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NO COUNTRY LEFT BEHIND



# ICAO – ICM Study on Competition and Air Connectivity

**Air transport efficiency diagnosis  
in the context of air carriers' network competition**

ICAO HQ, Montréal  
31 March 2016

*International Air Transport Symposium*



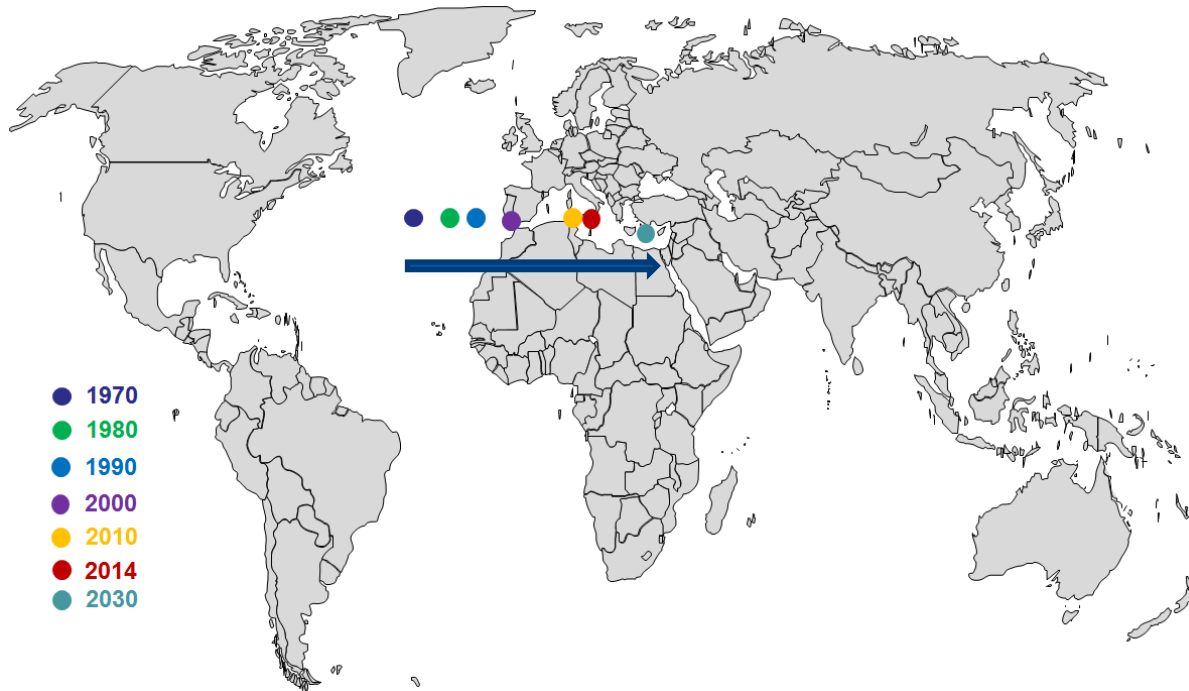


## Objective of this study

- Quantify the volume of direct and indirect traffic
- Quantify demand of specific country-pairs
- Measure air transport network efficiency



## Centre of gravity of departing and arriving passengers

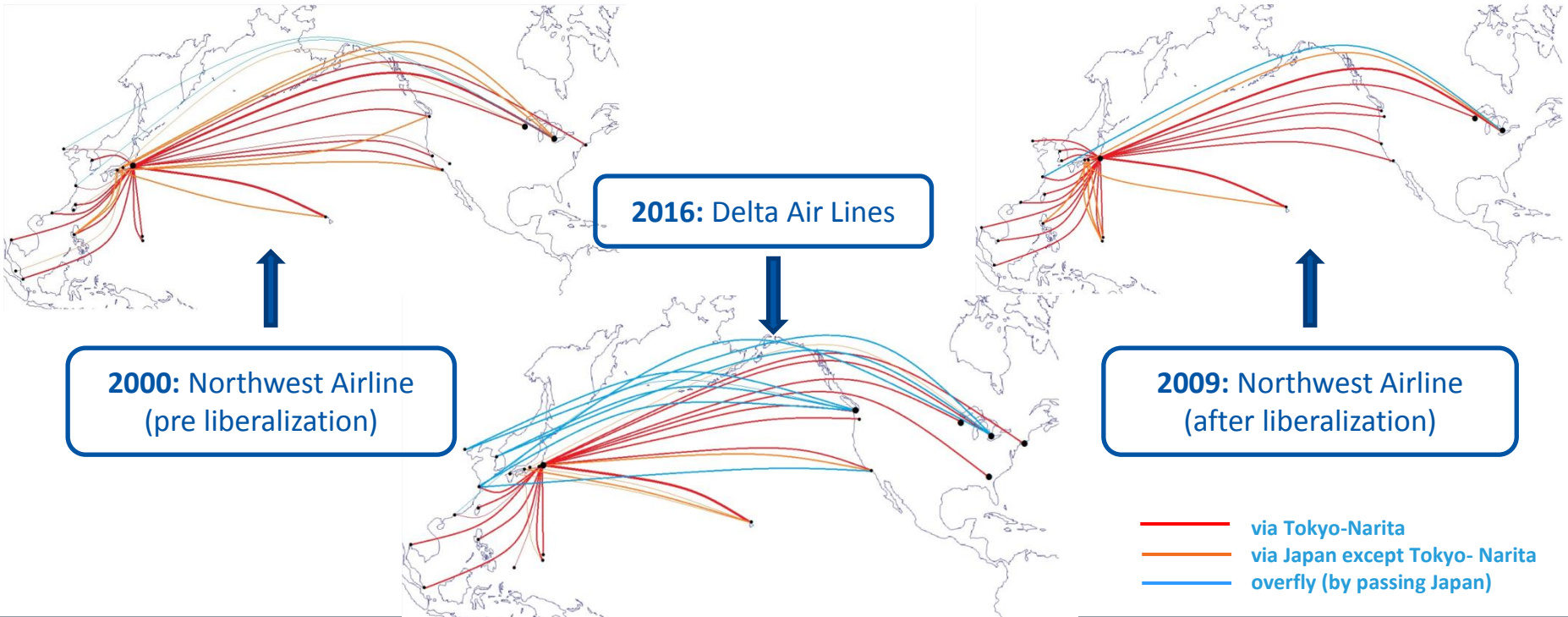


The centre of gravity has been steadily moving from the middle of North Atlantic to the middle of the Mediterranean sea in the last four decades. It is expected to move further east by 2030.





# Network dynamics: Northwest-Delta transpacific system





# ICAO-ICM Air Route Diagnostic Project

Quantify demand for true passenger origin and destination (O&D)

Explore gaps in the actual and optimal air network

Quantify cost of those gaps and network inefficiencies

Quantify the impact of competition on air connectivity

**Decision making tool for States, policy makers, and airlines to prioritize, identify factors that constraint development of an optimized route connectivity network and address existing gaps.**

Partnership with the **Interdisciplinary Center for Mathematical and Computational Modelling (ICM)** of the University of Warsaw.



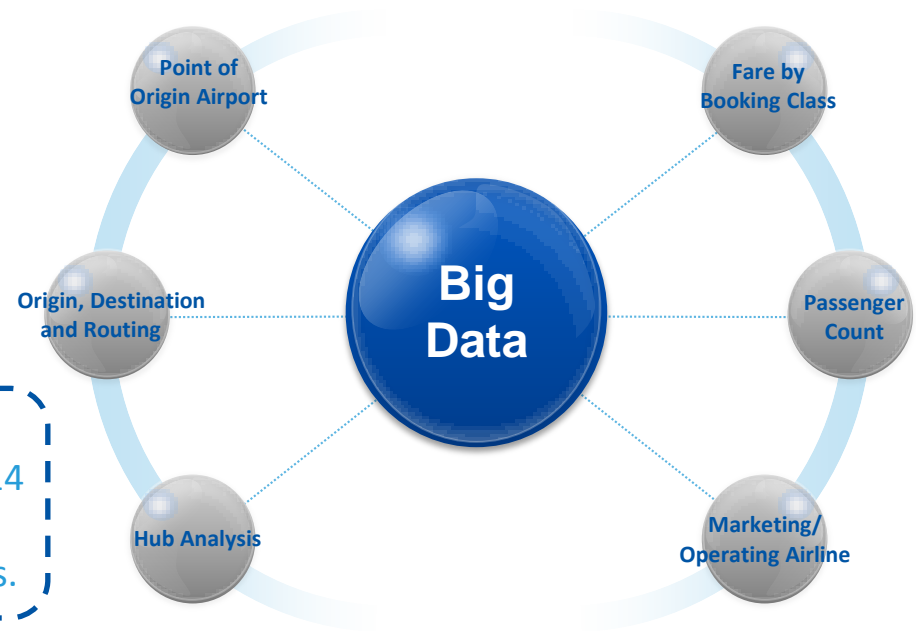


## Marketing Information Data Transfer (MITD) Data

MIDT is the bookings made in the global distribution systems (GDS) covering 3.3 billion passengers on more than 3 million departures with the ability to see their true origin/destination.



This study is based on one year of MIDT, and OAG airline schedule data corresponding to SUMMER 2014 and WINTER 2014 traffic seasons. Some validation checks has been done with ICAO air carriers statistics.





## Assumption for this analysis

Functionality of global air transport network is similar to the system of Communicating Vessels

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Therefore, special metrics can be introduced to evaluate behaviours of specific sub-system (i.e. country-pair traffic)

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### Definition of “international passenger”

At least one of the consecutive departure, transfer or arrival airports is located in the different State





## Measurement of air transport network efficiency

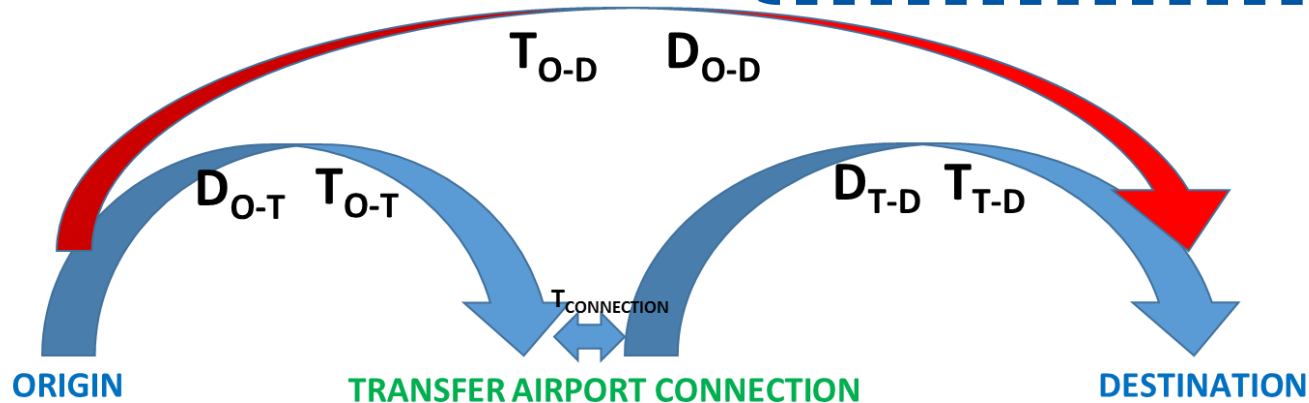
**Detour factor (DF):** “Sum of Origin to Connection + Connection to Destination”  
to “Origin to Destination direct connection”

**A ratio of trip times or trip distances:**

$$\text{Time wise: } DF_T = (T_{O-T} + T_{\text{CONNECTION}} + T_{T-D}) / T_{O-D}$$

or

$$\text{Distance wise: } DF_D = (D_{O-T} + D_{T-D}) / D_{O-D}$$





## Measurement of air transport network efficiency

Mean Weighted Detour Factor (MW DF) is DF weighted by the relevant passenger volumes for a set of city-pairs:

$$\text{MW DF} = \sum \frac{\text{PAX (O\&D)}}{\text{TTL PAX}} \text{DF}_{\text{O\&D}}$$



## Measurement of air transport network efficiency

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Origin and Destination Load Factor (O&D LF) is calculated based on **Available Seat Kilometers (ASK)** and **Revenue Passenger Kilometers (RPK)** corresponding to the complete country-to-country O&D passenger flow (CONNECTING ROUTE O&D):

$$\text{O\&D LF} = \frac{\Sigma \text{RPK}(\text{CONNECTING ROUTE O\&D})}{\Sigma \text{ASK}(\text{CONNECTING ROUTE O\&D})}$$



## Measurement of air transport network efficiency

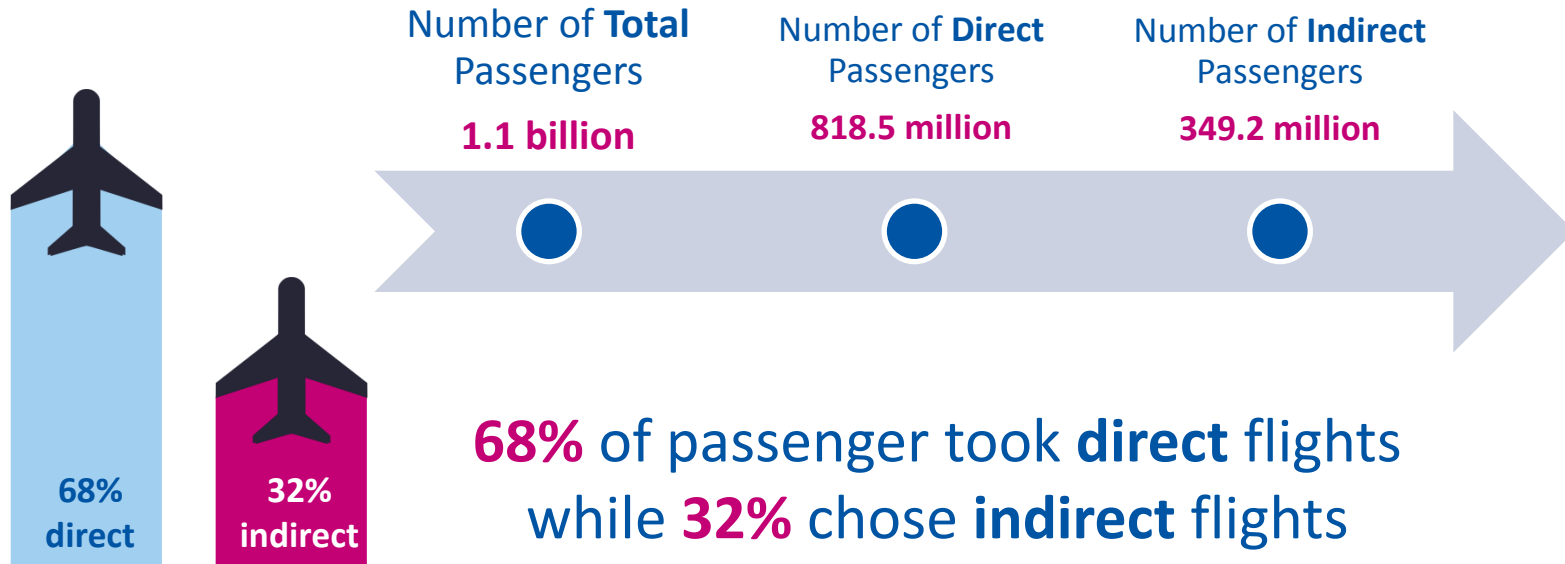
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**Efficiency Load Factor (ELF)** is a multidimensional measure of air transport system (route network & fleet mix) fit to the passenger demand. It is an efficiency level indication of the passenger carriage according to their O&D connectivity needs:

$$ELF = \frac{\Sigma RP_k (\text{DIRECT ROUTE O\&D})}{\Sigma ASK(\text{CONNECTING ROUTE O\&D})}$$

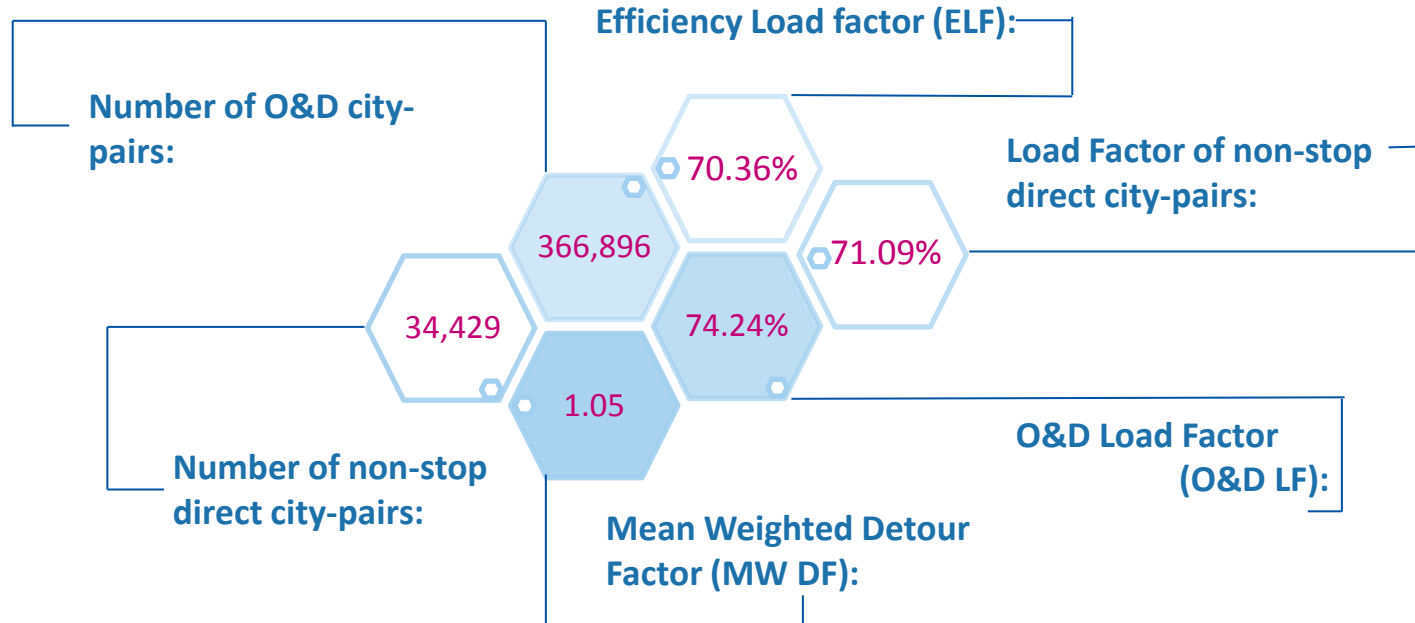


## Connectivity status (2014, preliminary)





## Connectivity status (2014, preliminary)





## Case studies

1

### SINGLE COUNTRY PAIR:

MEXICO <-> UNITED STATES

JAPAN <-> AUSTRALIA

UNITED STATES <-> INDIA

GERMANY <-> THAILAND

INDIA <-> CHINA

2

### DOUBLE COUNTRY PAIR, TRANS AFRICAN CONNECTIONS:

(MOROCCO, SENEGAL)

<->

(KENYA, UNITED REPUBLIC OF TANZANIA)



## Mexico <-> United States



### Major directional traffic airports:

USA.code	Total.pax	Airport.Name
1	LAX 2470118	Los Angeles International Apt
2	ORD 1208894	Chicago O'Hare International Apt
3	JFK 1037178	New York J F Kennedy International Apt
4	SFO 956192	San Francisco
5	IAH 930958	Houston Intercontinental Apt
6	MIA 849404	Miami International Apt
7	LAS 749187	Las Vegas McCarran International Apt
8	DFW 718347	Dallas/Fort Worth International Apt
9	DEN 630055	Denver Intl Apt
10	EWR 604512	Newark Liberty International Apt

Mexico.code	Total.pax	Airport.Name
1	CUN 6348092	Cancun
2	MEX 4541827	Mexico City Juarez Intl
3	GDL 2524324	Guadalajara
4	SJD 2132783	San Jose Cabo
5	PVR 1539404	Puerto Vallarta
6	MTY 908466	Monterrey Mariano Escobedo Intl
7	BJX 509223	Leon/Guanajuato
8	CZM 404396	Cozumel
9	MLM 250435	Morelia
10	MZT 231462	Mazatlan

Number of city pairs: 9,155

Number of RT, non-stop direct routes served : 227

Total RT Pax: 21,527,251

Direct connectivity pax: 12,001,418

Indirect connectivity pax: 9,525,833

Major hub connections	PAX	share
1	DFW Dallas/Fort Worth International Apt	1731362 0.18175439
2	IAH Houston Intercontinental Apt	1669958 0.17530834
3	ATL Atlanta Hartsfield-jackson Intl Apt	1016582 0.10671844
4	MEX Mexico City Juarez Intl	977262 0.10259071
5	PHX Phoenix Sky Harbor Intl Apt	743262 0.07802593
6	LAX Los Angeles International Apt	418018 0.04388257
7	CLT Charlotte	369929 0.03883429
8	MIA Miami International Apt	266776 0.02800553
9	DEN Denver Intl Apt	227777 0.02391150
10	ORD Chicago O'Hare International Apt	223092 0.02341968

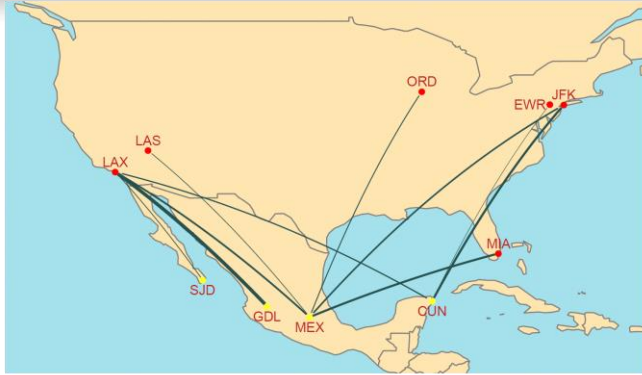
Mean weighted detour factor: 1.09072

Seats load factor for operated routes: 0.8068847

O&D load factor: 0.8047484

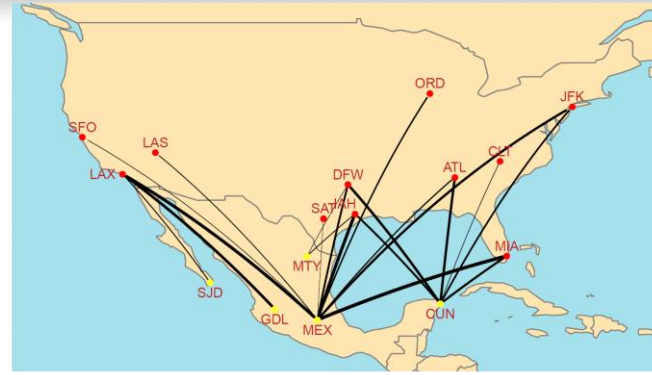
Efficiency load factor: 0.7510158





**DEMAND**

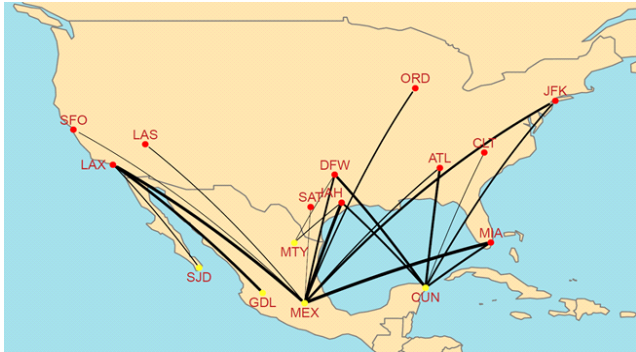
Major Country Pair O&D Airport Traffic Demand [PAX]



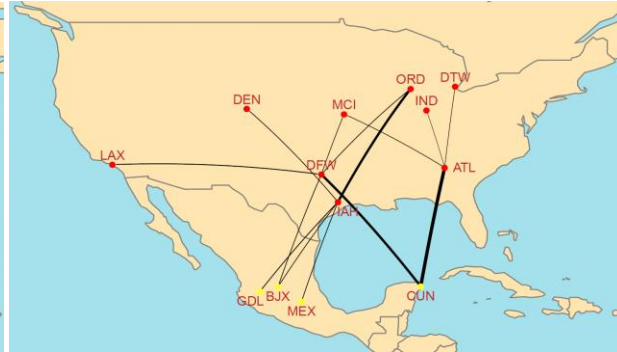
**SUPPLY**

Main Country Pair Direct Route Network Structure [SEATS]

Country Pair Major PAX FLOW Structure [PAX]



Direct non-stop

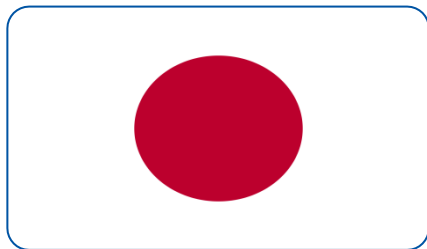


Connecting

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## Japan ↔ Australia



### Major directional traffic airports:

Japan.code	Total.pax	Airport.Name
1	NRT 743423	Tokyo Narita Intl
2	KIX 254291	Osaka Kansai International Airport
3	HND 65573	Tokyo Intl (Haneda)
4	NGO 63560	Nagoya Chubu Centrair International Apt
5	CTS 48104	Sapporo New Chitose Apt
6	FUK 45825	Fukuoka
7	ITM 19375	Osaka Intl (Itami)
8	OKA 7948	Okinawa Naha Apt
9	KOJ 3934	Kagoshima
10	OKJ 2767	Okayama

Australia.code	Total.pax	Airport.Name
1	SYD 324594	Sydney Kingsford Smith Apt
2	CNS 246089	Cairns
3	MEL 206723	Melbourne Airport
4	OOL 160920	Gold Coast
5	BNE 130958	Brisbane
6	PER 111392	Perth
7	ADL 43493	Adelaide International
8	CBR 9746	Canberra
9	AYQ 7606	Ayers Rock
10	DRW 6492	Darwin International

Number of city pairs: 510

Number of RT, non-stop direct routes served : 6

Total RT Pax: 1,276,989

Direct connectivity pax: 602,997

Indirect connectivity pax: 673,992

### Major hub connections

		PAX	share
1	SIN	Singapore Changi Apt	120950 0.17945317
2	HKG	Hong Kong International Apt	100054 0.14844983
3	SYD	Sydney Kingsford Smith Apt	95227 0.14128803
4	CNS	Cairns	67985 0.10086915
5	NRT	Tokyo Narita Intl	40179 0.05961347
6	TFE	Taipei Taiwan Taoyuan International Apt	32574 0.04832995
7	ICN	Seoul Incheon International Airport	32185 0.04775279
8	KUL	Kuala Lumpur International Airport	27020 0.04008950
9	NRT,SYD	Tokyo Narita Intl,Sydney Kingsford Smith Apt	20089 0.02980599
10	OOL	Gold Coast	11891 0.01764264

Mean weighted detour factor: 1.110004

Seats load factor for operated routes: 0.7852049

O&D load factor: 0.7780584

Efficiency load factor: 0.7068994



Major Country Pair O&D  
Airport Traffic Demand [PAX]

**DEMAND**



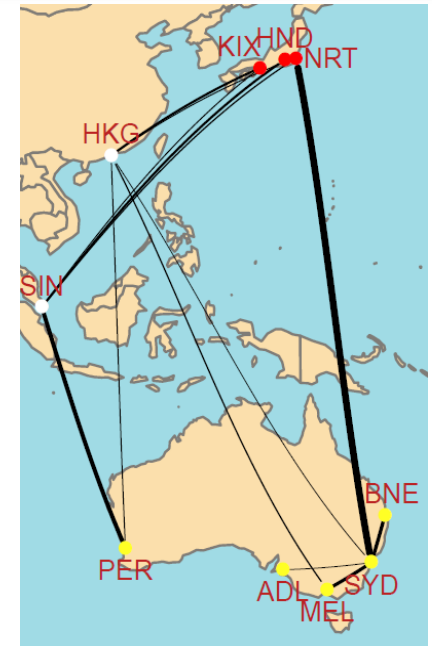
Main Country Pair Direct Route  
Network Structure [SEATS]

**SUPPLY**



Direct non-stop  
Country Pair Major PAX FLOW Structure [PAX]

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Connecting



## United States <-> India



### Major directional traffic airports:

USA.code	Total.pax	Airport.Name
1	JFK 675168	New York J F Kennedy International Apt
2	SFO 486382	San Francisco
3	EMW 430240	Newark Liberty International Apt
4	ORD 384552	Chicago O'Hare International Apt
5	LAX 273475	Los Angeles International Apt
6	IAD 245264	Washington Dulles International Apt
7	DFW 180650	Dallas/Fort Worth International Apt
8	IAH 178792	Houston Intercontinental Apt
9	BOS 150733	Boston Logan International Apt
10	ATL 123386	Atlanta Hartsfield-jackson Intl Apt

India.code	Total.pax	Airport.Name
1	DEL 980456	Delhi
2	BOM 896516	Mumbai
3	HYD 624579	Hyderabad Rajiv Gandhi Intl Arpt
4	BLR 491976	Bengaluru
5	MAA 440674	Chennai
6	AMD 344233	Ahmedabad
7	COK 185523	Kochi (IN)
8	CCU 124700	Kolkata
9	TRV 68329	Thiruvananthapuram
10	GOI 36909	Goa

Number of city pairs: 3,878

Number of RT, non-stop direct routes served : 4

Total RT Pax: 4,439,397

Direct connectivity pax: 398,494

Indirect connectivity pax: 4,040,903

### Major hub connections

		PAX	share
1	DXB	Dubai International	713119 0.17647516
2	LHR	London Heathrow Apt	439721 0.10881751
3	AUH	Abu Dhabi International Apt	296373 0.07334326
4	DOH	Doha	237476 0.05876805
5	FRA	Frankfurt International Apt	191528 0.04739733
6	EMW	Newark Liberty International Apt	172644 0.04272411
7	DEL	Delhi	164818 0.04078742
8	HKG	Hong Kong International Apt	111356 0.02755721
9	BOM	Mumbai	95180 0.02355414
10	JFK,DXB	New York J F Kennedy Intl Apt,Dubai Intl	68248 0.01688929

Mean weighted detour factor: 1.085855

Seats load factor for operated routes: 0.8414159

O&D load factor: 0.7823664

Efficiency load factor: 0.7285158



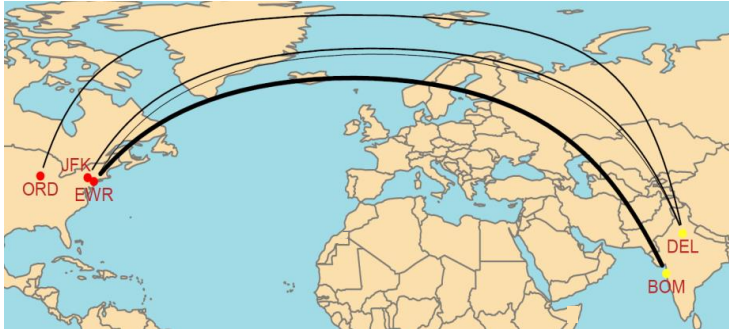
**DEMAND**

Major Country Pair O&D Airport Traffic Demand [PAX]



**SUPPLY**

Main Country Pair Direct Route Network Structure [SEATS]



Direct non-stop



Connecting

Country Pair Major PAX FLOW Structure [PAX]

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## Germany <-> Thailand



### Major directional traffic airports:

Germany.code	Total.pax	Airport.Name
1	FRA 567786	Frankfurt International Apt
2	MUC 333081	Munich International Airport
3	DUS 115239	Duesseldorf International Airport
4	TXL 109947	Berlin Tegel Apt
5	HAM 82028	Hamburg Airport
6	STR 16719	Stuttgart Airport
7	SXF 13094	Berlin Schoenefeld Apt
8	HAJ 12161	Hannover
9	BRE 6678	Bremen
10	NUE 6223	Nuremberg



Thailand.code	Total.pax	Airport.Name
1	BKK 885260	Bangkok Suvarnabhumi International Apt
2	HKT 232003	Phuket
3	USM 94017	Ko Samui
4	KBV 26297	Krabai
5	CNX 15211	Chiang Mai
6	UTH 6315	Udon Thani
7	KKC 4764	Khon Kaen
8	TDX 4439	Trat
9	CEI 2508	Chiang Rai
10	URT 2172	Surat Thani

Number of city pairs: 193

Number of RT, non-stop direct routes served : 3



Total RT Pax: 1,278,366

Direct connectivity pax: 362,010

Indirect connectivity pax: 916,356

### Major hub connections

		PAX	share
1	BKK	Bangkok Suvarnabhumi International Apt	133021 0.14516302
2	DXB	Dubai International	132493 0.14458682
3	AUH	Abu Dhabi International Apt	127819 0.13948618
4	DOH	Doha	80959 0.08834885
5	FRA	Frankfurt International Apt	43301 0.04725347
6	MCT	Muscat	40398 0.04408549
7	AUH,BKK	Abu Dhabi Intl ,Bangkok Suvarnabhumi Intl Apt	29338 0.03201594
8	SIN	Singapore Changi Apt	24140 0.02634347
9	KUL	Kuala Lumpur International Airport	22921 0.02501320
10	IST	Istanbul Ataturk Airport	22212 0.02423949

Mean weighted detour factor: 1.064653

Seats load factor for operated routes: 0.787561

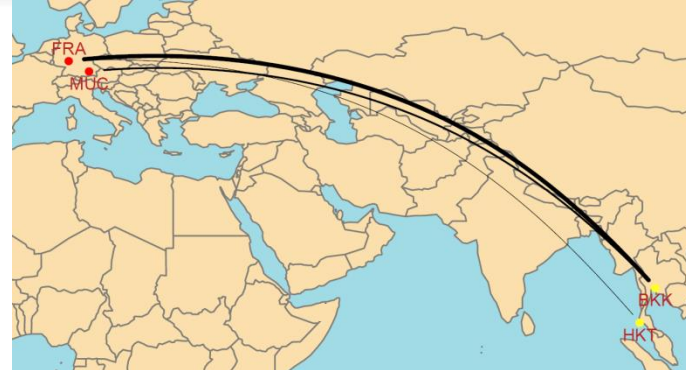
O&D load factor: 0.7347223

Efficiency load factor: 0.6981138



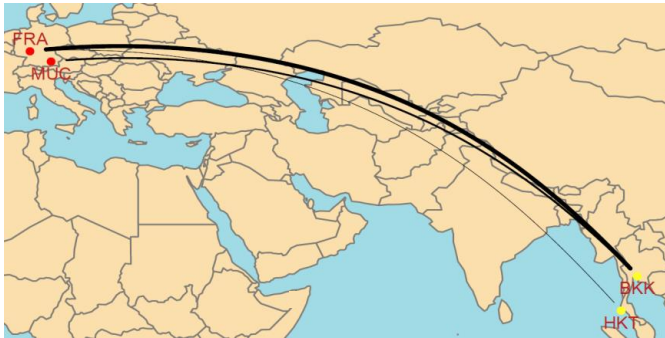
Major Country Pair O&D Airport Traffic Demand [PAX]

**DEMAND**

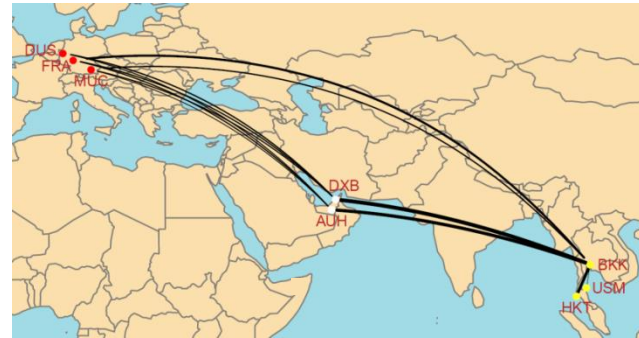


Main Country Pair Direct Route Network Structure [SEATS]

**SUPPLY**



Direct non-stop



Connecting

Country Pair Major PAX FLOW Structure [PAX]

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## India <-> China



### Major directional traffic airports:

	India.code	Total.pax	Airport.Name
1	DEL	358032	Delhi
2	BOM	204401	Mumbai
3	CCU	86767	Kolkata
4	MAA	84461	Chennai
5	BLR	68004	Bengaluru
6	HYD	36853	Hyderabad Rajiv Gandhi Intl Arpt
7	COK	20481	Kochi (IN)
8	AMD	15131	Ahmedabad
9	PNQ	5592	Pune
10	TRV	4925	Thiruvananthapuram

	China.code	Total.pax	Airport.Name
1	FVG	315307	Shanghai Pudong International Apt
2	CAN	158345	Guangzhou
3	PEK	154003	Beijing Capital Intl Apt
4	KMG	35093	Kunming
5	HGH	34707	Hangzhou
6	CTU	23097	Chengzhou
7	XMN	19901	Xiamen
8	TAO	19265	Qingdao
9	NKG	12551	Nanjing
10	XIY	10822	Xi'an Xianyang Apt

Number of city pairs: 1,214

Number of RT, non-stop direct routes served : 6

Total RT Pax: 915,449

Direct connectivity pax: 279,101

Indirect connectivity pax: 636,348

### Major hub connections

			PAX	share
1	HKG	Hong Kong International Apt	202574	0.31833839
2	KUL	Kuala Lumpur International Airport	62883	0.09881857
3	SIN	Singapore Changi Apt	52682	0.08278803
4	BKK	Bangkok Suvarnabhumi International Apt	44703	0.07024930
5	KMG	Kunming	40077	0.06297969
6	DEL	Delhi	33526	0.05268501
7	CAN	Guangzhou	31112	0.04889149
8	CTU	Chengdu	22471	0.03531244
9	CMB	Bandaranaikie Intl	17535	0.02755568
10	FVG	Shanghai Pudong International Apt	17269	0.02713767

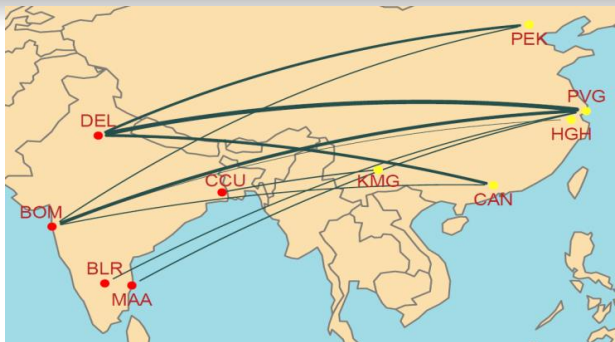
Mean weighted detour factor: 1.197112

Seats load factor for operated routes: 0.9039567

O&D load factor: 0.8032532

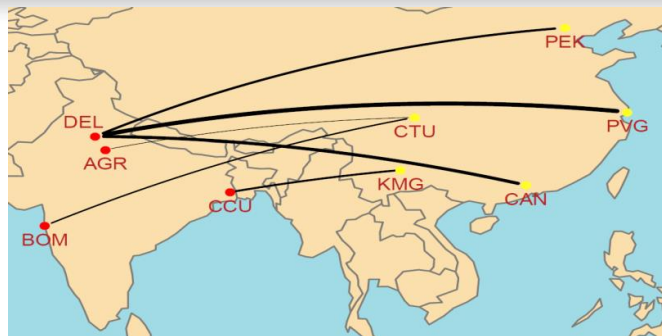
Efficiency load factor: 0.6905103





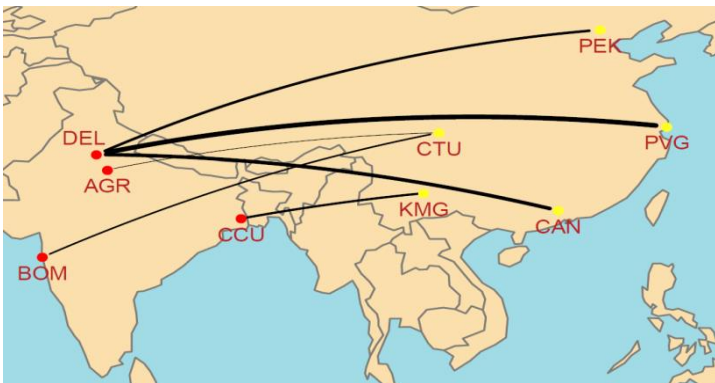
**DEMAND**

Major Country Pair O&D Airport Traffic Demand [PAX]

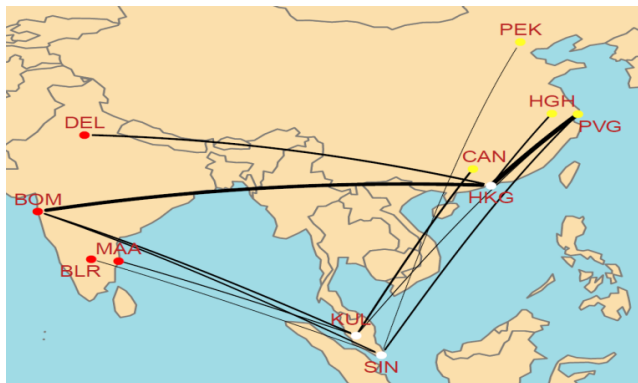


**SUPPLY**

Main Country Pair Direct Route Network Structure [SEATS]



Direct non-stop



Connecting

Country Pair Major PAX FLOW Structure [PAX]

**UTILIZATION**



## DOUBLE COUNTRY PAIR, TRANS AFRICAN CONNECTIONS:

(Morocco, Senegal) <-> (Kenya, United Republic of Tanzania)



Major directional traffic airports:

	MorSen.code	Total.pax		Airport.Name
1	DKR	12060		Dakar
2	CMN	10178	Casablanca	Mohammed V Apt
3	RAK	1870		Marrakech
4	RBA	842		Rabat
5	AGA	216		Agadir
6	TNG	82		Tangier
7	EUN	77		Laayoune
8	OZZ	17		Ouarzazate
9	ZIG	4		Ziguinchor
10	VIL	3		Dakhla

	KenTan.code	Total.pax		Airport.Name
1	NBO	17980	Nairobi Jomo Kenyatta	International Apt
2	DAR	5155		Dar Es Salaam
3	JRO	835		Kilimanjaro
4	MBA	795		Mombasa
5	ZNZ	378		Zanzibar
6	KIS	105		Kisumu
7	MWZ	64		Mwanza
8	ARK	28		Arusha
9	EDL	7		Eldoret
10	MYD	3		Malindi

Number of O&D RT city pairs: 39

Number of RT, non-stop direct routes served : 0

Total RT Pax: 25,350

Direct connectivity pax: 6,807

Indirect connectivity pax: 18,543

Major hub connections

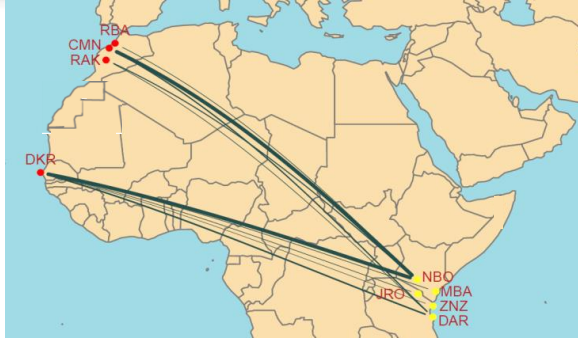
			PAX	share
1	DXB	Dubai International	2856	0.15402039
2	NBO	Nairobi Jomo Kenyatta International Apt	2324	0.12533031
3	ADD	Addis Ababa	1811	0.09766489
4	JED	Jeddah	1492	0.08046163
5	DOH	Doha	1470	0.07927520
6	BZV	Brazzaville	1245	0.06714124
7	CMN,DXB	Casablanca Mohammed V Apt,Dubai International	1019	0.05495335
8	CMN,DOH	Casablanca Mohammed V Apt,Doha	601	0.03241115
9	CAI	Cairo	490	0.02642507
10	JED,ADD	Jeddah,Addis Ababa	447	0.02410613

Mean weighted detour factor: 1.401994

Seats load factor for operated routes: -

O&D load factor: 0.750679

Efficiency load factor: 0.5421229



Major Country Pair O&D Airport Traffic Demand [PAX]

**DEMAND**

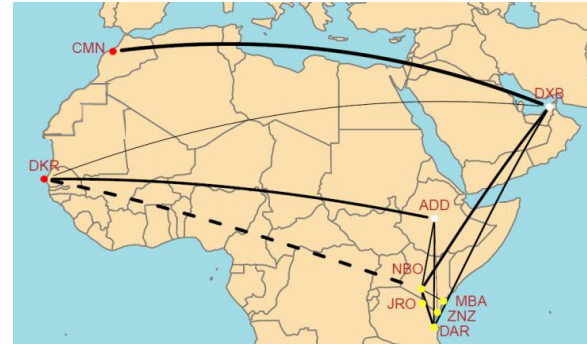


Main Country Pair Direct Route Network Structure [SEATS]

**SUPPLY**



Direct



Connecting

Country Pair Major PAX FLOW Structure [PAX]

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## Preliminary observation and next steps

Different connectivity patterns can be observed depending on:

- Market distance
- Demand potential
- Demand potential country share
- Airlines' strategies
- Trip purpose (leisure, business)
- Level of market access liberalization (bilaterals)
- Quality of schedule product offered (timing, frequency, connection type)

This model can be applied also to a forecasting tool specially in the scope of the necessary investments projections (e.g. evaluation of **return of** launching non-stop connection **investments**)

Further steps for country pair analysis:

- a) Inclusion of traffic connecting beyond and via each country pair
- b) Time-series/historical traffic trend



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# NO COUNTRY LEFT BEHIND



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North American  
Central American  
and Caribbean  
(NACC) Office  
Mexico City

South American  
(SAM) Office  
Lima

ICAO  
Headquarters  
Montréal

Western and  
Central African  
(WACAF) Office  
Dakar

European and  
North Atlantic  
(EUR/NAT) Office  
Paris

Middle East  
(MID) Office  
Cairo

Eastern and  
Southern African  
(ESAF) Office  
Nairobi

Asia and Pacific  
(APAC) Sub-office  
Beijing

Asia and Pacific  
(APAC) Office  
Bangkok



THANK YOU