28DS Domestic Segment Data
- (A.5) T-100 Data Bank 28IM International Market Data
- (A.6) T-100 Data Bank 28IS International Segment Data
- (A.7) Airport Activity Statistics of Certified Route Air Carrier (based on Schedules T-100 and T3, RSPA Form 41)
- (A.8) TRANSEARCH (Air Cargo Portion Only)
- (A.9) Air Carrier Activity Information System (ACAIS): (Reports include: Air Carrier Passenger Enplanements, All-Cargo Landings and Apportionments)
- (A.10) Worldwide Airport Traffic Report by Airports Association Council International
- (A.11) U.S. International Air Passenger and Freight Statistics
- (A.12) FAA Statistical Handbook of Aviation
- (A.13) Scheduled and Charter Freight Traffic Forecast by International Air Transport Association
- (A.14) World Air Cargo Forecast
- (A.15) FAA Aviation Forecasts
- (A.16) O & D Survey (Form 41)
- (A.17) FAA Air Traffic Activity
- (A.18) Truck Inventory and Use Survey (TIUS)
- (A.19) U.S. Exports by State of Origin
- (A.20) Handbook of Airline Economics, Aviation Week Group, New York, 1995.

(A.1) Commodity Flow Survey (1993)

- Purposes: Provide data on the flow of goods and materials by mode of transportation.
- Mode of Transportation: Intermodal, including air and truck transportation
- Sponsoring Organization: Bureau of Transportation Statistics and FHWA of US DOT; Bureau of the Census of US Department of Commerce.
- Performing Organization: Bureau of the Census of US Department of Commerce; Oak Ridge National Laboratory.
- Update Frequency: survey initiated for 1992 commodity flow activities (actual survey conducted in 1993); survey scheduled for 1997 and every 5 years thereafter for years ending in “2” and “7”; next survey will be conducted in 1998 for 1997 activities.

- **Sampling and Sample Size:** A sample of 200,000 domestic establishments randomly selected from a universe of approximately 800,000 establishments engaged in mining, manufacturing, wholesale, auxiliary establishments (warehouses) of multi-establishment companies, and some selected activities in retail and service was used. Each establishment reported a sample of approximately 30 outbound shipments for a two-week period in each of the four calendar quarters of 1992. This produced a total sample of approximately 13 million shipments.
- **Major Data Elements and Detail Levels:** for each sampled shipment, data elements of following detail level were collected.
 - domestic modes of transportation
 - OD: zip code of origin and that of domestic destination; for exports, the domestic destination was the port of exit; Oak Ridge National Laboratory estimated the distance of shipment based on OD and domestic modes of transportation
 - commodity classification: 5-digit Standard Transportation Commodity Classification
 - weight
 - value
 - misc.: containerization, hazard material, export.
- **Major Data Aggregation for Release to public:** Aggregating ODs into 89 National Transportation Analysis Regions (NTARs), which are combinations of Business Economic Areas (BEAs)
- **Degree of Disclosure Concern:** Only aggregated data were released, in the forms of 2 CD-ROMs, Printed source and Internet. As of March 1996, 141 reports had been published, which included a set of State reports, a set of NTAR reports, a preliminary United States Summary, and a final, more detailed United States Summary.
- **Applications:** Data from the Commodity Flow Survey provided key components for a variety of reports and special analyses, e.g., Transportation in the United States: A review; Transportation Statistics Annual Report, 1997; Truck Shipments in America: Shipments to, From, Within, and Through States.
- **Contact for Additional Information:** Commodity Flow Survey Branch, DOC/Bureau of the Census, Services Division, (301) 457-2108.
- **Availability:** Department of Transportation, Bureau of Transportation Statistics

(A.2) Nationwide Truck Activity and Commodity Survey (NTACS;1990)

- Purposes: Provide detailed annual and daily activity data for a sample of truck operators responding to the 1987 Truck Inventory and Use Survey (TIUS) in order to capture the temporal and geographic variation in truck use and to measure other detailed attributes of trucking that were beyond the scope of TIUS.
- Mode of Transportation: Truck, with linkage to air transportation. Survey solicits activity information on one sample day, and the solicited information includes information about each and every stop during the day. “Place type” of each stop is included in the information, and airport is a place type.
- Sponsoring Organization: FHWA of US DOT.
- Performing organization: Statistics and Data Analysis Group, Center for Transportation Analysis Energy Division, Oak Ridge National Laboratory.
- Update Frequency: Discontinued, and extended by Commodity Flow Survey.
- Sampling and Sample Size: The data were collected for days selected at random over a 12-month period ending in October of 1990. The 1990 NTACS sample of 44,002 trucks was a sub-sample of the approximately 105,000 sample truck respondents to the 1987 TIUS. Approximately 22,004 sample truck operators returned the 1990 NTACS questionnaires of which 9,794 operators reported some information on daily truck activity. (Only operators of trucks no less than four years old were sampled.)
- Major Data Elements and Detail Levels: for each sample shipment, data of following detail level were collected.
 - OD: city.
 - commodity classification: 2-digit codes.
 - weight
 - no value
 - modes of transportation: truck, but intermodal transfer can be inferred.
 - departure/arrival times
- Database Integration: None. “Preliminary comparisons with other data sources revealed inconsistencies. Individual estimates are not highly reliable and should be used cautiously only to give impressions of broad trends, patterns and distributions.”
- Degree of Disclosure Concern: A public-use file is available. The 1990 NTACS Summary Report contains many selected tables.
- Availability: ORNL/TM-12361, Oak Ridge National Laboratory.

(A.3) T-100 Data Bank 28DM Domestic Market Data

- Sponsoring Organization: US DOT-BTS Office of Airline Information
- Performing Organization: US DOT-BTS Office of Airline Information
- Update Frequency: Month. (Each monthly data tape contains three months worth of data. Annually, OAI provides a calendar year tape.)
- Sampling and Sample Size: (100% Sampling.) For details, see Section 2.4.3.
- Major Data Elements and Detail Levels:
 - carrier: large certified U.S. carrier except for charter carriers or all-cargo carriers with only domestic operations
 - operations: domestic scheduled passenger/cargo operations and all international operations of scheduled and non-scheduled passengers/cargo and all-cargo services, except international military charter operations
 - OD: none (airport data only)
 - airport: all U.S. airports used by the reporting carriers for the reported operations
 - freight enplaned/deplaned (weight)
 - enplaned at origin
 - commodity classification: mail, freight
 - passengers enplaned/deplaned
 - enplaned at origin
- Degree of Disclosure Concern: All in public domain.
- Contact for Additional Information: US DOT-BTS at (202) 366-4888.
- Availability: To obtain data tapes, contact National Archives and Records Administration (NARA) - Center for Electronic Records (NNXA) at (301) 713-6645.
- Value-Added Data Service Providers: Many.

Note: This and the three following databases are generated based on the information reported to the US DOT by large certified air carriers on Schedules T-100 and T-3, Research & Special Programs Administration (RSPA) Form 41, Uniform Systems of Accounts and Reports for Large Certified Air Carriers.)

(A.4) T-100 Data Bank 28DS Domestic Segment Data

- Sponsoring/Performing Organization: US DOT-BTS Office of Airline Information
- Update Frequency: Month. (Each monthly data tape contains three months with of data. Annually, OAI provides a calendar year tape.)
- Sampling and Sample Size: (100% Sampling.) For details, see Section 2.4.3.
- Major Data Elements and Detail Levels:
 - carrier: large certified U.S. carrier except for charter-only carriers or all-cargo carriers with only domestic operations
 - operations: domestic scheduled passenger/cargo operations and all international operations of scheduled and non-scheduled passengers/cargo and all-cargo services, except international military charter operations
 - OD: origin and destination U.S. airports
 - aircraft type
 - available freight capacity
 - freight enplaned at origin airport (weight)
 - freight transported on the segment (weight), i.e., on-board at departure
 - commodity classification: mail, freight
 - available seats
 - passengers enplaned at the origin airport
 - passengers transported (on-board)
 - block hours (aircraft hours ramp-to-ramp)
 - airborne hours
 - misc.: service class
 - departures scheduled
 - departures performed
- Degree of Disclosure Concern: All in public domain.
- Contact for Additional Information: US DOT-BTS at (202) 366-4888.
- Availability: To obtain data tapes, contact National Archives and Records Administration (NARA) - Center for Electronic Records (NNXA) at (301) 713-6645.
- Value-Added Data Service Providers: Many.

(A.5) T-100 Data Bank 28IM International Market Data

- Sponsoring/Performing Organization: US DOT-BTS Office of Airline Information
- Update Frequency: Month
- Sampling and Sample Size: 100% Sampling. (See Section 2.4.3 for more detail.)
- Major Data Elements and Detail Levels:
 - carrier: large certified U.S. carriers except charter-only carriers and all-cargo carriers with only domestic operations; all foreign carriers.
 - operations: all international operations of scheduled and non-scheduled passenger/cargo and all cargo services, except international military charters
 - OD: For U.S. carriers, at least one point has to be outside the U.S. or in one of its territories. All foreign carriers data must have at least one point in the U.S. or in one of its territories.
 - freight enplaned at origin airport (weight)
 - commodity classification: mail, freight
 - passengers enplaned at origin airport
- Degree of Disclosure Concern: Restricted; held confidential for three years after the report date.
- Contact for Additional Information: US DOT-BTS at (202) 366-4888.
- Availability: To obtain data tapes, contact National Archives and Records Administration (NARA) - Center for Electronic Records (NNXA) at (301) 713-6645.
- Value-Added Data Service Providers: Many.

(A.6) T-100 Data Bank 28IS International Segment Data

- Sponsoring/Performing Organization: US DOT-BTS Office of Airline Information
- Update Frequency: Month
- Sampling and Sample Size: 100% Sampling. (See Section 2.4.3 for details.)
- Major Data Elements and Detail Levels Include:
 - carrier: large certified U.S. carriers, except for charter-only carriers and all-cargo carriers with only domestic operations; all foreign carriers
 - operations: all international operations of scheduled and non-scheduled passenger/cargo and all cargo services, except international military charters.
 - OD: For U.S. carriers, at least one point has to be outside the U.S. or in one of its territories. All foreign carriers data must have at least one point in the U.S. or in one of its territories.
 - aircraft type
 - service class
 - available freight capacity
 - freight enplaned at origin (weight)
 - freight transported (weight), i.e., on-board at departure
 - commodity classification: mail, freight
 - available seats
 - passenger enplaned at origin airport
 - passengers transported (on-board)
 - block hours (aircraft hours ramp-to-ramp)
 - airborne hours
 - departures scheduled
 - departures performed
- Degree of Disclosure Concern: Restricted; held confidential for three years after the report date.
- Contact for Additional Information: US DOT-BTS at (202) 366-4888.
- Availability: To obtain data tapes, contact National Archives and Records Administration (NARA) - Center for Electronic Records (NNXA) at (301) 713-6645.
- Value-Added Data Service Providers: Many.

(A.7) Airport Activity Statistics of Certified Route Air Carrier (based on Schedules T-100 and T3, RSPA Form 41)

- Sponsoring/Performing Organization: Research & Special Programs Administration (RSPA) furnishes data; the Office of Aviation Policy, Plans and Management Analysis of the FAA compiles/publishes them.
- Reporting period: calendar year
- Update Frequency: annual
- Data Sources: compiled from information reported to the US DOT by large certified air carriers on Schedules T-100 and T-3, Research & Special Programs Administration (RSPA) Form 41, Uniform Systems of Accounts and Reports for Large Certified Air Carriers.
- Contents: (7 Tables)
 - Data Reported: Data for commuter, intrastate, and foreign-flag air carriers are not included.
 - Summary Tables:
 - Table 1: Summary of (Scheduled and Performed) Aircraft Departures, Enplaned Revenue Passengers, and Enplaned Revenue Tons of Cargo and Mail by Type of Service, by Carrier Group, and by Air Carrier.
 - Table 2: Summary of (Scheduled and Performed) Aircraft Departures, Enplaned Revenue Passengers, and Enplaned Revenue Tons of Cargo and Mail by Type of Service, by State and U.S. Area
 - Table 3: (Scheduled and Performed) Aircraft Departures, Enplaned Revenue Passengers, and Enplaned Revenue Tons of Cargo and Mail in total operations (Percent of Total Enplaned Passengers), All Services at Large Air Traffic Hubs
 - Table 4: (Scheduled and Performed) Aircraft Departures, Enplaned Revenue Passengers, and Enplaned Revenue Tons of Cargo and Mail in total operations (Percent of Total Enplaned Passengers), All Services at Medium Air Traffic Hubs
 - Table 5: (Scheduled and Performed) Aircraft Departures, Enplaned Revenue Passengers, and Enplaned Revenue Tons of Cargo and Mail in total operations (Percent of Total Enplaned Passengers), All Services at Small Air Traffic Hubs
 - Detailed Tables:
 - Table 6: Enplaned Revenue Passengers, and Enplaned Revenue Tons of Freight and Mail by Type of Service, by Community and by Air Carrier
 - Table 7: Aircraft Departures Scheduled and Aircraft Departures Performed, by Community, by Air Carrier, and by Aircraft Type

- Degree of Disclosure Concern: public domain
- Contact for Additional Information: FAA, Planning Analysis Division (APO-100), 800 Independence Avenue, S.W., Washington, D.C. 20591; (202) 267-3355.
- Availability: Order from U.S. Government Printing Office or National Technical Information Service

(A.8) TRANSEARCH (Air Cargo Portion Only)

TRANSEARCH is a source of freight traffic flow information covering rail, for-hire truckload, less-than-truckload, private truck, air and water. TRANSEARCH is a large database; we focus on only the air cargo portion.

- Performing Organization: Reebie Associates
- Update Frequency: annual
- Derivation Process: Air cargo information is mainly derived from the Airport Activity Statistics (AAS), together with some disaggregation. The AAS data reports the total tonnage originating at each airport. TRANSEARCH processing first assigns, and combines where necessary, the airport location into Business Economic Areas (BEAs). The origin tonnage is then desegregated into commodity classifications based on prior-year TRANSEARCH air cargo flow data and annual updating of commodity volumes at the 4-digit Standard Transported Commodity Code level. The tonnage by origin BEA and 4-digit commodity description are then desegregated into flow patterns to destination BEAs using a similar technique. Prior-year TRANSEARCH flows establish the destination patterns.
- Desegregation: validity unclear
- Major Data Aggregation for Release: OD: BEAs
- Degree of Disclosure Concern: proprietary
- Contact for Additional Information: Reebie Associates
- Availability: Reebie Associates, P.O. Box 1436, Greenwich, CT 06836; (203) 661-8661.

(A.9) Air Carrier Activity Information System (ACAIS): (Reports include: Air Carrier Passenger Enplanements, All-Cargo Landings and Apportionments)

- Purposes: The ACAIS is a database of passenger enplanement data and cargo landing data that support the FAA's Airport Improvement Program (AIP) activities and apportion AIP entitlement funds. Congress recognizes that air cargo activity is an important and growing segment of air commerce which will necessitate the development and expansion of airport facilities, particularly at airports having air cargo traffic. Accordingly, the entitlement legislation established a new entitlement program to allocate a portion of AIP funds among cargo service airports that handle more than 100 million pounds of all-cargo aircraft landed weight annually. (Note that aircraft landed weight is defined as the total weight of a landing aircraft, not just the weight of the cargo being carried.) Cargo entitlement funds are allocated each fiscal year based on each eligible cargo service airport's percentage of the landed weight at all eligible airports.
- Mode of transportation: air (passenger and cargo)
- Sponsoring Organization: FAA's Office of Airport Planning and Programming
- Performing Organization: Research and Special Programs Administration of the US DOT; Volpe National Transportation Systems Center
- Update Frequency: annual
- Relevant Tables:
 - Table 4: Airport Improvement Program Entitlement Fund Allocations Distribution of \$50,000,000 for cargo Hub Airports, Listed by State and by Sponsor Code for Fiscal Year XXXX
 - Table 5: Airport Improvement Program Entitlement Fund Allocations Distribution of \$50,000,000 for cargo Hub Airports, Listed by State and by Sponsor Code for Fiscal Year XXXX; Separated by Region
 - Table 31: F-1R- FY XXXX AIP Air Cargo Entitlement Fund Allocations, by Rank Order, All Cargo Service Airports
 - Table 32: F-1R- FY XXXX AIP Air Cargo Entitlement Fund Allocations, Separated by Regions
 - Table 33: Cargo Hub Airports Fiscal Year XXXX Apportionments Showing Site Number
 - Table 34: Summary of XXXX Cargo landings for FAA Form 5100-108 at Individual Airports
- Degree of Disclosure Concern: public domain
- Contact for Additional Information: RSPA/Volpe National Transportation System Center
- Availability: RSPA/VNTSC

(A.10) Worldwide Airport Traffic Report by Airports Council International

- Sponsoring/Performing Organization: Airports Council International
- Update Frequency: month
- Data Collected and Detail Levels: For each of the 370 airports, three types of information are reported: aircraft movements, commercial passengers, and cargo in tons. The aircraft movements section includes data by type of aircraft for commercial transport operations: passenger and combi aircraft, all-cargo aircraft, and general aviation and other aircraft. Commercial passenger information includes domestic, international passengers, and in-transit passengers. The domestic and the international passengers data is in the form of the sum of enplaned and deplaned passengers. Freight and mail data include domestic and international cargo, but the data is in the form of the sum of the amounts of the loaded and the unloaded cargo. The airports responding to the ACI survey are ranked in three different ways: by total passengers, by total cargo, and by total aircraft movements for a twelve-month reporting period.
- Degree of Disclosure Concern: The report is in the public domain.
- Contact for Additional Information: ACI
- Availability: ACI

The following reports contain relevant information.

(A.11) U.S. International Air Passenger and Freight Statistics

- Sponsoring/Performing Organization: US DOT, Office of the Secretary of Transportation (Office of the Assistant Secretary for Aviation and International Affairs; Office of International Aviation)
- Reporting Period: month (current year and previous year), year-to-date
- Update Frequency: monthly
- Data Sources: T-100 database
- Information relevant to air cargo trends:
 - freight trends
 - US vs. the World
 - top five US international freight gateways
 - change in world regional freight: nine regions of the world
 - country: top five country markets
- Relevant Tables: (Note: Freight tons do not include mail.)
 - Table 7: Freight Tons between U.S. and the World (Arrivals and Departures Combined) by Service Type (Scheduled or Chartered), Flag (US vs. non-US), 12 Individual Months (Current Year and Previous Year), and year-to-date
 - Table 8: Freight Tons between the United States and World Regions (Arrivals and Departures Combined) by Service Type (Scheduled or Chartered), Flag (US vs. non-US), Particular Month (Current Year and Previous Year), and year-to-date
 - Table 9: Freight Tons between the US and Other Countries (Arrivals and Departures Combined): Top 25 Countries Ranked by Total Number of Freight Tons for a Particular Month of a Particular Year and the Previous Year by Service Type (scheduled or chartered) and Flag (US vs. non-US)
 - Table 10: Freight Tons between the US and Other Countries (Arrivals and Departures Combined): Top 25 Countries Ranked by Total Number of Freight Tons for a Four-Month Period of a Particular Year and the Previous Year by Service Type (Scheduled or Chartered) and Flag (US vs. non-US)
 - Table 11: Top 15 US International Freight Gateways (Arrivals and Departures Combined; Scheduled and Non-Scheduled Combined) for a Particular Month of a Particular Year and the Previous Year by Flag (US vs. non-US)
 - Table 12: Top 15 US International Freight Gateways (Arrivals and Departures Combined; Scheduled and Non-Scheduled Combined) for a Four-Month Period of a Particular Year and the Previous Year by Flag (US vs. non-US)

- Degree of Disclosure Concern: public domain
- Contact for Additional Information: International Data System Division, Office of International Aviation, Department of Transportation, 400 Seventh Street, S.W., Washington, D.C. 20590; (202) 366-2372.
- Availability: Office of the Secretary of Transportation, US DOT, 400 Seventh Street, S.W., Washington, D.C. 20590

(A.12) FAA Statistical Handbook of Aviation

- Purposes: This report serves as a convenient source of historical data and presents statistical information pertaining to the FAA, the National Airspace System, Airports, Airport Activity, U.S. Civil Air Carrier Fleet, U.S. Civil Air Carrier Operating Data, Airman, General Aviation Aircraft, Aircraft Accidents, Aeronautical Production and Imports/Exports, and a Glossary of the terms used in this publication.
- Sponsoring/Performing Organization: FAA, Office of Aviation Policy, Plans and Management Analysis
- Update Frequency: annual
- Information Contents: (Numerous Tables)
 - Chapter IV: Airport Activity of Certified Route Air Carrier, including
 - summary of 12-month data of the reporting year from Airport Activity Statistics (AAS) discussed earlier.
 - American Flag Airline Traffic Enplaned - Ten-Year Trend
 - System Total
 - 50 States
 - Stations
 - Foreign Countries
 - Chapter VI: U.S. Certified Air Carriers - Operating Data, including
 - Total Ton-Miles Available in All Services of the Large Certified Air Carriers: 10-year trend
 - Revenue Ton-Miles Flown in All Services by Large Certified Air Carriers: 10-year trend
- Degree of Disclosure Concern: public domain
- Contact for Additional Information: FAA, Office of Aviation Policy
- Availability: National Technical Information Service, Springfield, Virginia 22161, or U.S. Government Printing Office

The following four databases/reports provide forecasts about air cargo, among other things.

(A.13) Scheduled and Charter Freight Traffic Forecast International Air Transport Association

- Sponsoring/Performing Organization: International Air Transport Association, Management Information Division
- Update Frequency: unclear
- Most Recent Edition: 1992 - 1996
- Forecast Methodology: Compilation of individual airline forecasts. For each country-pair where a participating airline operated freight service, the airline submitted estimates of the number of freight tons carried in each direction by all airlines combined in 1991, and forecasts of growth as annual percentages for 1992, 1993, and 1994. An average rate was submitted for 1995 and 1996. Where more than one airline provided forecasts for a country-pair, the arithmetic mean was used for the country-pair forecasts. The 1991 base year figures were used to weigh and aggregate country-pair forecasts into regional forecasts, by country and by region. 44 International carriers provided IATA with their input. Therefore, the forecast does not cover all country-pairs or all airlines.
- Major Information Contents:
 - Highlights
 - Total world international scheduled and charter freight volume projected annual rates of growth
 - Ranking of world regions in terms of average annual rates of growth for the period 1992 - 1996
 - Forecast methodology
 - Historical and forecast world trends
 - Country summary
 - Regional summary
 - Country to region forecasts
 - Regional forecasts
- Degree of Disclosure Concern: public domain
- Contact for Additional Information: Management Information Division, IATA, Route de l'Aéroport, P.O. Box 672, 1215 - Geneva 15 Airport, Switzerland
- Availability: Same as above

(A.14) World Air Cargo Forecast

- Sponsoring/Performing Organization: Boeing Commercial Airplane Group
- Update Frequency: every two years; most recent issue - 1996/1997
- Information Contents:
 - Significant World Airline Trends
 - World Overview and Forecast
 - Regional and inter-regional forecasts
 - North America
 - Latin America and North America
 - Europe and North America
 - Intra-Europe
 - Middle East
 - Africa
 - Asia and North America
 - Europe and Asia
 - Intra-Asia
 - World Freight Fleet
- Degree of Disclosure Concern: public domain
- Contact for Additional Information: Boeing Commercial Airplane Group
- Availability: Boeing Commercial Airplane Group

(A.15) FAA Aviation Forecasts

- Purposes: This report contains the Fiscal Years 1995 - 2006 FAA forecasts of aviation activity at FAA facilities. These include airports with FAA control towers, air route traffic control centers, and flight service stations. Detailed forecasts were made for the major users of the National Aviation System: air carriers, air taxi/commuters, military, and general aviation. The forecasts have prepared to meet the budget and planning needs of the constituent units of the FAA and to provide information that can be used by state and local authorities, the aviation industry, and the general public.
- Mode of transportation: Intermodal, including air and truck transportation
- Sponsoring/Performing Organization: Office of Aviation Policy, Plans and Management Analysis
- Update Frequency: unclear; most recent issue covers 1995 - 2006.

- Relevant Information Contents:
 - Economic environment
 - Commercial air carriers
 - Regionals/commuters
 - Forecast accuracy
 - Year-to-year data for FAA aviation forecasts

- Degree of Disclosure Concern: public domain

- Contact for Additional Information: Office of Aviation Policy, Plans and Management Analysis

- Availability: National Technical Information Service, Springfield, Virginia 22151

The following are useful in the sense that they provide key information about air passenger traffic, which shares many common resources with the air cargo traffic, about the National Aviation System, or about truck traffic, a portion of which is contributed by the ground portion of air cargo movement.

(A.16) O & D Survey (Form 41)

The O&D Survey begins with the passenger tickets used for all domestic flights on “large air carriers.” Prior to 1987, a 10% sample of these tickets is recorded by all domestic carriers, according to the industry rules and regulations. Beginning July 1, 1987, the Survey is collected primarily on the basis of a stratified, scientific sample of at least 1% of tickets in domestic major markets and 10% of tickets in all other domestic and in all international city-pair markets. This data is reported to the U.S. Department of transportation each quarter in the carrier’s Form 41 Reports.

(A.17) FAA Air Traffic Activity

This report contains data on terminal and en route air traffic activity, including airport operations, instrument operations, instrument approaches, airport advisories, etc.

(A.18) Truck Inventory and Use Survey (TIUS)

TIUS is a vehicle-based survey of truck activity conducted by the Bureau of the Census as part of the quinquennial Census of Transportation. It collects data to measure truck usage from a sample of approximately 150,000 trucks, vans, and minivans out of an entire population of 50 million private and commercial registered trucks. Data collection is performed through a mail survey sent to vehicle owners covering physical and operational vehicular statistics. TIUS data are modified to avoid disclosure of sampled vehicles or operating companies.

(A.19) U.S. Exports by State of Origin

U.S. Exports by State of Origin Data are collected by the Data User Services Division of the U.S. Bureau of the Census. Data records provide commodity and routing profiles on a State, regional, or national level. The data include an unknown proportion of errors due to such factors as reporting of a headquarters’ office as an origin or reporting of a transshipment port as an origin. Also, shipments without origin-destination information are not included in the database but are estimated in the databases. Export tapes are available for purchase approximately 4 months after close of period.

(A.20) Handbook of Airline Economics, Aviation Week Group, New York, 1995.

This handbook contains relevant information regarding air cargo and other key aspects of the air transportation. Example articles relevant to air cargo include:

- “The use of air cargo for U.S. international export shipments,” by John Dutton and Charles Edwards,
- “Airport routing patterns for the U.S. international air cargo market” by Rex J. Edwards.
- “The emergence of the international integrated all-cargo air carrier” by Tom Weidemeyer.