GOVERNMENT ARTS COLLEGE, PARAMAKUDI

UG DEPARTMENT OF MATHEMATICS

PROJECT TITLE:

GLOBAL AIR TRANSPORTATION NETWORK

SUBMITTED BY:

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DEPARTMENT OF MATHEMATICS

GOVERNMENT ARTS COLLEGE, PARAMAKUDI.

1 Introduction

Air transport networks are complex networks that span across multiple distance scales (from a few km to 10,000 km) and multiplex together over 5000 airline operators and has strong inter-dependencies with socioeconomic drivers. The air transport network carry 3.5 bn passengers per year and generate over 30 m jobs globally. The analysis of air transport networks to better understand its network properties goes back for over 10 years [1–4]. Both global and regional studies have explored their complex network structure across different network scales [5–7] with multi-layer analysis [6, 8]. The analysis predominantly focus on robustness from attacks or failures [9, 10], efficiency [4], and structural evolution [7]. The air transportation network is also responsible for the propagation of knowledge and

1.2 Data availability and network construction

Several air transport network data sources are available from academic and commercial databases. One of the most widely used commercial databases is the purchased OAG data. This case study paper will use a single month's sample in the year 2015, as well as open air transport data obtained from the US Bureau of Transportation Statistics to demonstrate results. The spatial resolution of the data includes 9000 global airports, each geo-tagged with coordinates, and the temporal resolution of the data are every civilian flight (dis-including cargo flights). Compared to open data, the purchased data from OAG offers a more comprehensive list of flights as well as passenger volume and flight class distribution (e.g. between first, business, and economy).

In order to construct a network from the data, airports are represented by nodes and flights are represented by weighted links. The vast majority of work uses regular scheduled flights and the seat number of each flight is used as a weight for the link. True passenger numbers (load) are commercially sensitive and cannot be obtained on a global scale. Each node, if connected to another, is usually a bi-directed connection with equal weighting (i.e., most flights transverse back and forth). When multiple flights exist between two airports, the total weight is the sum of the seats available. An example of the network is shown in Fig. 1.

Says

What have we heard them say?
What can we imagine them saying?

The Global Air Transportation Network dataset is a comprehensive collection of information on airports, airlines and their routes.

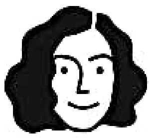
It contains information such as names, cities, countries, codes (IATA and ICAO), geographic latitudes and altitudes of airports across the world with detailed time zone and daylight saving time data

Thinks

What are their wants, needs, hopes, and dreams?
What other thoughts might influence their behavior?

This dataset has been compiled through meticulous labor by researchers all over the world to give you a comprehensive detail on air transportation networks from around the globe.

Air transport network or air transportation network (ATN) is an example of transport networks and spatial networks.



Persona's name

Short summary of the persona

Additionally, this includes information about airlines including their IDs, name aliases, IATA and ICAO codes, callsigns country of origin and active/ inactive status

The nodes of the network are the airports and the links represent direct flight routes between two airports(

Alternatively, cities can be considered as the nodes with links representing direct flight connection between them.

Does

What behavior have we observed?
What can we imagine them doing?

Feels

What are their fears, frustrations, and anxieties?
What other feelings might influence their behavior?

See an example

2

Brainstorm

Write down any ideas that come to mind that address your problem statement.

10 minutes

TIP

You can select a sticky note and hit the pencil [switch to sketch] icon to start drawing!

Person 1

We find that the worldwide air transportation network is a scale-free small-world network.

Person 2

Person 3

Person 4

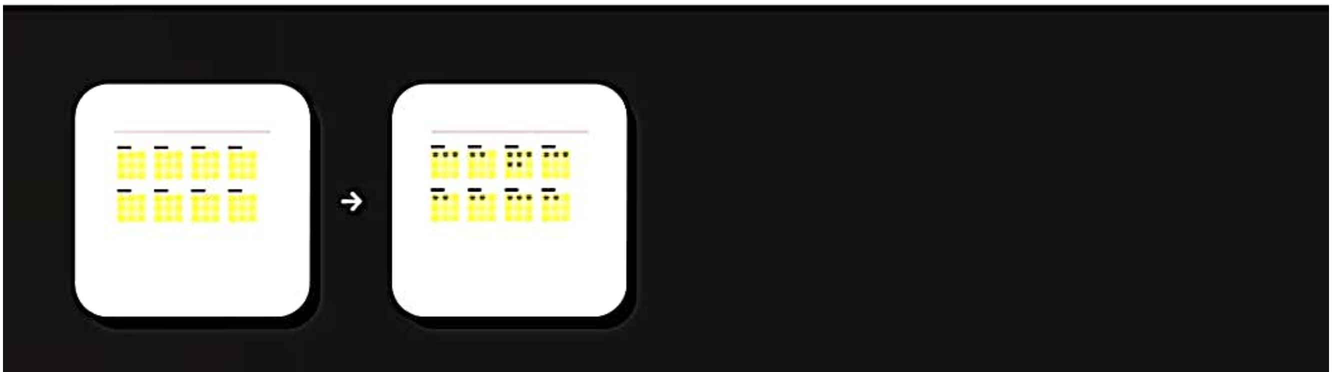
The worldwide air transportation network is responsible for the mobility of millions of people every day.

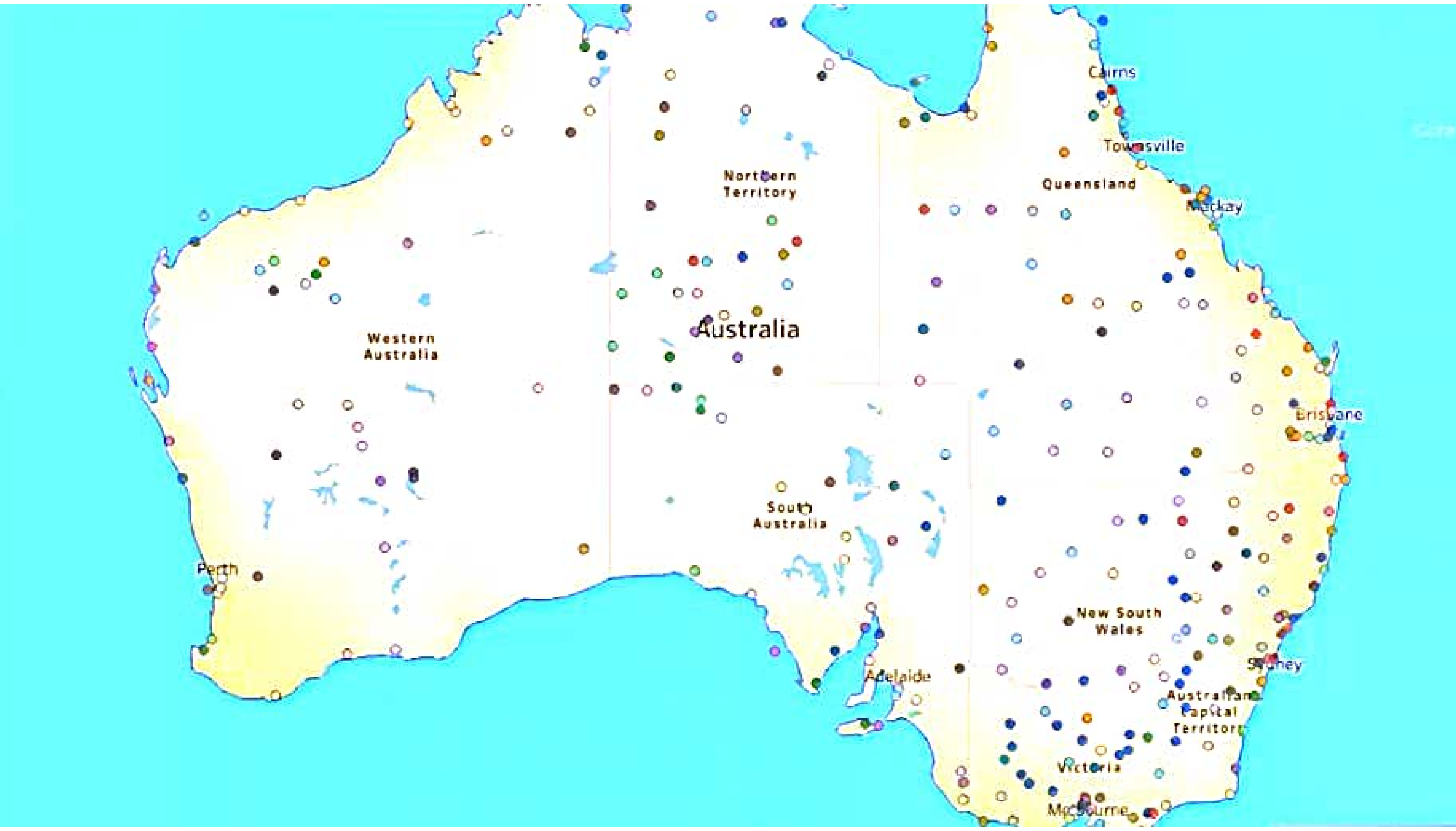
Person 5

Person 6

Person 7

Person 8





Cairns
Townsville
Queensland
Mackay
Northern Territory
Australia
Western Australia
Brisbane
South Australia
Perth
New South Wales
Sydney
Adelaide
Australian Capital Territory
Victoria
Melbourne


Middelburg
Eindhoven
Bruges
Antwerp
Dusseldorf
Dunkirk
Veurne
Ghent
Calais
E19
Brussels
Maastricht
Cologne
A 26
Poperinge
Bonn
Longuenesse
Lille
Belgium
Liège
Mons
Namur
Hauts-de-France
Amiens
Trier
Luxembourg

number of airports

22

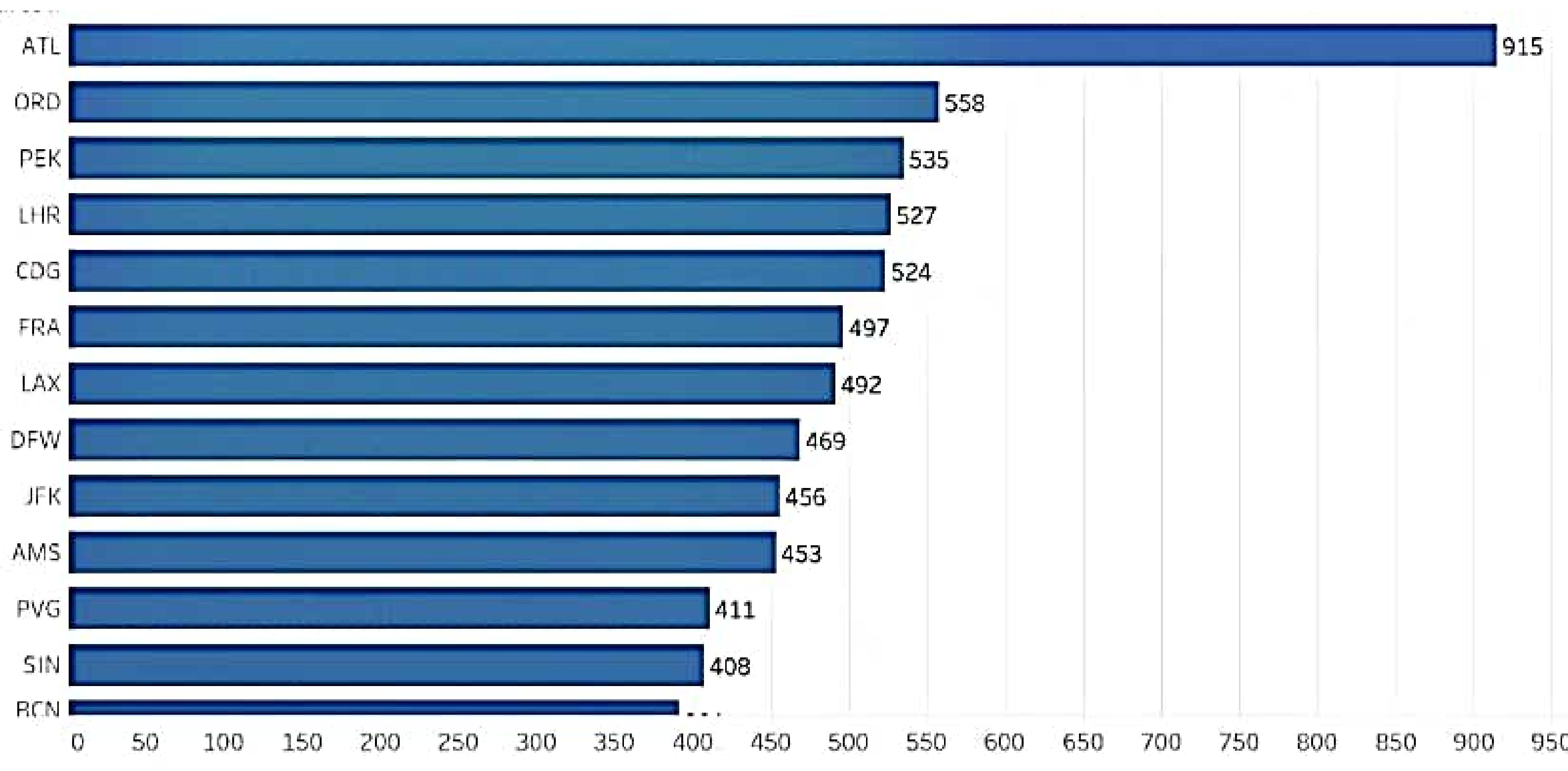
No. of Airports
148

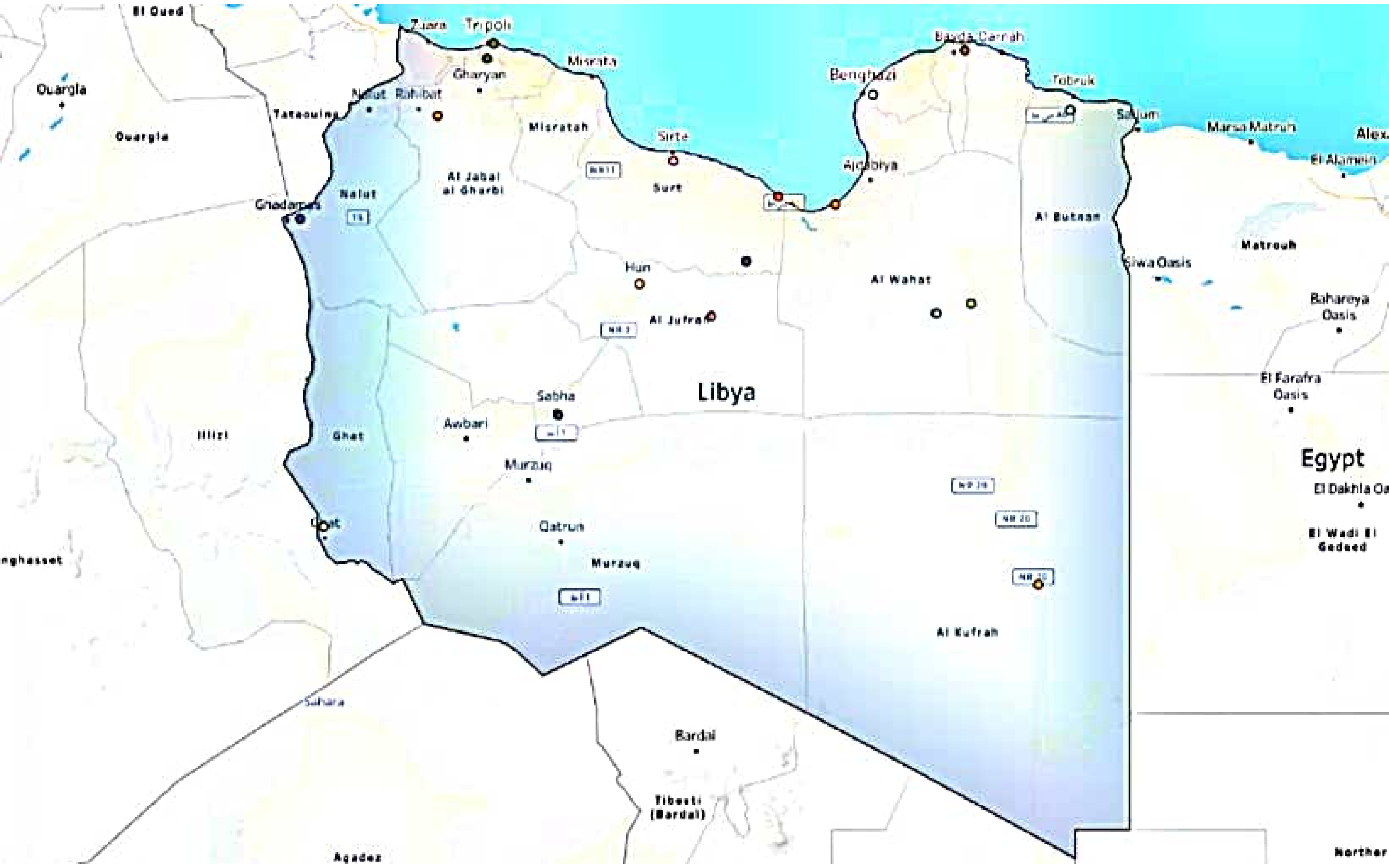
airports at higher altitude within a country

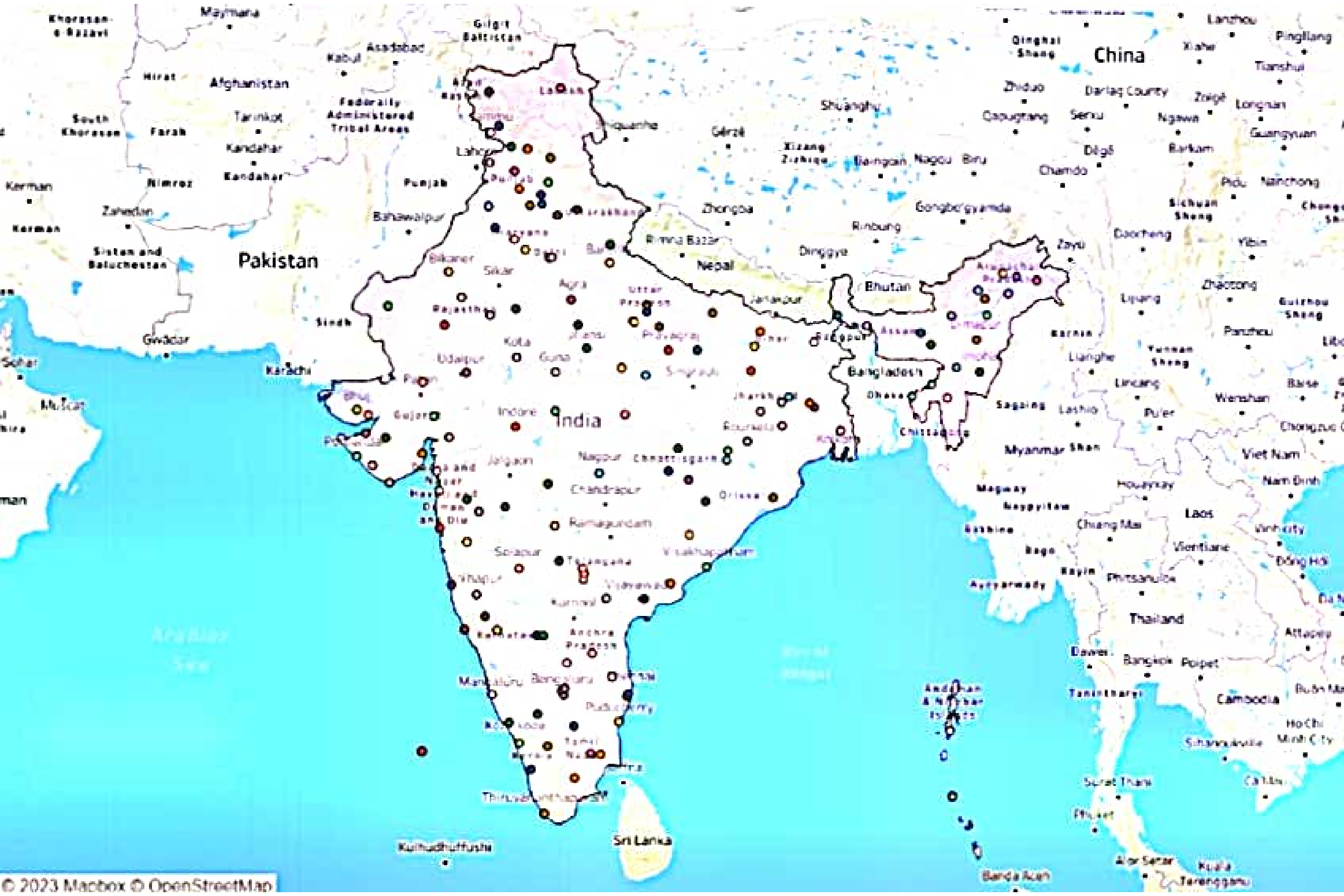
index n..	Airport Name	City	ICAO C..	
1	Zaranj Airport	Zaranj	OAZJ	1,572
	Tarin Kowt Airpo..	Tarin Kowt	OATN	4,429
	Shindand Airport	Shindand	OASD	3,773

Airport Name	City	ICAO Code	
Daocheng Yading Airport	Daocheng	ZUDC	14,472
Qamdo Bangda Airport	Bangda	ZUBD	14,219
Kangding Airport	Kangding	ZUKD	14,042
Ngari Gunsa Airport	Shiquanhe	ZUAL	14,022
El Alto International Airport	La Paz	SLLP	13,355
Capitan Nicolas Rojas Airport	Potosi	SLPO	12,913
Yushu Batang Airport	Yushu	ZYLS	12,816
Copacabana Airport	Copacabana	SLCC	12,591
Inca Manco Capac International Airpo..	Juliaca	SPJL	12,552
Golog Maqin Airport	Golog	ZLGL	12,426

Airline ..	Name	Icao	Callsign	
235	Avia Consult Flu..	AJF	AVIACONSULT	■
305	Amerer Air	AMK	AMER AIR	■
629	Amira Air	XPE	EXPERT	■
895	ABC Bedarsflug	FTY	FLY TYROL	■
972	Airlink	JAR	AIRLINK	■
989	Aero Charter Krif..	KFK	KRIFKA AIR	■
1040	Air Alps Aviation	LPV	ALPAV	■
1058	Avag Air	MBA	AVAG AIR	■
1358	Bannert Air	BBA	BANAIR	■
1364	BACH Flugbetrie..	BCF	BACH	■
1525	Business Flight S..	AUJ	AUSTROJET	■
1777	Christophorus Fl..	OEC	CHRISTOPHORUS	■
1999	Deadalos Flugtb..	IAY	IASON	■
2246	Euromanx Airwa..	EMX	EUROMANX	■
2408	Flugwerkzeuge ..	FWZ	Null	■
2566	Global Jet Austria	GLJ	GLOBAL AUSTRIA	■
2584	Goldeck-Flug	GDK	GOLDECK FLUG	■
2617	Grossmann Air S..	HTG	GROSSMANN	■
2702	Heli Ambulance ..	ALJ	ALPIN HELI	■
2788	Houston Jet Ser..	GGV	GREGG AIR	■
2810	IJM Internationa..	IJM	JET MANAGEME..	■
3034	Jetalliance	JAG	JETALLIANCE	■
3040	Jetfly Airlines	JFL	LINEFLYER	■
3318	Luftfahrt-Vermi..	LVD	AIR SANTE	■
3347	MAP-Manageme..	MPJ	MAPJET	■
3368	Magna Air	MGR	MAGNA AIR	■
3379	Mali Air	MAE	MALI AIREXPRESS	■
4142	Rath Aviaton	RAQ	RATH AVIATION	■
4518	Styrian Airways	STY	STYRIAN	■
4908	Teamline Air	TLW	Teamline	■
4964	Tyrolean Jet Ser..	TJS	TYROLJET	■
5003	Transped Aviation	TNP	TRANSPED	■
5021	Top Speed	TPD	TOP SPEED	■
5118	Tyrol Air Ambula..	TYW	TYROL AMBULA..	■
5342	VIF Luftahrt	VIF	VIENNA FLIGHT	■
6856	Rheintalflug	RTL	Rheintal	■
8434	Robin Hood Avia..	RHA	Sherwood	■
18011	Austrian Airtran..	AAT	Null	■


ATL
915
ORD
558
PEK
535
LHR
527
CDG
524
FRA
497
LAX
492
DFW
469
JFK
456
AMS
453
PVG
411
SIN
408
BCN
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950


El Oued
Zuara
Tripoli
Gharyan
Misrata
Benghazi
Tobruk
Ouargla
Nalut
Rahibat
Tataouine
Ouargla
Misratah
Sirte
Salum
Marsa Matruh
Al Jabal
al Gharbi
Surt
Ajdabiya
El Alamein
Nalut
Ghadames
Al Butnan
Matrouh
Siwa Oasis
Hun
Al Wahat
Bahareya
Oasis
Al Jufrah
Libya
El Farafra
Oasis
Sabha
Awbari
Illizi
Ghat
Egypt
Murzuq
Qatrun
Murzuq
Ghat
Al Kufrah
Sahara
Bardai
Tibesti
(Bardai)
Agadez

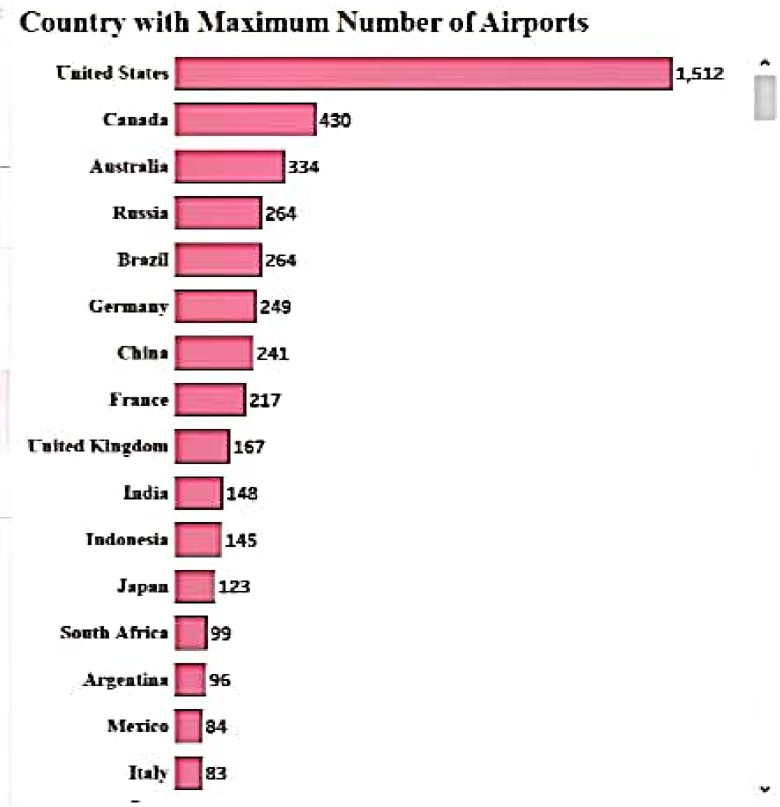

China
Pakistan
Afghanistan
India
Nepal
Bhutan
Bangladesh
Myanmar
Thailand
Laos
Cambodia
Sri Lanka
Kabul
Karachi
Lahore
Agra
Kota
Indore
Nagpur
Chandrapur
Solapur
Bengaluru
Puducherry
Visakhapatnam
© 2023 Mapbox © OpenStreetMap

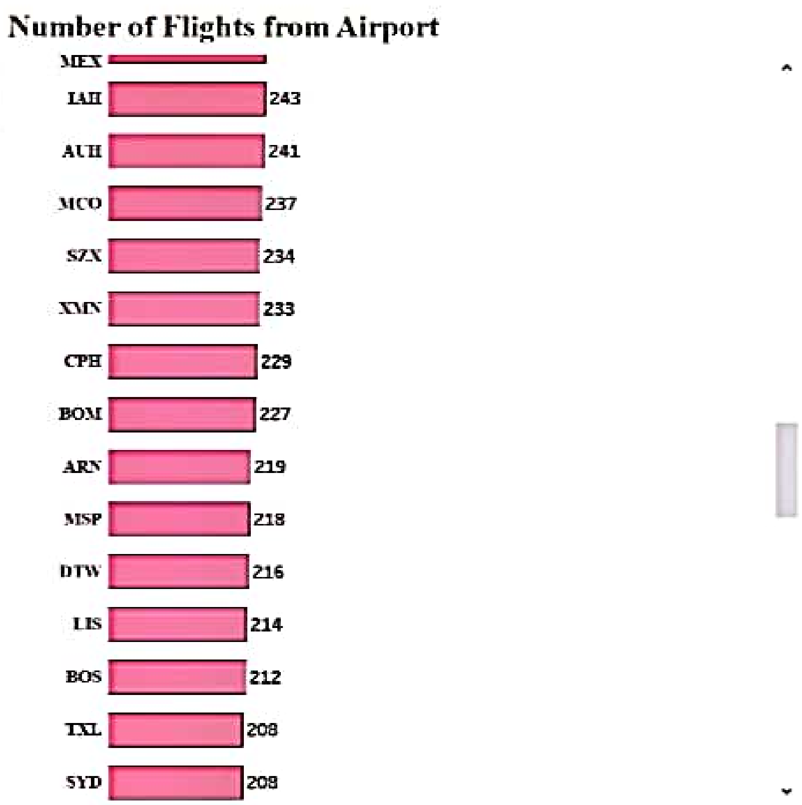
Airports at Higher Altitude within a Country

index n..	Airport Name	City	ICAO Code	
1	**Bario Airport**	Bario	WBGZ	**3,350**
2	**Bakalalan Airport**	Bakalalan	WBGQ	**2,900**
3	**Long Lellang Airport**	Long Datih	WBGF	**1,400**

Airports at Highest Altitude in World

Airport Name	City	ICAO Code	
Daocheng Yading Airport	Daocheng	ZUDC	**14,472**
Qamdo Bangda Airport	Bangda	ZUBD	**14,219**
Kangding Airport	Kangding	ZUKD	**14,042**
Ngari Gunsa Airport	Shiquanhe	ZUAL	**14,022**
El Alto International Airport	La Paz	SLLP	**13,355**
Capitan Nicolas Rojas Airport	Potosi	SLPO	**12,913**


Country with Maximum Number of Airports
United States
1,512
Canada
430
Australia
334
Russia
264
Brazil
264
Germany
249
China
241
France
217
United Kingdom
167
India
148
Indonesia
145
Japan
123
South Africa
99
Argentina
96
Mexico
84
Italy
83


Number of Flights from Airport
MEX
IAH
243
AUH
241
MCO
237
SZX
234
XMN
233
CPH
229
BOM
227
ARN
219
MSP
218
DTW
216
LIS
214
BOS
212
TXL
208
SYD
208

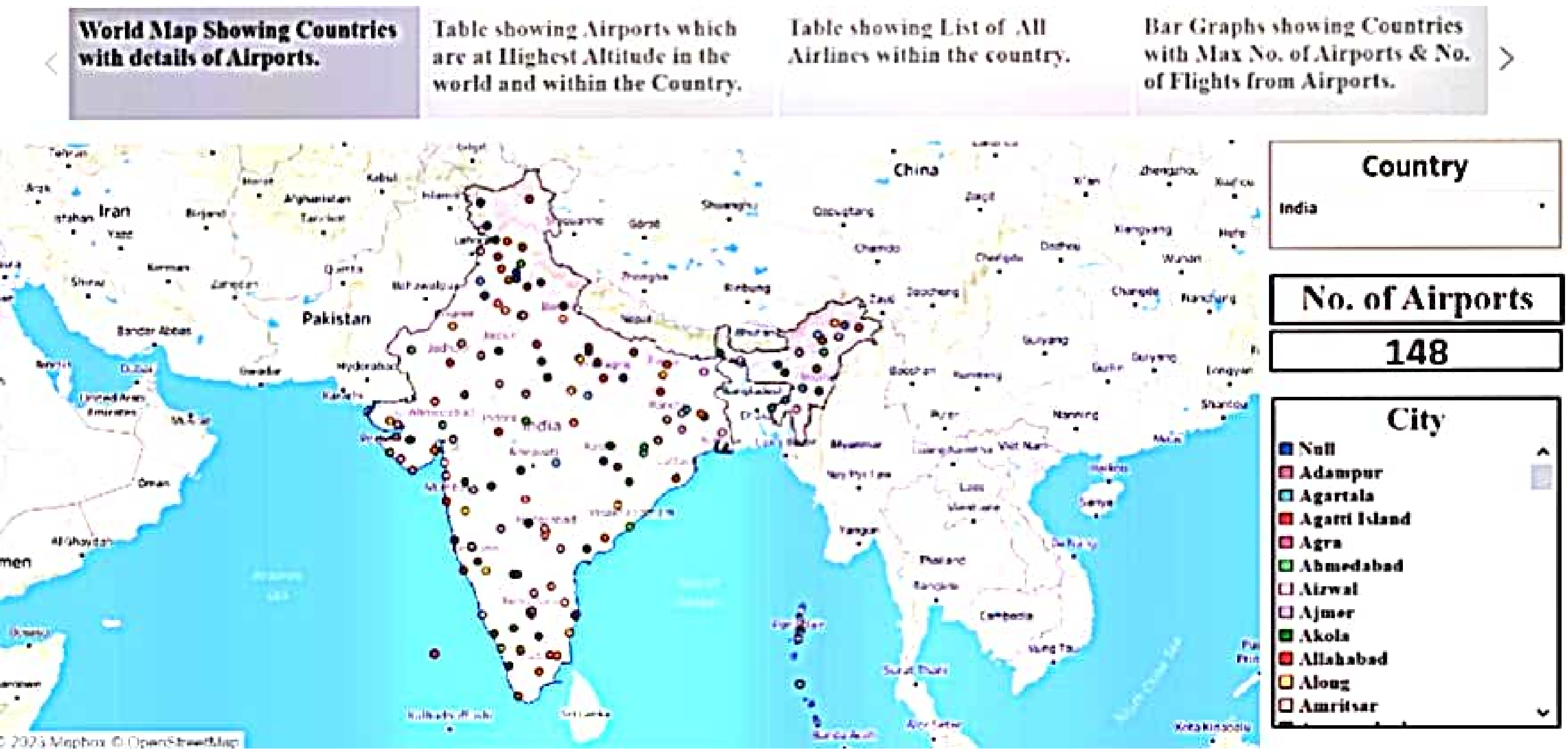
ut

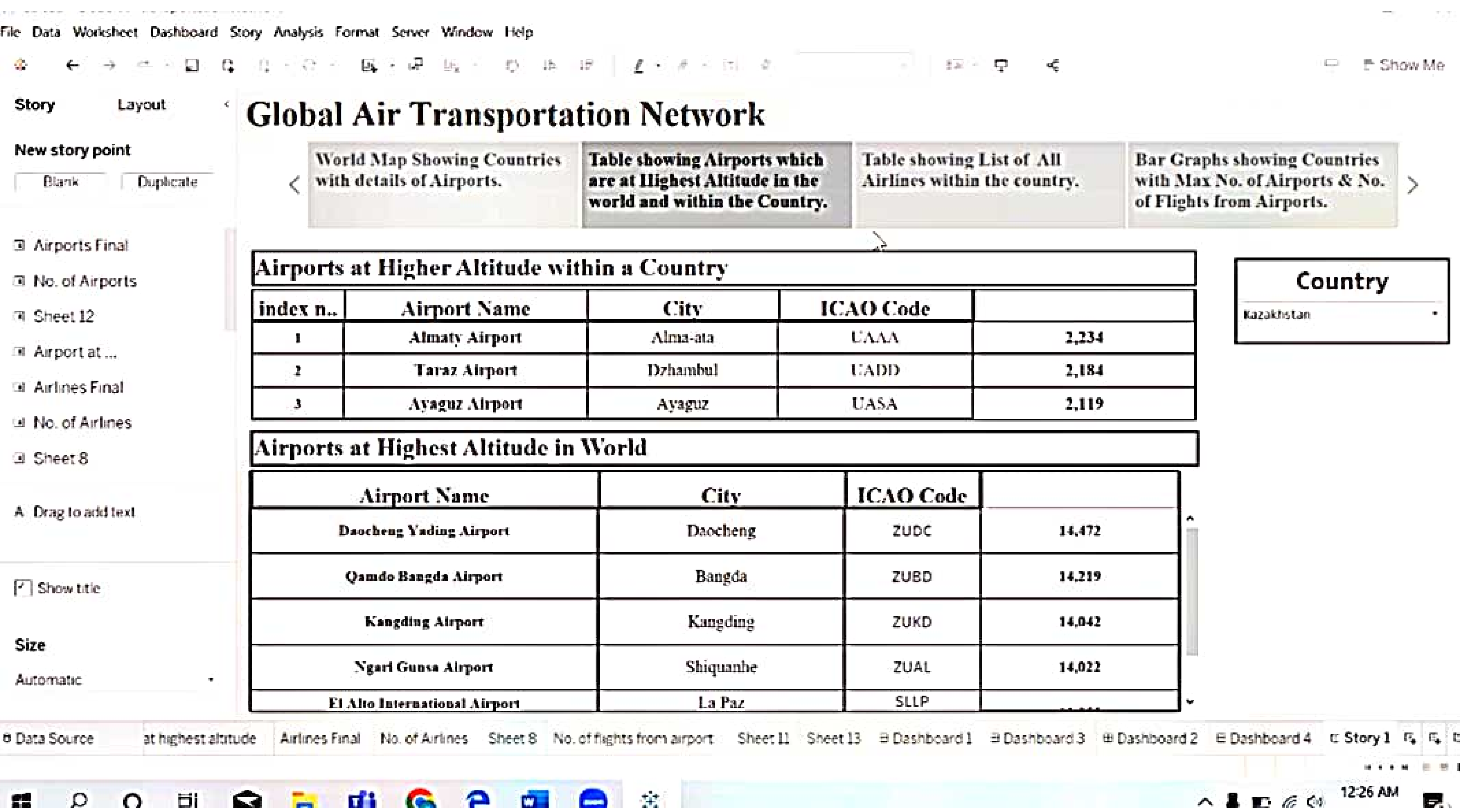
Airlines within a Country

Airline ID	Name	Icao	Callsign	
921	Air Greenland	GRL	GREENLAND	
1781	Cimber Air	CIM	CIMBER	
1954	DAT Danish Air Transport	DTR	DANISH	
3366	Maersk	Null	Null	
4776	Sterling Airlines	SNB	STERLING	
11856	Transavia Denmark	TDK	Null	
17115	Copenhagen Express	CX0	Copex	

Airline ID	Name	Icao	Callsign	
45	APSA Colombia	ABO	AEROEXPRESO	
46	Aerovias Bueno	ABU	AEROBUENO	
98	Aeroexpreso Interamericano	AEI	INTERAM	
110	ACES Colombia	AES	ACES	
245	Aeroejecutivos Colombia	AJS	AEROEJECUTIVOS	
258	Arca Aerovias Colombianas Ltda.	AKC	ARCA	
270	Aeroalas Colombia	ALE	AEROALAS	
297	Aerolineas Medellin	AMD	AEROLINEAS MEDELLIN	
339	Aerol	ANQ	ANTIOQUIA	
359	Aeroatlantico Colombia	AOK	Null	
375	Aerotaxi Del Valle	AOX	AEROVALLE	
385	Aerotransporte Petrolero	PET	AEROPETRO	
428	Aerotal Aerolineas Territoriales de Colom..	ART	AEROTAL	
474	AeroTACA	ATK	AEROTACA	
479	ASTRAL Colombia - Aerotransportes Esp..	ATP	ASTRAL	
670	Aerovilla	VVG	AEROVILLA	
735	AVESCA	VSC	AVESCA	
1000	AeroSucre	KRE	AEROSUCRE	

Airline ID	Name	Icao	Callsign	
110	ACES Colombia	AES	ACES	
1224	AeroRep	RPB	AEROREPUBLICA	
4691	SATENA	NSE	SATENA	
5020	TAMPA	TPA	TAMPA	
11765	EasyFly	EFY	EASYFLY	
16151	CCML Airlines	CCC	Null	
16262	Fly Colombia (Interliging Flights)	3FF	Null	
18946	VivaColombia	VVC	Null	
19813	Air Colombia	7KK	Null	
20073	Air America CO	7ZC	Null	


World Map Showing Countries with details of Airports.
Table showing Airports which are at Highest Altitude in the world and within the Country.
Table showing List of All Airlines within the country.
Bar Graphs showing Countries with Max No. of Airports & No. of Flights from Airports.
China
Iran
Pakistan
India
© 2023 Mapbox © OpenStreetMap
Country
India
No. of Airports
148
City
Null
Adampur
Agartala
Agatti Island
Agra
Ahmedabad
Aizwal
Ajmer
Akola
Allahabad
Along
Amritsar


File Data Worksheet Dashboard Story Analysis Format Server Window Help
Show Me
Story Layout
New story point
Blank Duplicate
Airports Final
No. of Airports
Sheet 12
Airport at ...
Airlines Final
No. of Airlines
Sheet 8
Drag to add text
Show title
Size
Automatic
Global Air Transportation Network
World Map Showing Countries with details of Airports.
Table showing Airports which are at Highest Altitude in the world and within the Country.
Table showing List of All Airlines within the country.
Bar Graphs showing Countries with Max No. of Airports & No. of Flights from Airports.
Airports at Higher Altitude within a Country
index n.. | Airport Name | City | ICAO Code |
1 | Almaty Airport | Alma-ata | UAAA | 2,234
2 | Taraz Airport | Dzhambul | UADD | 2,184
3 | Ayaguz Airport | Ayaguz | UASA | 2,119
Country
Kazakhstan
Airports at Highest Altitude in World
Airport Name | City | ICAO Code |
Daocheng Yading Airport | Daocheng | ZUDC | 14,472
Qamdo Bangda Airport | Bangda | ZUBD | 14,219
Kangding Airport | Kangding | ZUKD | 14,042
Ngari Gunsa Airport | Shiquanhe | ZUAL | 14,022
El Alto International Airport | La Paz | SLLP |
Data Source at highest altitude Airlines Final No. of Airlines Sheet 8 No. of flights from airport Sheet 11 Sheet 13 Dashboard 1 Dashboard 3 Dashboard 2 Dashboard 4 Story 1
12:26 AM

World Map Showing Countries with details of Airports.

Table showing Airports which are at Highest Altitude in the world and within the Country.

Table showing List of All Airlines within the country.

Bar Graphs showing Countries with Max No. of Airports & No. of Flights from Airports.

Airlines within a Country

Airline ID	Name	Icao	Callsign	
97	**Aerofumigaciones Sam**	AEG	FUMIGACIONES SAM	
171	**Aerogala**	AGQ	GALASERVICE	
200	**Alpine Air Chile**	AIH	ALPINE CHILE	
427	**Aeromet Servicios**	ARS	METSERVICE	
660	**Aeropuelche**	PUE	PUELCHE	
752	**Aerocardal**	CDA	CARDAL	
795	**Aerovias DAP**	DAP	DAP	
809	**Aerolineas Del Sur**	DLU	DEL SUR	
852	**Aerosec**	ERK	AEROSEC	
936	**Aerohein**	HEI	AEROHEIN	
958	**Aeroingenieria**	ING	AEROINGE	
1100	**Aeromet Linea Aerea**	MTE	AEROMET	

Country

Chile

Number of Airlines

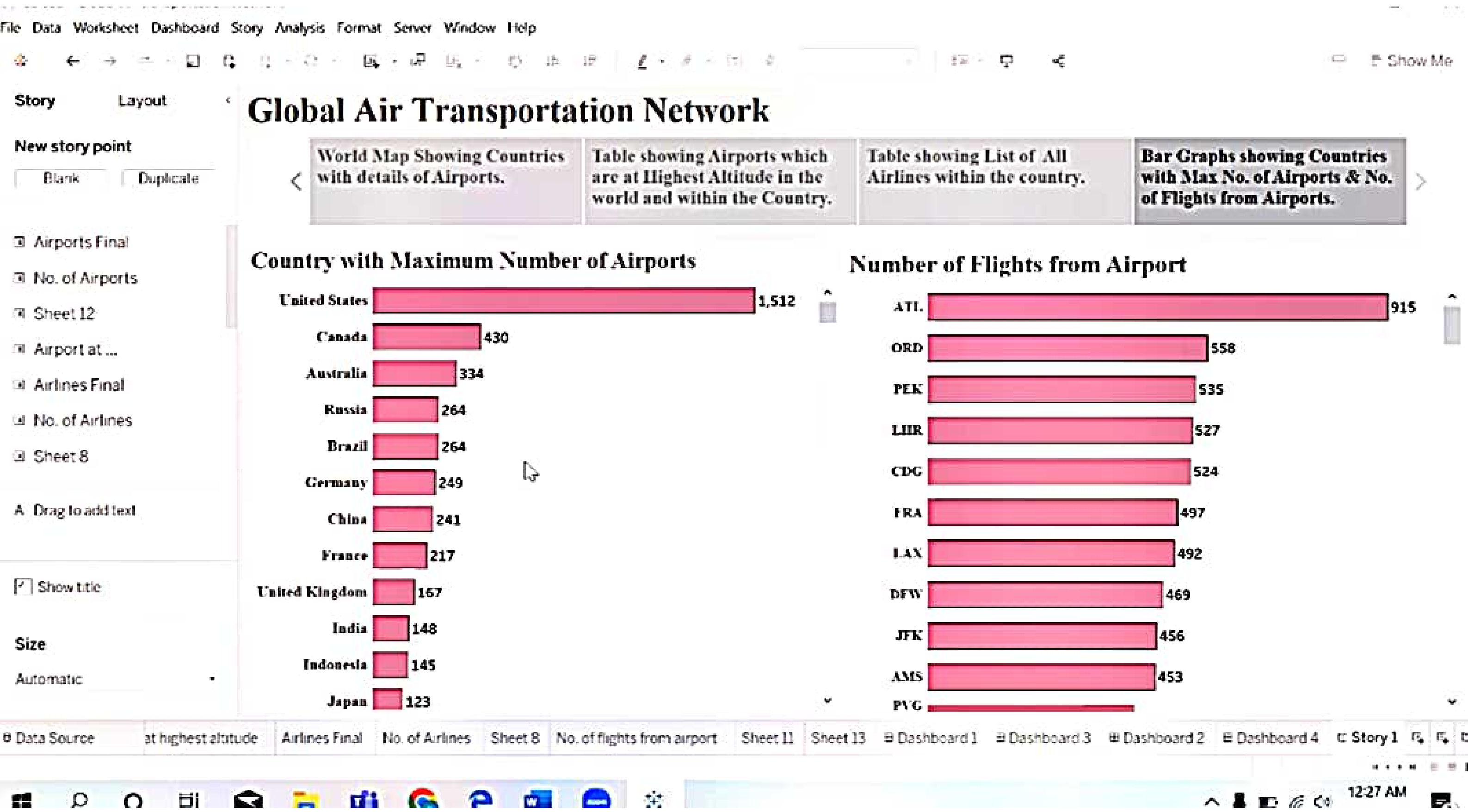
44

Active

(All)

Active

N Y


File Data Worksheet Dashboard Story Analysis Format Server Window Help
Show Me
Story
Layout
New story point
Blank
Duplicate
Airports Final
No. of Airports
Sheet 12
Airport at ...
Airlines Final
No. of Airlines
Sheet 8
Drag to add text
Show title
Size
Automatic
Global Air Transportation Network
World Map Showing Countries with details of Airports.
Table showing Airports which are at Highest Altitude in the world and within the Country.
Table showing List of All Airlines within the country.
Bar Graphs showing Countries with Max No. of Airports & No. of Flights from Airports.
Country with Maximum Number of Airports
United States 1,512
Canada 430
Australia 334
Russia 264
Brazil 264
Germany 249
China 241
France 217
United Kingdom 167
India 148
Indonesia 145
Japan 123
Number of Flights from Airport
ATL 915
ORD 558
PEK 535
LHR 527
CDG 524
FRA 497
LAX 492
DFW 469
JFK 456
AMS 453
PVG
Data Source
at highest altitude
Airlines Final
No. of Airlines
Sheet 8
No. of flights from airport
Sheet 11
Sheet 13
Dashboard 1
Dashboard 3
Dashboard 2
Dashboard 4
Story 1
12:27 AM

5 Conclusions

Almost half of the world's population is carried by airlines each year, and understanding this mode of transport is important from economic and scientific perspectives. In this case study paper, we reviewed both bottom-up (max. entropy agent model) and top-down (network science) approaches to better understand the fundamental science behind air transport networks. A summary of key key findings is given in Fig. 11.

In Sect. 2.2, using simple socioeconomic indicators, we were able to construct a very accurate entropy-maximization interaction model that can predict traffic volume for Australia. Using the population and distance functions, the spatial interaction model can forward estimate the impact of population growth. In Sect. 3.2, using historical data, we were able to identify how hubs evolved over time to become more influential. In Sect. 4, looking into the future, using random graph theory, it seems that reduced flight cost will lead to increased hub influence.