

2015

FY13-FY15 Scope III Emissions Methodology and Data

Mohamad Farzinmoghadam

University of Massachusetts - Amherst, mfarzinmoghadam@larp.umass.edu

Ludmilla Pavlova-Gillham

University of Massachusetts - Amherst, lpavlova@cp.umass.edu

Follow this and additional works at: https://scholarworks.umass.edu/sustainableumass_data

 Part of the [Oil, Gas, and Energy Commons](#), and the [Sustainability Commons](#)



This work is licensed under a [Creative Commons Attribution 4.0 License](#).

Farzinmoghadam, Mohamad and Pavlova-Gillham, Ludmilla, "FY13-FY15 Scope III Emissions Methodology and Data" (2015).
Campus Data. 30.

Retrieved from https://scholarworks.umass.edu/sustainableumass_data/30

This Article is brought to you for free and open access by the Sustainable UMass at ScholarWorks@UMass Amherst. It has been accepted for inclusion in Campus Data by an authorized administrator of ScholarWorks@UMass Amherst. For more information, please contact scholarworks@library.umass.edu.

UMass Scope 3 GHG Emissions

Employee and Student Commutes
Annual Vehicle Miles Traveled Fiscal Year 2013 -2015

Campus Employee Air Travel Emissions
Fiscal Year 2013 -2015

UMass Scope 3 GHG Emissions

Employee and Student Commutes
Annual Vehicle Miles Traveled Fiscal Year 2013 -2015

Project Objectives

- Develop a method for calculating campus Scope III emissions related to passenger vehicle commuting
- Calculate UMass FY 2013 -2015 Scope III emissions
- Document the process for future application and improvement

Data Sources

UMASS Parking Services

Database of parking permits and their holders

MASS GIS resources

ARCGIS online geocoding Service

Use the Esri Geocoding Service to convert an address or place name to latitude and longitude. For example, if you know the address of a business and want to put it on a map, you can use geocoding to find the coordinates.

Neighboring States resources

ARCGIS online North America Routing Service

The World Route service can be used to find the best way to get from one location to another or to visit several locations. The service can be used to generate routes in and between many countries around the world.

UMass Parking Services Data Format

10,269 Records for FY 13 in Excel, 4,478 Employees and 5,791 Students

8,416 Records for FY 14 in Excel, 4,457 Employees and 3,959 Students

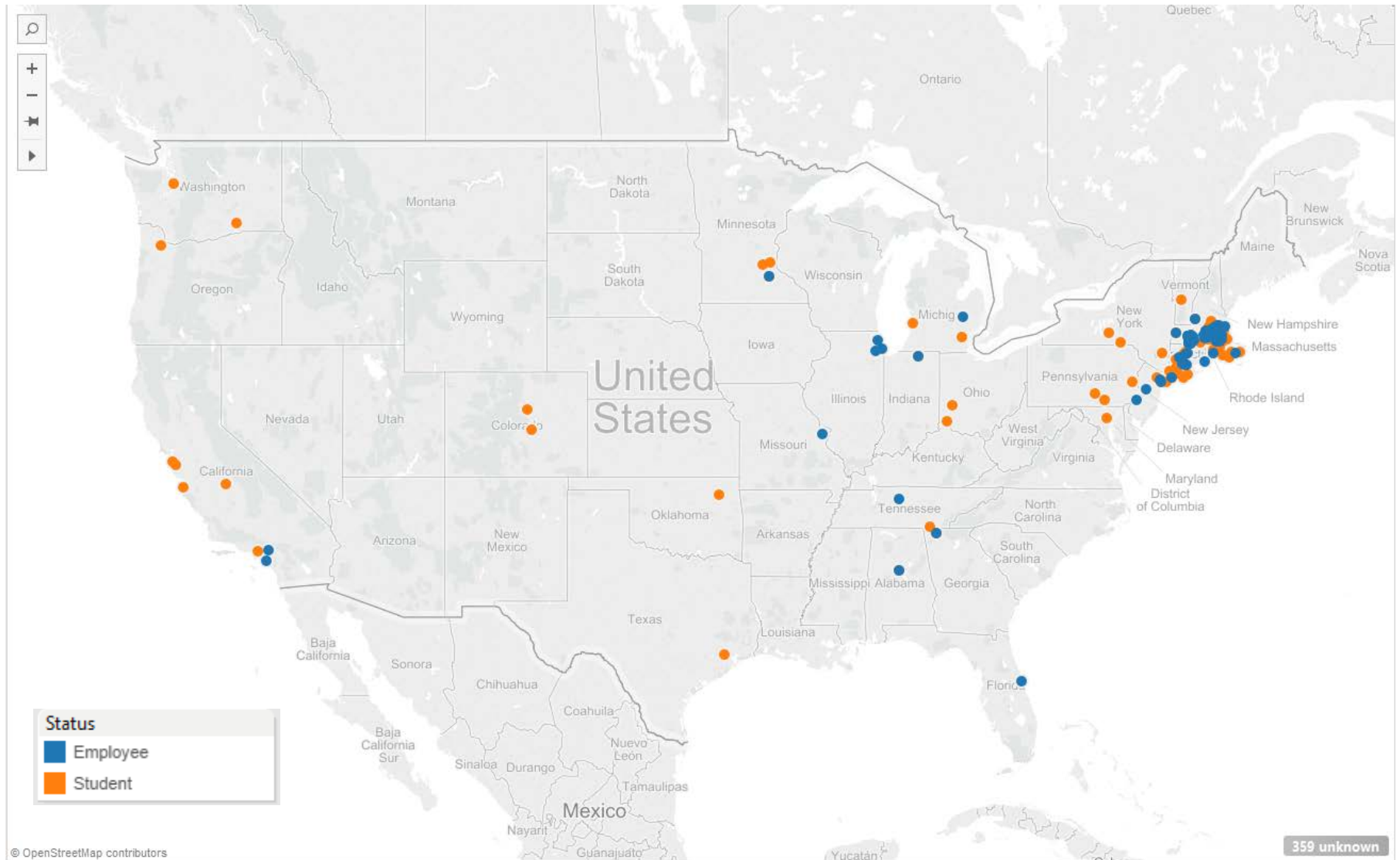
9,758 Records for FY 15 in Excel, 4,484 Employees and 5,274 Students

id	Status	address	city	State	zip	LOT	MAKE	MODEL	YEAR
1000	Employee	10 Palley Village Place	Amherst	MA	01002	Lot 67	TOYO		2000
1001	Employee	61 Woodbridge Terrace#6	South Hadley	MA	01075	Lot 65	MINI		2006
1002	Employee	221 Massachusetts Ave	Boston	MA	02115	Lot 24	LEXU	ES250	2010
1003	Employee	104 State Street	Northampton	MA	01060	Lot 32	HOND	CRV	2001
1004	Employee	60 Patterson Avenue	Springfield	MA	01119	Lot 65	AUDI		2013
1005	Employee	112 SUNSET DRIVE	SPRINGFIELD	MA	01109	Lot 33	NISS	VERSA	2007
1410	Employee	280 Green River Road	Greenfield	MA	01301	Upper Garage	FORD	FOC	2008
1416	Employee	West Leyden Rd	Leyden	MA	01337	Motorcycle	BMW		2007
1417	Employee	West Leyden Rd	Leyden	MA	01337	Lot 27	HOND		2001
1418	Employee	22 Salem Place	Amherst	MA	01002	Lower Garage	NISS	ALT	2002
1419	Employee	66 Gulf Road	Belchertown	MA	01007	Transit	TOYO		2007
1432	Employee	156 School St	Greenfield	MA	01301	Night	TOYO	COR	2010
1530	Employee	86 S Plain Rd	Sunderland	MA	01375	Special	PONT	VIB	2009
1556	Employee	10A Hadley Rd.	Sunderland	MA	01375	Child Care	HYUN	ELA	2007
1576	Employee	404 Alvord Place	South Hadley	MA	01075	Upper Garage	SUBA	FOR	2008
11269	Student		WORCESTER		01604	Lot 66	HYUN	ELA	2013

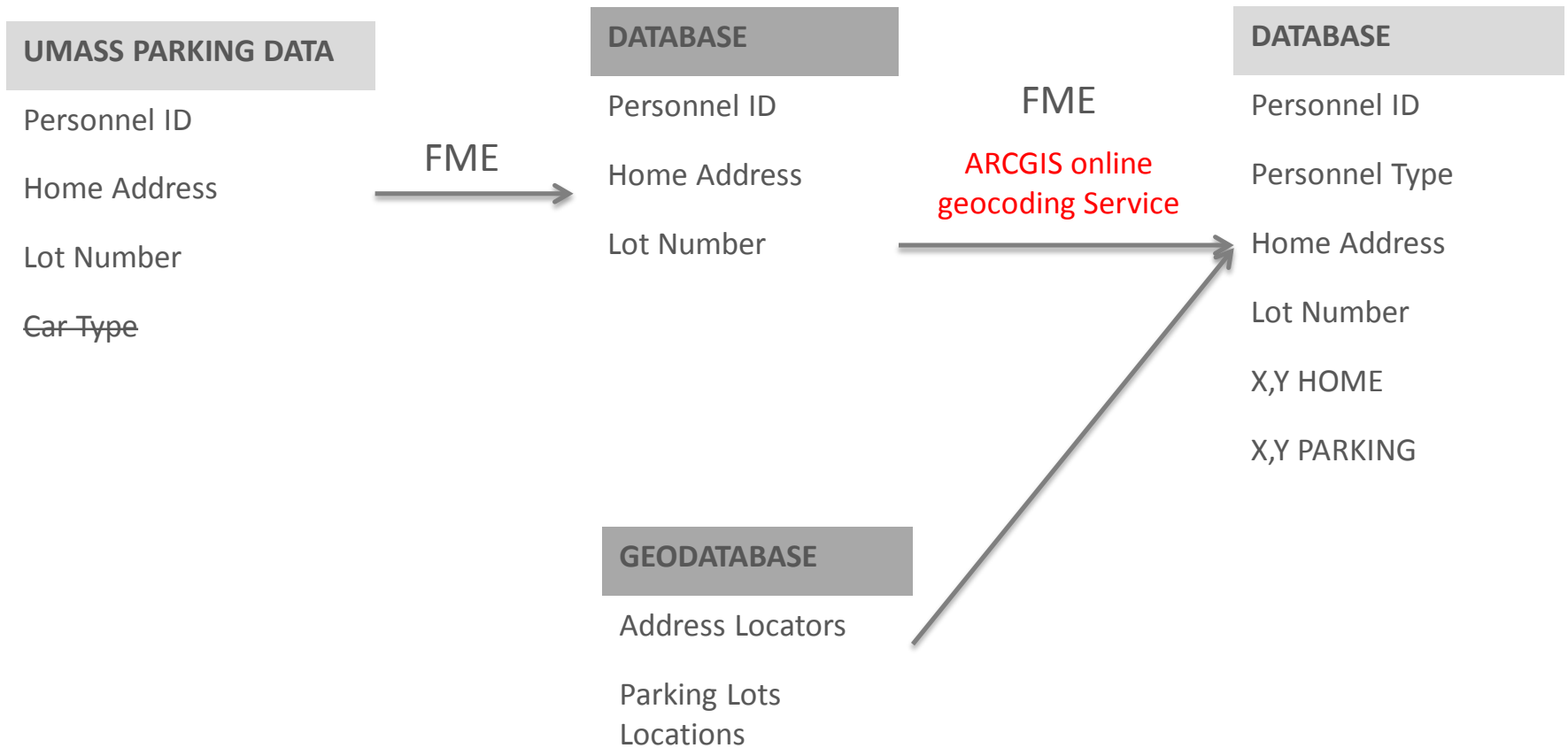
Data Quality

- Requires manual input
- Typos in City Names – Ex. 7 versions of Amherst, 6 for Belchertown
- Lacks Personnel Type Detail
- Includes Lot Numbers that don't have a clear location
- Uses abbreviations for Vehicle Make and Model/ lacks an authoritative vehicle list
- Home address for commuting purposes may not be valid

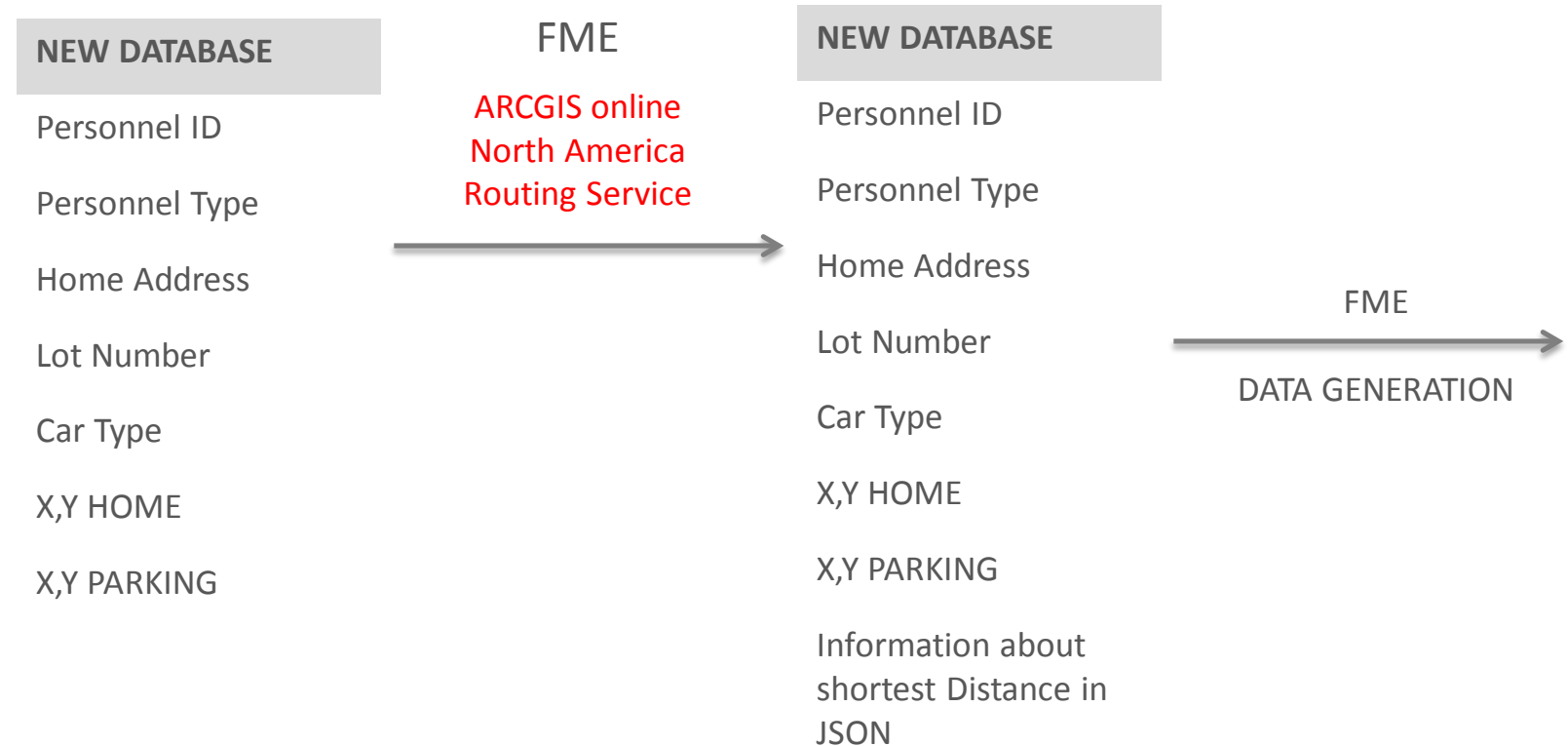
Map of home addresses in data



Analytical Methodology



Analytical Methodology



Employee Commuting - Base Assumptions of the Analysis

Max work days/employee = (52 weeks x 5 days) – 15 holidays = 245 days

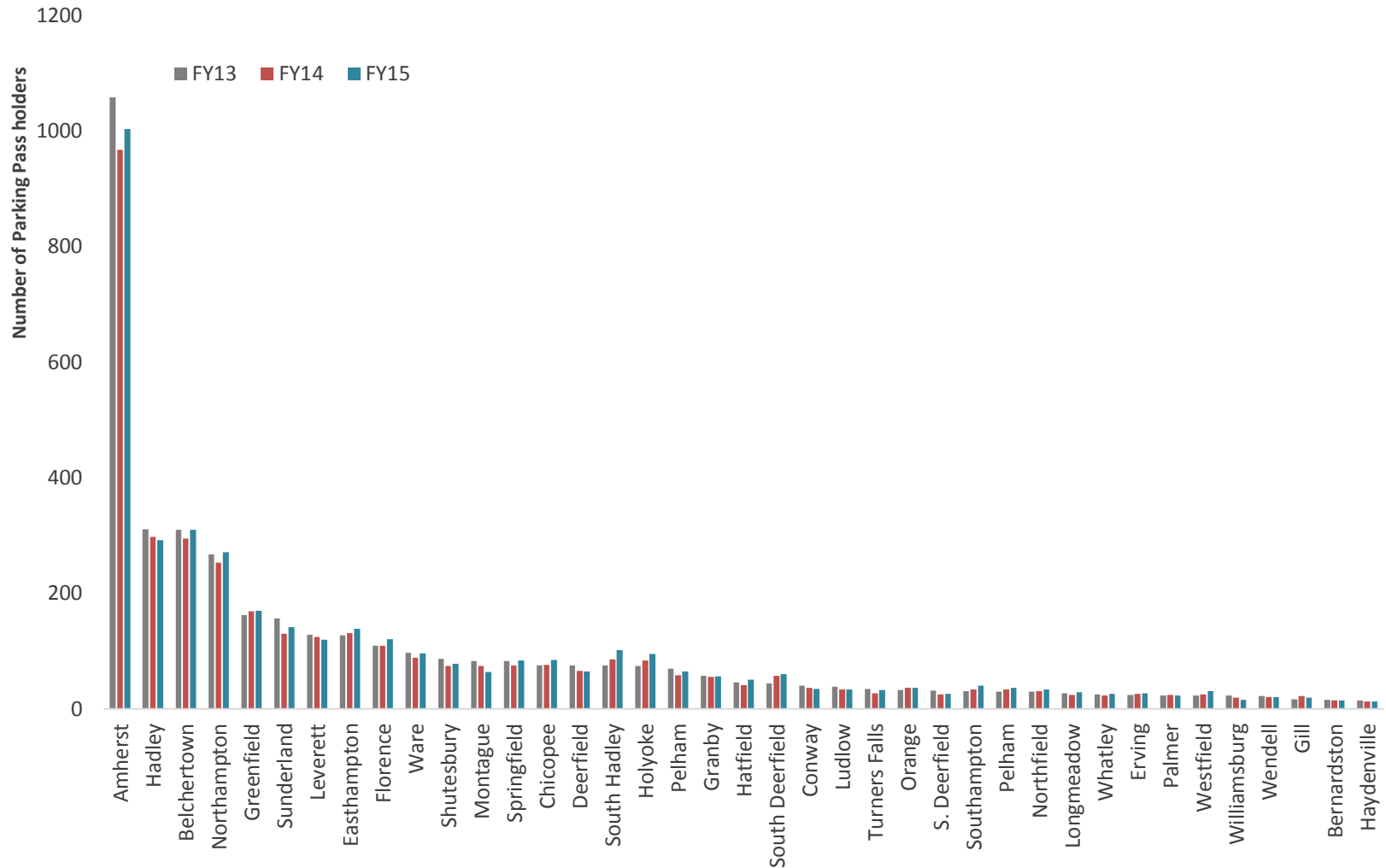
Employees park on campus an average of 80% of the time

$$245 \times 0.8 = 196 \text{ days}$$

Total AVMT per person = Commute/miles X 196 days

Correction for long-distance commuters

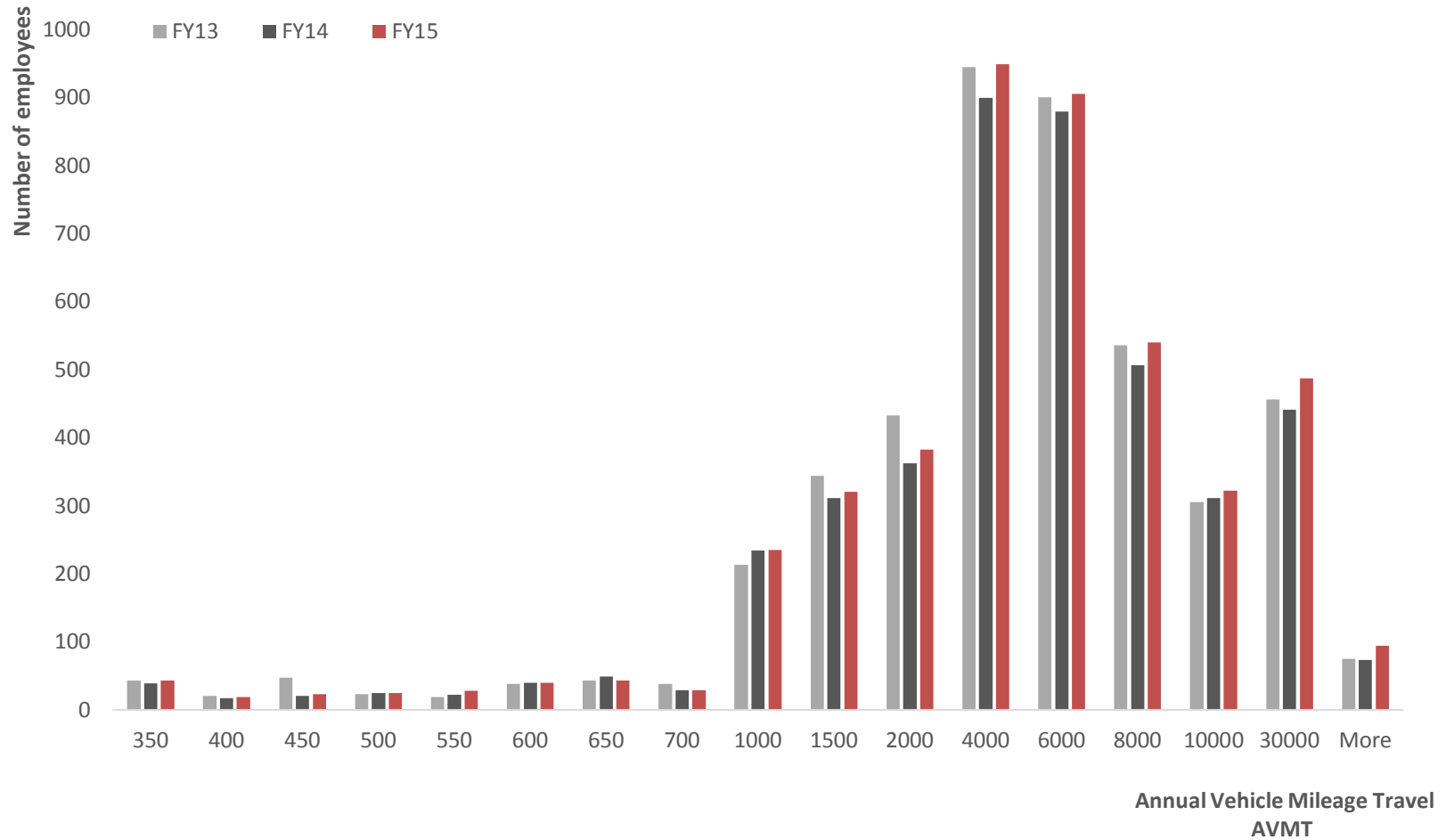
Home Towns of Employee Permit Holders



Employees AVMT percentage Distribution

<i>Annual VMT</i>	<i>FY13</i>	<i>Percentage FY13</i>	<i>FY14</i>	<i>Percentage FY14</i>	<i>FY15</i>	<i>Percentage FY15</i>
350	43	1.0%	39	0.9%	43	1.0%
400	20	0.4%	17	0.4%	19	0.4%
450	47	1.0%	20	0.5%	23	0.5%
500	23	0.5%	25	0.6%	25	0.6%
550	19	0.4%	22	0.5%	28	0.6%
600	38	0.8%	40	0.9%	40	0.9%
650	43	1.0%	49	1.2%	43	1.0%
700	38	0.8%	29	0.7%	29	0.6%
1000	213	4.8%	234	5.5%	235	5.2%
1500	344	7.7%	311	7.3%	320	7.1%
2000	433	9.7%	362	8.5%	382	8.5%
4000	945	21.1%	899	21.1%	949	21.2%
6000	900	20.1%	879	20.6%	905	20.2%
8000	536	12.0%	506	11.9%	540	12.0%
10000	305	6.8%	311	7.3%	322	7.2%
30000	456	10.2%	441	10.4%	487	10.9%
More	75	1.7%	73	1.7%	94	2.1%
Total	4478	100%	4257	100%	4484	100%

UMass Employees - AVMT Distribution 2013 - 2015



Employees AVMT 2013 – 2015 Trends

	Drive Time	Annual VMT	% Change
FY 13			
Total	686,422	24,162,666	0.00%
Average	153	5,396	0.00%
Max	714	36,495	
Min	1.03	21.89	
Median	131	4,066	
FY 14			
Total	662,160	23,342,066	-3.40%
Average	156	5,483	1.62%
Max	727	36,456	
Min	5.20	75.83	
Median	134	4,140	
FY 15			
Total	711,957	25,439,485	8.99%
Average	159	5,673	3.47%
Max	765	36,456	
Min	3.06	64.30	
Median	136	4,180	

Students Commuting - Base Assumptions of the Analysis

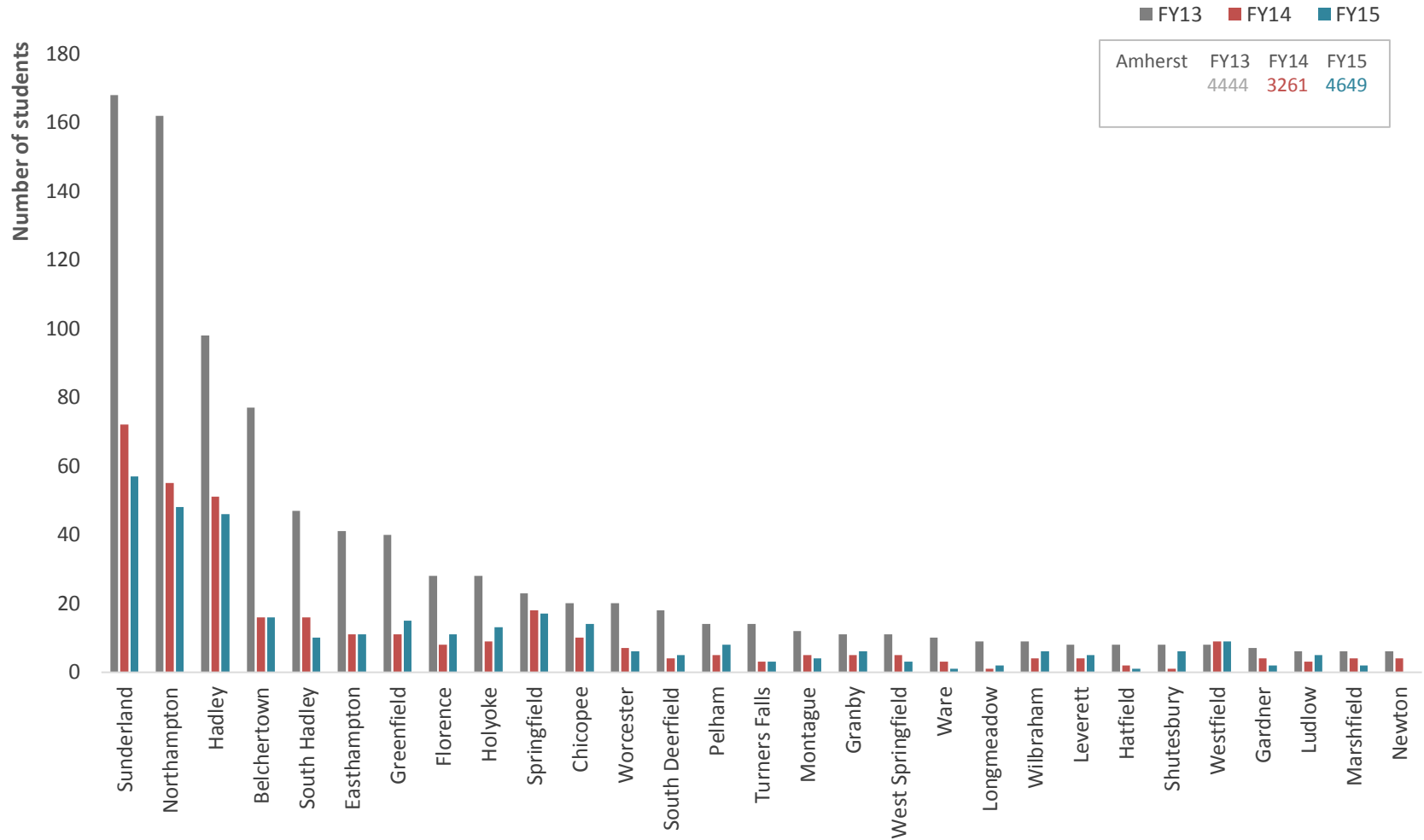
Max student study days = (32 weeks x 5 days) – 5 = 155 days

Students park on campus an average of 80% of the time

$$155 \times 0.8 = 124 \text{ days}$$

Total AVMT per student = Commute/miles X 124 days

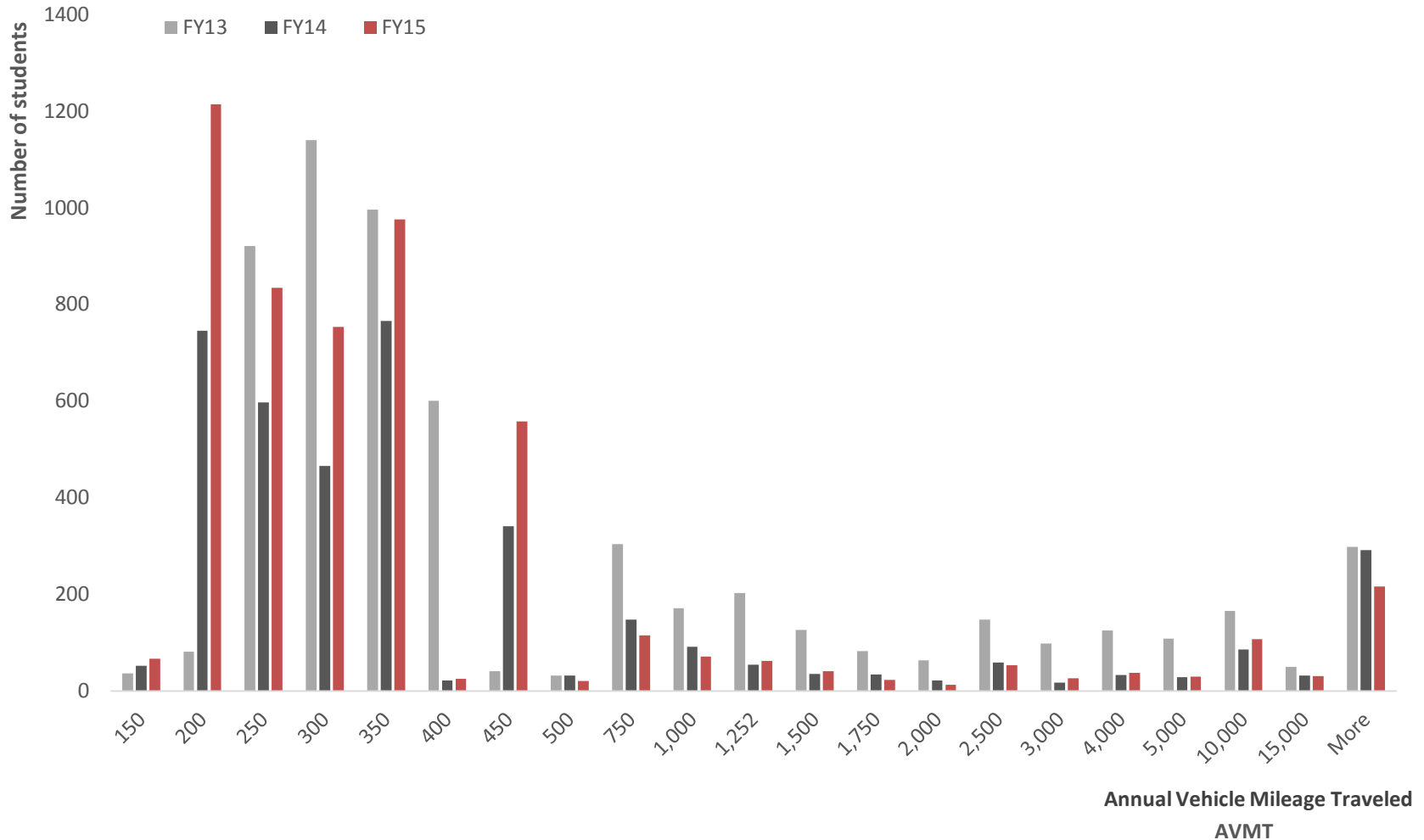
Home Towns of Student Permit Holders



Students AVMT percentage Distribution

<i>Annual VMT</i>	<i>FY13</i>	<i>Percentage FY13</i>	<i>FY14</i>	<i>Percentage FY14</i>	<i>FY15</i>	<i>Percentage FY15</i>
150	37	0.6%	52	1.3%	67	1.3%
200	82	1.4%	745	18.8%	1214	23.0%
250	920	15.9%	597	15.1%	834	15.8%
300	1139	19.7%	466	11.8%	753	14.3%
350	996	17.2%	765	19.3%	975	18.5%
400	600	10.4%	22	0.6%	25	0.5%
450	41	0.7%	341	8.6%	558	10.6%
500	32	0.6%	32	0.8%	21	0.4%
750	304	5.2%	148	3.7%	115	2.2%
1,000	171	3.0%	92	2.3%	71	1.3%
1,252	203	3.5%	55	1.4%	62	1.2%
1,500	126	2.2%	35	0.9%	41	0.8%
1,750	83	1.4%	34	0.9%	23	0.4%
2,000	64	1.1%	22	0.6%	13	0.2%
2,500	148	2.6%	59	1.5%	54	1.0%
3,000	98	1.7%	18	0.5%	26	0.5%
4,000	125	2.2%	33	0.8%	38	0.7%
5,000	108	1.9%	29	0.7%	30	0.6%
10,000	166	2.9%	86	2.2%	107	2.0%
15,000	50	0.9%	32	0.8%	31	0.6%
More	298	5.1%	292	7.4%	216	4.1%
Total	5791	100.0%	3955	100.0%	5274	100.0%

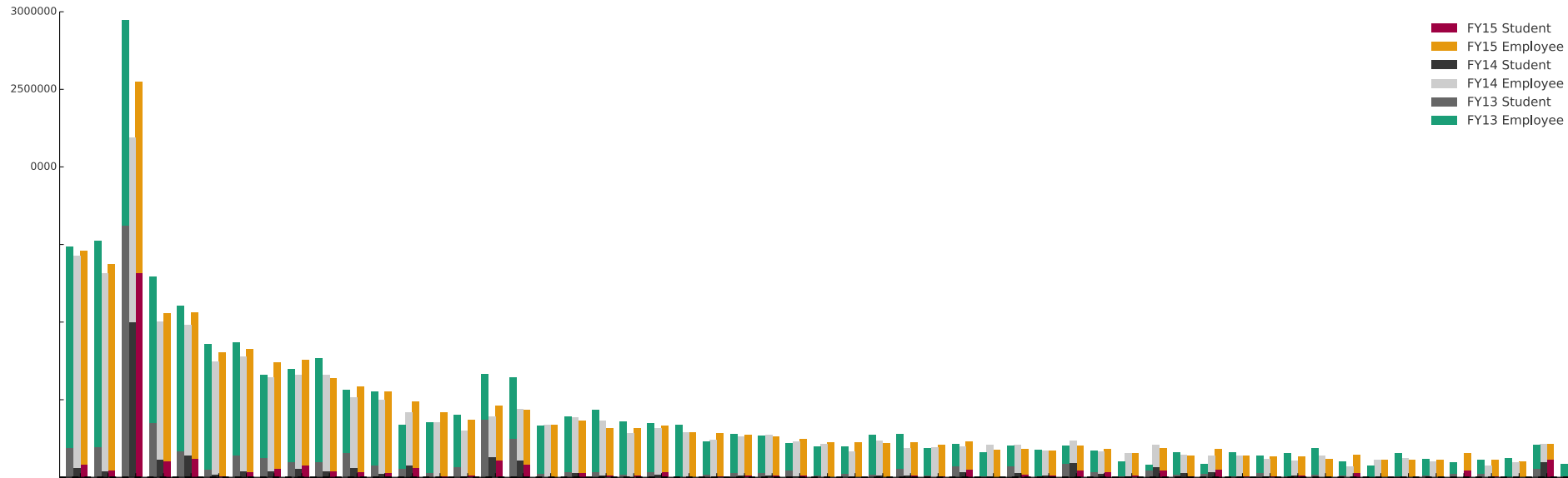
UMass Students AVMT Distribution 2013 - 2015



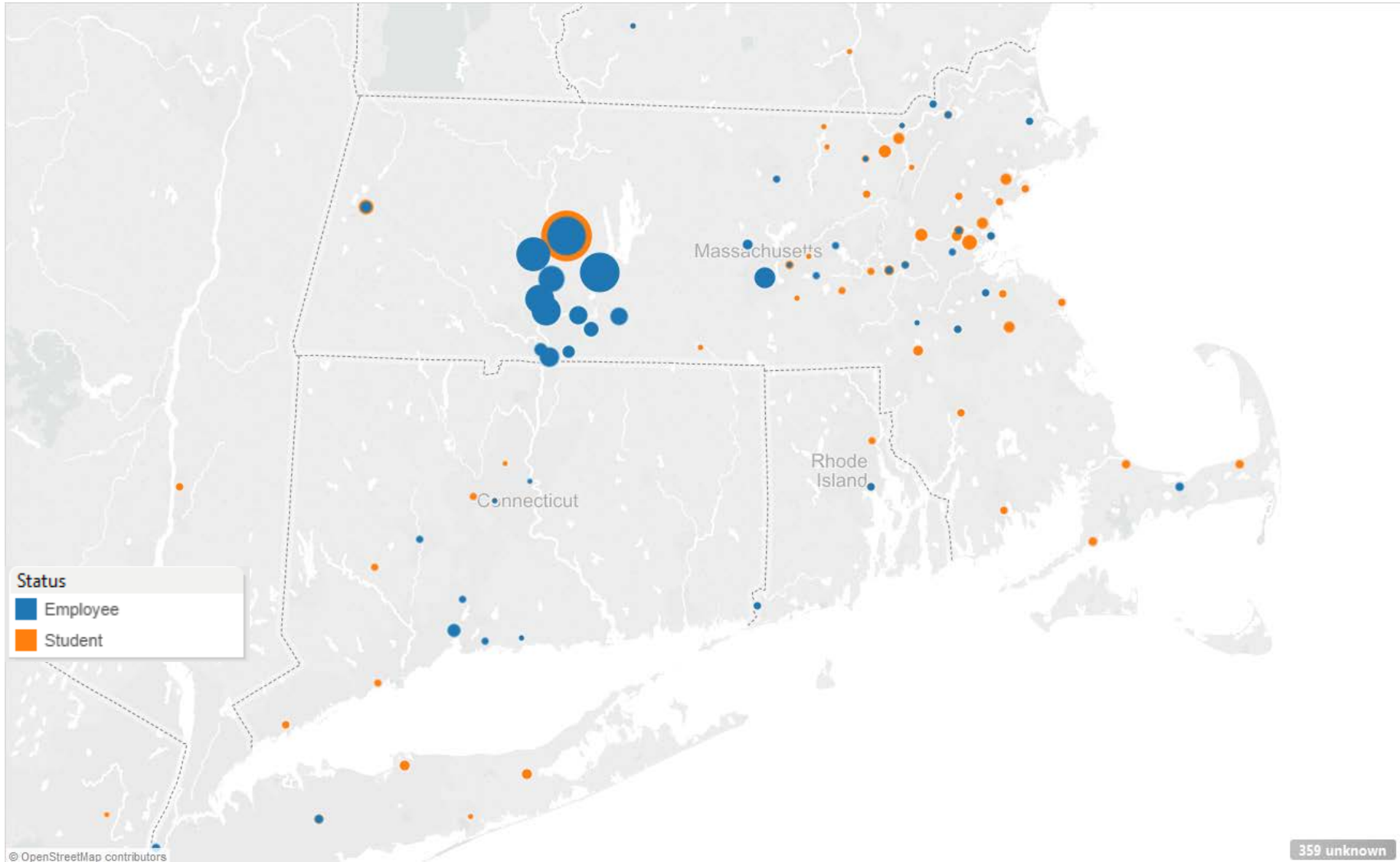
Students Annual Vehicle Mileage Traveled 2013 – 2015 Trends

	Drive Time	Annual VMT	% Change
FY 13			
Total	314,356	12,028,588	0.00%
Average	54	2,077	0.00%
Max	506	23,089	
Min	0.39	13.48	
Median	20	303	
FY 14			
Total	223,323	9,142,290	-24.00%
Average	56	2,312	11.29%
Max	558	23,064	
Min	0.00	13.28	
Median	20	315	
FY 15			
Total	213,184	7,835,854	-14.29%
Average	40	1,486	-35.73%
Max	531	23,064	
Min	0.38	13.28	
Median	14	266	

UMass Total Commuter's AVMT Distribution Trend



Map of Total AVMT Commuter Distribution



EPA Co2 Calculation Method

Annual Vehicle Mileage Traveled

×

8.89×10^{-3} metric tons CO₂/gallon gasoline

×

1/21.4 miles per gallon for car/truck average

Divided by

0.988 metric tons CO₂/gallon gasoline

Metric Tons per year

Number of Homes Total Energy Usage/year

Number Homes Total Electricity Usage/year

Barrels of Oil/year

UMass Scope III GHG Emissions – Estimated AVMT Method

	Drive Time	Annual VMT	Percentage of Change	CO2 Equivalent Emission (Metric Tons)
Students				
FY13	314,356	12,028,588	0.00%	5,063
FY14	223,323	9,142,290	-24.00%	3,848
FY15	213,184	7,835,854	-14.29%	3,298
Employees				
FY13	686,422	24,162,666	0.00%	10,171
FY14	662,160	23,342,066	-3.40%	9,826
FY15	711,957	25,439,485	8.99%	10,708
UMass Campus Total				
FY13	1,000,778	36,191,255	0.00%	15,234
FY14	885,484	32,484,356	-10.24%	13,674
FY15	925,141	33,275,339	2.43%	14,007

UMass Scope 3 GHG Emissions

Campus Employee Air Travel Emissions
Fiscal Year 2013 -2015

Project Objectives

- Develop a method for calculating campus Scope III emissions related to employee air travel
- Calculate UMass FY 2013 -2015 Scope III emissions
- Document the process for future application and improvement

Data Sources

Procurement Business Service

Departmental and Individual procurement data shows Air-tickets, origins, and destinations.

ESRI USA Airports Hub Size

U.S. Airports provides the boundaries for thousands of airports and runways. Attributes for each airport in this database include location id (airport code), owner, elevation, congestion level, and large certified air carrier enplanements.

EPA Air Travel Emission Factors

Center for Corporate Climate Leadership GHG Emission Factors Hub. This document was designed to provide organizations with a regularly updated and easy-to-use set of default emission factors for organizational greenhouse gas reporting.

Great Circle Mapper

The Great Circle Mapper began in 1996 as a free tool for visualizing the path between airports around the globe—a geodesic, commonly known as the great circle path—and for computing the distance along this path.

A comprehensive database containing over 40,000 airports and other facilities allows users to generate maps using nearly any airport in the world.

UMass Procurement Business Service Data Format

42,060 Records in Excel

9,059 FY 12 95 Records before FY12
 19,900 FY 13
 6,701 FY 14
 6,016 FY 15

MCC	MCC Description	Tkt Number	Depart Travel Date	Dest City	Orig City	FY	Fare Base	Service Class	Passenger Name	Transaction Post Date
3007	Air France	05723356334043	4/19/2013	BOD	CDG	2013N		N		4/19/2013
3007	Air France	05723356334043	4/19/2013	CDG	BOD	2013Q		Q		4/19/2013
3007	Air France	05723360542594	4/29/2013	MEX	CDG	2013R		R		4/29/2013
3000	United Airlines	01626034506180	6/29/2012	ORD	BDL	2012ED/D		ED		7/2/2012
3000	United Airlines	01626034676140	6/30/2012	ORD	BDL	2012ED/D		ED		7/2/2012
3000	United Airlines	01629211077826	6/29/2012	CLE	LAX	2012ED/D		ED		7/2/2012
3000	United Airlines	01629212140651	6/28/2012	IAD	SFO	2012ED/D		ED		7/3/2012
3008	Lufthansa	22070723263010	6/28/2012	CDG	MUC	2012FARE		T		7/2/2012
3008	Lufthansa	22070723263010	6/28/2012	IST	ZRH	2012FARE		T		7/2/2012

ESRI USA Airports Hub Size

ObjectID *	Shape *	NAME	FCC	LOC_ID	USE	OWNERNAME
0	Polygon	Talkeetna Airport	D58	TKA	PU	
1	Polygon	Hooper Bay Airport	D58	HPB	PU	
2	Polygon	Unalaska Airport	D58	DUT	PU	
3	Polygon	Point Hope Airport	D58	PHO	PU	
4	Polygon	Gambell Airport	D58	GAM	PU	St Of Ak Dotpf/N Region
5	Polygon	Nome Airport	D58	OME	PU	St Of Ak Dotpf North Reg
6	Polygon	Shishmaref Airport	D58	SHH	PU	State Of Ak Dotpf N Rgn
7	Polygon	Edward G Pitka Sr Airport	D58	GAL	PU	St Of Alask Doptf North Reg
8	Polygon	Ralph Wien Memorial Airport	D58	OTZ	PU	
9	Polygon	Selawik Airport	D58	WLK	PU	
10	Polygon	Wiley Post-Will Rogers Memorial Airport	D58	BRW	PU	
11	Polygon	Wainwright Airport	D58	AWI	PU	
12	Polygon	Cold Bay Airport	D58	CDB	PU	State Of Ak Dotpf-Central Rgn
13	Polygon	Sand Point Airport	D58	SDP	PU	
14	Polygon	King Salmon Airport	D58	AKN	PU	
15	Polygon	Bethel Airport	D58	BET	PU	State Of Ak Dotpf-Central Rgn
16	Polygon	McGrath Airport	D58	MCG	PU	
17	Polygon	Dillingham Airport	D58	DLG	PU	State Of Ak Dotpf-Central Rgn
18	Polygon	Emmonak Airport	D58	EMK		
19	Polygon	Homer Airport	D58	HOM	PU	State Of Ak Dotpf-Central Rgn
20	Polygon	Soldotna Airport	D58	SXQ	PU	City Of Soldotna
21	Polygon	Kodiak Airport	D58	ADQ	PU	
22	Polygon	Kenai Municipal Airport	D58	ENA	PU	
23	Polygon	Elmendorf AFB	D58	EDF	PR	
24	Polygon	Merrill Field Airport	D58	MRI	PU	
25	Polygon	Campbell Airstrip	D58	CSR	PR	
26	Polygon	Ted Stevens Anchorage International Airport	D58	ANC	PU	
27	Polygon	Northway Airport	D58	ORT	PU	State Of Alaska Dotpf/N. Rgn
28	Polygon	Merle K Mudhole Smith Airport	D58	CDV	PU	Dot Nothern Region
29	Polygon	Gulkana Airport	D58	GKN	PU	St Of Ak Dotpf Nor Rea

EPA Air Travel Emission Factors

Fiscal Year	MMBtu / passenger mile	kg CO ₂ / mile	kg CH ₄ / mile	kg N ₂ O / mile
1990	0.004766563	0.915466074	9.21535E-06	1.05924E-05
1991	0.004536137	0.871210476	8.76986E-06	1.00803E-05
1992	0.004413371	0.84763205	8.53252E-06	9.80749E-06
1993	0.004457418	0.856091779	8.61768E-06	9.90537E-06
1994	0.004344826	0.834467317	8.4E-06	9.65517E-06
1995	0.004282079	0.819872594	8.27869E-06	9.51573E-06
1996	0.004095891	0.798821716	7.91872E-06	9.10198E-06
1997	0.004091169	0.797900734	7.90959E-06	9.09149E-06
1998	0.00388095	0.756901694	7.50317E-06	8.62433E-06
1999	0.004009144	0.781903342	7.75101E-06	8.90921E-06
2000	0.003892236	0.759102716	7.52499E-06	8.64941E-06
2001	0.003848188	0.750512019	7.43983E-06	8.55153E-06
2002	0.003607876	0.703644097	6.97523E-06	8.0175E-06
2003	0.003492953	0.681230677	6.75304E-06	7.76212E-06
2004	0.003407854	0.664633774	6.58852E-06	7.57301E-06
2005	0.003231973	0.630331682	6.24848E-06	7.18216E-06
2006	0.003141605	0.612707309	6.07377E-06	6.98135E-06
2007	0.003040058	0.59290244	5.87744E-06	6.75568E-06
2008	0.002936042	0.572616204	5.67635E-06	6.52454E-06
2009	0.002774477	0.541106325	5.36399E-06	6.16551E-06
2010	0.002690893	0.52480488	5.20239E-06	5.97976E-06
2011	0.002690893	0.52480488	5.20239E-06	5.97976E-06
2012	0.002690893	0.52480488	5.20239E-06	5.97976E-06
2013	0.002690893	0.52480488	5.20239E-06	5.97976E-06

Great Circle Mapper



BDL - Airport

BDL

Map

Distance

Search

Airport Info

Detailed information for an airport code

[FAQ](#)
[Featured Maps](#)
[More](#)
[Home](#)

Location

City: Windsor Locks, Connecticut, United States
Near (Alt.): Hartford, Springfield
Name: Bradley International Airport
ICAO / IATA: [KBDL](#) / [BDL](#)
FAA: [BDL](#)

Details

Type: Airport ([Part 139 Class I](#))
Use: Public/Civil, International (customs port of entry)
Latitude: 41°56'21"N (41.939145)
Longitude: 72°41'00"W (-72.683370)
Datum: WGS 1984
Elevation: 173 ft (53 m)
Runways: 3
Longest: 9510 × 200 ft (2899 × 61 m), paved

Time

Time Zone: UTC-5 (DST-4)
Local Time: 04 Dec 2013 12:43 EST

Weather

METAR: KBDL 041651Z 0000KT 10SM BKN120 BKN250 06/M02 A3010 RMK AO2 SLP193 T00611022
TAF: KBDL 041141Z 0412/0518 0000KT P6SM FEW030 BKN120
FM041700 0000KT P6SM SCT070
FM050400 0000KT P6SM BKN040
FM050800 0000KT 5SM BR BKN025
FM051100 VRB03KT 3SM -DZ BR BKN010

Related Locations

Nearby: [United States \(US\)](#)
Farthest: [MGV: 11738 mi / 18891 km](#)
[Margaret River, WA, AU](#)

Find:

(all) Airport Heliport Seaplane Base Ultralight Flightpark STOLport Gliderport

beyond 0 mi

but within 100 mi

any heading

Find



- [Location](#)
- [Details](#)
- [Time](#)
- [Weather](#)
- [Related Locations](#)
- [Other Information](#)
- [Airport Diagram](#)
- [Sectional Chart](#)
- [Satellite Image](#)

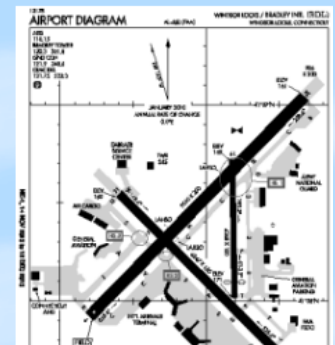
Taxi Bradley Airport

www.aaacab.net

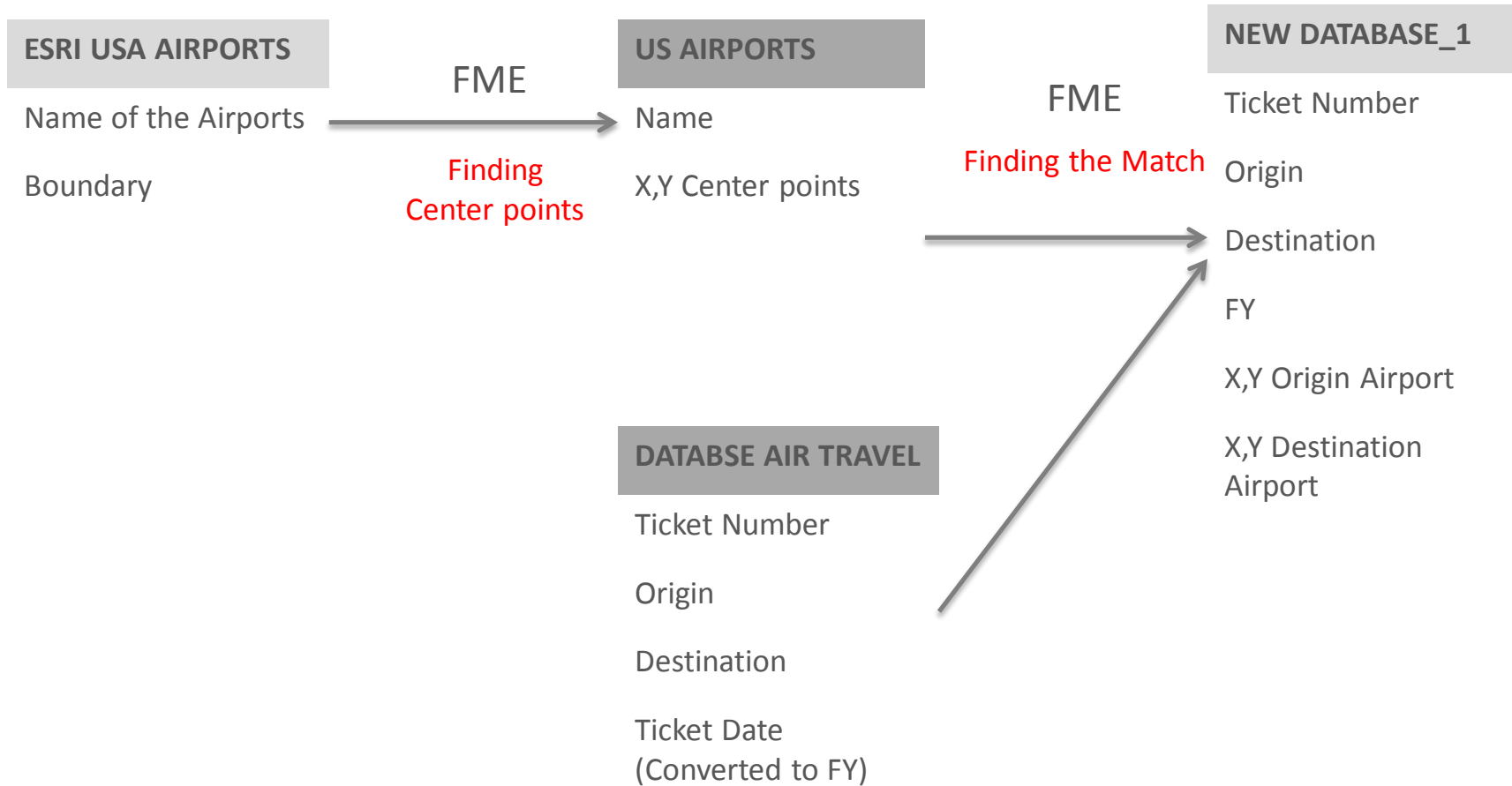
All Airports No Local pay cash
Get 10% Off Bradley Int'l
Airport



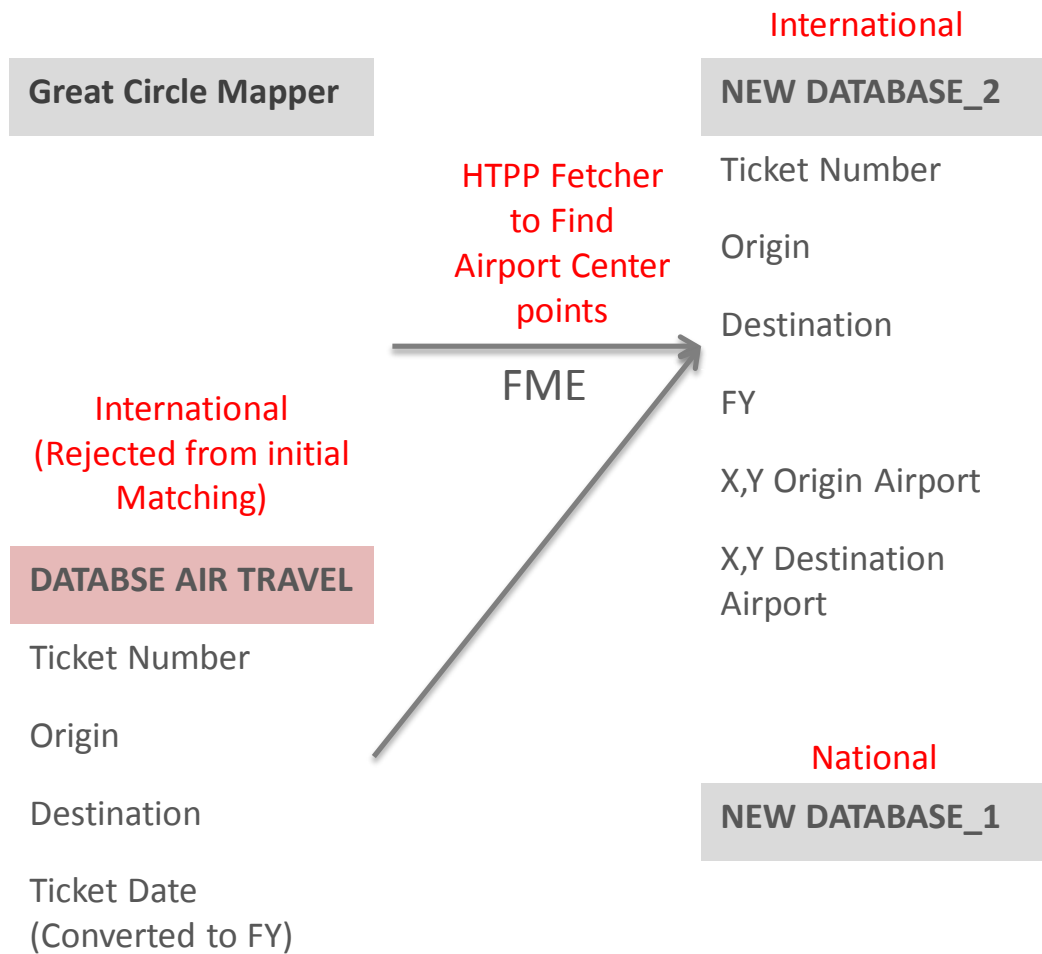
Airport Diagram



Analytical Methodology



Analytical Methodology



Analytical Methodology

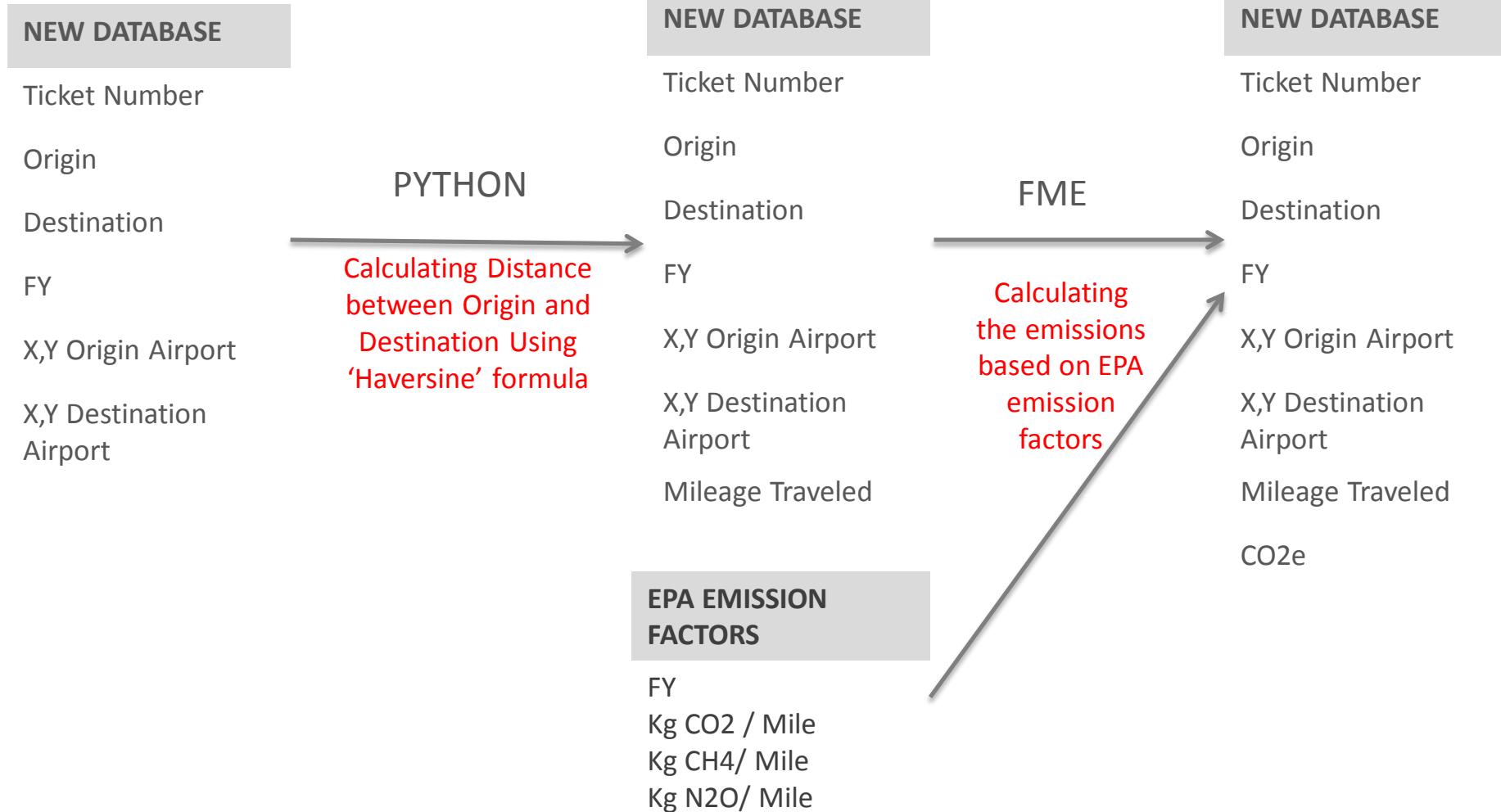
$$a = \sin^2\left(\frac{\Delta\varphi}{2}\right) + \cos(\varphi_1) \times \cos(\varphi_2) \times \sin^2\left(\frac{\Delta\beta}{2}\right)$$

$$C = 2 \times \text{Arctan2}(\sqrt{a}, \sqrt{1-a})$$

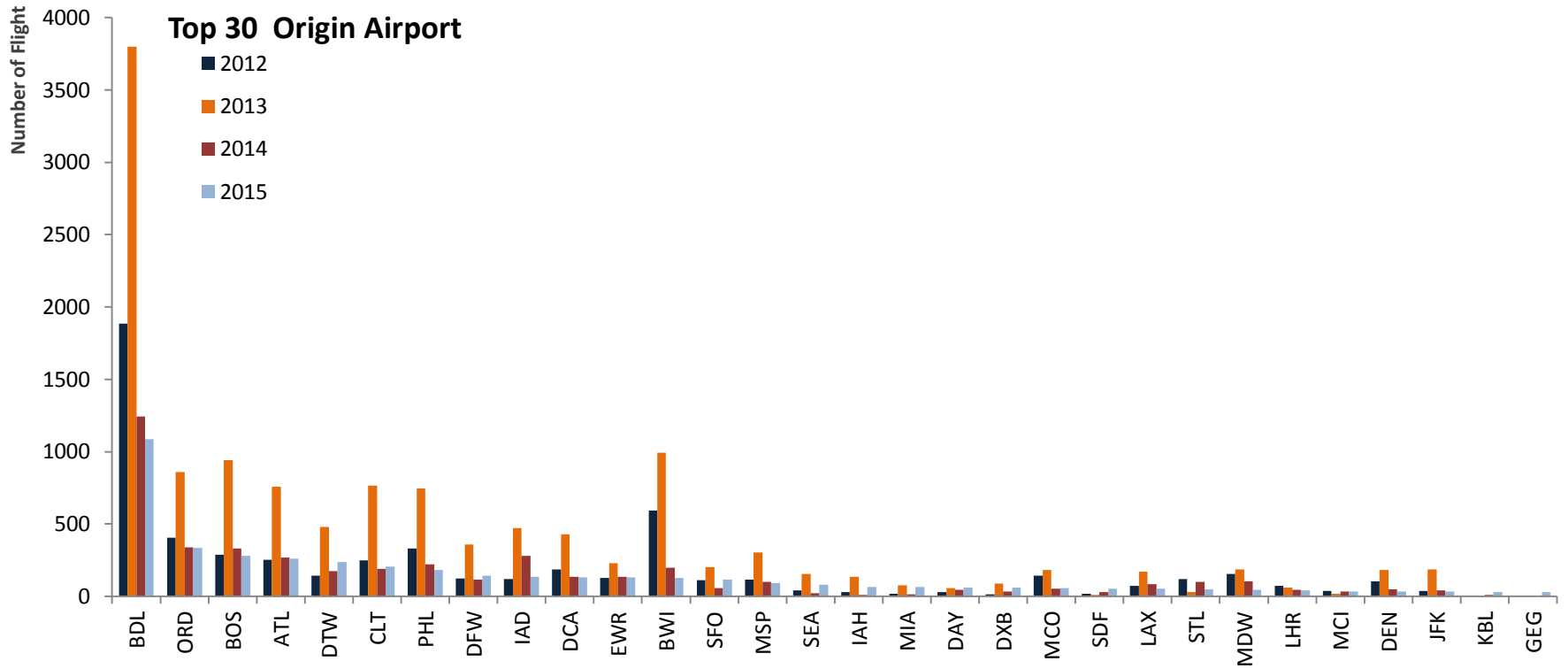
$$\text{Distance} = R \times C$$

Using the “**Haversine**” formula to calculate the great-circle distance between two points
The shortest distance over the earth’s

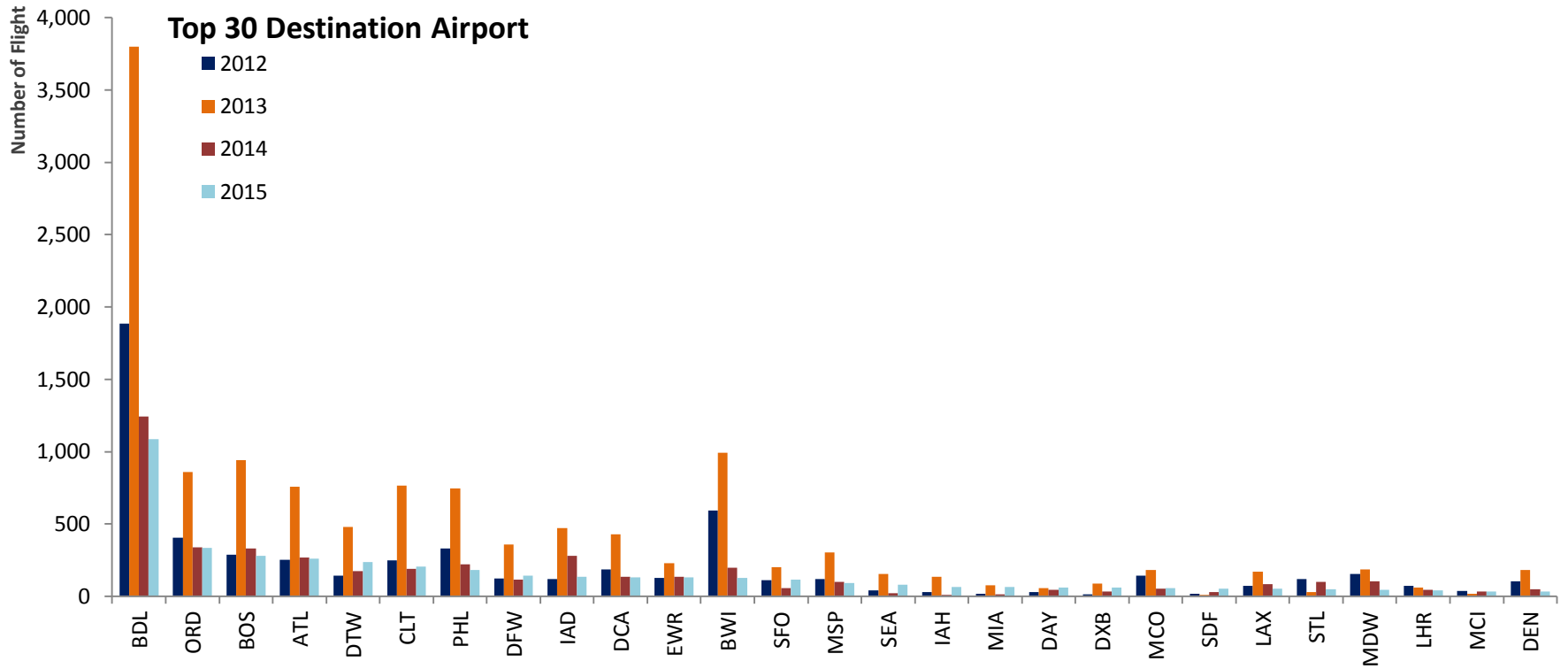
Analytical Methodology



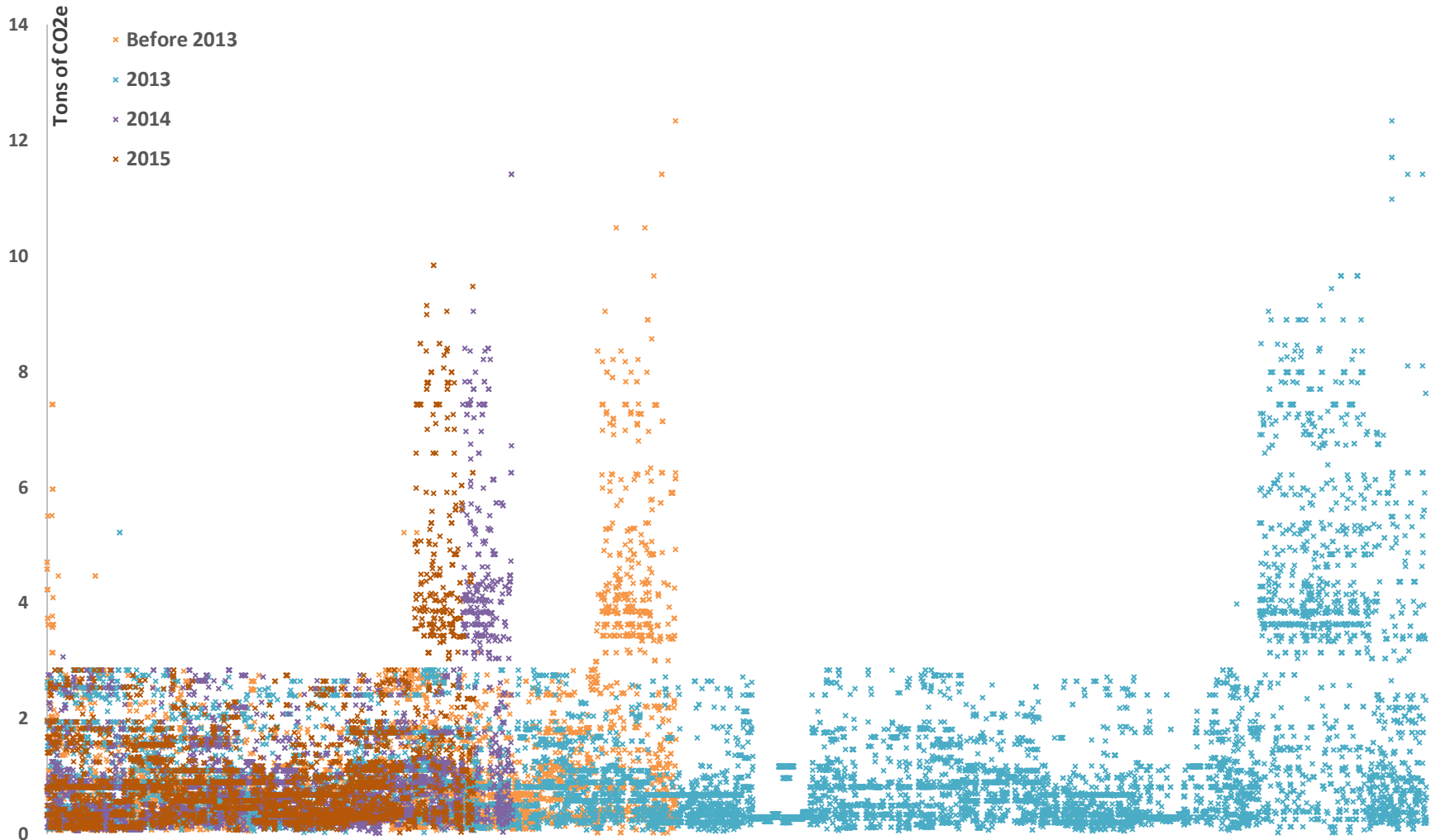
Origin Airports



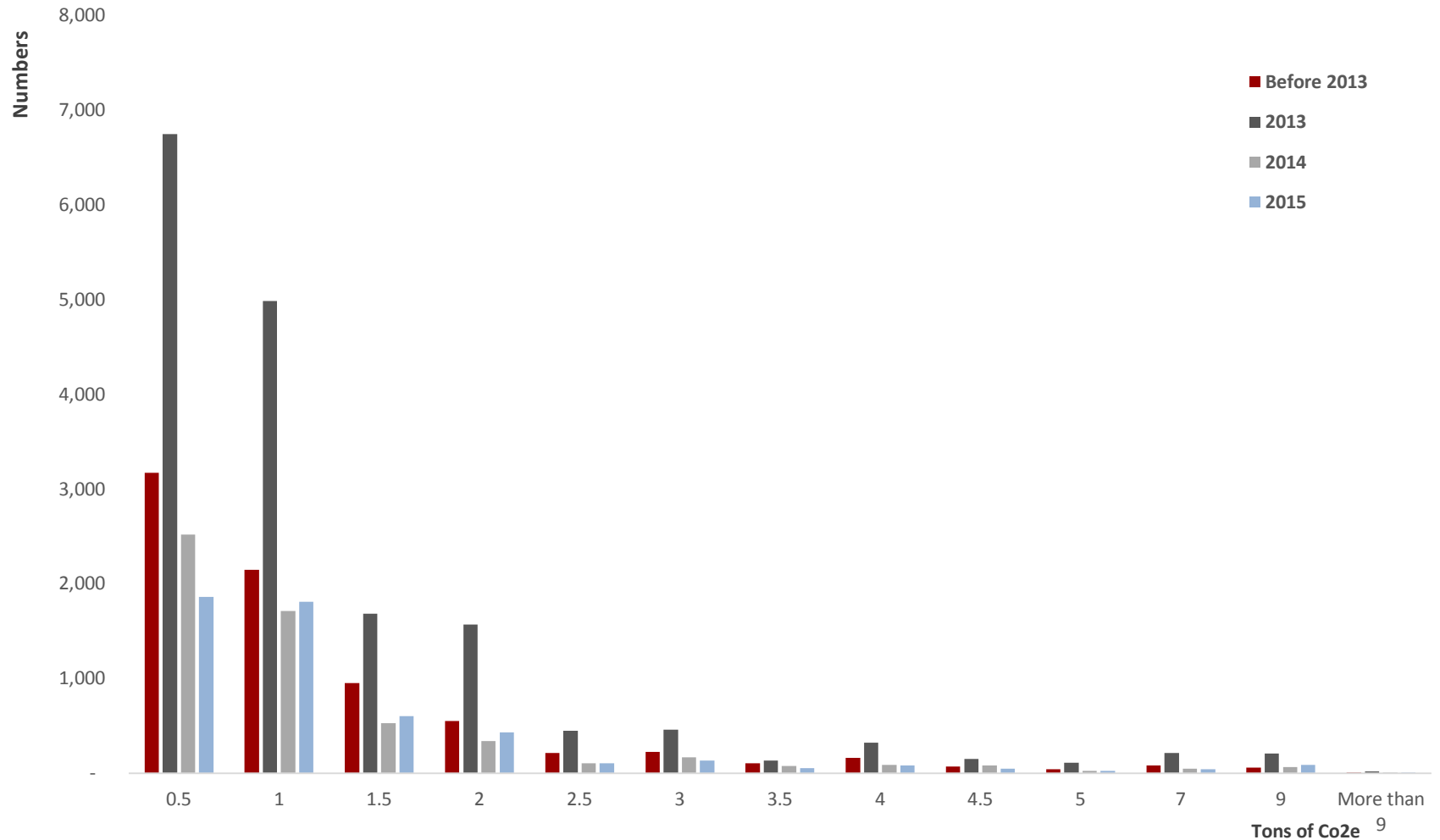
Destination Airports



UMass Air Travels Co2e emissions



UMass Air Travels Co2e emissions Distribution



UMass Air Travels Co2e emissions Table

CO2e	Before 2013	2013	2014	2015
0.5	3,170	6,749	2521	1,863
1	2,146	4,985	1,714	1,807
1.5	949	1,682	529	604
2	549	1,569	341	427
2.5	210	446	101	106
3	223	460	164	131
3.5	104	131	77	52
4	163	322	87	83
4.5	71	148	81	45
5	43	108	26	24
7	78	211	44	38
9	58	204	65	84
More than 9	7	19	3	5

UMass Air Travels Co2e emissions (FY 12-15)

FY	CO2e	Total Numbers	MEAN CO2e	MEDIAN CO2e	MIN CO2e	MAX CO2e
2011	57.10	16	3.56	2.02	0.089	7.434
2012	7903.11	7686	1.02	0.67	0.021	12.336
2013	18572.68	17033	1.09	0.67	0.029	12.336
2014	5781.74	5753	1.00	0.60	0.025	11.414
2015	5995.90	5270	1.06	0.67	0.025	11.414
Total	38310.55	35758	1.06	0.67	0.021	12.336

UMass Air Travels Co2e emissions (FY 12-15)

