AIR CARGO LOGISTICS CENTERS: Technical Indicators for New Projects in the Metropolitan Airports System of Mexico

Juan Pablo Antún, Instituto de Ingeniería, Universidad Nacional Autónoma de México

Angélica Lozano, Instituto de Ingeniería, Universidad Nacional Autónoma de México

Rodrigo Alarcón, Instituto de Ingeniería, Universidad Nacional Autónoma de México

INTRODUCTION

This work presents some results of a research on logistics centers for air cargo in the Metropolitan Airports System of Mexico (MASM), which is composed of the international airports of Mexico City, Toluca, Puebla and Querétaro (Antún et al., 2009). This project was supported by the Program on Logistics Competitiveness (PROLOGYCA) of the Economy Ministry of the Federal Government.

Mexico was the country with the larger movement of air cargo in Latin America in 2008. The International Airport of Mexico City (MEX) was el number two, according the amount of the air cargo movement, after the airport of Sao Paulo Guarulhos (GRU). In an international comparison, MEX had the rank 43 (now July 2009, it has the rank 49).

The analysis of technical characteristics of Air Cargo Terminals within airports (first and second lines) and Logistics Centers for Air Cargo in third line out of the airports, were based on a benchmarking of logistics process operations of air cargo in leading airports in Asia: Hong Kong (HKG), Seoul (INC), Shangai (PDG), Tokyo Narita (NRT), Singapore (SIN), Taipei Taoyuan (TPE), Bangkok Suvarnabhumi (BKK) y Kuala Lumpur (KUL).

Technical parameters for the design of new projects of Air Cargo Terminals for the MASM were obtained considering that: the air cargo terminals in these airports are new y/o recent renewed, the cargo volumes are important, and the performance indicators show excellent service levels.

Additional parameters for the design of new projects of air cargo terminals within the MASM took into account the following: a) the connectivity and accessibility of each airport of the MASM, related to the road network and the especially new highways in the Central Region (Arco Norte, Circuito Mexiquense y Libramiento Norte de Toluca,); b) problems related to the location respect to the urban areas; and c) opportunities for the development on RFS links, considering operations congestion within the air cargo terminal at the International Airport of Mexico City (MEX).

This study was based on a set of previous researches: i) a general review of the situation of air cargo terminals in the airports of the Central Region (Antún et al., 2005); ii) an exploration on the decision processes of the agents linked to air cargo (Antún et al., 2008b), and iii) an analysis on the opportunities for logistics operators of air cargo in third line, operating in alliance with the low cost airlines (Antún et al., 2008c).

PANORAMA OF AIR CARGO IN MEXICO

Air Cargo and Airports in Mexico

Brazil, Mexico, Chile and Colombia are the countries in Latin America (LA), with the larger movement of air cargo. The International Airport of Mexico City (MEX) has the second place in air cargo movement in LA, only after the Sao Paulo Guarulhos Airport (GRU) in Brazil (see Table 1).

In Mexico, the airports that traditionally move the larger volumes of air cargo are the following: Mexico City (MEX), Guadalajara (GDL), Monterrey (MTY) and Cancun (CUN) (Martner et al., 2003; Gradilla et al., 2005).

However, a group of airports, which has emerged with an air cargo volume linked to specific market niches, is also important: the Airport of Toluca (TLC), that is a gateway of a global integrator (Fedex); the Airport of Puebla (PBC) and the Airport of Bajío in León (BJX), which are linked to the automobile industry; the Airport of San Luis Potosí (SLP) which is the "hub" of a local domestic leader courier operator (Estafeta); and the Airport of Saltillo (SLW) which is a domestic hub, in the northern part of the country, of another global integrator leader (DHL) (Herrera et al., 2005).

In this emergent panorama, the following airports also must also been considered: the Intercontinental Airport of Querétaro (QRO), which is linked to automobile spare parts and to the aeronautical industry; the Airport of Merida (MID), which is the head of air connections for domestic courier operators (Estafeta, Multipack) and a Mexican air cargo leader (MasAir); the Airport of Tijuana (TIJ), which is another head for domestic logistics operators but has also a good location for solving the problems and emergencies of the trans-border operations linked to the exportation assembly plant industry, and has a great potential for traffic to/from East according the availability of air connections with China; the Airport of Juarez City (CJS) and Airport of Reynosa (REX), that assist the exportation assembly plant industry; and the Airport of La Paz (LAP), linked to the tourist services supply chain in Baja California Sur (Rico 2001; 2004, 2007).

Airport Consortiums

In Mexico, the airports have been conceded to five airport consortiums and to mixed entities where are involved ASA (Airports and Auxiliary Services), the federal government and sometimes, private investors. The five airport consortiums are the following: the Mexico City Airport Consortium, which currently controls ASA; ASA Airport Consortium; Pacific Airport Consortium (Grupo Aeroportuario del Pacífico, GAP); Center-Northern Airport Consortium (Grupo Aeroportuario Centro Norte, OMA); and Southeastern Airport Consortium (Grupo Aeroportuario del Sureste, ASUR).

ASA operates the International Airport of Mexico City (MEX), and through the ASA Airport Consortium, the following airports: Obregón City, Sonora; El-Carmen City, Campeche; Colima City, Colima; Campeche City, Campeche; Chetumal, Quintana-Roo; Cuernavaca, Morelos; Victoria City, Tamaulipas; Guaymas, Sonora; Loreto, Baja-California-Sur; Matamoros, Tamaulipas; Nuevo Laredo, Tamaulipas; Nogales, Sonora; Poza Rica, Veracruz; Palenque, Chiapas; Puerto Escondido, Oaxaca; San Cristóbal de las Casas, Chiapas; Tehuacán, Puebla; Tamuín, San-Luis-Potosí; Tepic, Nayarit; and Uruapan, Michoacán. The unique air cargo terminal is in the International Airport of Mexico City (MEX).

The Pacific Airport Consortium (GAP) operates the following airports: Guadalajara, Jalisco; Aguascalientes City, Aguascalientes; Guanajuato City, Guanajuato; La Paz, Baja-California-Sur; Los Cabos, Baja-California-Sur; Los Mochis, Sinaloa; Manzanillo, Colima; Mexicali; Baja-California; Morelia, Michoacán; Puerto Vallarta, Jalisco; and Tijuana, Baja-California. Just the Airport of Guadalajara (GDL) and the Airport of Tijuana (TIJ) have air cargo terminals.

The Center-Northern Airport Consortium (OMA) operates the following airports: Monterrey, Nuevo-León; Acapulco, Guerrero; Juarez City, Chihuahua; Culiacán, Sinaloa; Durango, Durango ; Mazatlán, Sinaloa; Reynosa, Tamaulipas; San-Luis-Potosí City, San-Luis-Potosí; Tampico, Tamaulipas; Torreón, Coahuila; Zacatecas City, Zacatecas; and Zihuatanejo, Guerrero. Only four airports have air cargo terminals: Monterrey (MTY), Juarez City (CJS), Reynosa (REX) and San Luis Potosí City (SLP).

The Southeastern Airport Consortium (ASUR) operates the following airports: Cancún, Quintana-Roo; Cozumel, Quintana-Roo; Huatulco, Oaxaca; Mérida, Yucatáb; Minatitlán, Veracruz; Oaxaca City, Oaxaca; Tapachula, Chiapas; Veracruz CIty, Veracruz; and Villahermosa, Tabasco. Just the Airport of Cancún (CUN) and the Airport of Mérida (MID) have air cargo terminals.

ASA and some regional governments, and sometimes private investors, operate some airports with air cargo terminals. ASA, the Estado de Mexico Region Government and private investors operate jointly the Airport of Toluca (TLC), where there is an air cargo terminal (used by FEDEX). ASA, the Puebla Region Government and private investors operate jointly the Airport of Puebla (PBC), where there is an air cargo terminal (operated by the WTC). ASA and the Querétaro Region Government operate jointly the Airport of Querétaro (QRO), where there is an air cargo terminal. ASA and the Coahuila Region Government operate jointly the Airport of Saltillo (SLW), where there is an air cargo terminal (used by DHL).

The Metropolitan Airports System of Mexico (MASM) is formed of the following set of airports located in the center of the country: MEX, TLC, PUE, CVJ and QRO.

Air cargo & full cargo aircraft

In general in the world, only 40% of the air cargo is moved in “full-cargo” aircrafts, because the resting 60% is moved in the baggage’ compartment ("bellies") of the airplanes for passengers (Alvarez, 2007).

The supply of direct air connections with “full-cargo” airplanes for the international air cargo traffic, with origin or destination in Mexico, is relatively scarce (example, Air France and Cargolux). Hence, this need has been partly covered by means of full-cargo transcontinental connections on the USA airports with connections to airports in Mexico, through full-cargo feeder airlines. For example, the Lufthansa’s full-cargo connection between Frankfurt (FRA) and Los Angeles (LAX), and the MASAir’s full-cargo links between LAX and MEX, GDL, MTY and MID.

It is necessary to stand out that, the full-cargo operation is carried out through a polygonal design on specific market niches, because an aircraft cannot travel without a critical payload. For example, in 2007, Cargolux used to operate the following "polygonal connection": Hong Kong (HKG) - Barcelona (BCN) - Mexico City (MEX) - Los Angeles (LAX) - Newark (EWK) – Luxembourg (LUX) - Dubai (DXB) - Hong Kong (HKG) (Antún et al., 2008c).

The leading airlines in Mexico (Aeroméxico and Mexicana) don't operate full-cargo airplanes; then, they transport air cargo within the “bellies” of airplanes for passengers. The same situation exists for most of the foreign airlines, which are leading companies in the passenger movement between Mexico and Latin America. The exceptions are the following: some LAN’s connections (but not LAN Perú and LAN Argentina), links between Mexico and Europe (for example, Iberia), links between Mexico and USA (for example, American, Delta and Continental), and links between Mexico and Asia (for example, JAL).

Air cargo en passenger low cost airlines

Although the leading passengers low cost airlines, that operate in Mexico (Volaris and Interjet), have identified important marginal utilities (3% - 5%), they are even in the process for developing successful alliances with in-land logistics operators to introduce cargo using the remaining capacity of their passenger airplanes, as similar companies are successfully doing in other parts of the world (for example, Air Berlin) (Antún et al., 2008a).

However, Volaris has innovative alliances, with Regional-Cargo for the freight handling in ramp, reception and dispatching, in three air cargo terminals (CUN, GDL and LAP), and with Braniff for the operation of Road Feeders Services (RFS) in MEX and CUN.

Road Feeders Services (RFS)

The air cargo operations are not always carried out on air connections (in bellies or in full-cargo); frequently, they are combined with in-land connections, by means of RFS (Road Feeders Services) or "air truck". A RFS has a specific program where trips are identified by means of connection flights codes, and a suitable capacity truck is assigned to each trip. In case of congestion in the operations of an airport, related to the growth of air cargo operations through full-cargo links, an alternative airport is searched for the establishment of a second full-cargo link; and then to distribute the cargo origins/destinations for RFS.(Antún, 2008c)

In Mexico, the development of RFS has a great potential for in-land connections on freeways. In the central region of Mexico, the new high-specification highways (the Arco-Norte, a bypass of the Metropolitan Zone of Mexico City, as well as the Circuito-Mexiquense) have changed the territorial relationships of the “megapolitan” system of cities.

Hence, hypotheses with RFS operation can be explored, with a great vision prospective; some of the hypotheses are the following:

i. The Airport of Puebla (PBC) can also be considered in the hinterland of the Industrial Parks in Querétaro, and can be an excellent alternative to assist supply chains of the appliances industry.
ii. The Airport of Toluca (TLC) can be an excellent alternative to assist supply chains of the automobile industry in the Bajío region, given that it currently do it for the Toluca-Lerma region; or it can facilitate the strategic operation of the distribution centres which are in the new Logistics Centres of the Jilotepec micro-region.
iii. Due to its connexion with the Circuito-Mexiquense highway, Tizayuca has an excellent location for an Air Cargo Logistics Centre in third line of the International Airport of Mexico City (MEX), independently that a freight airport can be developed there, in the medium term.

In the southern-southeastern Region, the Airport of Cancun (CUN) has a number of connections to Europe, Latin America and the Caribbean. Then, this airport has an excellent opportunity for becoming a cross-docking with inventories for mega-distribution to a number of products to the Latin American capitals. For example, automobile spare parts and European products, as currently do the Airport of Miami (MIA) and their Free Trade Zone, but without the visa requirement and the complications of the guarding of some strict security routines.

In the central-western Region, the Airport of Guadalajara (GDL) is an ideal point for future full-cargo connections to Hong Kong (HKG) and Singapore (SIN), -a suitable scenary for a "polygonal" is HKG(or SIN)-GDL-LAX-HKG(or SIN)- which can be used by the computers industry, and can also be used for the exportation of agricultural premium products from Bajío and Michoacán, through an appropriate RFS network.

Strategic opportunity

The economic and financial crisis, which was arrived to be here at least two more years, in spite of some optimistic opinions, has severely hit air cargo at interregional and intraregional levels.

IATA said that 10.1 percent overall drop in position traffic in 2009 was the largest declines since the end of WW2. However, in December 2009, the freight demand was increased by 24.4%. Last year, Latin American and Middle East carriers got respectively increases by 21% and 7%, over the peak cargo levels of 2008. Director general and CEO Giovanni Bisignani said IATA figures for Dec. 2009 compared to the previous month suggest growth remains "basically flat with a 0.2% decline". He added, "In terms of demand, 2009 goes into the history books as the worst year the industry has ever seen. We have permanently lost 3.5 years of growth in the freight business." IATA noted that freight demand is still 9.0 percent lower than early 2008 although a recent purchasing managers' survey suggests freight volumes will rise this year.

Asia-Pacific carriers accounted for over 60% of the increase in international air freight in 2009 - outperforming their 45% global market share. Despite this improvement, freight volumes remained 8.0% below peak levels.

IATA reported that European airlines' traffic was 20% below 2008 peak levels reflecting the "glacial pace of economic recovery" in the region compared to Asia-Pacific. "The industry starts 2010 with some enormous challenges. The worst is behind us, but it is not time to celebrate. Adjusting to 2.5-3.5 years of lost growth means that airlines face another Spartan year focused on matching capacity carefully to demand and controlling costs.

The relocation and world spreading trends of productive processes, as well as the consumption globalization do not have return…. Demand of air cargo, as any transportation, is derived from the economic activity; and, obviously it will be re-impelled when the world economy will recover its growth (Airbus, 2009).

This period, with the smaller demand, represent an opportunity for planning the development of Air Cargo Logistics Centres in Mexico, and building the bases for a competitive performance for the supply chains' logistics with air cargo segments.

In this paper, we present the first results of a study (Antún et al., 2009) promoted by PROLOGYCA found of the Ministry of Economy, and with the collaboration of the Mexican Air Cargo Freight-forwarders Association (Asociación Mexicana de Agentes de Carga, AMACARGA) and the National Air Industry Council (Cámara Nacional de la Industria Aérea, CANAERO). This study will allow the following:

i) To obtain a prospective diagnosis of the air cargo in Mexico.
ii) To know the impact that the current concessions, given to logistics agents and operators, had have on the air cargo logistics performance for the supply chains competitiveness.
iii) To evaluate the current situation of the Air Cargo Terminals in the airports of Mexico.
iv) To identify the technical characteristics of the Air Cargo Logistics Centres (ACLC), in first and second lines, in air cargo leading airports in countries with development and global positioning similar to those of Mexico City.
v) To evaluate the opportunities for developing ACLC in third line outside of the airport limits, as well as to promote the development of RFS in Mexico.
i) To formulate bases for public policies, which promote the innovation of the concessions terms given to logistics air cargo operators, in the Mexico's airports.
ii) To establish strategies for the development of Air Cargo Logistics Centres.

AIRPORTS AND RECENT EVOLUTION OF THE AIR CARGO

Excluding the "hubs" of the global integrators[1] and the "tranfers points"[2], with emblematic ACLC in first and second lines, then the airports with the highest air cargo volume are the following: Hong Kong (HKG), Seul-Incheon (INC), Singapore-Changi (SIN), Shanghai-Pudong (PVG), Beijing (PEK), Tokyo-Narita (NRT), Bangkok-Suvarnabhumi (BKK), Taipei-Taoyuan (TPE), Dubai(DXB), Paris-Charles of Gaulle (CDG), Amsterdam-Schipoll (AMS), Frankfurt (FRA), Los Angeles (LAX), Miami (MIA) and Chicago (ORD).

Table 1 shows the World's 50 Top Cargo Airports: Ranks, Cargo (x1000 ton) & Change 2006-2009. The International Airport of Mexico City (MEX) had been in the following ranks: 44 (2006), 41 (2007), 43 (2008) y 49 (2009), under the ranks of Sao Paulo-Guarulhos (GRH), 36 (2006), 37 (2007), 39 (2008) y 41 (2009).

Among the interesting aspects of Table 1, the following are highlighted:

i) The stability of HKG; it is the leading airport in the handling of air cargo.
ii) The importance of INC; probably, it is not just because of its Korean Air Asian links, and its coverage on Europe and USA, but also because of its RFS with ferries through the Yellow Sea toward the northern ports of China.
iii) The setback of NRT and KIX, maybe due to high costs in JAL & ANA.
iv) The TPE's decline due to the inauguration of PVG, and the availability of new full-cargo wide-fuselage airships in the companies of the People Republic of China.
v) The relatively stable operation of SIN (probably, due to the relative power of the world leading freight-forwarders linked to the supply chains of their European clients), in front of the lunge of the new Airport of Bangkok-Suvarnabhumi (BKK),

[1] As Memphis (MEM) for FEDEX, Louisville (SDF) for UPS
[2] As Anchorage (ANC)

and the enviable performance of the new ThaiCargo Terminal which won't allow a larger cargo growth in KUL.

vi) The consolidation of the Air France-KLM Cargo alliance, which transforms CDG+AMS into a destination for "in tandem" airports with more cargo than FRA+MXP (now that Lufthansa started operations in Italy).

vii) The take off of DXB, without a doubt due to the creativity of its logistics trans-borders mega-distribution products, the commercial aggressiveness of Skycargo, which is the cargo filial of EmiratesAir, and the existence of Dubai Logistics City, perhaps the ACLC in third line (ACLC3) more important in the world.

viii) The stability of LAX, ORD and JFK as gateways for the air cargo in USA, and of MIA, as air cargo hub of Europe on Latin America.

The performance in 2007, before the global crisis, of the Latinoamerica's 20 Top Cargo Airports is shown in Table 2. Note that three airports in Mexico, MEX, GDL and MTY, are among the Latinoamerica's 20 Top Cargo Airports.

Table 1: World's 50 Top Cargo Airports, 2006-2009
Source: AirCargo World July 2006, July 2007, July 2008, July 2009; based on Airports Council International.

Airport	*IATA*	*2006 Rank**	*2006 Cargo*	*2007 Rank**	*2007 Cargo*	*% Change*	*2008 Rank**	*2008 Cargo*	*% Change*	*2009 Rank**	*2009 Cargo*	*% Change*
Hong Kong	HKG	2	3,437	2	3,609	5.1	2	3,773	4.5	2	3,661	-3
Tokyo Narita	NRT	4	2,290	5	2,280	-0.5	7	2,253	-1.2	8	2,100	-2.7
Osaka Kansai	KIX	22	869	23	842	-3.1	25	852	0.5	24	845	-0.1
Incheon Seoul	INC	5	2,150	4	2,337	8.7	4	2,556	9.4	4	2,424	-5
Shangai Pudong	PVG	8	1,856	6	2,159	16.3	5	2,495	15.5	3	2,603	1,7
Beijing	PEK	24	782	21	1,029	31.6	20	1,191	15.8	18	1,366	14.5
Singapore	SIN	9	1,855	9	1,932	4.2	11	1,918	-0.7	10	1,884	-1.8
Taipei Taoyuan	TPE	13	1,705	13	1,699	-0.4	15	1,606	-5.5	15	1,493	-7
Bangkok Suvarnab	BKK	19	1,141	19	1,182	0.4	19	1,220	-3.2	20	1,773	-3.9
Kuala Lumpur	KUL	31	656	32	671	2.2	31	648	-3.7	27	667	2.2
Manila	MNL	39	412	42	412	10	48	387	-5.6			
Jakarta	CGK	50	349	46	384	11.5	45	399	4	39	492	4
Dubai	DXB	18	1,315	17	1,504	14.4	13	1,168	-11	11	1,825	9.4
Mumbai	BOM	38	434	39	479	10	36	536	12.1	34	559	4.2
Delhi	DEL	41	389	45	398	2.5	42	432	8.7	42	450	4.2
Frankfurt	FRA	6	1,963	7	2,128	8.4	8	2,169	2	7	2,111	-2.7
Paris Charles De G	CDG	11	1,771	11	1,855	5	6	2,298	7.8	6	2,280	-0.8
Amsterdam Schipo	AMS	16	1,496	16	1,560	4.3	14	1,651	5.4	14	1,603	-3
London Heathrow	LHR	17	1,390	18	1,344	-0.3	18	1,396	3.9	16	1,486	6.5
Luxembourg	LUX	27	743	26	752	1.9	23	857	14	25	788	-8
Milano Malpensa	MXP	43	384	40	412	7	40	486	16	45	416	-14.5
Madrid	MAD	45	365									
Copenhagen	CHP	48	355	47	380	7	46	395	4.1			
Zurich	ZRH	49	352									
Los Angeles	LAX	7	1,929	10	1,907	-1.1	12	1.878	-1.5	13	1,630	-11.9
Miami	MIA	12	1,762	12	1,831	3.9	10	1,923	5	12	1,807	-6
New York JF Kenne	JFK	14	1,649	14	1,660	0.2	16	1,596	-2.8	17	1,450	-9.8
Chicago O´Hare	ORD	15	1,548	15	1,618	4.8	17	1,524	-2.2	19	1,332	-13.1
Atlanta	ATL	25	765	28	746	-2.8	28	720	-3.5	30	655	-9
Dallas/Ft Worth	DFW	28	720	27	748	1.5				28	660	
Houston	IAH	42	384	43	407	3.1	44	411	0.8	47	412	-0.4
Sao Paulo Guarulh	GRU	36	475	37	496	-0.2	39	488	-1.5	41	470	-3.7
Mexico DF	MEX	44	380	41	416	9.5	43	411	-1.3	49	382	-7
Bogota	BOG									35	548	
Memphis (FEDEX)	MEM	1	3,598	1	3,692	2.6	1	3,841	4	1	3,695	-3.8
Anchorage (Transf	ANC	3	2,609	3	2.804	5.9	3	2,826	0.6	5	2,340	-17
Louisville (UPS)	SDF	10	1,815	8	1,983	9.3	9	2,078	4.8	9	1,974	-5

Tables 3 and 4 show the performance in 2007 and 2008, of the Asia's 20 Top Cargo Airports. Note the resilience of the Asian airports in front of the crisis, the larger impact of it on the Japanese airports, and the emergence of PVG versus the deterioration of TPE.

Another interesting aspect is revealed from the analysis of the World's 20 Top Fast Growth Cargo Airports (Table 5), before of the global crisis in 2007. This aspect is the taking off of medium airports, among them Guadalajara (GDL), which has the second place in air cargo volume in Mexico.

Airport	*IATA Code*	*World Rank*	*Asia Rank*	*Tonnage x10*	*% Change*
Hong Kong	HKG	2	1	3,609	5.1
Seoul Incheon	INC	4	2	2,337	8.7
Tokyo Narita	NRT	5	3	2,280	-0.5
Shanghai Pudong	PVG	6	4	2,159	16.3
Singapore Changi	SIN	9	5	1,932	4.2
Taipei Taoyuan	TPE	13	6	1,699	-0.4
Bangkok Suvarnabhumi	BKK	19	7	1,182	3.6
Beijing	PEK	21	8	1,029	31.6
Osaka Kansai	KIX	23	9	842	-3.1
Tokyo Haneda	HND	24	10	833	4.3
Baiyun Guangzhou	CAN	25	11	825	9.9
Kuala Lumpur	KUL	32	12	671	2.2
Shenzen	SZX	34	13	559	21
Manila	MNL	42	14	419	8.9
Jakarta	CGK	46	15	384	11.5
Shangsha Hong Qiao	SHA	48	16	364	1.1
Nagoya	NGO	57	17	307	na
Chengdu	CTU	60	18	295	17.7
Fukuoka	FUK	61	19	292	0.8
Sapporo	CTS	66	20	267	-0.5

Table 3: Asia's 20 Top Cargo Airports: Ranks, Cargo (x1000 ton) 2007 & Change 2007/2006
Source: Data from Airports Council International

AIRCARGO LOGISTICS CENTERS (ACLC)

Typology of ACLC

The air cargo does not speak and walks by itself, as passengers in an airport, but rather it is subject to a series of logistics operations (preparation, loading/unloading, prosecution of orders in cross-dock with or without inventories, reception/expedition, customs, land-vehicles management, etc.), where a set of actors and agents participates, as air company, handling in ramp operators, security inspectors, sanity inspectors, customs, freight-forwarders, logistics operators for RFS, etc. (Vila, 2003)

The logistics operations are carried out by logistics operators, under some concession form. The characteristics of concessions to the different agents, on the air cargo logistics processes, induce air cargo logistics practices with different competitive behavior, which

Airport	IATA Code	World Rank	Asia Rank	Tonnage (1000Tn)	Change %
Hong Kong	HKG	2	1	3,773	4.5
Seoul Incheon	INC	4	2	2,556	9.4
Shanghai Pudong	PVG	5	3	2,495	15.5
Tokyo Narita	NRT	7	4	2,253	-1.2
Singapore Changi	SIN	11	5	1,918	-0.7
Taipei	TPE	15	6	1,606	-5.5
Bangkok Suvarnubhumi	BKK	19	7	1,220	-3.2
Beijing	PEK	20	8	1,191	15.8
Tokyo Haneda	HND	24	9	851	4.3
Osaka Kansai	KIX	25	10	846	0.5
Guangzhou	CAN	30	11	695	6.4
Kuala Lumpur	KUL	31	12	648	-3.7
Shenzen	SZX	33	13	616	10.1
Jakarta	CGK	46	14	399	4
Shangha Hong Qiao	SHA	47	15	388	6.9
Manila	MNL	48	16	387	-5.6
Chengdu	CTU	56	17	328	11.1
Fukuoka	FUK	62	18	293	0.1
Nagoya	NGO	64	19	276	-10
Sapporo	CTS	67	20	274	2.7

Table 4: Asia's 20 Top Cargo Airports: Ranks, Cargo (x1000 ton) 2008 & Change 2008/2007
Source; Data from Airports Council International

Airport	IATA Code	Fastest Rank	World Rank	Tonnagex1000	%Change
Subang	SZB	1	163	73	37.2
Beijing	PEK	2	21	1,029	31.6
Huntsville	HSV	3	164	69	29.2
Muscat	MCT	4	139	96	25.9
Xi'An	XIY	5	135	99	25.8
Liege	LGG	6	44	406	24.6
Bangalore	BLR	7	102	166	24.4
Shenzen	SZX	8	34	559	21
Hyderabad	HYD	9	199	44	20.9
Abu Dhabi	AUH	10	69	259	20.1
Damman	DMM	11	174	60	20.1
Tampa	TPA	12	130	109	19.8
Lagos	LOS	13	127	116	19.6
Male	MLE	14	198	45	19.2
Nairobi	NBO	15	75	242	18.9
Guadalajara	**GDL**	**16**	**119**	**124**	**18.7**
Chengdu	CTU	17	60	295	17.7
Budapest	BUD	18	168	66	17.3
Shanghai Pu(	PVG	19	6	2,159	16.3
Hanoi	HAN	20	129	110	16.9

Table 5: World's 20 Top Fast Growth Cargo Airports: Fast Ranks, World Rank, Cargo (x1000 ton) 2007 & Change 2007/2006
Source: Data from Airports Council International

have impact non just on the logistics costs, but also on the perception of the external trade global behavior of the in current globalized markets.

Air Cargo Logistics Centres in "first line with air side" (ACLC1), also called Air Cargo Terminals, and in "second line without side air" (ACLC2), are developed inside the airport's limits, in order to get appropriate and competitive logistics operations.

Also in recent years, Air Cargo Logistics Centres in "third line" (ACLC3), linked to leading airports, had been developed outside of the airport's limits. Their development had been made by means of the appraisement of locations with good land connexion through high specifications highways, in the hinterland of a relatively congested airport.

Frequently, the ACLC2 within the airport's limits, includes a General Services Building (GSB) for the Air Cargo Community, as well as the required facilities for the different government agencies.

Functional areas of an ACLC

The functional areas of an ACLC are those where logistics processes operations are developed, with certain homogeneity: i) *Logistics Areas*: storage and distribution areas, transfer areas, logistics post-finish areas and added-value operations areas; ii) *Intermodal Areas*: areas for transference between air and truck modes; and iii) *Areas for Services*: specialized service areas for dangerous goods, valuable goods, alive animals and perishable goods; service areas for freight-forwarders and transportation companies; and service areas for government agencies (customs, animal and plant health control, control of illicit drugs, weapons control, pharmaceutical products control, etc).

TECHNICAL GUIDELINES FOR ACLC PROJECTS IN MEXICO

ACLC in first line (ACLC1)

Cargo Platforms

In order to assure an efficient cargo handling, a cargo platform or ramp on the air side, should be considered as the continuation of the Cargo Terminal. Some characteristics of the cargo platform are the following:

- i) The configuration of the aircraft parking area in a cargo platform depends on the local restrictions and requirements, and it should consider the required equipment for in-land handling.
- ii) The design of a cargo platform should provide, in each plane position, a nearby area for the required equipment, for the shipment and transportation of ULDs entering and leaving.
- iii) The parking for the handling equipment should be located between the cargo way on the air side and the Cargo Terminal, and/or along the external borders of the platform, without impeded the aircraft manoeuvres.
- iv) The service roads for cargo should be separated from taxiway.

In-Transit Cargo

Not the whole cargo that enters will be imported or will have destination in the air terminal.

In the hub airports, the cargo is essentially in-transit cargo; for example, the typical case is the Airport of Singapore (SIN), but also other leading airport as Seoul-Incheon (INC) where in-transit cargo is over 58%.

In these airports, an additional space is required for i) the un-consolidation of unattached cargo, ii) a storage area for the leaving unattached cargo, and iii) an area for the consolidation of goods which will be put in "pallets" or containers.
For the transfer of intact containers (un-consolidation and consolidation is not required), it is necessary an additional space for their temporary storage.

In Mexico, the unique airport where a project of this type could be developed is the Airport of Cancun (CUN). This airport could assist the market segments, which is now assisted by MIA, for cargo mega-distribution with origin in Europe and destination in the Latin American capital cities.

However, errors in market studies can be translated in lost investments, as is the case of the under-employed automatic silo in the Cargo Terminal of Iberia in MAD, originally projected with similar objectives.

Parameters for the sizing of Cargo Terminals

According IATA, the determination of the size of a cargo terminal must be based on the annual cargo movement estimation: the required space will depends on the technology level (based on Ashford, 1992) in use, which defines the capacity for the cargo handling at area units. Table 6 presents the IATA's parameters on Cargo Terminal's capacity (ton/m^2) by technology level.

A recent analysis based on Cases Study of Cargo Terminals in airports of Asia reveals more conservative values obtained with base on the estimated operative capacity (Castillo et al., 2009; González et al., 2009; López et al., 2009; Pacheco et al., 2009; Rivero et al., 2009). These results are shown in Table 7.

Note that, the high technology Cargo Terminals are equipped with multiple levels for the containers storage, which are transported inside of the terminal by means of automated vehicles on rails. The multi-level systems, as the existing ones in HKG, INC, SIN and BKK, are very efficient in the use of the cargo terminal's floor area, and have the large advantage of an important reduction of the damages to containers when they are managed by forklift trucks (Aran, 2003)

Technology Level	Ton/m2
Low	5
Medium	10
High	17

Table 6: IATA's parameters on Cargo Terminal's capacity (ton/m2) by technology level
Source: IATA (2004)

TECHNICAL FACTS	AIRPORT							
	HKG	INC	PVG	SIN	TPE	BKK	KUL	NRT
N°of Runways	2	3	3	2	2	2	2	2
Runways average length (m)	3,800	3,833	4,000	4,000	3,505	3,850	4,087	3,090
Runway Wide (m)	n/a	60	n/a	60	n/a	60	60	n/a
ILS	n/a	Cat IIIb	Cat IIb	Cat IIIb	Cat II	Cat III	Cat II	Cat III y Cat I
N° Air Cargo Terminals	2	4	3	9	4	2	1	2
Total Cargo Throughout (ton)	3,600,000	2,400,000	2,600,000	1,800,000	1,500,000	1,200,000	667,500	2,100,000
Total Cargo Area (m^2)	460,000	300,000	543,100	470,000	345,000	90,000	440,000	295,800
Total Cargo Capacity (ton/year)	4,410,000	4,000,000	4,200,000	3,000,000	n/a	966,000	n/a	2,500,000
(Total Cargo Capacity, ton)/ (Area,m^2)	9.6	13.3	7.7	6.4	n/a	10.7	n/a	8.5

Table 7: Technical Indicators for Air Cargo Terminals: (1) Cargo Capacity per area unit in top Asia's Airports
Source: Research on official Reports from Asia Airports

Although IATA recommends that, the plant of the building cargo terminal must have 60-90 meters distance, between the air side and the docks in land side, the new multi-level facilities as HKG and SIN surpass it.

Critical elements of a Cargo Terminal are micro-location and width of the air side access doors. The basic module recommended by IATA, has a clearing of 18 meters and can contain three air side access doors. Each door should have a typical width of 5 meters, where loaded "pallets" and "dollies" can pass.

In the land side, it is common that the manoeuvres yard for freight trucks, which is located between the cargo terminal and the trucks parking, area has length over 35 meters.
For a trucks parking, it is better to use parameters for Logistics Centres as Zones for Port Logistics Activities (ZPLA) and Merchandize' Integrated Centres (MIC) (Antún et al., 2005).

In the new Cargo Terminals there is not physical division among the importation, exportation and in-transit areas. When such division exists, there is a total detriment in the use of the space and the flexible methods for handling goods, producing a lingering stay in warehouse. It is fundamental to agree with the Custom, a project without physical divisions.

Micro-location Criteria

The chosen site should be in harmony with the master plan of the whole airport, which should be periodically revised and upgraded, taking into account the future extension of the passenger and cargo terminals.

A plot with enough area for initial facilities and future extensions should be provided.

The plot should include a suitable space for a cargo platform, adjacent to the main cargo terminal, with the purpose of having a direct access. The adjacent area to the cargo platform should be designated only for the cargo process facilities, where each facility can be expanded.

Other related to cargo facilities, such as "freight forwarders" facilities, fiscal warehouses, custom' offices and other types of offices, should be located in a second line or land side.

In-Land Connectivity

In the Air Side

Given that the majority of the cargo is currently transported by means of passenger aircraft, it is always necessary to connect the Cargo Terminal with the platform at Passenger Terminal by a high-quality service road (or a tunnel, like MIA) for all of the goods movement aspects toward and from planes in the Passenger Terminal.
At least a road, with "in-bond" characteristic and two lanes (minimum width 10 meters, preferable 12 meters) must exist. On this road, "dollies" with "pallets" and large containers must easily pass between the passenger and the cargo terminals. Its pavement structure should be designed to support a wheel pressure of up to 1,500 kg/Pa with a typical load for axis of until 10 Tn.
In the service road, slopes must be avoided as much as possible; they must be under 4%, especially in tunnels and bridges. Also, the number of curves must be minimized; in case that a curve is required, the design parameter for the turn radius is 20 meters.
A 3 meters width delimited lane must be provided in each side of the service road, in order to allow emergency stops of vehicles, without blocking vehicle flow.

In the Land Side

At least a 10 meters width and two lanes public road should exist, for the access of trucks to the land side at Cargo Terminal.
The development of additional parking spaces, of at least 18 meters width, on the other side of the public road and along the cargo terminal façade, is recommended (like the layout at BCN Cargo Terminal). Such spaces are for the trucks that have to wait the liberation of the freight to be transported by them, or for the drivers rest.

Layout

Longitudinal

An air cargo terminal, designed in only one line, have the advantage of housing several modules operated by different airlines, global courier companies and cargo agents. In this case, it is possible to expand the facility on at least one side of the building. The design of the Cargo Terminal building should be such that the modules' rates, longitude and width, provide the enough lineal facades and number of platforms for the loading/unloading truck operations.

The space assignment to the operators and agents who carry out the "handling" is suitable by means of modules, which have to be as flexible in dimensions as possible respect to the dimensions defined by the columns. Each assigned module should have access to the aeronautical area or side air and to the land side. It is recommendable, to use a system of dismantled partitions, which can be re-located when be required, making easy the space assignments changes inside the Terminal. The definition of the modules, the space assignment and the partition systems for each warehouse operator, requires take into account the regulations of the customs authority for the warehousing processes. This type of longitudinal lay-out was adopted by INC and BKK (Figures 1 y 2).

Figura 1(left)   AirCargo Terminals in Seoul-Incheon Airport
Source: Pacheco, B; Antún, JP; Alarcón, R (2009)

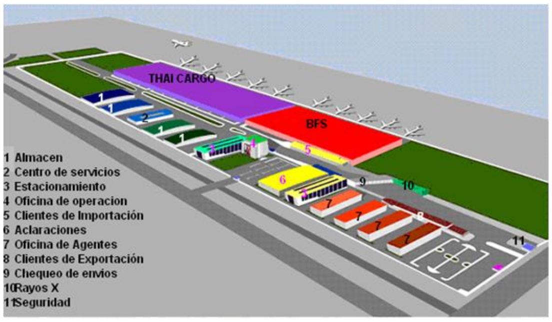


Figura 2 (right) AirCargo Terminals in Bangkok-Suvarnabhumi Airport
Source: Lopez, L; Antún, JP; Alarcón, R (2009)

Multi-level

The multi-level lay out is a kind of multiplied to up longitudinal layout; in general from level 2, the ramps for vehicles obviate the difference between side air and side land.

The dimension of the cargo terminal building can be defined, when the operational requirements of all the lessees are known. The facility dimensions should be enough for all the areas and functions of the cargo process, which take place between the side air in the lower level and the several upper levels. The space and functional requirements of an automated system, for the high productivity cargo handling, must be considered in order to avoid the potential facility obsolescence. This type of Cargo Terminals, highly sophisticated, is successfully operating in HKG and SIN (see Figures 3 y 4).

Figura 3 (left) Hong Kong "Super Terminal 1"
Source: Rivero, D; Antún, JP; Alarcón, R (2009)

Figura 4 (right) AirCargo Terminals at Singapore Changi International Airport: CAC & ALPS
Source: Lopez, L; Antún, JP; Alarcón, R (2009)

Interior Flows

Doors and entrances

The access to the Cargo Terminal building should be through enough large doors for the equipment in use. The air side doors should allow that hoist, "dollies" and other vehicles can pass; their typical dimensions are 5 meters high and 5 meters width. The typical dimensions of the land side access doors are of 4 meters high and 3 meters width.
It is recommendable to use mechanical or electrical devices for the automatic opening and closing of the access doors, with the necessary security measures; the doors manual operation is very slow and problematic. Such devices must be included in the direct interface between, the air side transportation equipment and the vehicles coming from the land side, and the containers handling.

Clearance and space among the columns

The clearance among the columns of the Cargo Terminal must be as large as possible; usually, it is 15 meters. The storage and operational systems, as well as the main corridors and access doors, should be considered for the design of the columns network of the cargo terminal.
Also, it is necessary to take into account the future flexibility of the building. When containers 6 meters width are used, related with the EVT for the ULD storage system, the clearance among columns should be at least 22 meters.

Free roof height

The roof height design should consider different types of free roof heights:

i) In the basic cargo operation, the unattached goods are usually moved by using forlift; here, the minimum roof height should be 5 meters; note that the floor storage requires a larger space that the vertical storage systems, which improve productivity and service to client.

ii) In a vertical storage system operation, the roof height is defined according the number of storage levels, the distance among each level, and the free space requirement above of the merchandise stored in the upper shelf; then, the building should be designed with appropriate height and enough floor resistance.

Containers storage

In the containers storage system, the distance among vertical levels depends on the height of the containers. According IATA standards, three categories exist: low cover 1.7 m, main cover 2.4 m and complete contour 3 m. The roof height depends on the containers heights combination, 1.7, 2.4, and 3 m; then, three arrays of 3m containers require a 12m roof height.

ACLC in second line (ACLC2)

The ACLC2 includes the General Services Building, naves for medium term storage, offices and naves for added value processes of the "freight forwarders". It also includes the road, with at least of 10 meters width and of two lanes, between the ACLC2 and the ACLC1.

Medium term storage

Medium term storage outside of the Cargo Terminal with air side can de required as a result of the slow customs liberation and lack of airships capacity.
Also in this case, the nave roof height depends on the goods process mechanization degree. It is suggested that access doors have 4 meters of high and 3 meters width.

Building of General Services

The General Services Building has offices and offers a wide range of services. It is the ACLC neuralgic centre, where the activities for the goods transportation development are interrelated. The building usually includes modular offices for air companies, logistics operators, services customs officers, commerce, banks and business centre.

ACLC in third line (ACLC3)

Given the limited areas within an airport, it is desirable the development of facilities outside of the airport, but in its immediate hinterland. It is fundamental that, the ACLC3 has good land connections to the airport and the regional highways network.

The development of a third line is generally formed of companies and logistics operators, whom offer added value services, for industries (Free Processing Zone, FPZ) as Far Glory, near the Airport of Taipei-Taoyuan (Figure 5), and for distribution centres (Free Trade Zone, FTZ) as the ProLogis Logistics Park near the airport of Tokyo-Narita (Figure 6).

Figure 5 Far Glory AirCargo Park in Taipei-Taoyuan International Airport
Source: Castillo, S; Antún, JP; Alarcón, R (2009)

In the Metropolitan Airports System of Mexico, the congestion in the area of the International Airport of Mexico City (MEX), the recent Arco-Norte, a high-specifications toll highway which is a bypass of the metropolitan area, and the Vialidad-Mexiquense, a highway that connects the airport with the NAFTA Corridor, are creating strategic opportunities for the development of ACLC3, in particular in Tizayuca, where a project for the Hidalgo Logistics Platform (PLATAH) is developed.

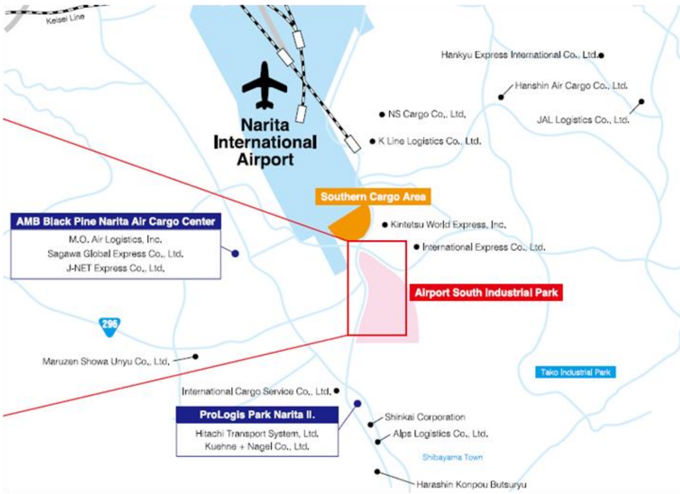


Figura 6 AirCargo Logistics Parks in the International Airport Tokyo-Narita hinterland's
Source: Pacheco, B; Antún, JP; Alarcón, R (2009)

Figure 7 Planned Tokyo-Narita Airport vicinity industrial parks
Source: Pacheco, B; Antún, JP; Alarcón, R (2009)

INDICATORS OF THE ACLC PERFORMANCE

The indicators of an ACLC performance are designed essentially to measure the reach of the time constraint satisfaction goals. Table 8 presents a typical monthly report of the performance of the Cargo Terminal of Thai Cargo, in the new International Airport of Bangkok-Suvarnabhumi (BKK). The clients' satisfaction survey is a way to analyze the performance without the preconceived indicators restrictions. The results of the biannual survey 2008 to the customers of the Cargo Terminal of the new International Airport of Shanghai-Pudong (PVG) are presented in the Table 9.

Table 8. Monthly Report Performance Standards in BKK (july 2009)
Source: International Airport of Bangkok-Suvarnabhumi

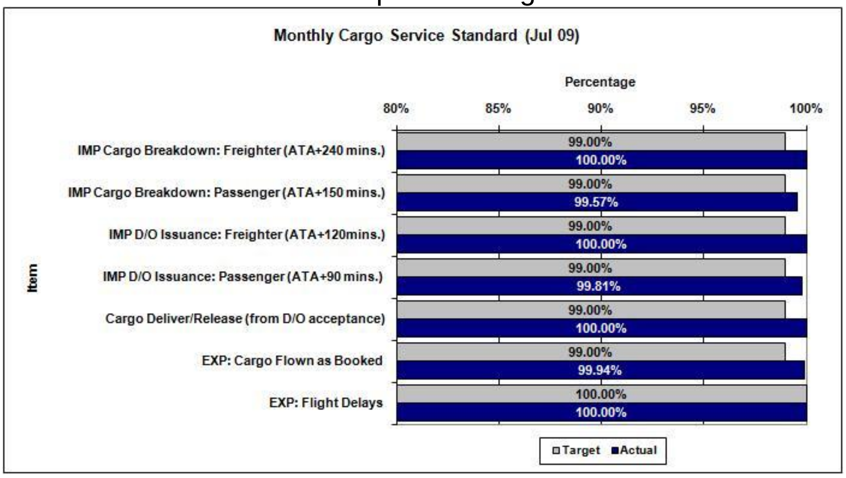
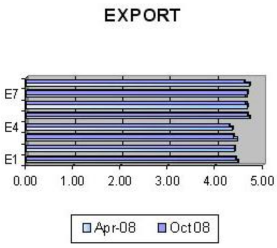
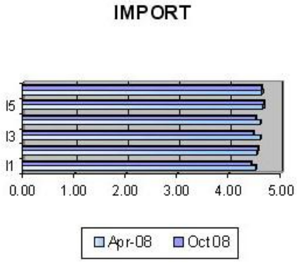
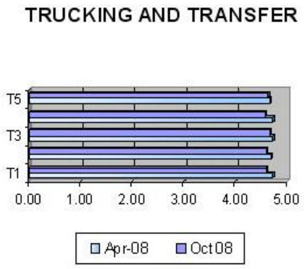


Table 9. Customer satisfaction on PVG: Bi Annual Report, apr/oct 2008
Source: International Airport of Shanghai-Pudong







EXPORT E1: Goods acceptance E2: Palletizing E3: Hand-over time to G.H E4: AWB acceptance E5: Manifesting E6: Dead Load Weight Statement E7: FFM/UCM/SCM/others E8: Tracing	IMPORT I1: Import goods breakdown I2: Import goods delivery I3: AWB delivery I4: Filing system for customer I5: Tracing I6: Automatic SITA messaging	TRUCKING & TRANSFER T1: Feedback of booking T2: Handling time T3: Information for customers T4: Filing system for customers T5: Tracing

Code:
1=very unsatisfied / 2=unsatisfied /4=satisfied /5=very satisfied

Finally, the Cargo Terminal Performance Standards in top Asia's Airports are presented in Table 10.

BY WAY OF CLOSURE

The Mexican economy is one of the more globalized of Latin America.
The country competitiveness is threatened by the weaknesses in the supply chains logistics.

More and more the supply chains are global, and more frequently they have transportation chains with air cargo segments.

Tight supply chains with optimized logistics, which require more air cargo, are more and more needed, hence the importance of promoting the development Air Cargo Logistics Centres in the main Mexican airports, as well as in airports with strategic opportunities, in order to preserve the competitiveness of the Mexican products in the global market (computer equipment and their spare parts, refrigerators and home appliances, cars and automobile spare parts, jeans denim making and high design women lingerie, premium and organic vegetables, avocados and exotic fruits, etc.)

Table 10. Technical Indicators for AirCargo Terminals: (2) Performance Standards in top Asia's Airports
Source: Research on official Reports from Asia Airports

HONG KONG (HKG)	Indicator	Target	Fulfilment (Aver. 2008)
Landside Services	Export Cargo reception (within 15 minutes)	96%	99-100%
	Import Cargo collection (within 30 minutes)	96%	100%
Cargo Breakdown	Cargo Breakdown - Passenger Aircraft (ATA+5 hrs)	96%	99-100%
	Cargo Breakdown - Freighter Aircraft (ATA +8 hrs)	96%	99-100%

SEOUL-INCHEON (INC)	Indicator	Target	Fulfilment (Aver. 2008)
Landside Services	Truck waiting Time (within 30 min.)	98.0%	98.6%
	Cargo Acceptance (within 15 min.)	96.0%	99.7%
	Cargo release (within 30 min.)	96.0%	99.1%
Cargo Breakdown	Cargo Document Classification (within 3 hrs.)	95.0%	99.7%
	Passenger Plane (within 3 hrs.)	95.0%	99.8%
	Narrow-body Freighter (within 4.5 hrs.)	95.0%	100.0%
	Wide-body Freighter (within 7.5 hrs.)	95.0%	100.0%
	Perishable Cargo (within 2.5 hrs.)	98.0%	99.8%
	Express Cargo (within 2 hrs.)	98.0%	100.0%

BANGKOK SUVARNABHUMI (BKK)	Indicator	Target	Fulfilment (Aver. 2008)
Import	Cargo Breakdown Freighter (ATA+4 hrs.)	99%	100%
	D/O issuance Freighter (ATA+2 hrs)	99%	100%
Export	Cargo Flown as Booked	99%	99.94%

SHANGHAI PUDONG (PVG)	Indicator	Target	Fulfilment (Aver. 2009)
Performance Standards	Truck Queuing Time (within 30min)	90%	100%
	Cargo Availability Time (within 30 min)	90%	96%
	Break-Down Time (General Cargo) (within 6-8 hrs)	90%	100%
	Break-Down Time (Perishable Cargo) (within 3 hrs)	90%	100%
	Break Down Time (Express Cargo) (within 90 mins)	90%	100%
	BUP Check-in Time (within 60 mins)	90%	99%

SINGAPORE CHANGI (SIN)	Indicator	Target	Fulfilment (Aver. 2008)
Performance Standards	Cargo available of passenger aircraft ATA+ 3.5 hrs	90%	> 99%
	Cargo available within of freigter aircraft ATA + 5.5 hrs	90%	> 99%
	Cargo documents available within 2 hours of passenger aircraft arrival	90%	> 99%
	Cargo documents available within 4 hours of freigter aircraft arrival	90%	> 99%

ACKNOWLEDGMENT

The authors recognize and thank the collaboration of Germán Luyando, in the elaboration of a preliminary document on the Technical Norms for a Cargo Terminal Study and Project.
The authors also thank Benjamín Pacheco, Balduíno González, Luis Macías, David Rivero, Luis López, Sergio Castillo and Gustavo Camacho for their valuable help in the preparation of technical records on the Air Cargo Terminals of airports in Asia.
Supports of Rodolfo Hernández, of the Ministry of Economy of the Federal Government of Mexico, and Cecilia Palazuelos, President of the Mexican Association of Air Cargo Agents (AMACARGA) are appreciated.

REFERENCES

Airbus (2009) Flying Smart, Thinking Big: Global Market Forecast 2009-2028, Airbus Industries, Blagnac, 164 p

Alvarez Robles, O (2007) El Transporte de Carga Aérea en España: condicionantes y perspectivas, elaborado para División de Prospectiva y Estudios del Transporte, Secretaria General de Transportes, Ministerio de Fomento, Madrid, Junio, 50 p.

Antún, JP; Lozano, A; Luyando G (2005) Desarrollo de Centros Logísticos Aeroportuarios, Informe Final, Proyecto DGAPA-PAPIIT IN102103, Instituto de Ingeniería, Universidad Nacional Autónoma de México,

Antún, JP; García Nieto, C; García Benítez, F (2008a) "Oportunidades para operadores logísticos de carga aérea en 3ra línea operando en alianza con low cost airlines", Memorias del VIII Congreso de Ingeniería de Transporte (CIT2008); La Coruña (España), Junio 1-5, 2008 (en CD).

Antún, JP; Lozano, A; Alarcón, R (2008b) "Áreas de oportunidad en la modelación para los retos que enfrenta la logística de carga aérea", Memorias del XIV Congreso Latinoamericano de Investigación de Operaciones (XIV CLAIO), Cartagena de Indias (Colombia), Septiembre 9-12, 2008 (en CD).

Antún JP; Lozano, A; Alarcón, R (2008c) "Operadores logísticos en carga aérea: exploración de procesos en la toma de decisiones", Memorias del XV Congreso Panamericano de Ingeniería de Tránsito y Transporte (XV PANAM), Cartagena de Indias (Colombia), Septiembre 14-17, 2008 (en CD).

Antún, JP; Lozano, A; Alarcón, R (2008c) "Áreas de oportunidad en la modelación para los retos que enfrenta la logística de carga aérea", Memorias del XIV Congreso Latinoamericano de Investigación de Operaciones (XIV CLAIO), Cartagena de Indias (Colombia), Septiembre 9-12, 2008 (en CD).

Antún JP; Lozano, A; Alarcón, R (2009) Prospectiva del desarrollo de Centros Logísticos de Carga Aérea: Análisis de la situación actual de las concesiones en los aeropuertos y su impacto en la logística de la carga aérea; (b) Estrategias para el desarrollo de Centros Logísticos de Carga Aérea en la Región Centro de México, propuesta técnica aprobada con recursos del Programa de Competitividad en Logística (PROLOGYCA), Secretaría de Economía (en desarrollo).

Arán, J (2003) Descubrir la Carga Aérea, Centro de Documentación y Publicaciones AENA, Aeropuertos Españoles y Navegación Aérea, Madrid, 199 p

Ashford, N (1992) Airport engineering,Wiley, New York

Castillo, S; Antún, JP; Alarcón, R (2009) Análisis de los Aeropuertos Líderes en Asia; Estudio de Caso 6: Aeropuerto de Taipei-Taoyuan (TPE), Documento Interno, Instituto de Ingeniería-UNAM, México DF

Castillo, S; Antún, JP; Alarcón, R (2009) Análisis de los Aeropuertos Líderes en Asia; Estudio de Caso 10: Aeropuerto de Kaohsiung (KHH), Documento Interno, Instituto de Ingeniería-UNAM, México DF

Cifuentes,V; Vargas, M, ed (2007) Aeropuertos Modernos: Ingeniería y Certificación, Aeropuertos y servicios Auxiliares (ASA), Instituto Politécnico Nacional, México DF, 303 p.

Gradilla, L; Rico, O (2005), Análisis espacial de la distribución de la carga transportada por aire en México, Publicación Técnica No. 269, Instituto Mexicano del Transporte, Sanfandila, México, 139 p

Gonzalez, B; Antún, JP; Alarcón, R (2009) Análisis de los Aeropuertos Líderes en Asia; Estudio de Caso 4: Aeropuerto de Shanghai-Pudong (PVG), Documento Interno, Instituto de Ingeniería-UNAM, México DF

Gonzalez, B; Antún, JP; Alarcón, R (2009) Análisis de los Aeropuertos Líderes en Asia; Estudio de Caso 9: Aeropuerto de Aeropuerto de Beijing (PEK), Documento Interno, Instituto de Ingeniería-UNAM, México DF

Gonzalez, B; Antún, JP; Alarcón, R (2010) Benchmarking de Terminales de Carga en Aeropuertos en México, Documento Interno, Instituto de Ingeniería-UNAM, México DF (en proceso)

Herrera, A (2000) Elementos para el Análisis de la Seguridad en el Transporte Aéreo Comercial en México, Publicación Técnica No. 269, Instituto Mexicano del Transporte, Sanfandila, México, p

Herrera, A (2001) Simulación de operaciones aeroportuarias. el caso de despegues y aterrizajes en el aeropuerto internacional de la ciudad de México, , Publicación Técnica No. 180, Instituto Mexicano del Transporte, Sanfandila, México, 81 p.

Herrera, A; Bustos, A; Martner,C; Rico, O; Acha, J; Aguerrebere, R; Heredia, F (2005) Diagnóstico de la Carga Aérea en México, Publicación Técnica N0 273, Instituto Mexicano del Transporte, Sanfandila, México, 194 p.

Hall, R (2001) Truck scheduling for ground to air connectivity, Journal of Air Transport Management, Vol 7; No 6, November, pp: 331-338

Herrera, A (2008) Innovaciones en la tecnología aeroportuaria, Publicación Técnica No. 317, Instituto Mexicano del Transporte, Sanfandila, México, 113 p

Horonjeff, R; McKelvey,F ; Sproule, W; Young, S (2010) Planing and Design of Airports (5th ed), McGraw-Hill International Editions, New York

IATA (2004) Airport Development Reference Manual, International Air Transport Association, Montreal-Geneva, 722 p

IATA (2009) Monthly Traffic Analysis, International Air Transport Association, Montreal-Geneva

Jianxin Ou; Hong Zhou; Zhengdao Li (2007) A Simulation Study of Logistics Operations at an Air Cargo Terminal, Wireless Communications, WiCom 2007, Proceedings of the

IEEE International Conference on Wireless Communications: Networking and Mobile Computing, 21-25 Sept. 2007, pp: 4403 – 4407, Beijing.

Lopez, L; Antún, JP; Alarcón, R (2009) Análisis de los Aeropuertos Líderes en Asia; Estudio de Caso 5: Aeropuerto de Singapore-Changi (SIN), Documento Interno, Instituto de Ingeniería-UNAM, México DF

Lopez, L; Antún, JP; Alarcón, R (2009) Análisis de los Aeropuertos Líderes en Asia; Estudio de Caso 7: Aeropuerto de Bangkok-Suvarnabhumi (BKK), Documento Interno, Instituto de Ingeniería-UNAM, México DF

Martner, C; Perez, J; Herrera, A (2003) Diagnóstico general sobre la plataforma logística de transporte de carga en México, Publicación Técnica No. 233, Instituto Mexicano del Transporte, Sanfandila, México, 113 p

Pacheco, B; Antún, JP; Alarcón, R (2009) Análisis de los Aeropuertos Líderes en Asia; Estudio de Caso 2: Aeropuerto de Seoul-Incheon (INC), Documento Interno, Instituto de Ingeniería-UNAM, México DF

Pacheco, B; Antún, JP; Alarcón, R (2009) Análisis de los Aeropuertos Líderes en Asia; Estudio de Caso 3: Aeropuerto de Tokyo-Narita (NRT), Documento Interno, Instituto de Ingeniería-UNAM, México DF

Rico, O (2001) El Transporte de Carga Aéreo Doméstico en México, Publicación Técnica No. 168, Instituto Mexicano del Transporte, Sanfandila, México, 157 p

Rico Galeana, O (2004) Análisis espacial del Transporte Aéreo de Carga en México, Publicación Técnica No 264, Instituto Mexicano del Transporte, Sanfandila, México

Rico Galeana, Oscar (2007) Análisis de series de tiempo de la carga transportada en los principales aeropuertos mexicanos, Publicación Técnica No.294 , Instituto Mexicano del Transporte, Sanfandila, México

Rivero, D; Antún, JP; Alarcón, R (2009) Análisis de los Aeropuertos Líderes en Asia; Estudio de Caso 1: Aeropuerto de Hong Kong (HKG), Documento Interno, Instituto de Ingeniería-UNAM, México DF

Rivero, D; Antún, JP; Alarcón, R (2009) Análisis de los Aeropuertos Líderes en Asia; Estudio de Caso 8: Aeropuerto de Kuala Lumpur (KUL), Documento Interno, Instituto de Ingeniería-UNAM, México DF

Vila, C (2003) Logística de la Carga Aérea: Manual de los procesos logísticos del transporte aéreo de mercancías, LogisBook, Barcelona, 223p.