

# ISyE6203 Transportation and Supply Chain Systems

## Air Cargo Transportation



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# Importance of Air Cargo

- Items carried by air are high value goods such as aircraft and auto parts, computers, electronic and optical equipment, pharmaceuticals, machine tools, precision instruments, and perishable foodstuffs
  - Airfreight traffic constitutes less than 2 percent of all tonnage transported
  - However, it represents over a third of the total value of all international trade



# Air Ton-Kilometers (Millions)

Year	Total	% Change	International	% Change
– 1984	39670	12.99%	28940	14.84%
– 1988	53270	10.24%	41020	11.80%
– 1992	62560	6.89%	50750	9.40%
– 1993	68440	9.40%	55660	9.67%
– 1994	77210	12.81%	64690	16.22%
– 1995	83120	7.65%	70320	8.70%
– 1996	88810	6.85%	75200	6.94%



# Airfreight Growth

- The average annual growth in air cargo internationally during the last decade is 7.9 percent
- It is projected that among the six major shipping regions (Africa, Asia/Pacific, Europe, Middle East, North America, Latin America & Caribbean), the A/P region will have the largest share of airfreight traffic in the next decade



# Airfreight Growth

- In today's highly competitive world of business, time to market and good customer service are crucial
- Air cargo is no longer confined to the speedy shipment of emergency supplies
  - It is often the most advantageous and economical when all factors are considered
  - Air transport of goods has become one of the most effective tools to explore and serve world markets



# 1998 Airfreight Flows

	NA	SCA	EMEA	AP	Total
NA	1.7	3.4	17.5	13.7	36.3
SCA	3.4	1.1	3.6	1.6	9.7
EMEA	17.5	3.6	18.8	17.4	57.3
AP	13.7	1.6	17.4	17.7	50.4



# Major Cargo Airports - Tons

Rank	Airport	Total Cargo	% Change
1	MEMPHIS (MEM)	2,368,975	6.1
2	LOS ANGELES (LAX)	1,861,050	-0.7
3	MIAMI (MIA)	1,793,009	1.5
4	HONG KONG (HKG)	1,654,356	-8.8
5	TOKYO (NRT)	1,637,521	-5.8
6	NEW YORK (JFK)	1,604,422	-3.7
7	FRANKFURT/MAIN (FRA)	1,464,955	-3.3
8	CHICAGO (ORD)	1,441,829	2.5
9	SEOUL (SEL)	1,425,009	-9.1
10	LOUISVILLE (SDF)	1,394,999	3.7



# Rank      Airline      Million Tons

1	Federal Express	9,615
2	Lufthansa	6,221
3	United Parcel Service	5,516
4	Korean Air Lines	5,125
5	Singapore Airlines	4,828
6	Air France	4,596
7	Japan Airlines	4,050
8	British Airways	4,047
9	KLM	3,709
10	United Airlines	3,422



# US Air Carriers Output

	1998			1999		
	Domestic	International	Total	Domestic	International	Total
Total Revenue Ton Miles - Charter Service (millions)	5,869	3,478	9,347	5,664	3,059	8,723
Total Revenue Ton Miles - All Services (millions)	60,170	31,482	91,652	62,743	32,781	95,524
Total Available Ton Miles - All Services (millions)	105,367	53,867	159,234	109,655	55,605	165,260
Weight Load Factor - All Services (%)	57.1	58.4	57.6	57.2	59	57.8
Revenue Aircraft Departures - Scheduled Service (thousands)	7,803	489	8,292	8,116	501	8,617
Revenue Aircraft Miles - Scheduled Service (millions)	4,766	1,072	5,838	5,051	1,110	6,161
Revenue Aircraft Hours - Scheduled Service (thousands)	11,794	2,150	13,944	12,459	2,228	14,687



# US Air Carriers Cargo Output

	1998			1999		
(millions ton-miles)	Domestic	International	Total	Domestic	International	Total
Freight & Express	7,002	11,129	18,131	7,313	12,033	19,346
Mail	1,856	509	2,365	1,797	498	2,295
Total	8,858	11,638	20,496	9,110	12,531	21,641



# US Air Carriers Revenues

	1998			1999		
	Domestic	International	Total	Domestic	International	Total
Passenger	63,991	16,995	80,986	66,933	17,234	84,167
Freight & Express	5,791	4,906	10,697	5,828	5,411	11,239
Mail	1,423	285	1,708	1,471	263	1,734
Charter	2,777	1,044	3,821	2,643	1,063	3,706
Public Service	2	0	2	4	48	52
Other	12,510	3,741	16,251	13,721	3,626	17,347
Total Operating Revenues	86,494	26,971	113,465	90,600	27,645	118,245
(millions US\$)						



# Top 10 US Air Travel Markets

1	New York	Los Angeles	3,728
2	New York	Chicago	2,982
3	New York	Boston	2,821
4	New York	Miami	2,800
5	New York	Orlando	2,777
6	New York	San Francisco	2,743
7	Honolulu	Kahului, Maui	2,691
8	New York	Washington	2,551
9	New York	Atlanta	2,546
10	New York	Ft. Lauderdale	2,386

(thousands of passengers traveling either way)



# Top 10 US Passenger Airports

Rank	Airport	Passengers
1	Atlanta	77,940
2	Chicago O'Hare	72,568
3	Los Angeles	63,877
4	Dallas/Ft. Worth	60,000
5	San Francisco	40,387
6	Denver	38,034
7	Minneapolis/St. Paul	34,216
8	Detroit	34,038
9	Miami	33,899
10	Las Vegas	33,669



# Top 10 US Cargo Airports

Rank	Airport	Metric Tons
1	Memphis	2,413
2	Los Angeles	1,952
3	New York Kennedy	1,905
4	Anchorage	1,677
5	Miami	1,651
6	Chicago O'Hare	1,532
7	Louisville	1,486
8	Newark	1,206
9	Indianapolis	1,108
10	Dayton	894



# Top 10 US Passenger Airlines

	Number of Aircraft	Employees (full-time equivalent)	Number of Passengers (thousands)	Revenue Passenger Miles (millions)	Passenger Revenues (millions US\$)	Net Profit (Loss) (millions US\$)
Delta	581	70,640	105,434	104,699	13,203	1,286
United	590	92,216	86,472	125,372	15,441	1,204
American	697	87,600	84,637	111,878	14,694	626
Southwest	312	26,938	65,288	36,484	4,499	474
US Airways	383	39,852	55,812	41,467	6,848	273
Northwest	410	49,999	54,692	74,144	8,587	288
Continental	363	38,730	43,880	57,963	6,975	498
Trans World	184	20,259	25,790	26,009	2,962	-353
America West	123	11,162	18,686	17,694	2,024	117
Alaska	89	8,962	13,604	11,765	1,480	119



# Top 10 US Cargo Airlines

	Number of Aircraft	Employees (full-time equivalent)	Cargo Revenues (millions US\$)	Net Profit (Loss) (millions US\$)
FedEx	624	118,947	5,924	432
Airborne Express	114	5,774	1,101	123
DHL Airways	27	9,316	911	122
United	590	92,216	906	1,204
Emery Worldwide	39	4,369	799	-11
Northwest	410	49,999	724	288
American	697	87,600	634	626
United Parcel Service	231	4,858	595	66
Delta	581	70,640	557	1,286
Evergreen Int'l	18	550	286	12



# Aircraft Characteristics

Aircraft	Number of Seats	Average Cargo Payload (tons)	Airborne Speed (miles/hour)	Flight Length (miles)	Fuel Consumption (gallons/hour)	Aircraft Operating Cost (\$/hour)
B747-100	462	4.34	512	2,297	3,517	\$7,224
B747-400	375	9.07	537	4,065	3,351	6,455
B747-F	0	70.96	498	2,186	3,866	7,045
L-1011-100/200	320	9.68	496	1,403	2,557	4,891
DC-10-10	297	9.15	496	1,402	2,311	5,703
B-777	274	9.68	524	3,355	2,132	3,804
MD-11	259	8.86	527	3,073	2,464	6,539
B757-200	186	1.98	467	1,207	1,063	2,623
A320-100/200	148	0.62	461	1,192	818	2,227
MD-80	139	0.35	432	795	944	2,139
B727-200	150	0.54	441	698	1,320	2,567
B727-F	0	10.74	460	704	1,305	4,804



# US Air Carrier Safety Record

	Departures (millions)	Fatal Accidents	Fatalities	Fatal Accident Rates per 100,000 departures
1989	6.6	8	131	0.121
1990	6.9	6	39	0.087
1991	6.8	4	62	0.059
1992	7.1	4	33	0.057
1993	7.2	1	1	0.014
1994	7.5	4	239	0.053
1995	8.1	2	166	0.025
1996	8.2	3	342	0.036
1997	8.2	3	3	0.037
1998	8.3	1	1	0.012
1999	8.6	2	12	0.023

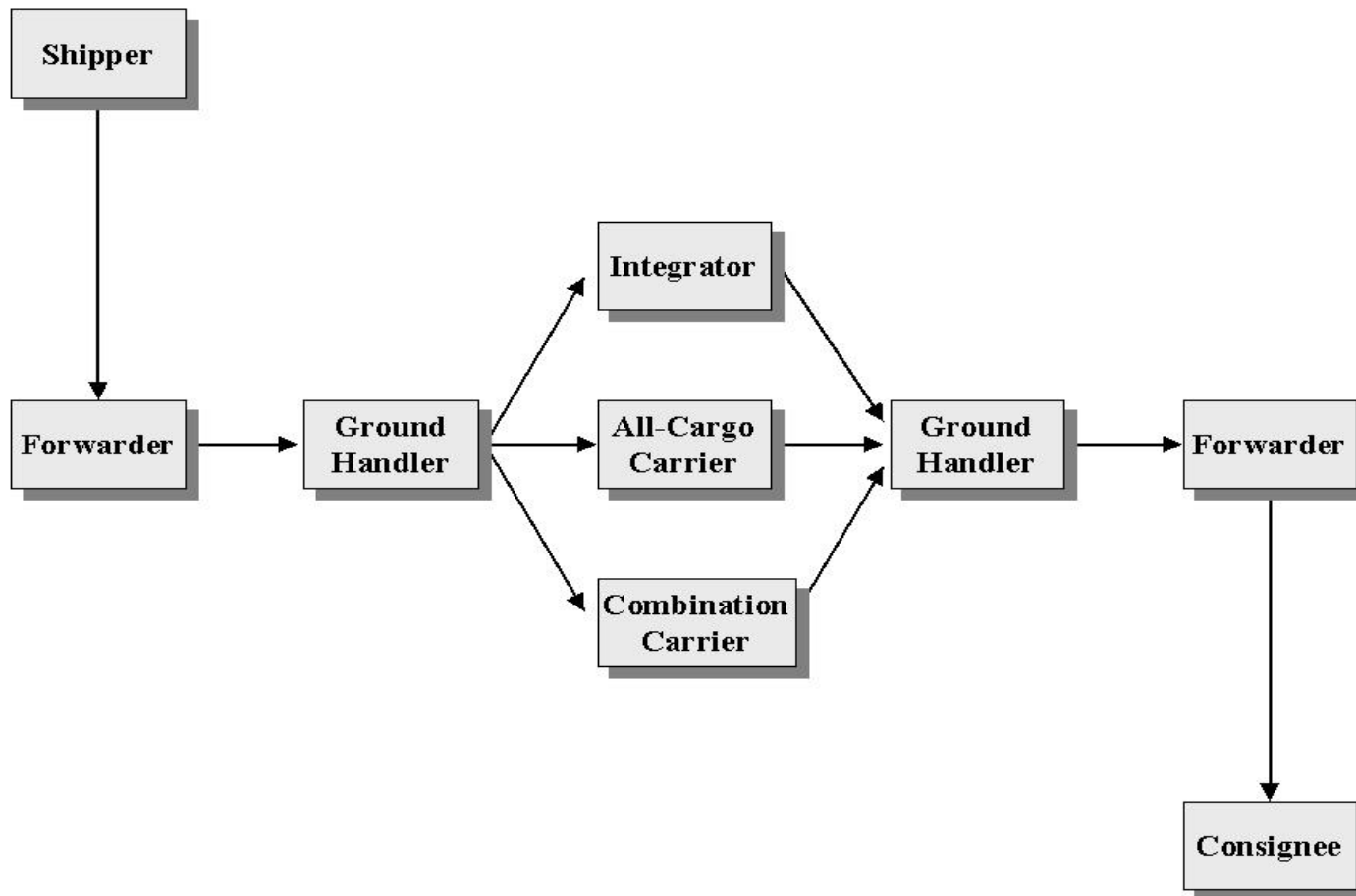


# FAA Aviation Forecasts

Fiscal Year	Number of Passengers (millions)	Passenger Miles (millions)	Passenger Jet Aircraft	Cargo Jet Aircraft	Domestic Departures (millions)
2000	650.4	670.7	4,824	1,046	7.4
2001	670.6	698	5,094	1,098	7.6
2002	691.2	726	5,390	1,150	7.8
2003	713.3	756.8	5,654	1,202	8
2004	742	793.7	5,926	1,251	8.2
2005	773.8	833.2	6,186	1,298	8.5
2006	806.7	874.4	6,463	1,357	8.7
2007	839.5	916	6,736	1,410	9
2008	874	960.2	7,024	1,467	9.2
2009	909.1	1,005.70	7,330	1,525	9.5
2010	944.7	1,052.60	7,637	1,580	9.8
2011	981.8	1,101.90	7,946	1,631	10.1



# Air Cargo System



# Air Cargo System

- **Shipper (Consignor)** – A company that contracts for the carriage of goods
- **Freight forwarder** – An agent that accepts cargo from shippers to be tendered to an airline to transport to the shipper's destination
- **Ground Handler** – An agent or company that provides ground handling services



# Air Cargo System

- **Integrator (Integrated carrier)** – A company that integrates the activities provided by trucking companies, freight forwarders, and carriers
  - DHL, Fedex, TNT, UPS
  - Significant threat to freight forwarders
- **Consignee** – The receiving party of the goods that are sent from the point of origin
  - End node of the air cargo supply chain



# Air Cargo Shippers

- High technology manufactured products, such as electronics products, are transported mainly through air
  - This sector is highly competitive and growing
- Apple, Compaq, Dell, Gateway, HP, IBM, Intel, Motorola, NEC, and Xerox
  - Heavily dependent on air transport
- Some agricultural produce
  - Flowers from the Netherlands



# Combination Carriers

- Scheduled flights for passengers that carry cargo in their belly
- Examples: Lufthansa, United Airlines, Northwest Airlines, Japan Airlines, Singapore Airlines, Cathay Pacific
- Also operate scheduled and chartered freighters for transporting goods
- Combination carriers have introduced time-guaranteed services (such as Singapore Airlines' Swiftrider and Timerider) to meet the requirements of their shippers



# Integrated Carriers

- The four major integrated carriers are
  - Federal Express Corporation (FedEx)
  - United Parcel Service (UPS)
    - UPS Logistics competes with freight forwarders
  - TNT Express Worldwide
    - Primarily uses other carriers to transport its goods
  - DHL Worldwide Express
- Traditionally, documents and packages
- Expansion is into heavier freight



# Airport Operations

- Ground handling operations at the airport play a crucial role in the air cargo system
  - Wide range of facilities such as coolers, chilled rooms, livestock rooms, and security vaults



# Air Cargo Storage Systems

Tokyo Air  
Cargo  
Terminal



# Air Cargo Storage Systems

The computerized storage and retrieval system in the Singapore airport

- Automated storage system, mechanised materials handling, container/pallet elevating transfer vehicles



# Air Cargo Storage Systems

- Loose cargo that arrives at the terminal before a specified time is stored in a bin and later retrieved for loading on the airplane
- Current practice at the SATS terminal 5 is to assign the arriving cargo randomly to bins
  - Fast storage and slow retrieval
  - In the worst case, each item (waybill) for a flight could be in a different bin



# Customs, Regional Realities

- Customs procedures vary widely between different nations
- International cargo transport requires strategies tailored to individual countries
- Customs process may not be transparent
  - Lengthy delays, high tariffs, imposed agents, bribes especially in some countries
  - These have combined to drive up logistics costs and hamper the viability of operations



# Some Observations

- Air cargo is step-child of passenger service
  - On the plus side - lots of frequency
  - On the minus side - low priority within the airline in general, e.g. Delta uses 737 in S.A.
  - SIA does not deal directly with shippers
- Dedicated freighters exist but not many
- FedEx, UPS, DHL have success but limited capacity



# Air Cargo Research Areas

- Air cargo operations at airports
  - Efficient material, information flows in airfreight terminals
  - Storage and retrieval systems
  - Appropriate performance metrics to evaluate air cargo hubs



# Air Cargo Research Areas

- Booking procedures, pricing, and yield management
  - Present ways of allocating capacity appear to be not responsive enough in dynamic environment of manufacture-to-order
  - Integrators may be winning
  - Capacity availability on certain lanes and during peak periods is of great importance
  - Better procedures could provide better service and more revenue to carriers



# Air Cargo Research Areas

- Air cargo network capacity and sensitivity analysis
  - Analysis of current capacity on lanes
  - How large an increase in demand (total or for a given market) is the air cargo system equipped to handle
  - If demand increases beyond this level, what is the most cost-effective way to provide the required additional capacity



# Capacity and Sensitivity

- What is effect on the freight handled by one airport if another airport increased its capacity
- What are the attributes of an air cargo hub that determine its effectiveness and volume
- How should freighter capacity be scheduled with respect to both routing and time
- On what routes is there insufficient capacity
- Would small changes in the passenger schedule provide significant benefits to cargo

