



| ICAO

# Big Data Analysis for Air Connectivity and Competition

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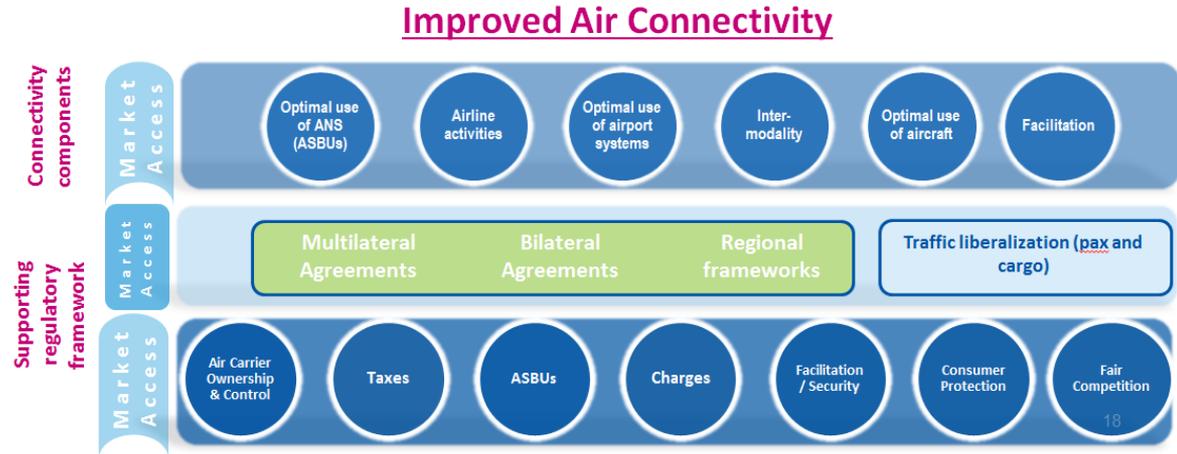
5 December 2017



# Definition of air connectivity

Movement of passengers, mail and cargo involving the minimum of transit points

- which makes trip as short as possible
- with optimal user satisfaction
- at the minimum price possible





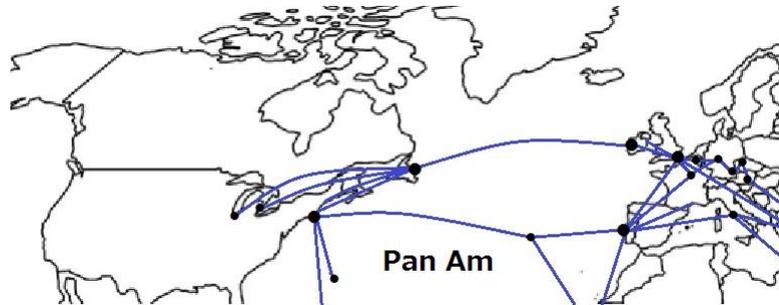
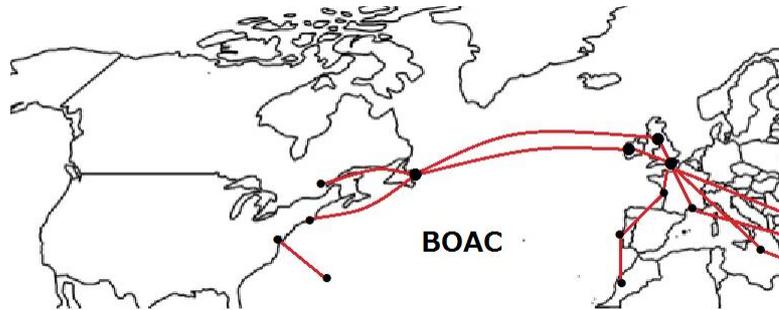
# Improved connectivity leads to economic growth

## Connectivity directly impacts UN Sustainable Development Goals (SDGs)

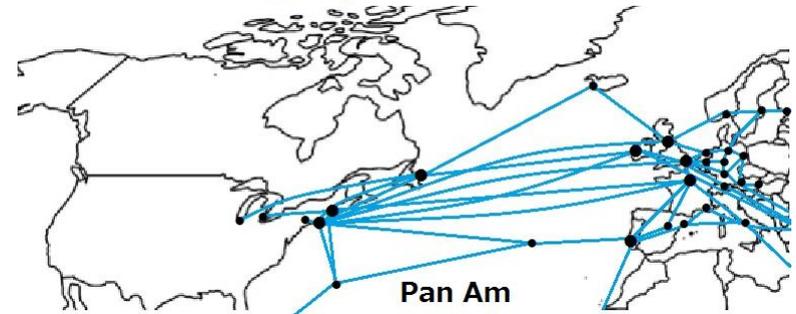
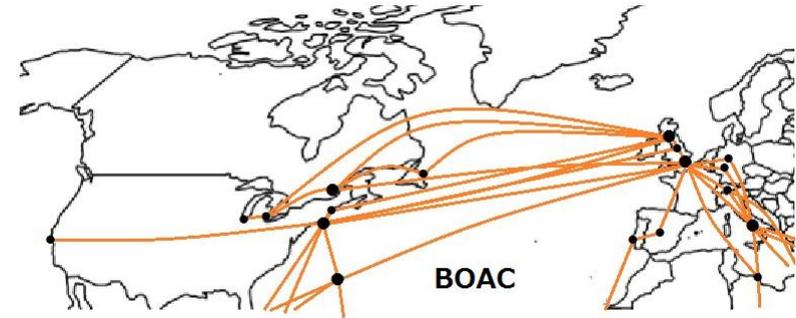


## Network dynamics: BOAC and Pan Am transatlantic system

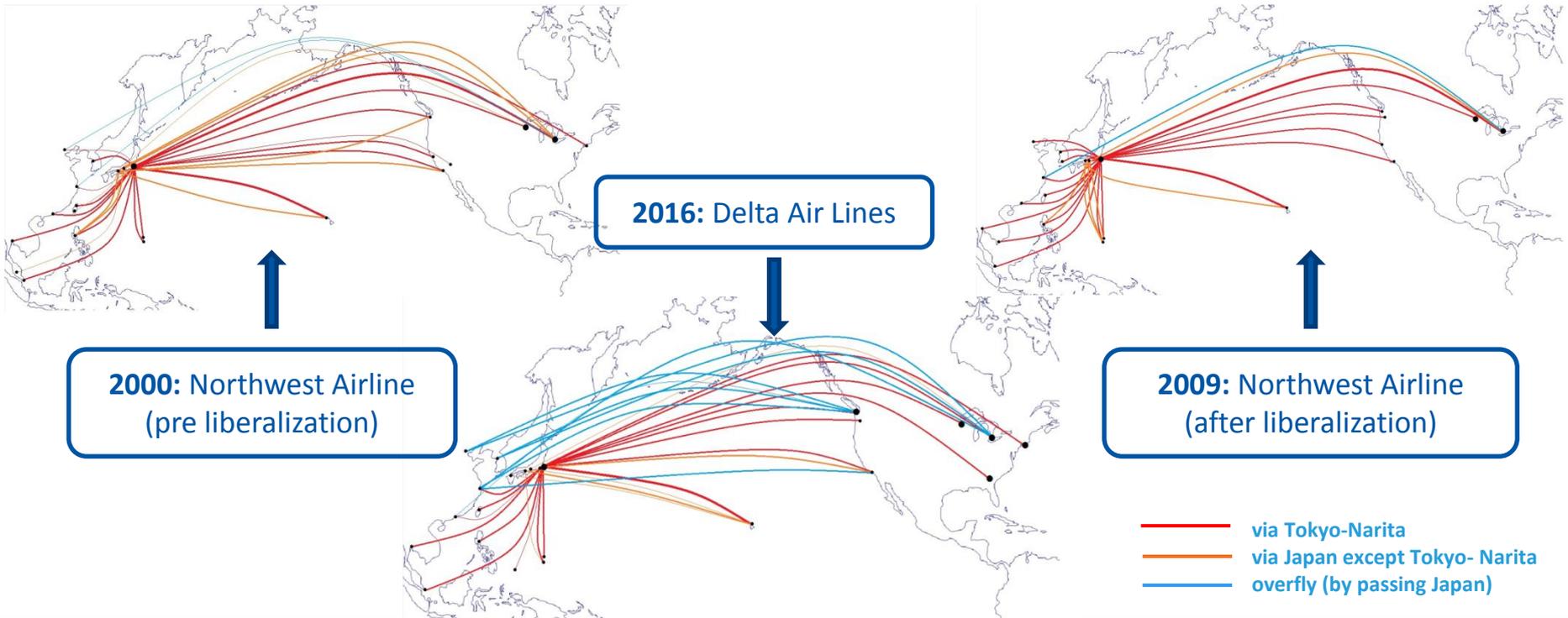
1946-47



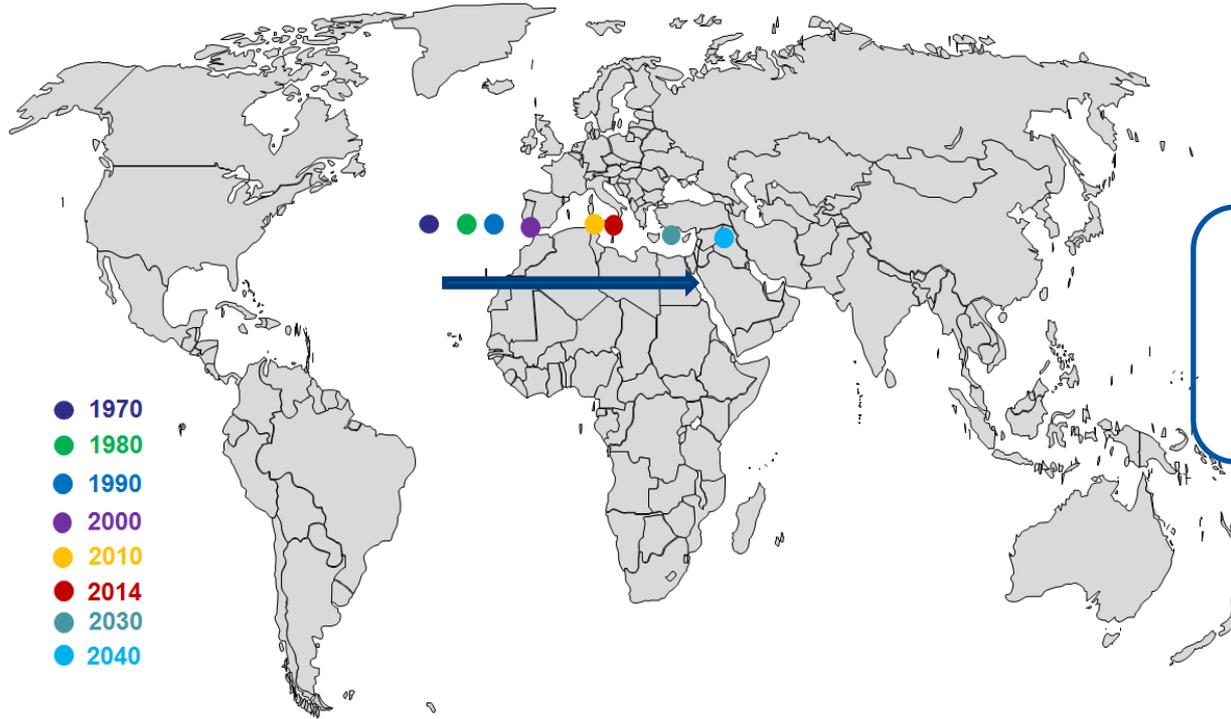
Mid-1950s



## Network dynamics: Northwest-Delta transpacific system



# Centre of gravity



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 2040.

Geographical centre of gravity of departing/arriving passengers

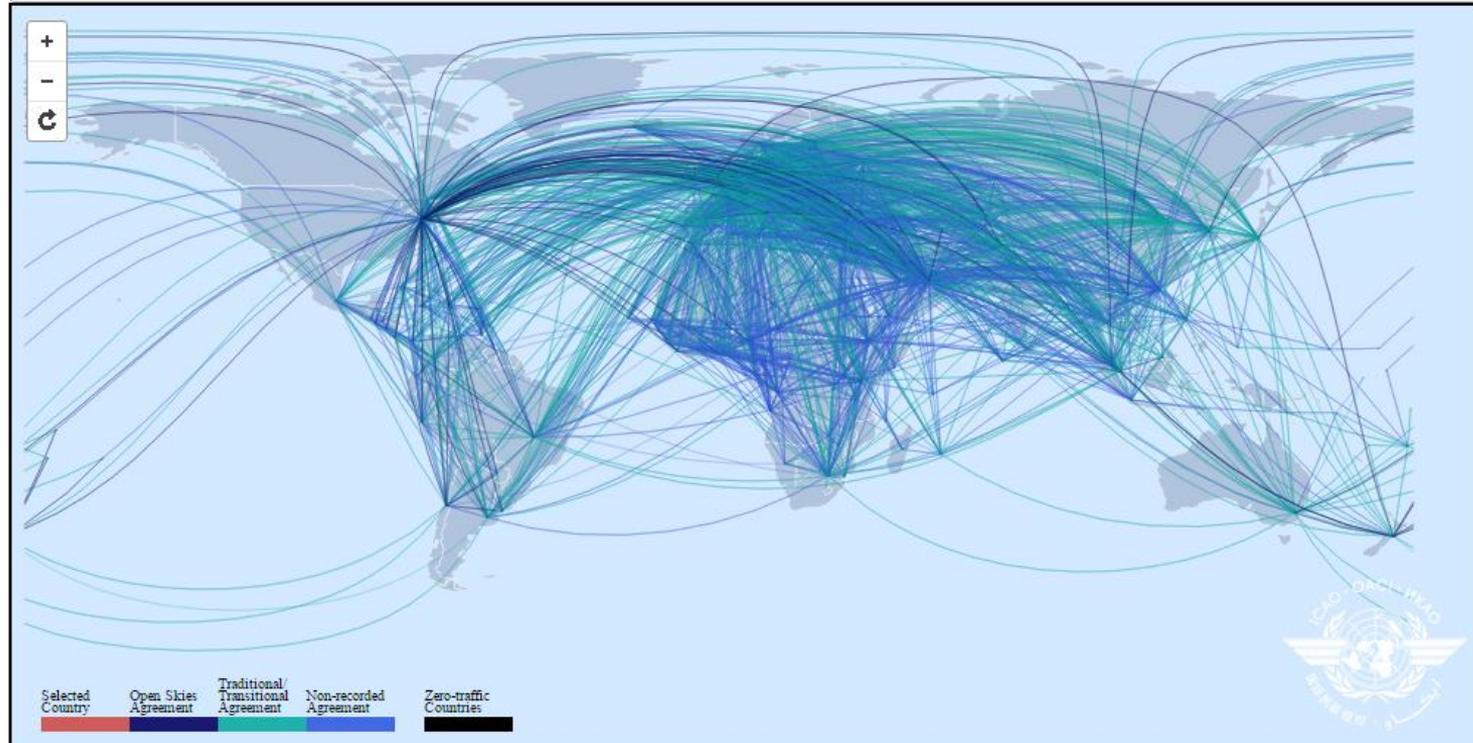


# Air route network 2015





# Web of bilateral air services agreements

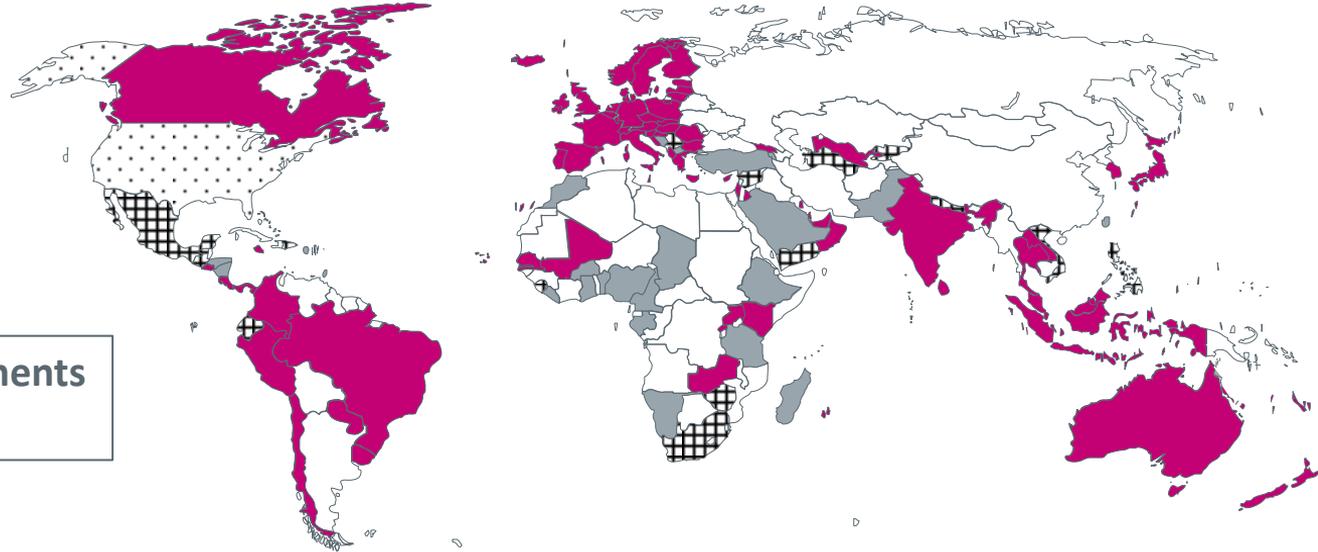


2014 data

# Bilateral open skies

-  States which signed open skies agreements with both the US and third countries
-  States which signed open skies agreements with the US only
-  States which signed open skies agreements with the third countries only

**Over 400 Open Skies Agreements involving 146 States**

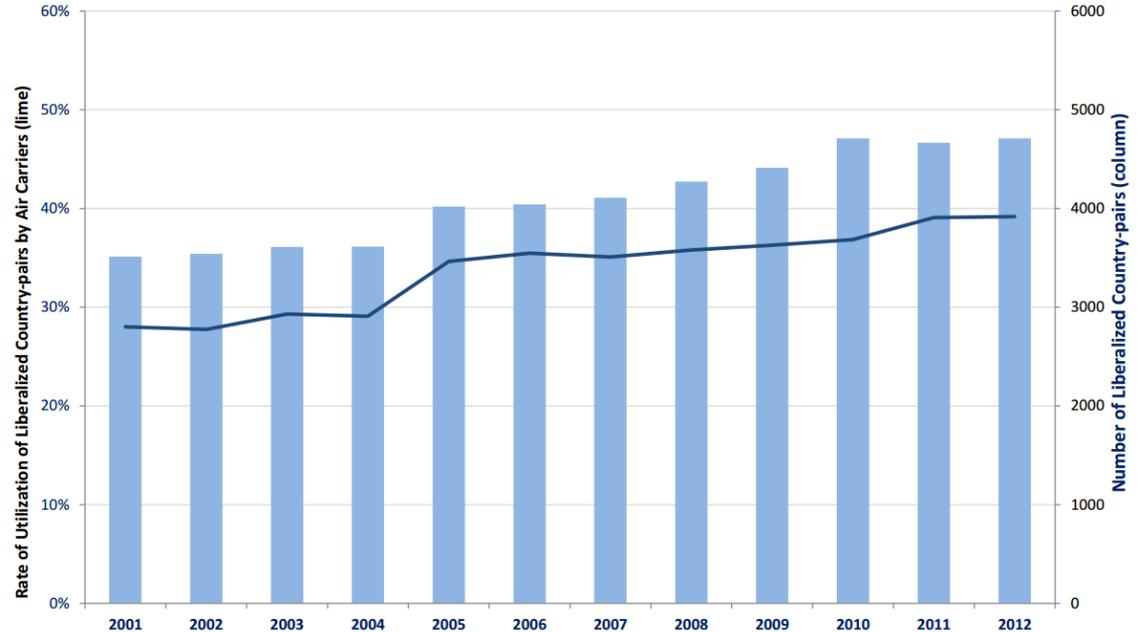


# Utilization of air connectivity

Comparing the number of markets made available by air transport liberalization (“available” or “reserved” connectivity) with the number of those markets having actual air services (“real” connectivity)

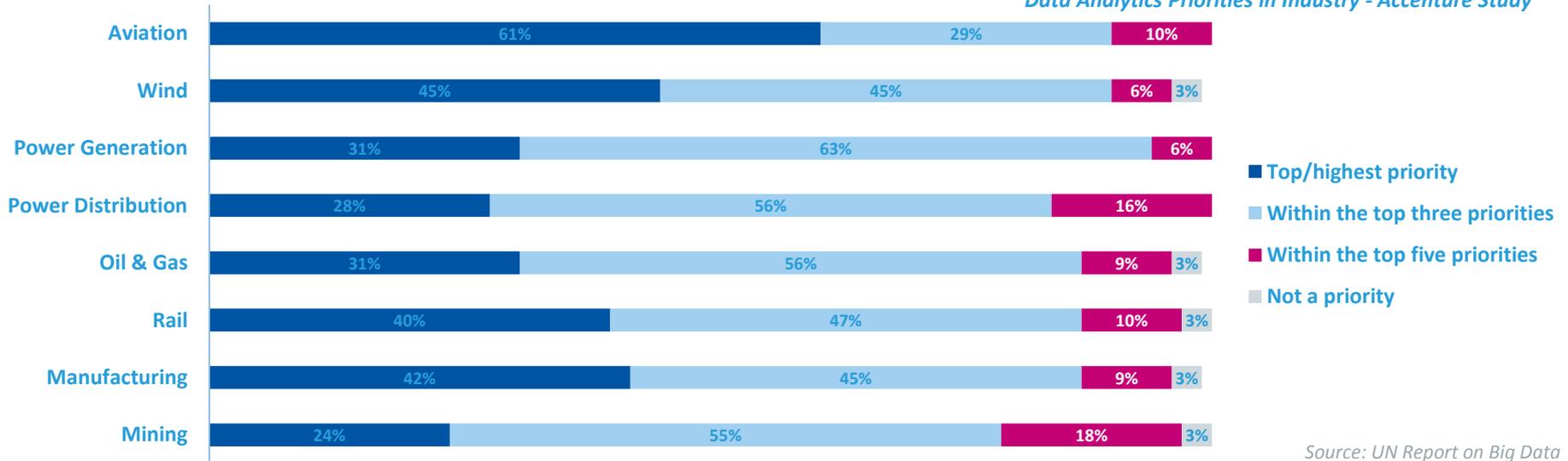
**About 60% of available connectivity opportunities do not have direct flights**

A Utilization Rate of Connectivity Opportunities at the Global Level

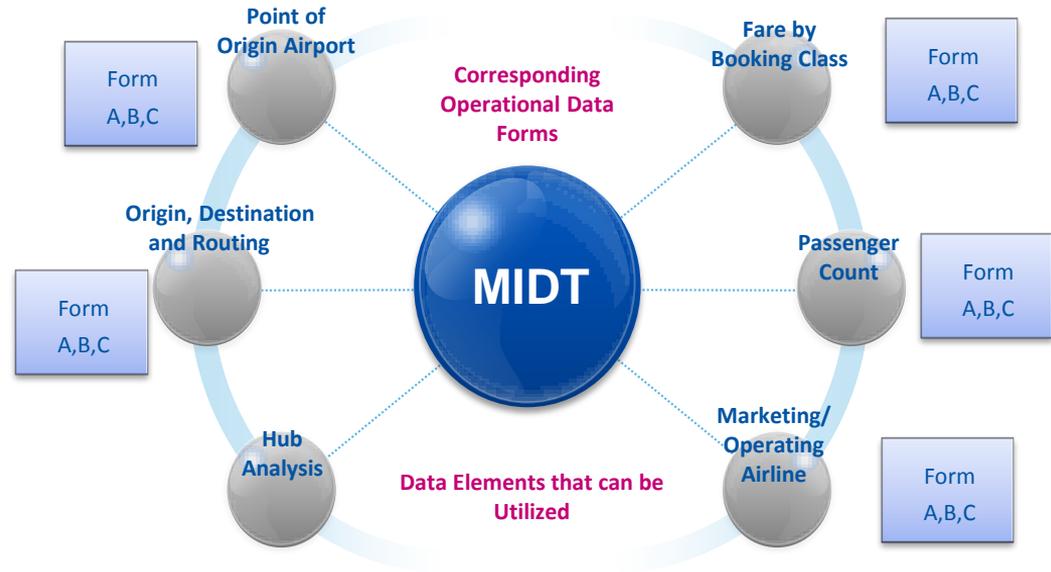


## Big Data analytics has become the highest priority for the aviation industry

*Data Analytics Priorities in Industry - Accenture Study*



Marketing Information Data Transfer (MIDT) are 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.



# Air transport diagnostic project

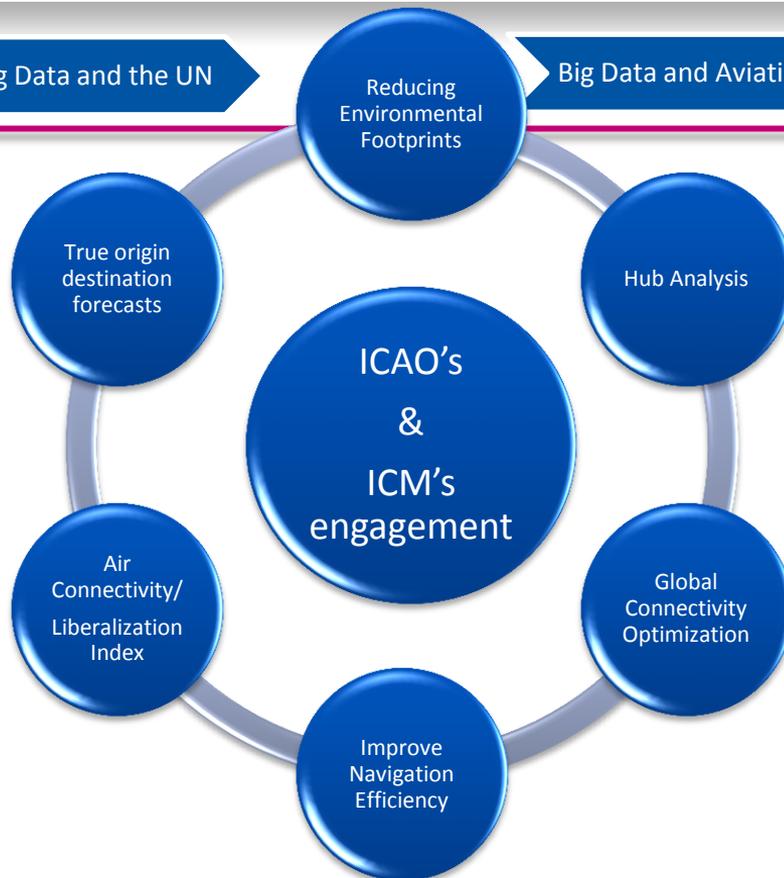
Reflections on Big Data

Big Data and the UN

Big Data and Aviation

ICAO's Engagement

Way Forward



*Joint research project of ICM and ICAO*

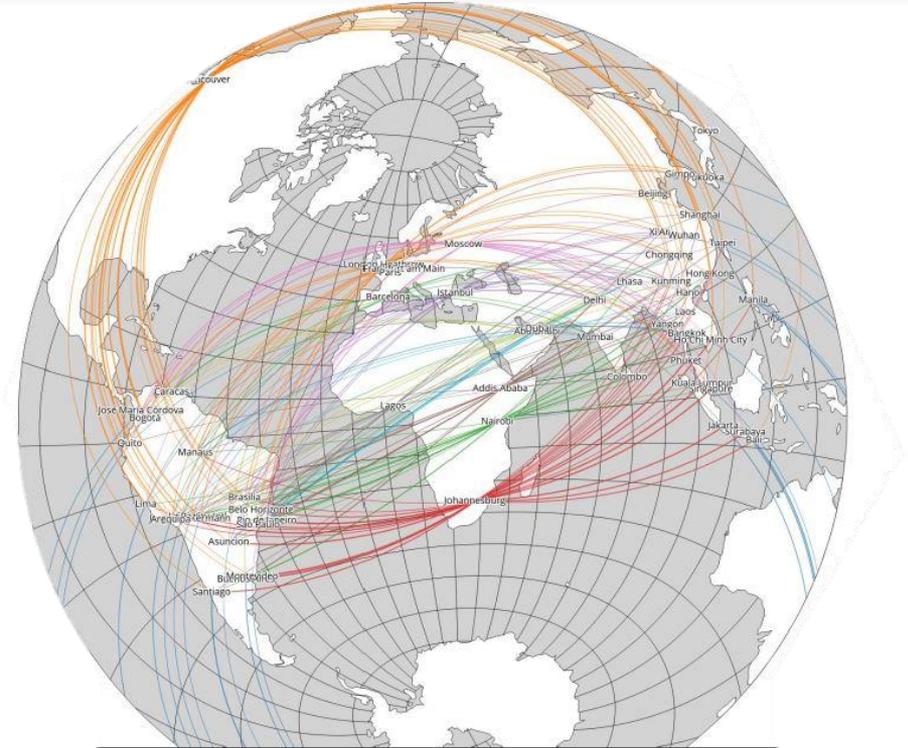
**Partnership with the Interdisciplinary Center for Mathematical and Computational Modelling (ICM) of the University of Warsaw.**

*Using latest technologies, ICM and ICAO are working on a Air Transport Diagnostics Project.*

## Air Transport Diagnostics Project

- Detour factor reduction
- Improve navigation, economic and energy **efficiency**
- Liberalization to meet **unserved consumer demand**
- Increased **connectivity**

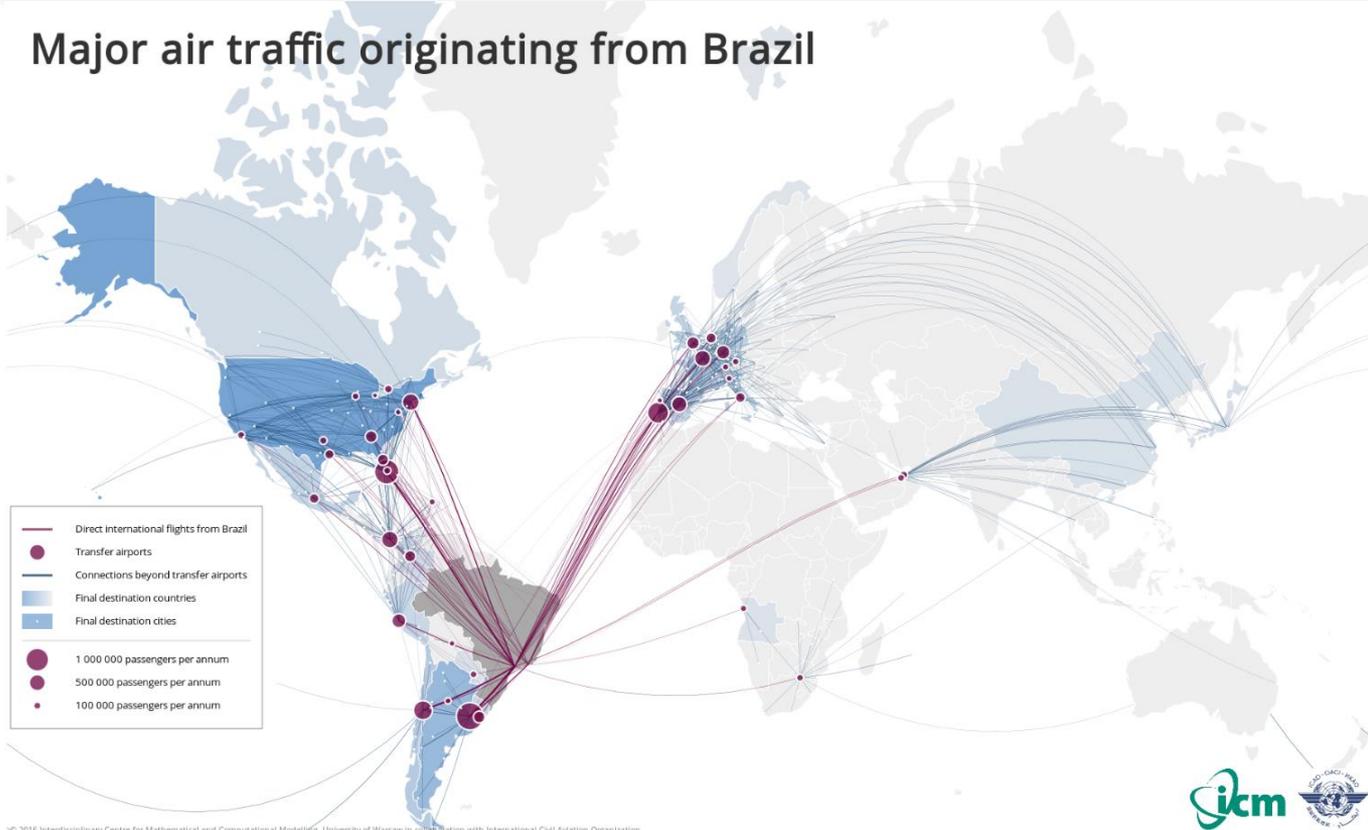
**Optimized Global Network**



South America-South East Asia **optimized connection model case**  
- distant markets/out of nonstop commercial aircraft range capability

# Direct vs indirect flights (Brazil)

## Major air traffic originating from Brazil



- 77 direct non-stop routes from Brazil
- 90,000 O&D city pairs with 2,200 different connections

# Direct vs indirect flights (Global, 2015)

## Worldwide Figures



Number of **Total**  
Passengers  
**1.272 billion**

Number of **Direct**  
Passengers  
**880 million**

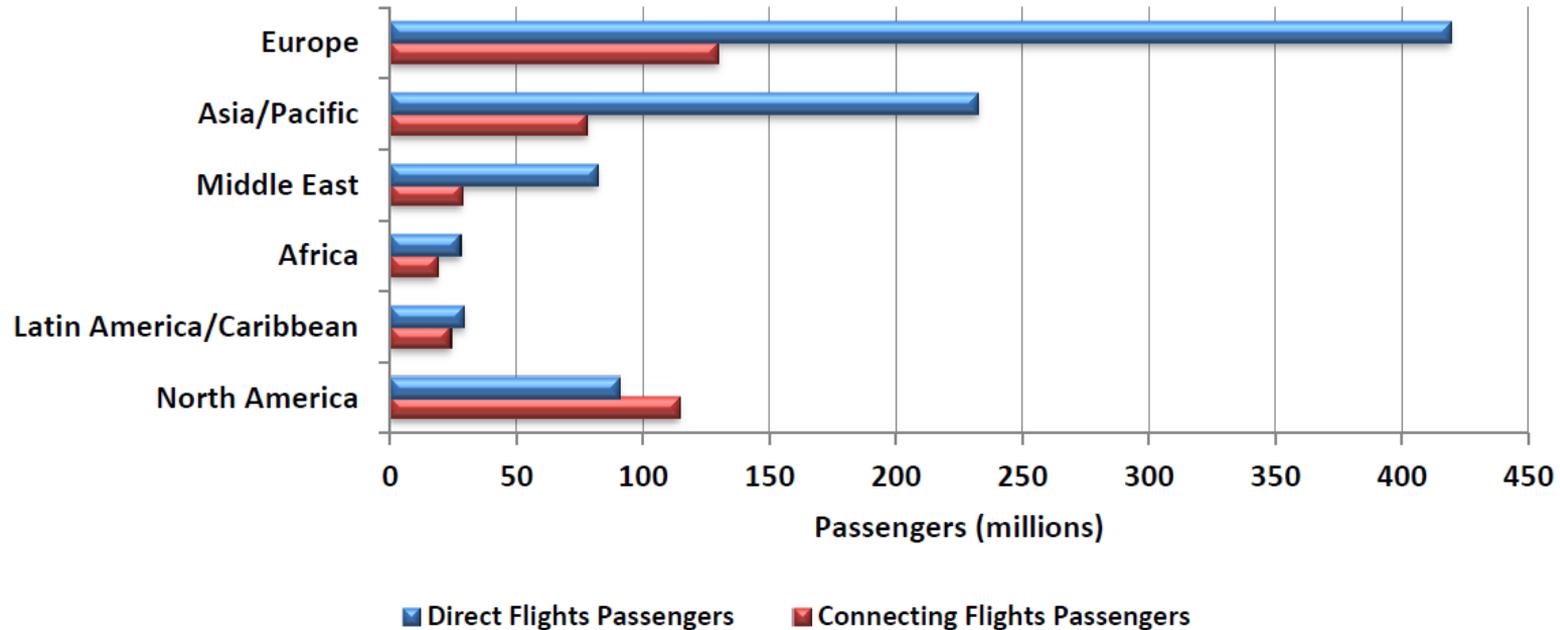
Number of **Indirect**  
Passengers  
**392 million**

**69%** of passenger took **direct** flights  
while **31%** chose **indirect** flights  
to reach final destinations

# Direct vs indirect flights

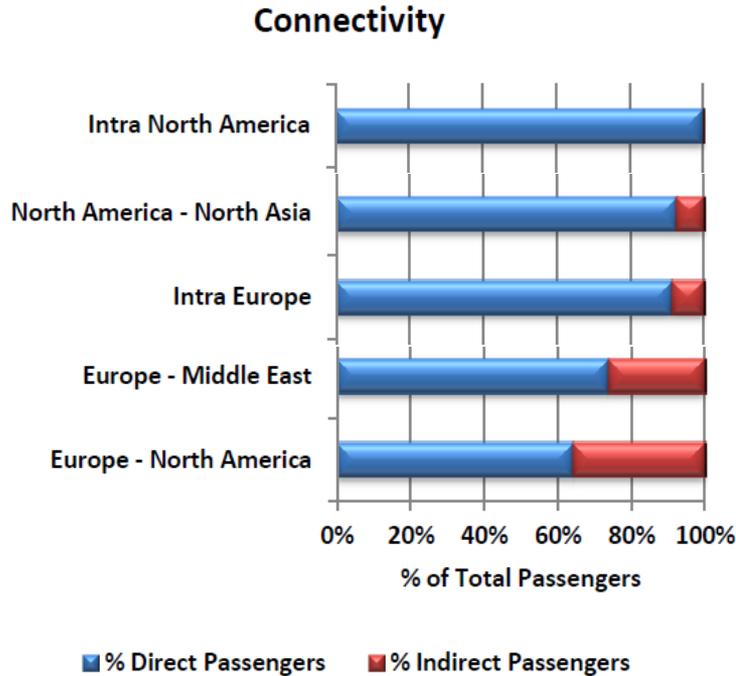
(Regional break-down, 2015)

## International Passengers Flow by Region of Departure 2015



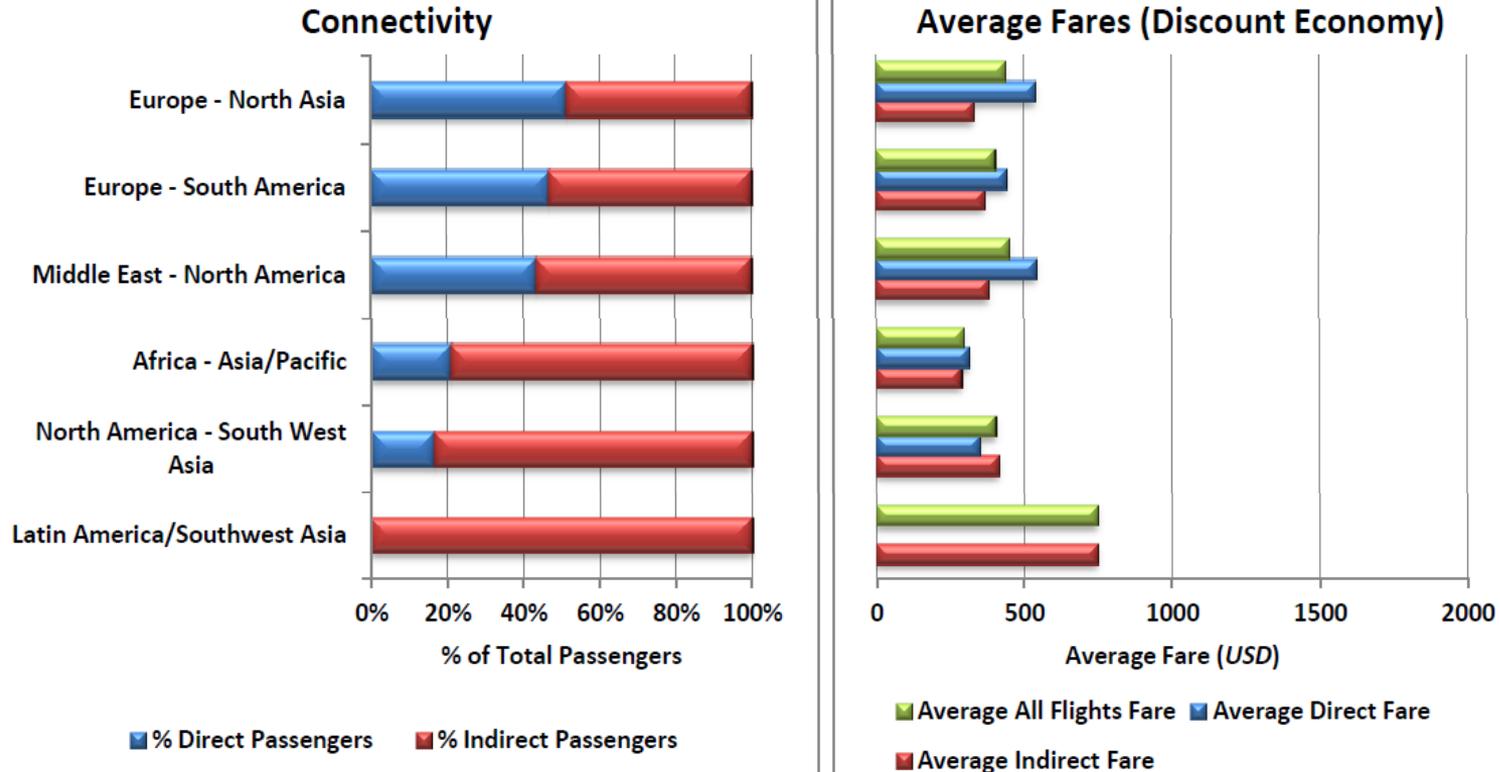
# Direct vs indirect flights

(Average discounted economy fares, 2015)



# Direct vs indirect flights

(Average discounted economy fares, 2015)





# Measurement of air connectivity by State

## Global Air Connectivity Index

Departure	Destination Country Count 2015	Proportion of 2015 Pax	0 Stop (Direct) 2015	1 Stop 2015	2 Stops 2015	Weighted Average Stops 2015
United States	224	8.26%	43.03%	49.75%	7.22%	0.64
United Kingdom	222	6.72%	81.74%	16.78%	1.48%	0.20
Germany	219	5.13%	73.48%	24.57%	1.95%	0.28
Spain	215	4.61%	81.34%	16.77%	1.89%	0.21
China	215	4.38%	72.45%	25.70%	1.85%	0.29
France	217	3.72%	75.79%	22.51%	1.70%	0.26
Italy	213	3.66%	71.80%	25.67%	2.53%	0.31
Japan	215	2.80%	73.74%	23.21%	3.05%	0.29
United Arab Emirates	212	2.21%	85.58%	13.56%	0.86%	0.15
Republic of Korea	212	2.15%	84.70%	14.04%	1.26%	0.17
Canada	218	2.14%	51.79%	41.02%	7.18%	0.55
Thailand	214	2.13%	74.48%	23.01%	2.51%	0.28
India	213	1.99%	50.89%	43.04%	6.07%	0.55
Turkey	206	1.91%	75.22%	23.22%	1.56%	0.26
Hong Kong (China SAR)	213	1.86%	86.61%	12.76%	0.63%	0.14

The World Bank uses this connectivity index in its major report which focuses on understanding the role of connectivity in economic growth and development



# Measurement of air connectivity by State

## Global Air Connectivity Index

Departure	Arrival	Proportion of Departing Passengers 2015	0 Stop (Direct) 2015	1 Stop 2015	2 Stops 2015	Weighted Average Stops 2015
United States	Mexico	11.90%	56.08%	41.66%	2.26%	0.46
United States	Canada	11.73%	56.68%	40.31%	3.00%	0.46
United States	United Kingdom	6.57%	63.28%	33.56%	3.16%	0.40
United States	Japan	3.56%	58.47%	35.14%	6.39%	0.48
United States	Germany	3.52%	29.63%	63.79%	6.59%	0.77
United States	China	3.42%	38.40%	56.08%	5.51%	0.67
United States	Puerto Rico	3.22%	66.67%	31.97%	1.36%	0.35
United States	Brazil	2.82%	36.24%	53.65%	10.11%	0.74
United States	Dominican Republic	2.78%	64.57%	33.73%	1.71%	0.37
United States	France	2.64%	41.19%	54.23%	4.58%	0.63
United States	Italy	2.50%	23.02%	66.89%	10.09%	0.87
United States	India	2.24%	9.58%	71.90%	18.52%	1.09
United States	Spain	1.67%	25.11%	60.60%	14.29%	0.89
United States	Australia	1.60%	32.47%	55.35%	12.19%	0.80
United States	Jamaica	1.57%	54.55%	43.65%	1.80%	0.47
United States	Colombia	1.51%	47.74%	46.15%	6.11%	0.58

The World Bank uses this connectivity index in its major report which focuses on understanding the role of connectivity in economic growth and development

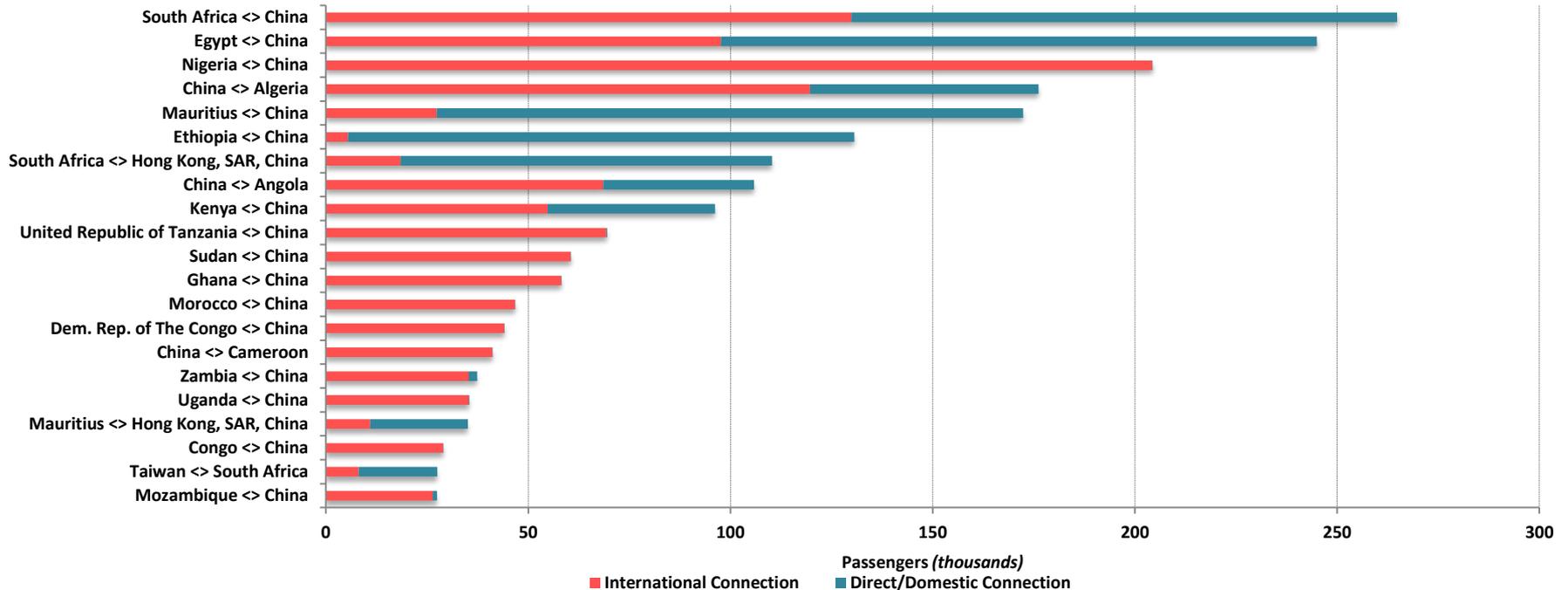


# Case Study 1: China - Africa



# Country pairs between Africa and China- 2015

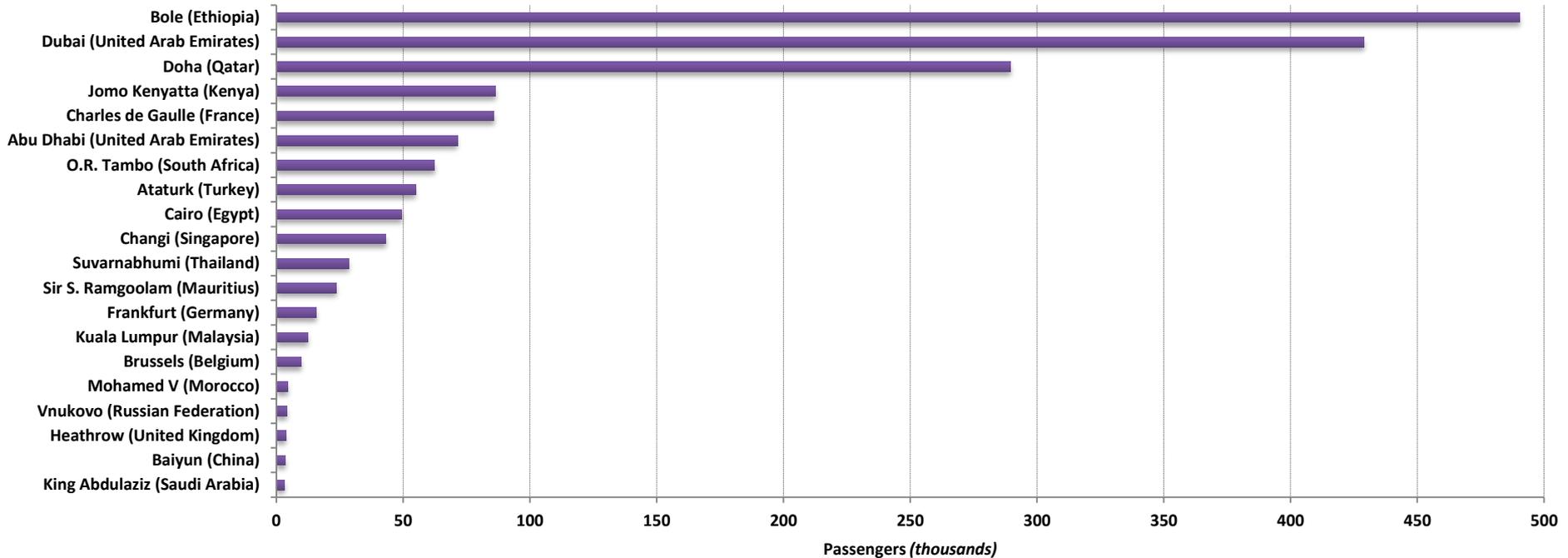
## Top 20 Country-Pairs by Passengers (Two Ways, Number of Passengers, 2015)





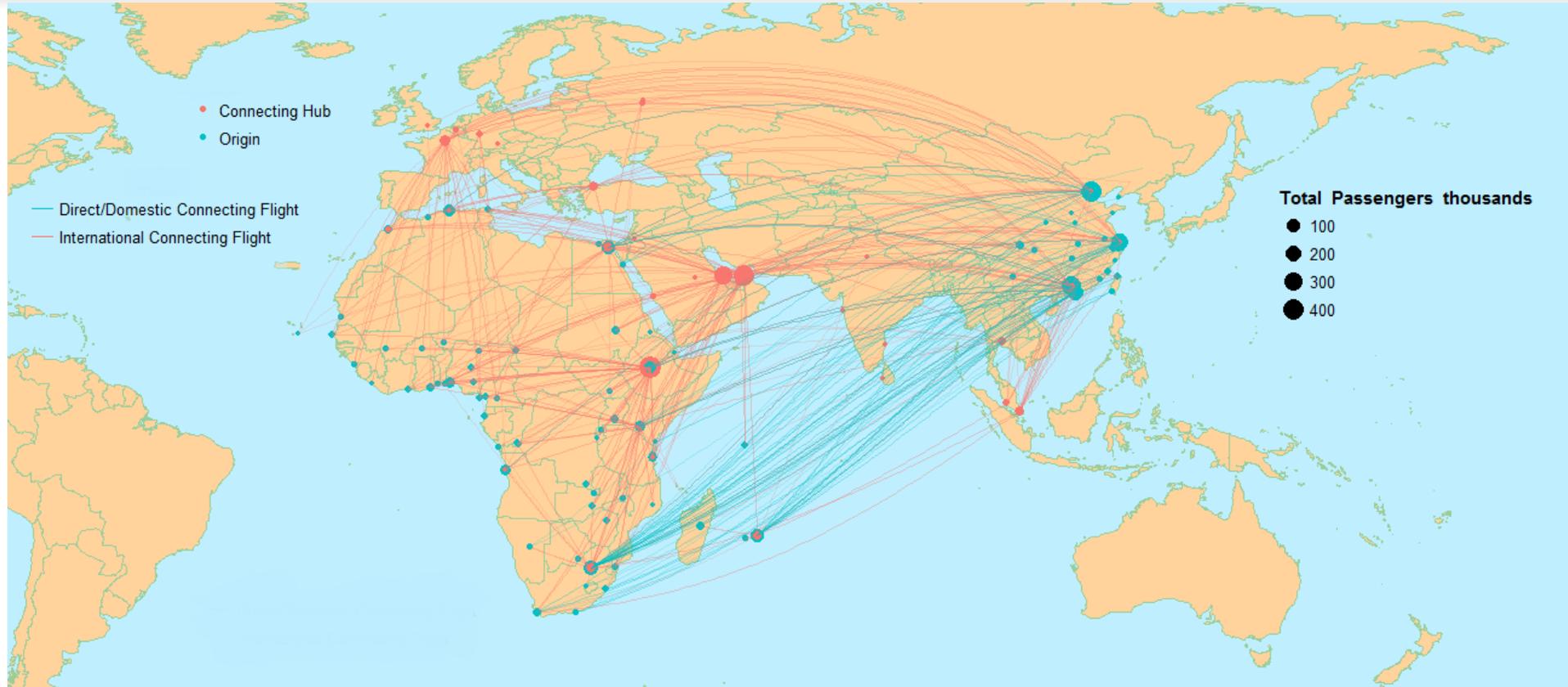
# Top 20 hubs between Africa and China-2015

## Top 20 International Airports Connecting Africa <-> China Passengers (Two Ways, Number of Passengers, 2015)





# Connectivity map China-Africa in 2015



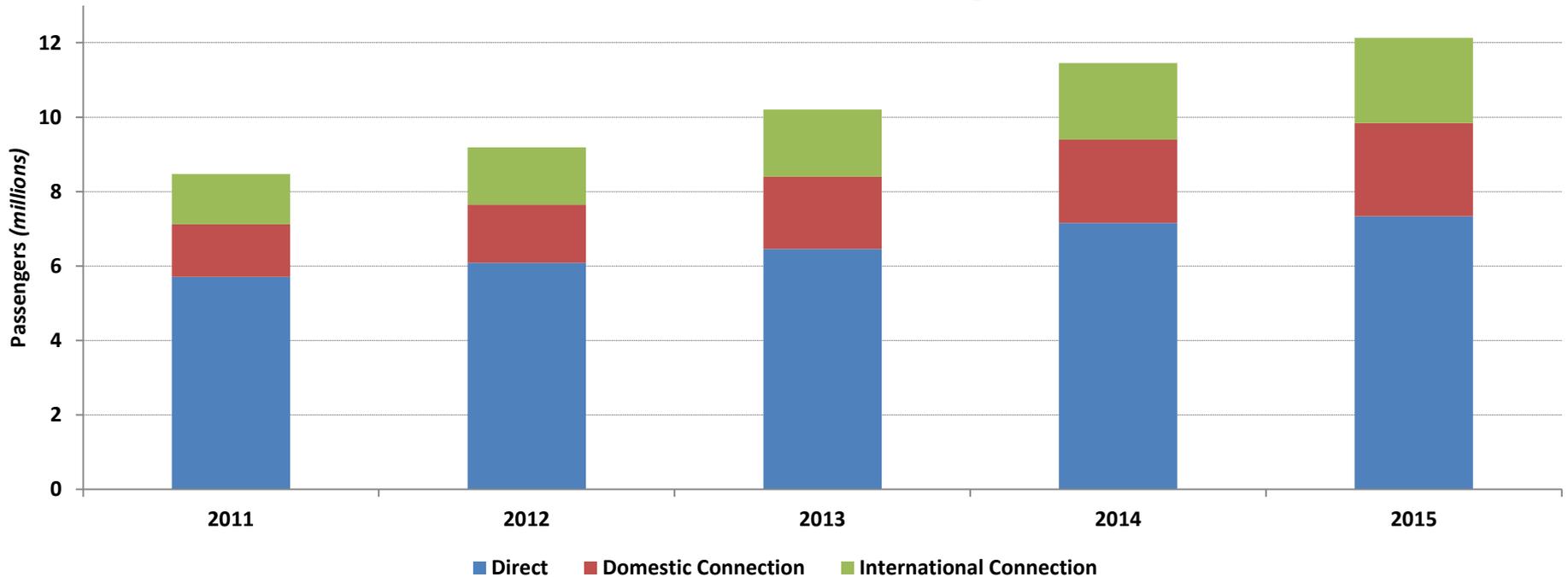


ICAO

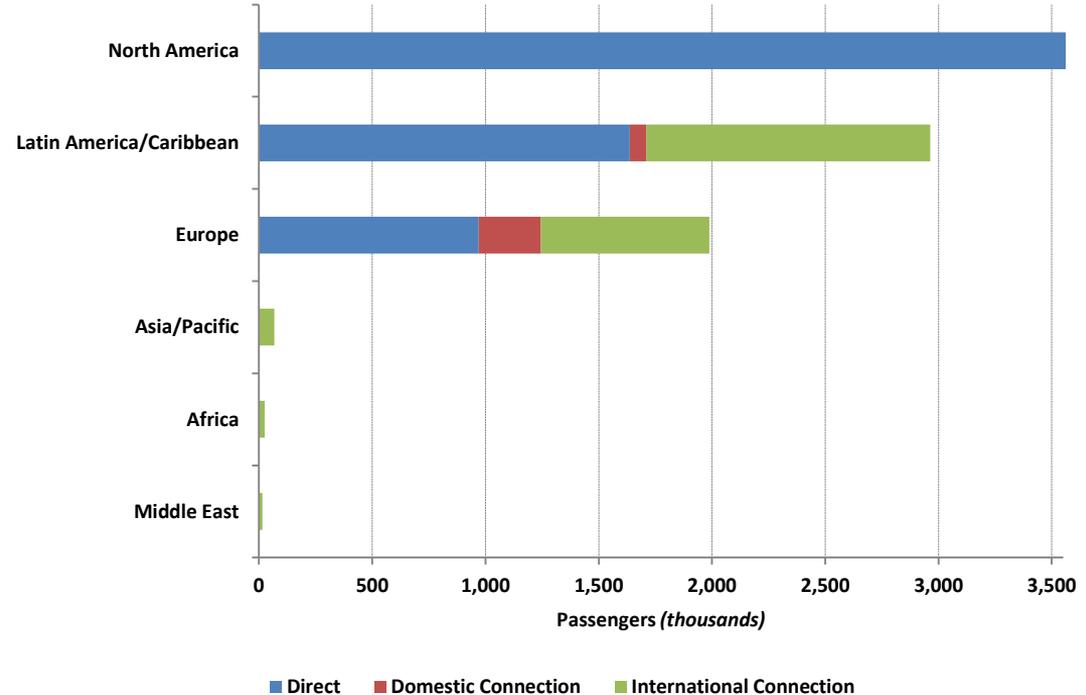
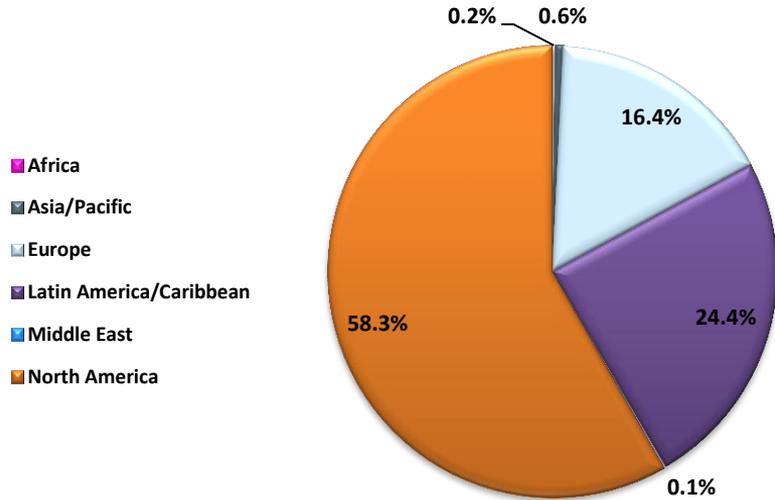
UNITING AVIATION

## Case Study 2: Dominican Republic

## International Traffic from/to Dominican Republic (All Carriers, Number of Passengers)



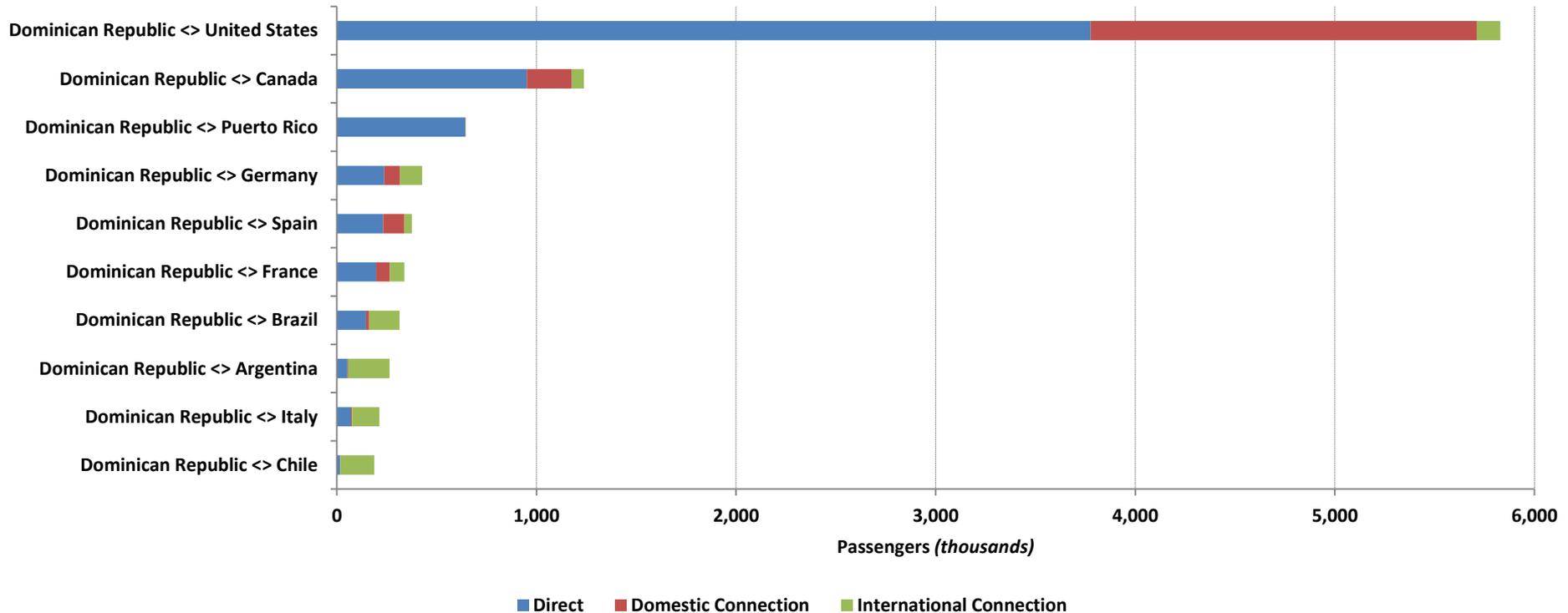
Distribution of International Passengers Traffic from/to Dominican Republic 2015 (All Carriers)





# Top 10 Country pairs by passengers 2015

## Top 10 Country Pairs\* by Passengers 2015 (All Carriers, Traffic from/to Dominican Republic)

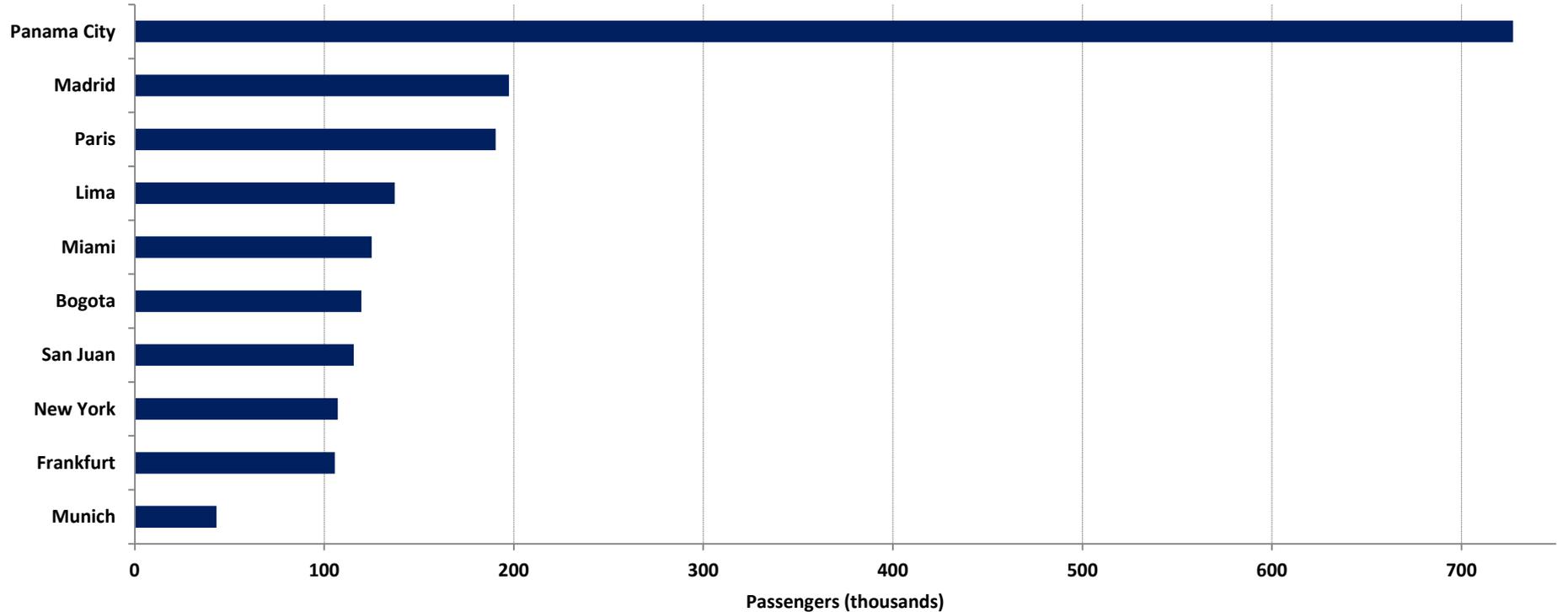


\* Country pairs Includes Territories of states



# Top 10 hubs by passengers 2015

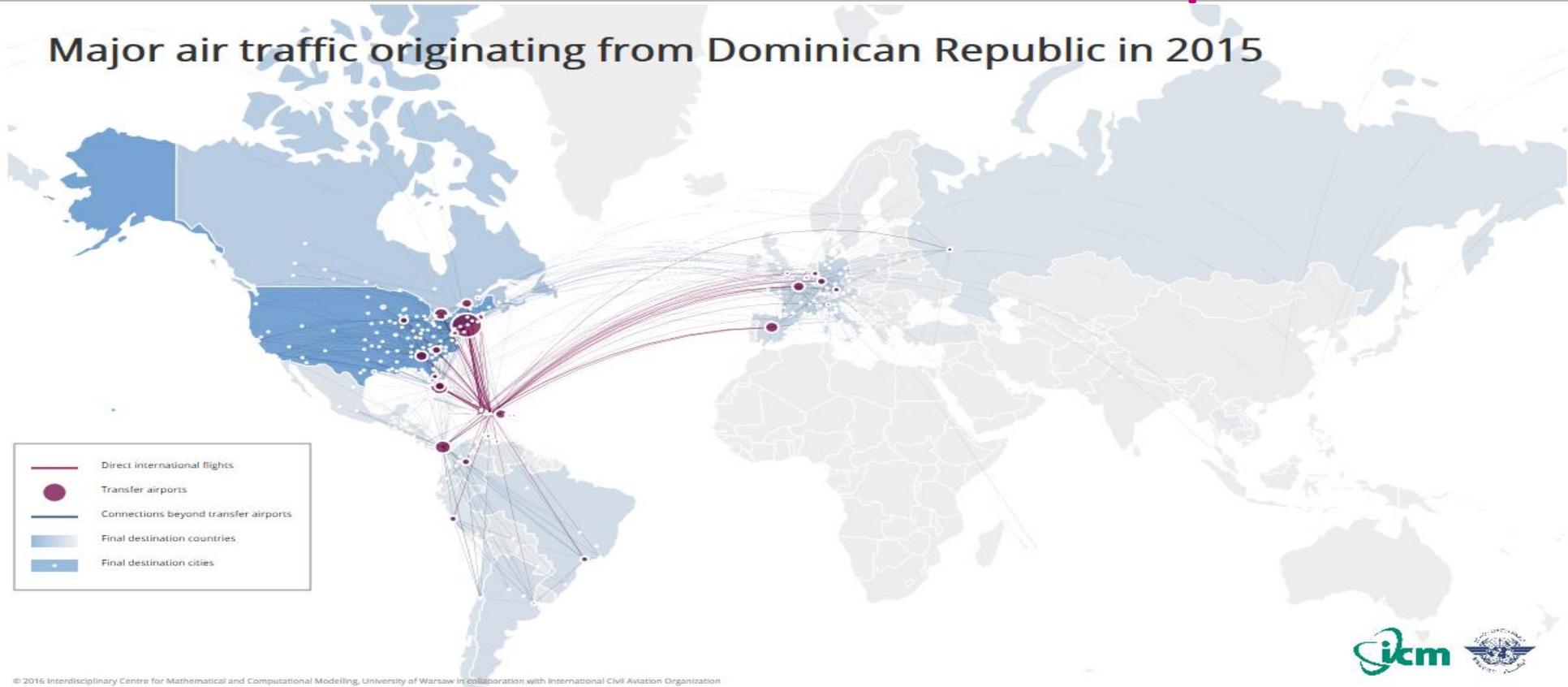
Top 10 International Hubs by Passengers 2015 (All Carriers, Traffic from/to Dominican Republic)





# Connectivity map from Dominican Republic in 2015

## Major air traffic originating from Dominican Republic in 2015





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# Case Study 3: Incheon Airport

# Direct destinations of ICN-origin passengers

Rank No.	From ICN to:	Passenger 2015	Share 2015	Cumulative Share
1	Hong Kong (HKG)	1,214,541	6.9%	6.9%
2	Bangkok (BKK)	843,494	4.8%	11.6%
3	Shanghai (PVG)	765,602	4.3%	16.0%
4	Osaka (KIX)	721,018	4.1%	20.1%
5	Taipei (TPE)	635,905	3.6%	23.7%
6	Qingdao (TAO)	597,793	3.4%	27.0%
7	Tokyo (NRT)	565,643	3.2%	30.2%
8	Fukuoka (FUK)	487,705	2.8%	33.0%
9	Manilla (MNL)	483,088	2.7%	35.7%
10	Beijing (PEK)	467,604	2.6%	38.4%
11	Hanoi (HAN)	467,575	2.6%	41.0%
12	Singapore (SIN)	445,889	2.5%	43.5%
13	Guam (GUM)	342,077	1.9%	45.5%
14	Cebu (CEB)	332,264	1.9%	47.4%
15	Kuala Lumpur (KUL)	303,855	1.7%	49.1%
16	Guangzhou (CAN)	268,880	1.5%	50.6%
17	Los Angeles (LAX)	262,004	1.5%	52.1%
18	Ho Chi Minh City (SGN)	250,214	1.4%	53.5%
19	Tianjin (TSN)	243,473	1.4%	54.9%
20	Dalian (DLC)	229,488	1.3%	56.2%
21	Shenyang (SHE)	220,884	1.2%	57.4%
22	Shenzhen (SZX)	208,843	1.2%	58.6%
23	Yanji (YNJ)	208,444	1.2%	59.8%
24	Phuket (HKT)	196,833	1.1%	60.9%
25	Saipan (SPN)	188,655	1.1%	62.0%

17.7 million passengers originating from ICN (67.7% of total passengers from/through ICN) took direct flights to reach 173 final destinations



# Connecting points of ICN-origin passengers

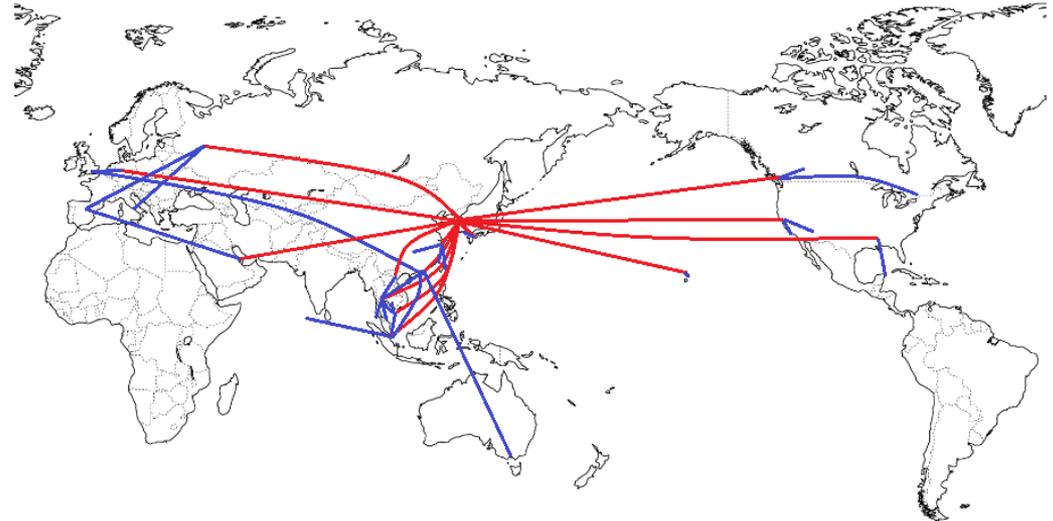
Rank No.	From ICN to final destinations via:	Passenger 2015	Share 2015	Cumulative Share
1	Hong Kong (HKG)	196,006	6.9%	6.9%
2	Dubai (DXB)	142,937	5.0%	11.9%
3	Shanghai (PVG)	130,085	4.6%	16.5%
4	Istanbul (IST)	121,616	4.3%	20.7%
5	Frankfurt (FRA)	113,598	4.0%	24.7%
6	Moscow (SVO)	112,722	4.0%	28.7%
7	San Francisco (SFO)	108,909	3.8%	32.5%
8	Singapore (SIN)	98,823	3.5%	36.0%
9	Doha (DOH)	93,795	3.3%	39.3%
10	Tokyo (NRT)	89,054	3.1%	42.4%
11	Bangkok (BKK)	87,666	3.1%	45.5%
12	Paris (CDG)	79,830	2.8%	48.3%
13	Ho Chi Minh City (SGN)	73,192	2.6%	50.8%
14	Helsinki (HEL)	72,814	2.6%	53.4%
15	Detroit (DTW)	72,584	2.5%	55.9%
16	Dallas/Fort Worth (DFW)	68,170	2.4%	58.3%
17	Beijing (PEK)	63,335	2.2%	60.6%
18	Seattle (SEA)	59,290	2.1%	62.6%
19	Los Angeles (LAX)	57,995	2.0%	64.7%
20	Abu Dhabi (AUH)	54,963	1.9%	66.6%
21	Amsterdam (AMS)	53,457	1.9%	68.5%
22	Munich (MUC)	52,148	1.8%	70.3%
23	Fukuoka (FUK)	51,750	1.8%	72.1%
24	Kuala Lumpur (KUL)	50,403	1.8%	73.9%
25	Vancouver (YVR)	49,398	1.7%	75.6%

**3 million passengers originating from ICN (11.6% of total passengers from/through ICN) took connecting flights to reach 423 final destinations**



# Top 25 connecting routes from ICN

Rank No.	Connecting point	Final Destination	Passenger 2015
1	Honolulu (HNL)	Kahului (OGG)	20,353
2	Shanghai (PVG)	Zhangjiajie (DYG)	18,920
3	Ho Chi Minh City (SGN)	Singapore (SIN)	18,547
4	Bangkok (BKK)	Phuket (HKT)	18,104
5	Singapore (SIN)	Male (MLE)	14,867
6	Ho Chi Minh City (SGN)	Siem Reap (REP)	14,610
7	Hong Kong (HKG)	Singapore (SIN)	13,611
8	Vancouver (YVR)	Toronto (YYZ)	13,005
9	San Francisco (SFO)	Los Angeles (LAX)	12,811
10	Shanghai (PVG)	Taipei (TPE)	12,151
11	Fukuoka (FUK)	Busan (PUS)	11,940
12	Hong Kong (HKG)	London (LHR)	11,054
13	Bangkok (BKK)	Koh Samui (USM)	9,891
14	Moscow (SVO)	Rome (FCO)	9,607
15	Shanghai (PVG)	Wenzhou (WNZ)	9,422
16	Doha (DOH)	Madrid (MAD)	9,294
17	Frankfurt (FRA)	London (LHR)	9,048
18	Hanoi (HAN)	Bangkok (BKK)	8,975
19	Moscow (SVO)	Madrid (MAD)	8,922
20	Hong Kong (HKG)	Melbourne (MEL)	8,726
21	Hong Kong (HKG)	Bangkok (BKK)	8,616
22	Dallas/Fort Worth (DFW)	Cancun (CUN)	8,603
23	Ho Chi Minh City (SGN)	Bangkok (BKK)	8,483
24	San Francisco (SFO)	Las Vegas (LAS)	8,446
25	Vancouver (YVR)	Calgary (YYC)	8,330



— Direct international flights from ICN  
— Connections beyond transfer airports

# Passengers travelling via ICN

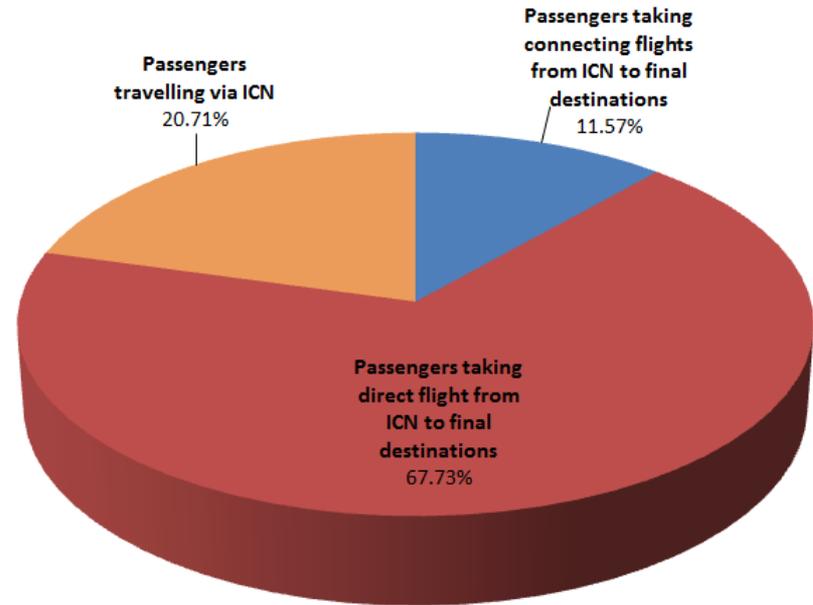
Rank No.	Through ICN to:	Passenger 2015	Share 2015	Cumulative Share
1	Los Angeles (LAX)	208,483	4.2%	4.2%
2	Manilla (MNL)	194,365	3.9%	8.1%
3	Tokyo (NRT)	187,726	3.8%	11.9%
4	Busan (PUS)	163,250	3.3%	15.2%
5	Osaka (KIX)	160,880	3.3%	18.5%
6	Fukuoka (FUK)	134,240	2.7%	21.2%
7	Shanghai (PVG)	132,386	2.7%	23.9%
8	New York (JFK)	123,458	2.5%	26.4%
9	Bangkok (BKK)	121,569	2.5%	28.8%
10	Hong Kong (HKG)	117,563	2.4%	31.2%
11	Ho Chi Minh City (SGN)	112,662	2.3%	33.5%
12	Nagoya (NGO)	102,107	2.1%	35.5%
13	Honolulu (HNL)	95,860	1.9%	37.5%
14	Qingdao (TAO)	92,130	1.9%	39.3%
15	Beijing (PEK)	91,586	1.9%	41.2%
16	Denpasar (DPS)	82,003	1.7%	42.8%
17	Dalian (DLC)	80,047	1.6%	44.5%
18	Singapore (SIN)	79,760	1.6%	46.1%
19	Sapporo (CTS)	78,072	1.6%	47.7%
20	San Francisco (SFO)	75,679	1.5%	49.2%
21	Shenyang (SHE)	71,773	1.5%	50.6%
22	Vladivostok (VVO)	67,410	1.4%	52.0%
23	Saipan (SPN)	66,263	1.3%	53.3%
24	Seattle (SEA)	64,396	1.3%	54.6%
25	Jakarta (CGK)	59,786	1.2%	55.8%

**5.4 million passengers connected at ICN (20.7% of total passengers from/through ICN) to reach 193 final destinations**



## passengers from/through ICN

Rank No.	Airline	Passenger 2015	Share 2015
1	Korean Air	8,406,391	32.4%
2	Asiana	6,457,882	24.9%
3	Jeju Air	1,009,260	3.9%
4	China Southern	893,820	3.4%
5	China Eastern	822,329	3.2%
6	Jin Air	753,372	2.9%
7	Air China	571,706	2.2%
8	Cathay Pacific	519,141	2.0%
9	Thai Airways	425,971	1.6%
10	Vietnam Airlines	386,845	1.5%
11	Eastar Jet	362,945	1.4%
12	Singapore Airlines	311,694	1.2%
13	Philippine Airlines	299,903	1.2%
14	T'Way Airlines	247,587	1.0%
15	Air Asia X	220,655	0.9%
16	Shandong Airlines	218,839	0.8%
17	United Airlines	204,511	0.8%
18	Aeroflot	194,822	0.8%
19	Delta Air Lines	193,887	0.8%
20	Lufthansa	190,243	0.7%
21	Air Asia Zest	183,709	0.7%
22	China Airlines	166,108	0.6%
23	Emirates	161,860	0.6%
24	EVA Air	154,655	0.6%
25	Turkish Airlines	148,626	0.6%

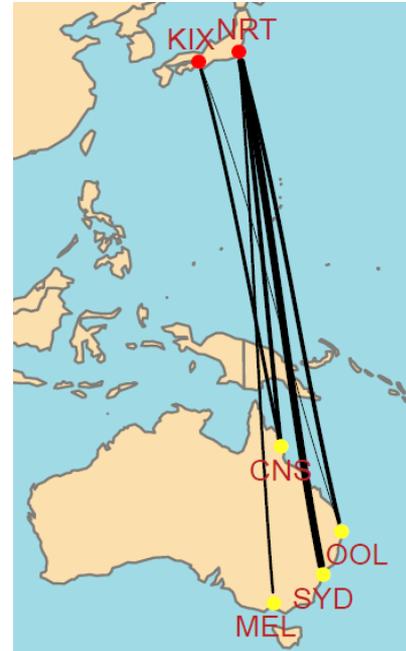




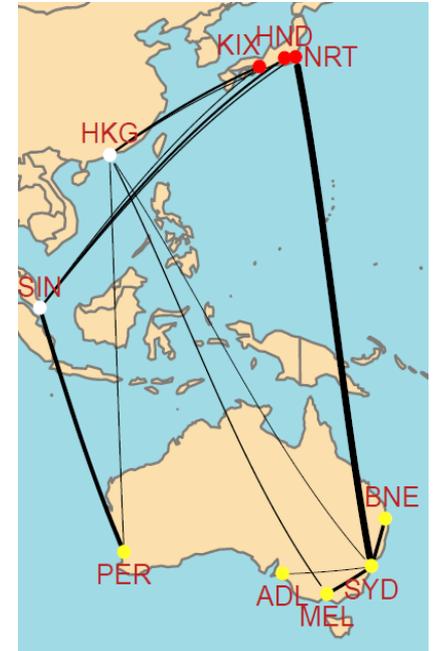
# Case Study 4: Country-Pair Analysis

# Australia-Japan (2014)

Routes between Australia and Japan	Passengers	Share (%)
6 direct non-stop flights	602,997	47.22%
via Singapore (SIN)	120,950	9.47%
via Hong Kong (HKG)	100,054	7.84%
via Sydney (SYD)	95,227	7.46%
via Cairns (CNS)	67,985	5.32%
via Tokyo (NRT)	40,179	3.15%
via Taipei (TPE)	32,574	2.55%
via Incheon (ICN)	32,185	2.52%
via Kuala Lumpur (KUL)	27,020	2.12%
NRT-SYD double connection	20,089	1.57%
via Gold Coast (OOL)	11,891	0.93%
Other 500 connecting city-pairs	125,838	9.85%
<b>Total</b>	<b>1,276,989</b>	<b>100.00%</b>



Direct non-stop routes

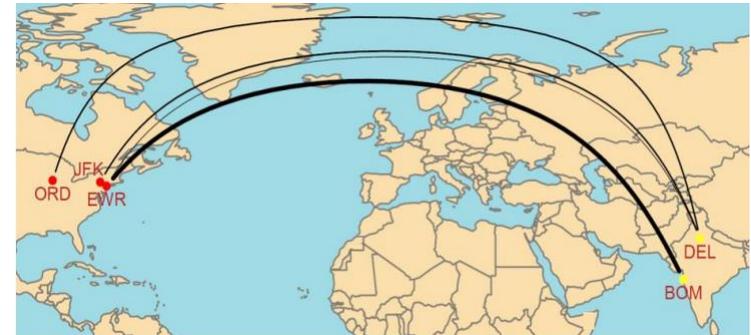


Major connecting routes

# India-United States (2014)

Routes between India and United States	Passengers	Share (%)
4 direct non-stop flights	398,494	8.98%
via Dubai (DXB)	713,119	16.06%
via London (LHR)	439,721	9.90%
via Abu Dhabi (AUH)	296,373	6.68%
via Doha (DOH)	237,476	5.35%
via Frankfurt (FRA)	191,528	4.31%
via Newark (EWR)	172,644	3.89%
via Delhi (DEL)	164,818	3.71%
via Hong Kong (HKG)	111,356	2.51%
via Mumbai (BOM)	95,180	2.14%
JFK-DXB double connection	68,248	1.54%
Other 3,868 connecting city-pairs	1,550,440	34.92%
<b>Total</b>	<b>4,439,397</b>	<b>100.00%</b>

Direct non-stop routes



Major connecting routes





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