Preliminary Characterization of Unmanned Air Cargo Routes Using Current Cargo Operations Survey

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- Cargo **Demand**, introduce **UAS** at airports to:
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  - Supplement cargo trucks
  - Alleviate pilot shortage
- UAS **Access**, for example:
  - Infrastructure to enable auto-land
  - Amount of VFR interactions

Methodology

Assess Cargo **Demand** **Access** for UAS

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- Identified airports at which cargo operations occur
- Aggregate flight data:
  - 07/20/21 – 02/17/22
  - Classified flights as cargo based on airline

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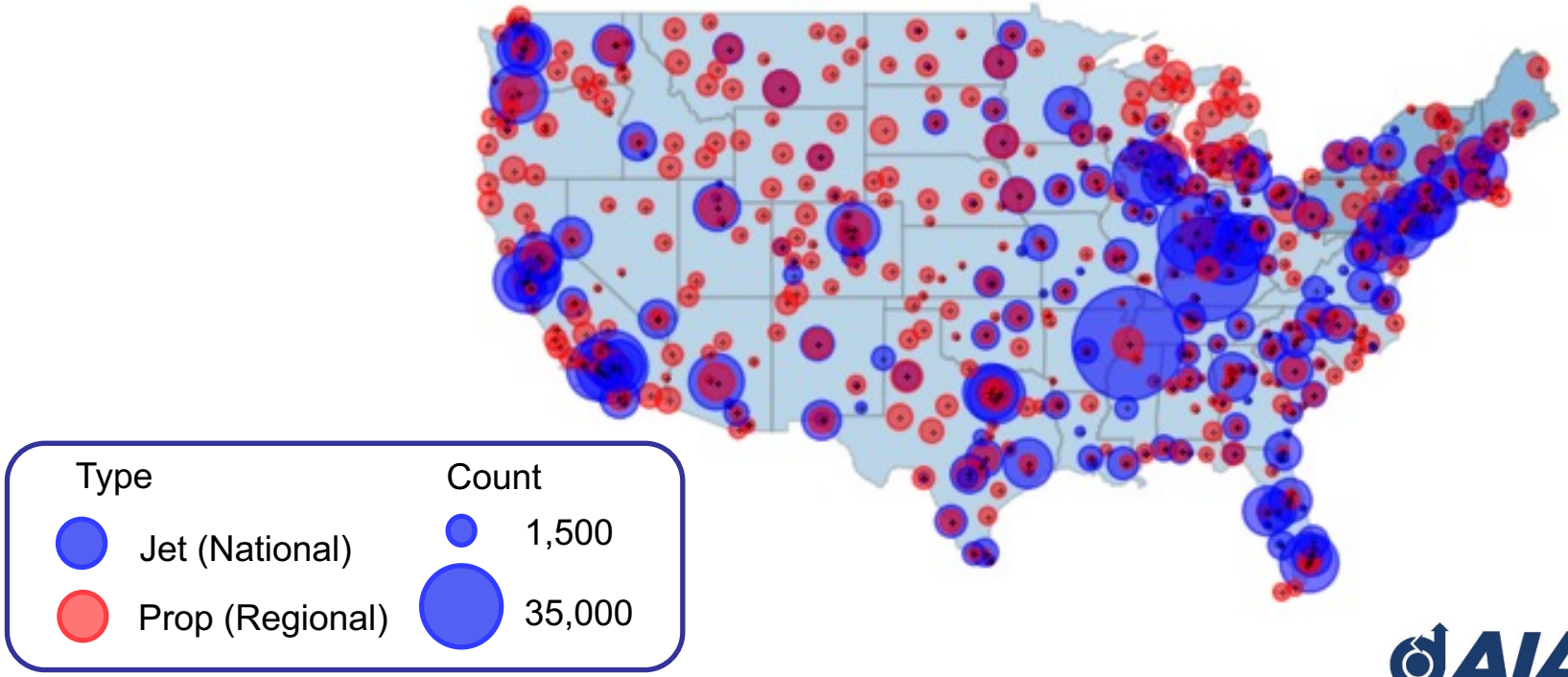
Access for UAS

- Identified availability of supporting technology and infrastructure
- Used FAA airport and runway data:
  - NASR
  - NPIAS
  - OPSNET

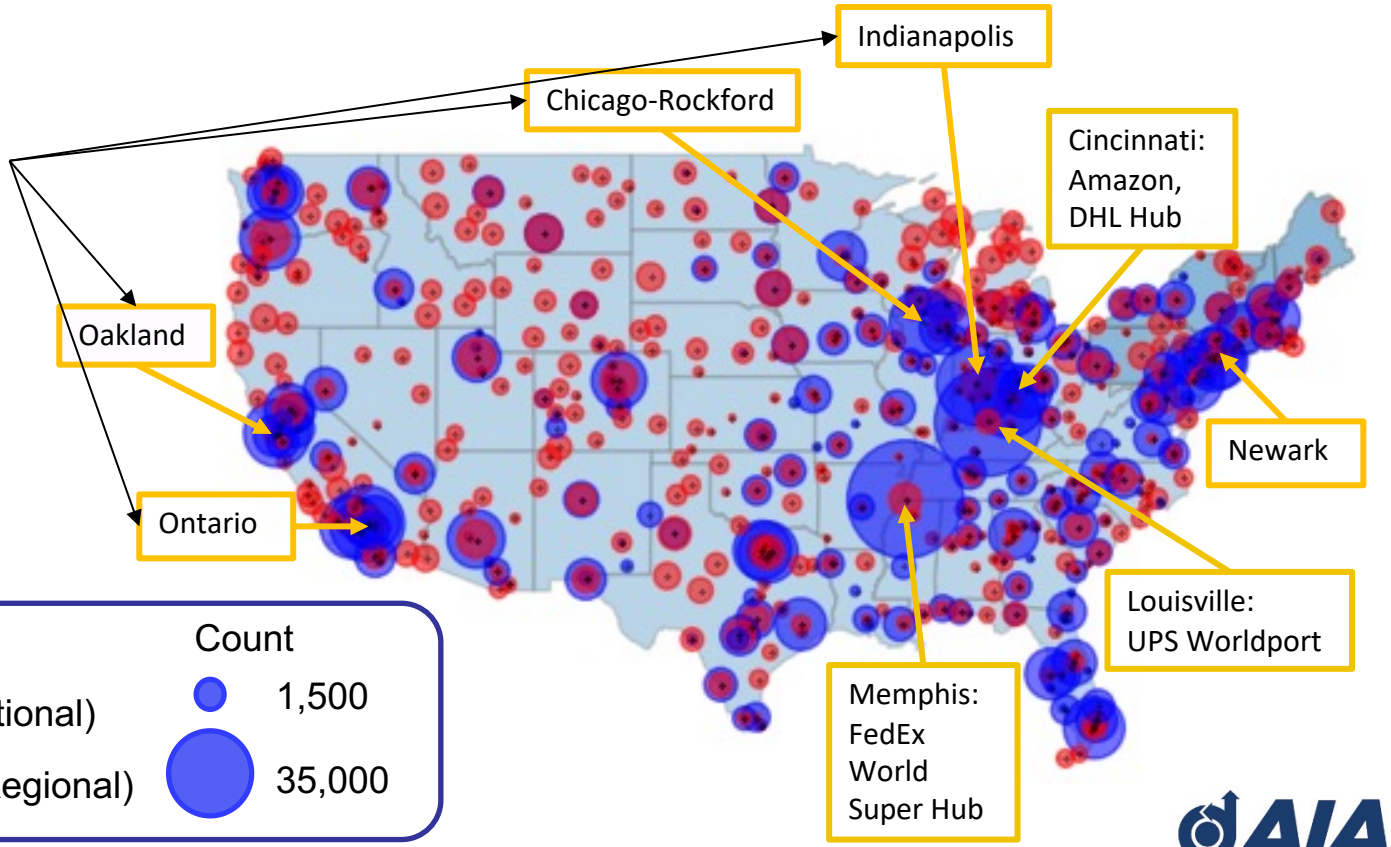
Demand

Distribution of Cargo Demand



Distribution of Jet Cargo Demand

Examples of national jet operations



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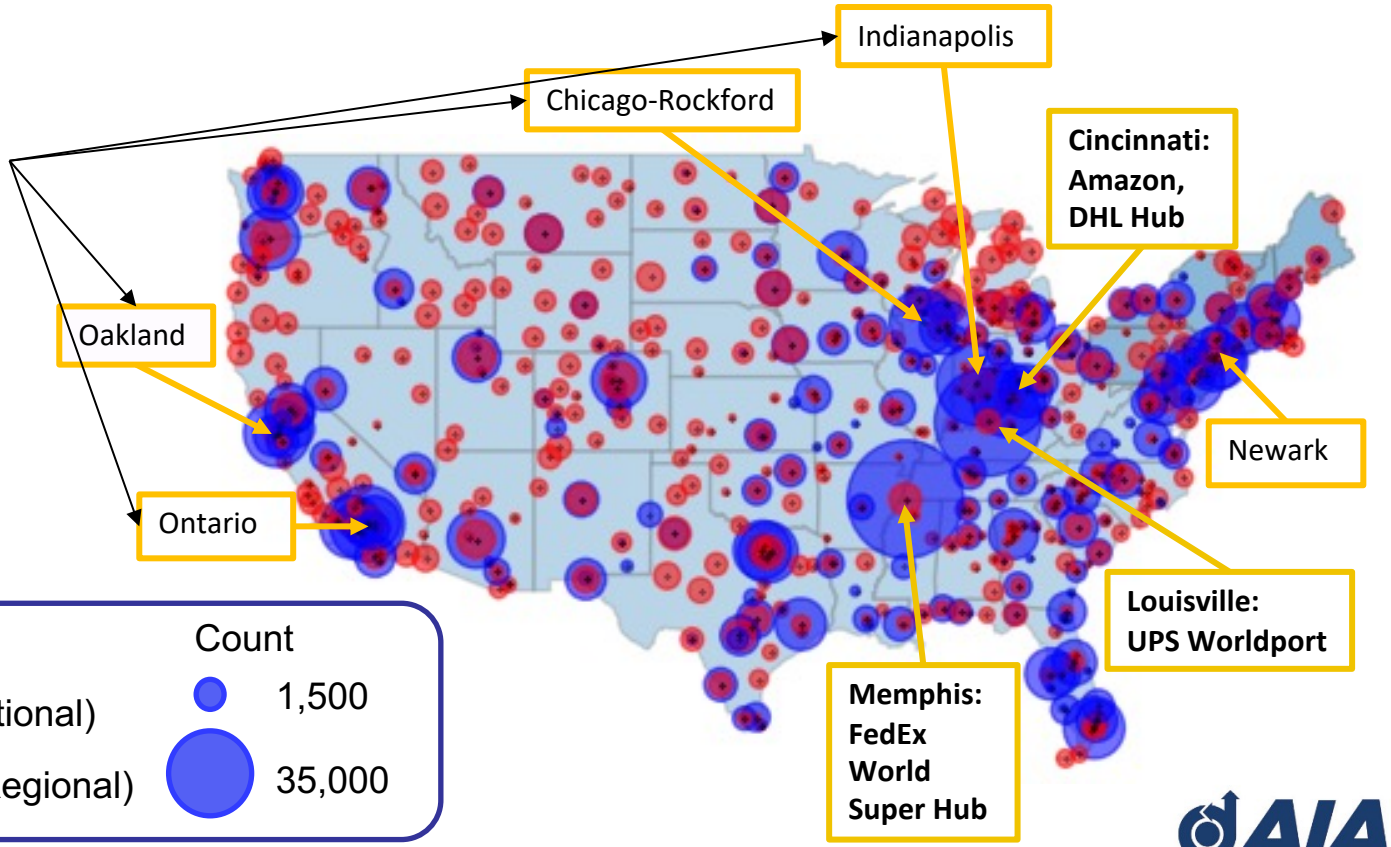
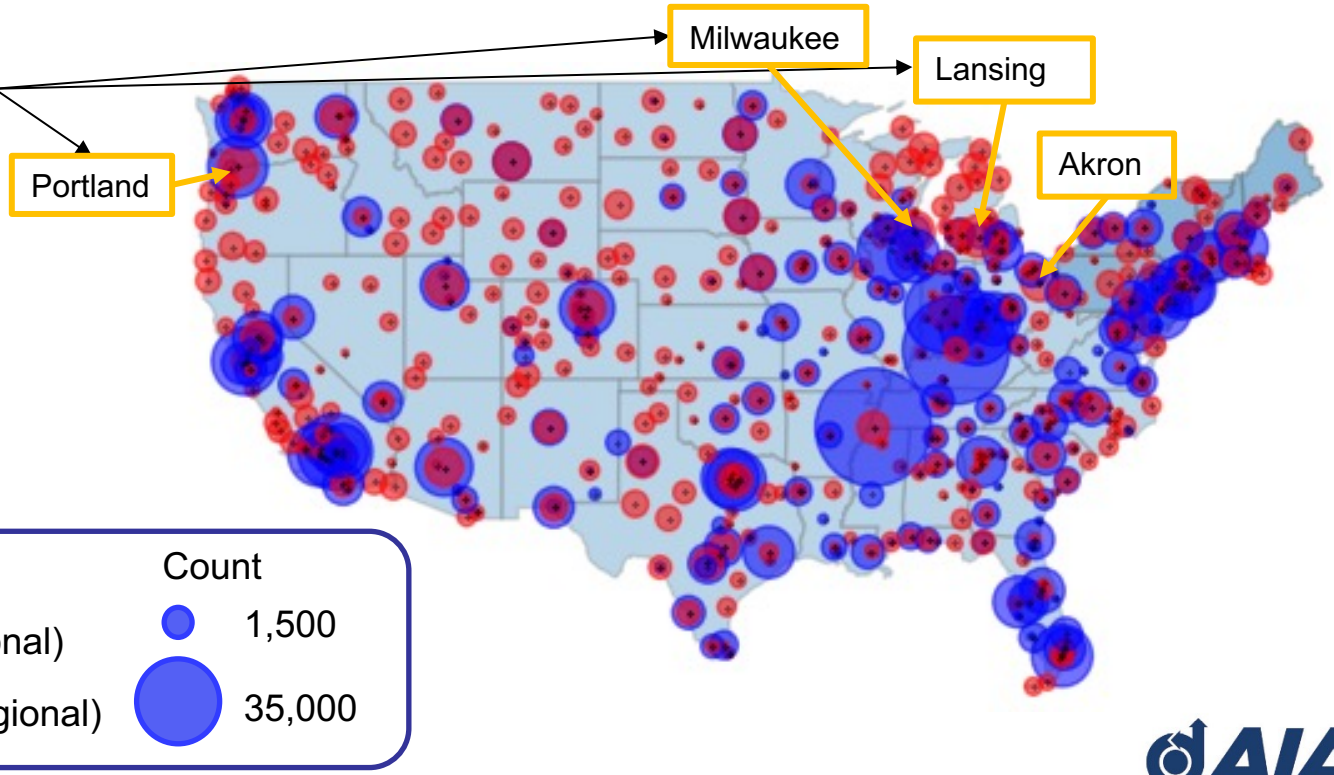


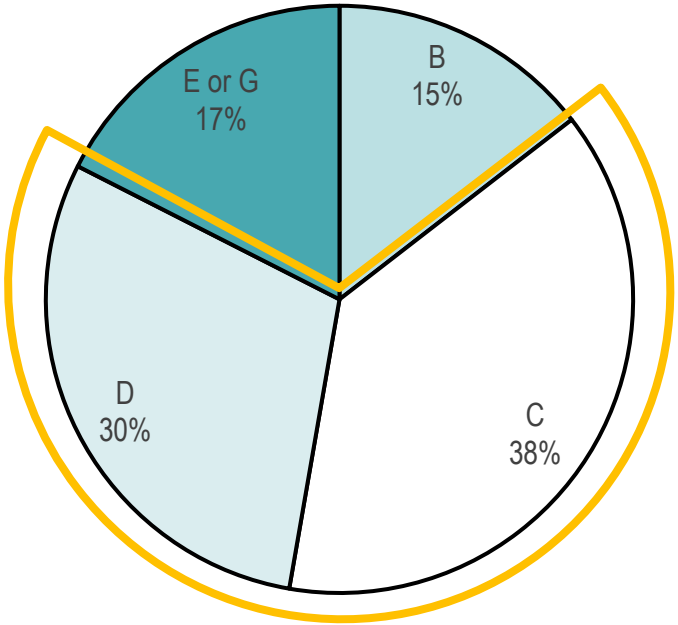
Distribution of Prop Cargo Demand

Examples of national prop operations



Percentage of Cargo Departures by Airport Class

Airport Airspace Class



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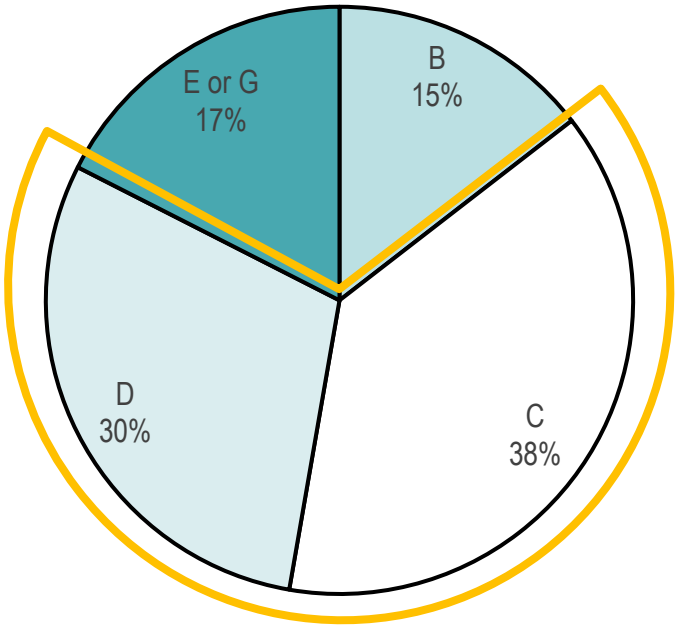
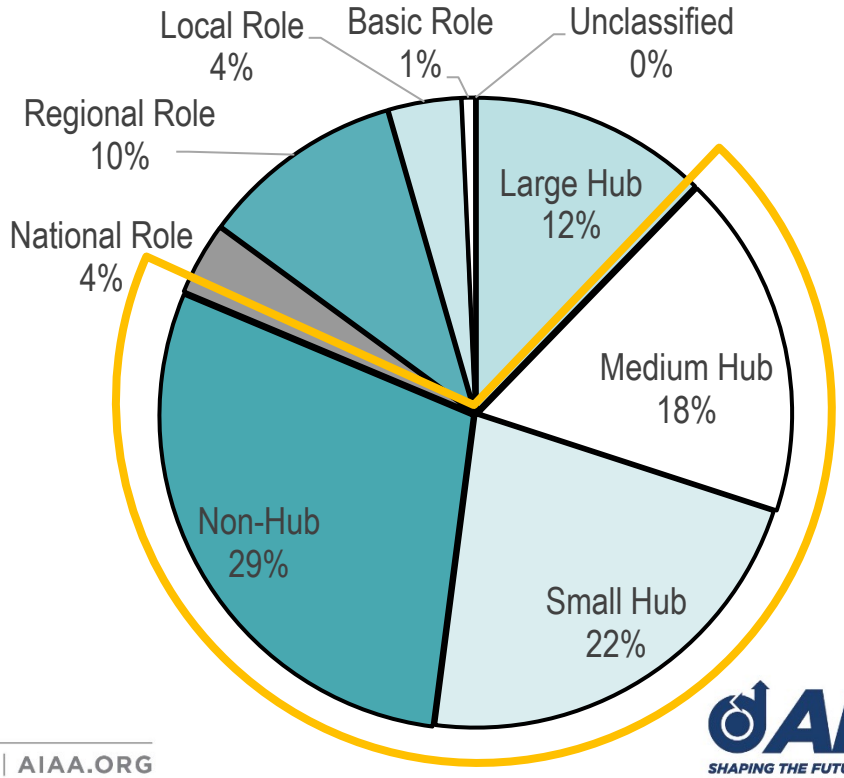


FAA NPIAS Airport Classification

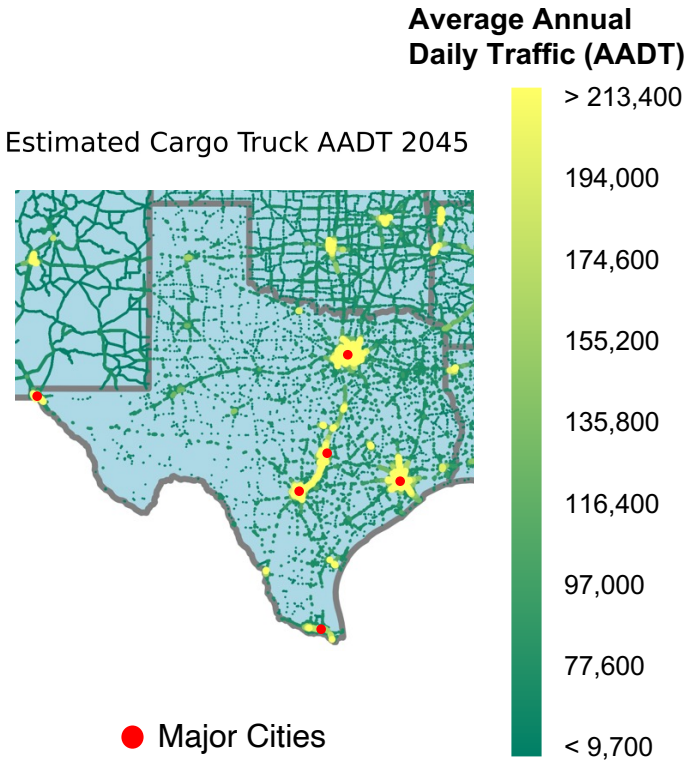


Example In-Depth Analysis: Texas

Why Texas?

State is a representative sample of multi-modal cargo operations:

- Several major metropolitan areas
- Vast rural areas
- Eight of the Top 75 cargo airports
- Highways (heavy levels of cargo truck traffic)



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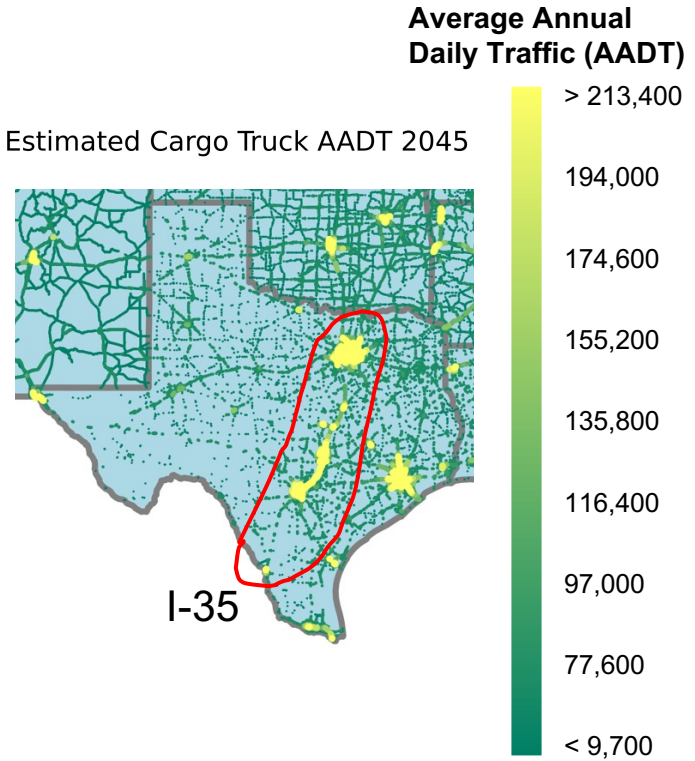
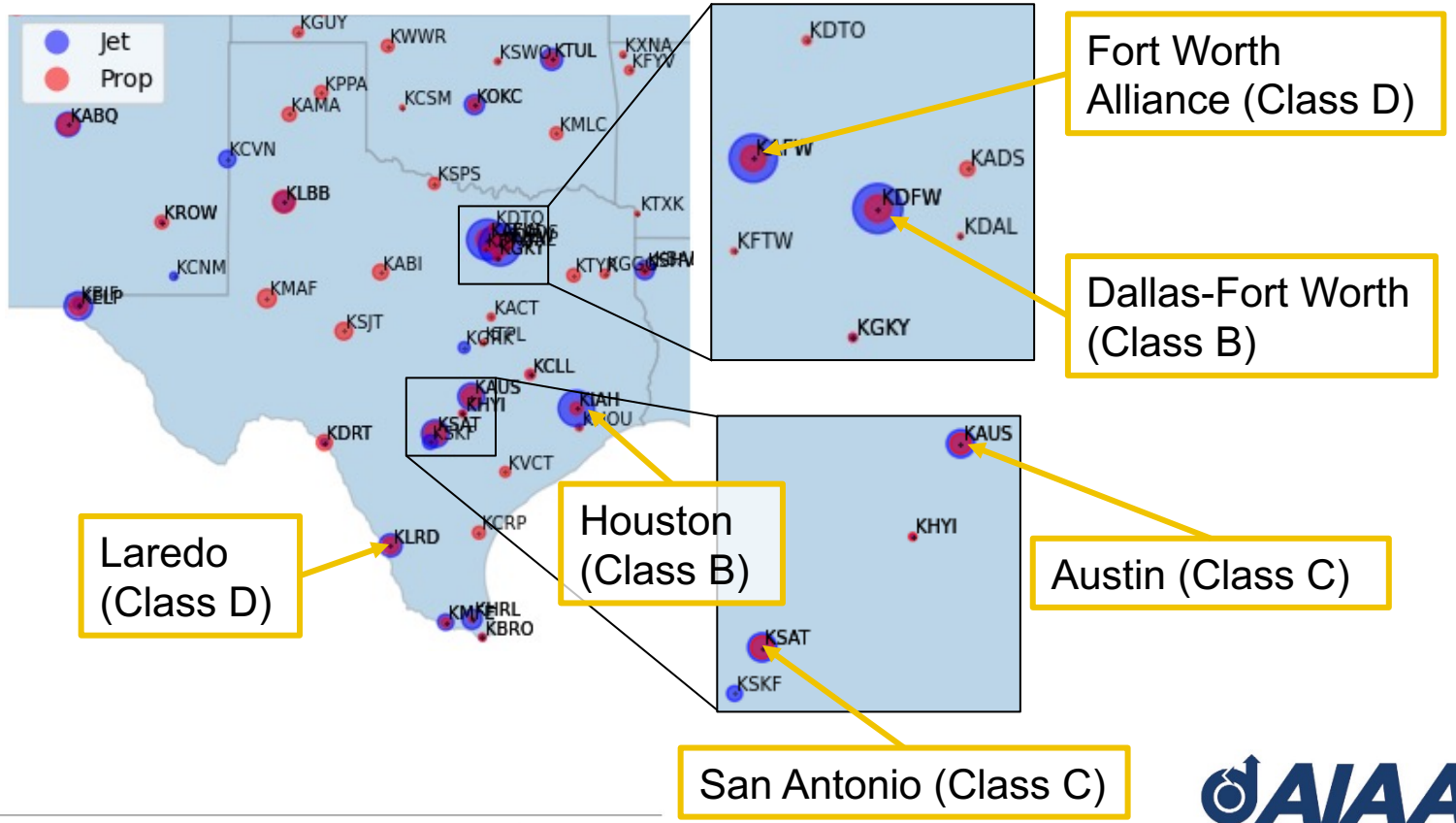


Demand in Texas

Texas: Distribution of Jet Cargo Demand



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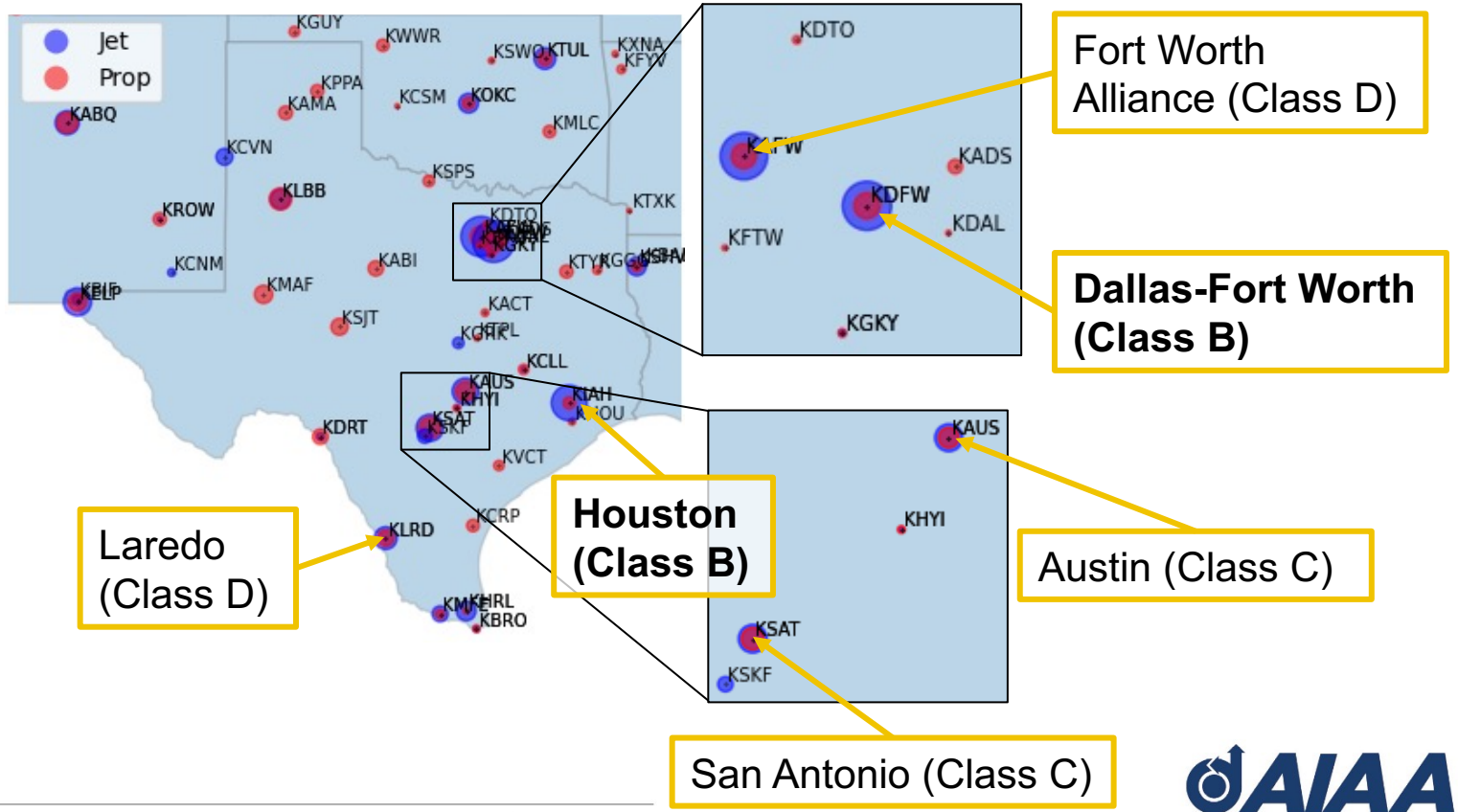

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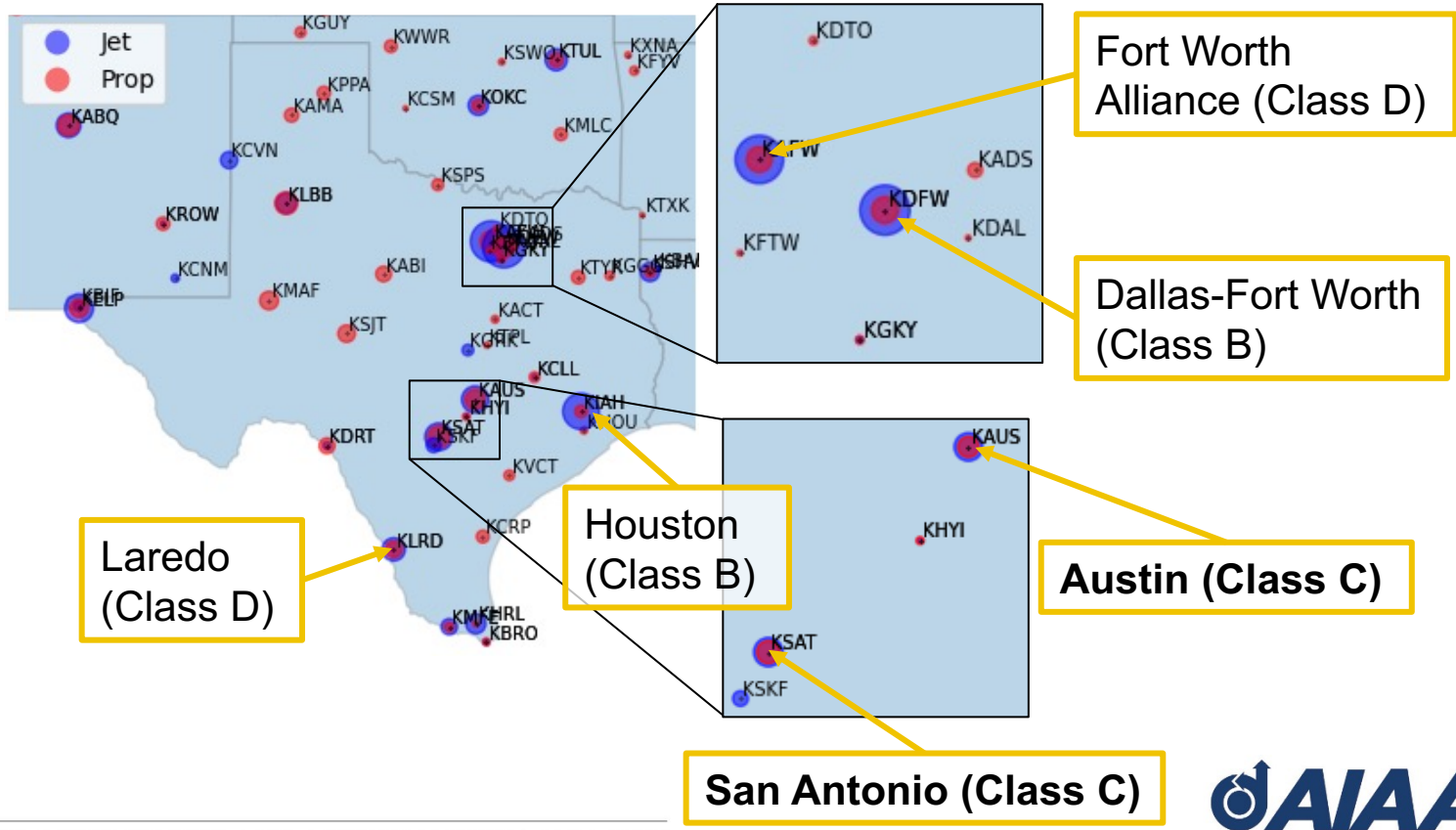

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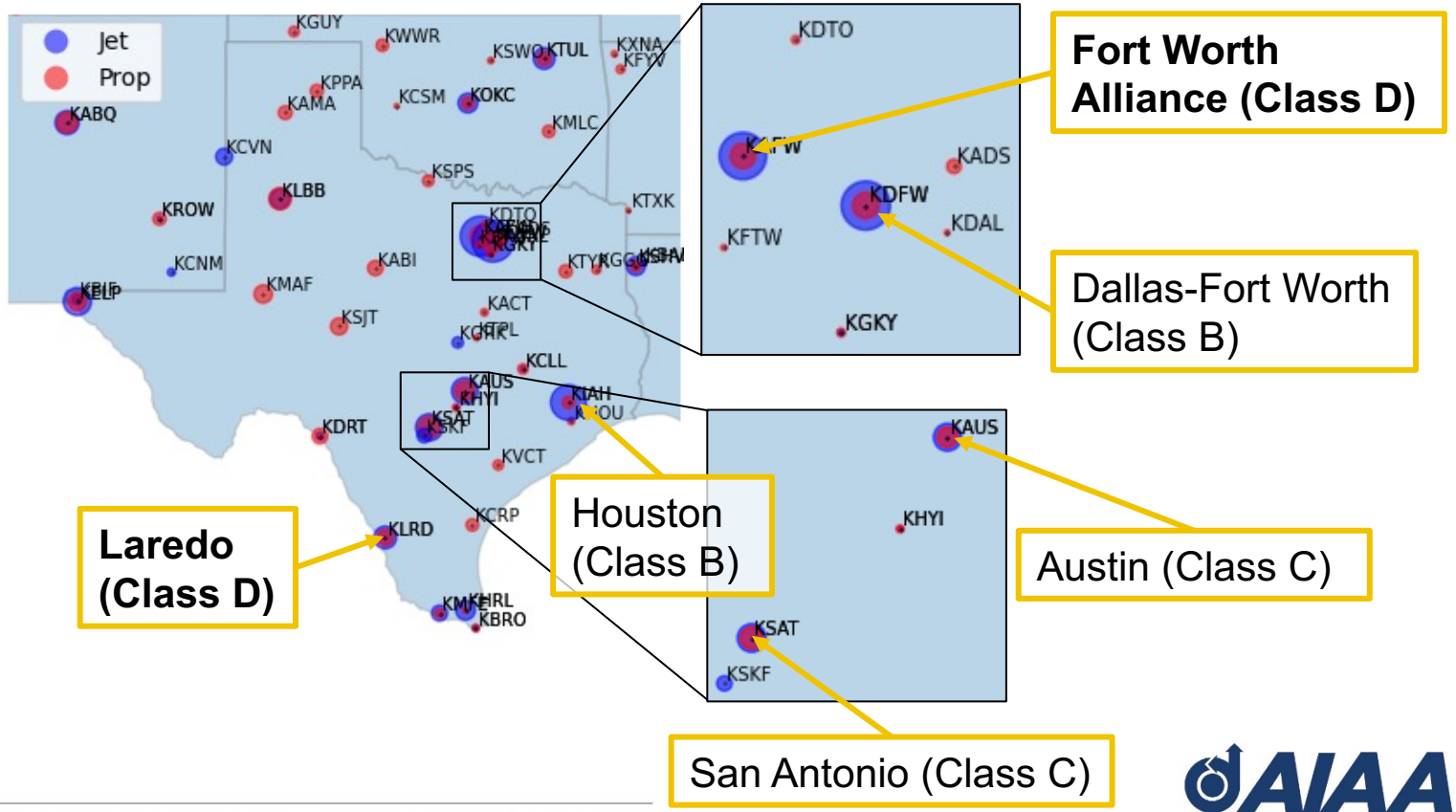
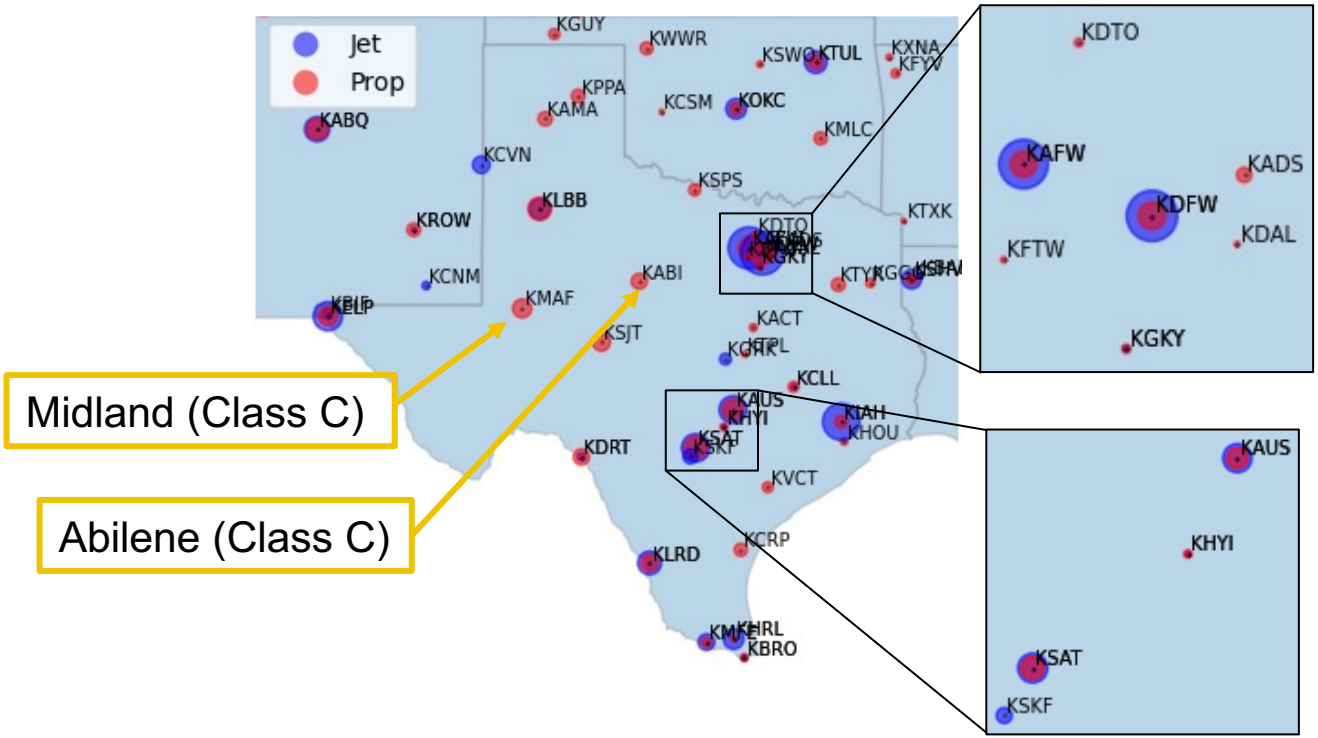


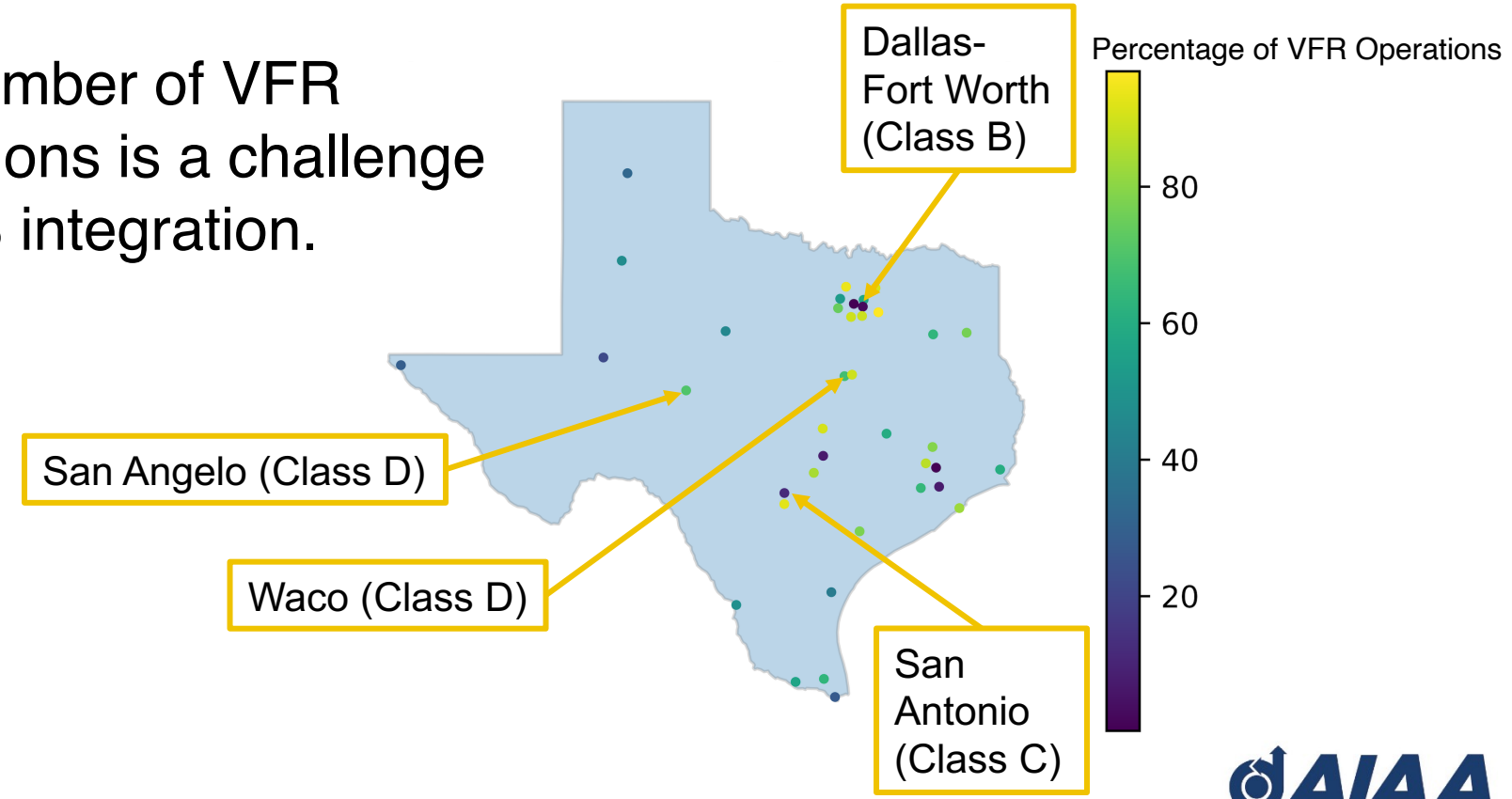
Texas: Distribution of Prop Cargo Demand



Access in Texas

Texas: VFR Percentage of Operations

High number of VFR interactions is a challenge for UAS integration.



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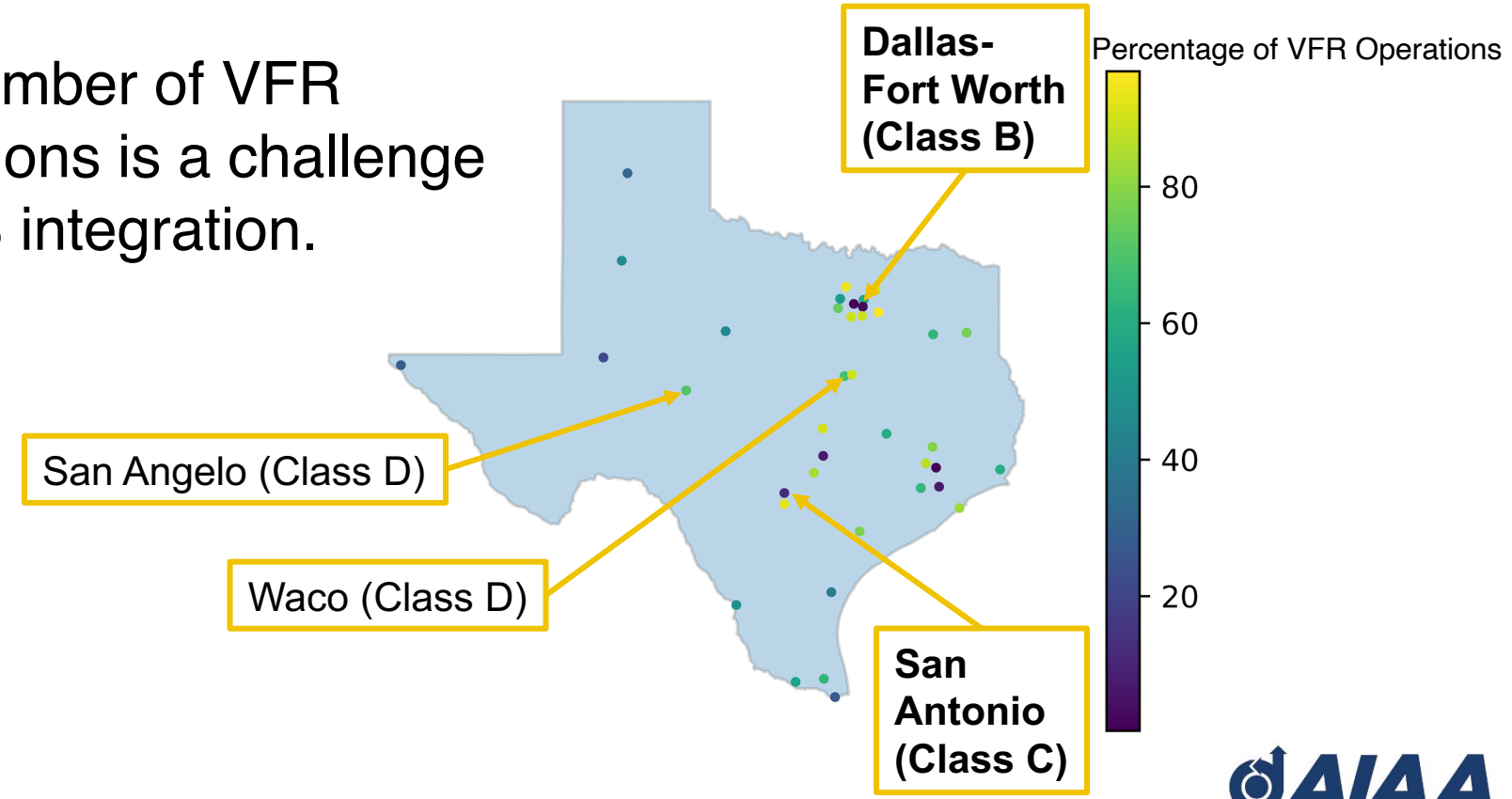

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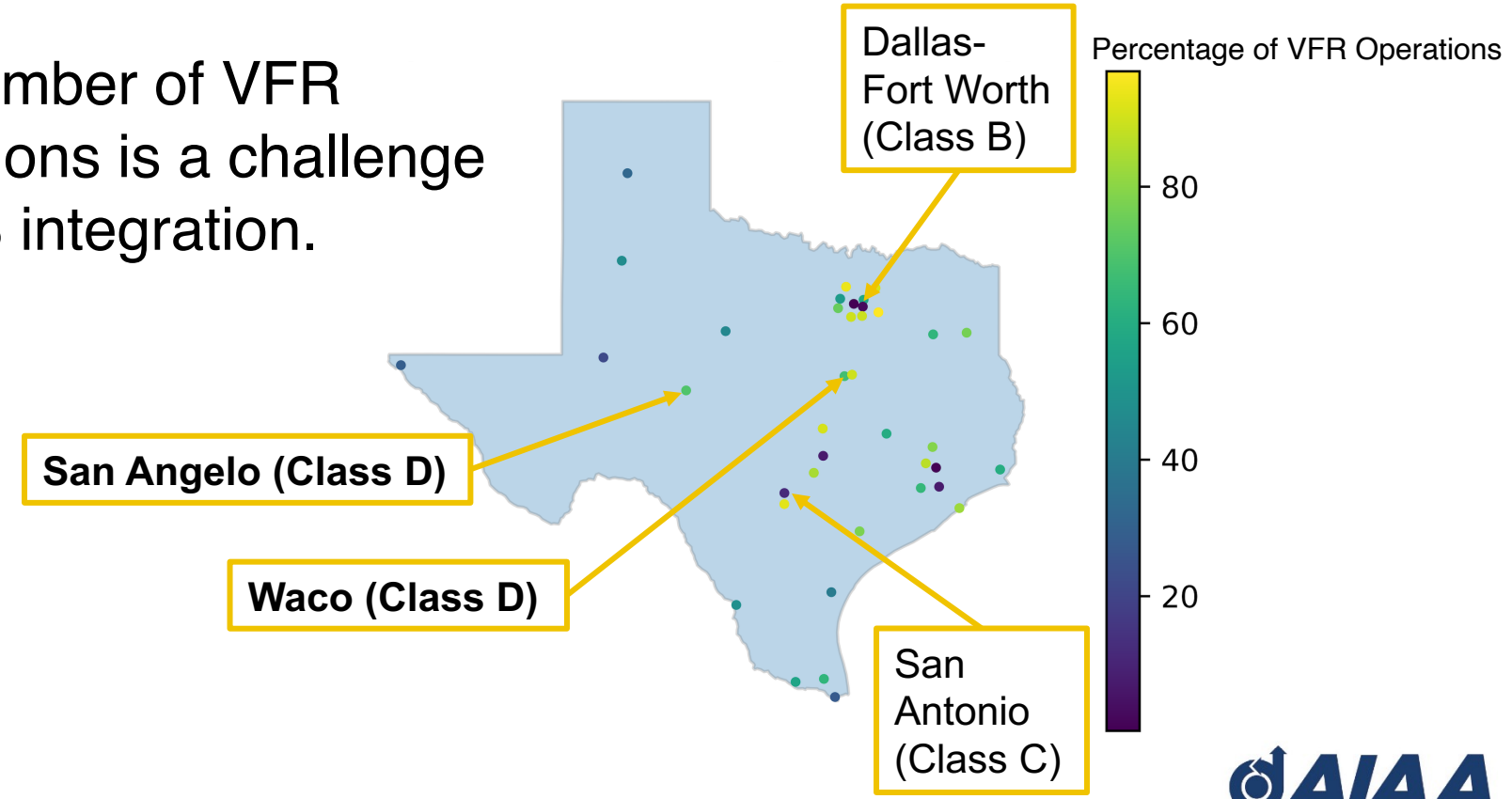
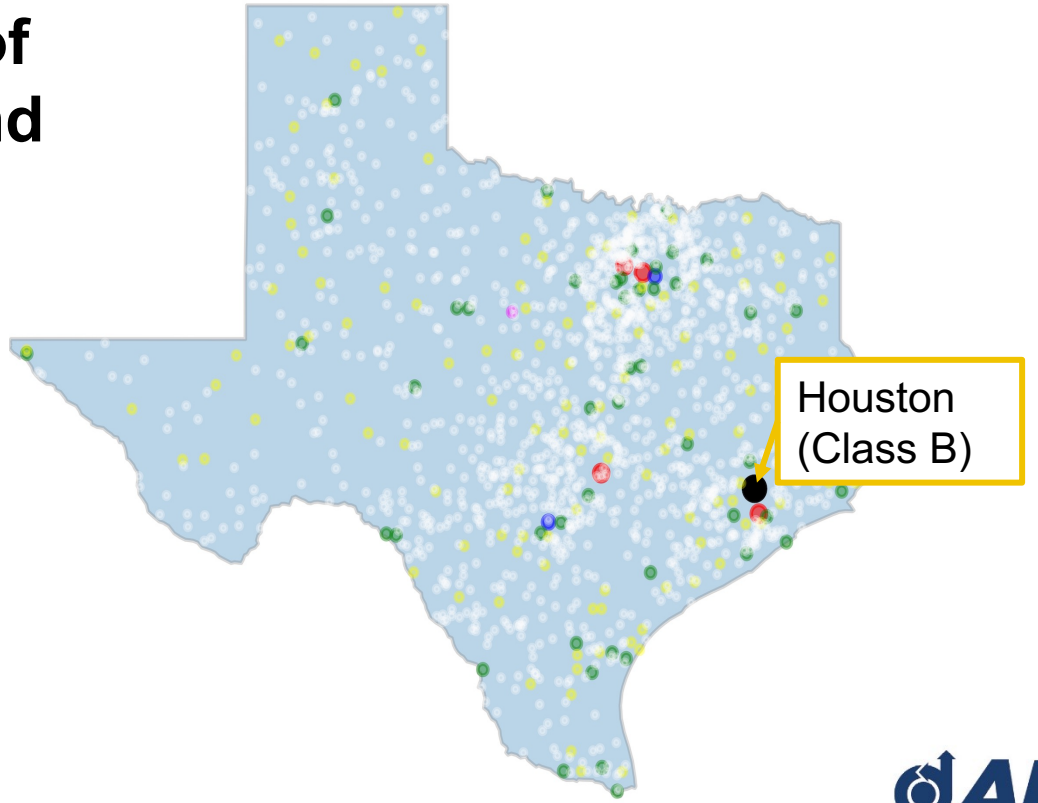


Texas: Instrument Approach Procedures

IAPs by probability of use for UAS auto-land

- CAT I GLS
- CAT III ILS
- CAT II ILS
- CAT I ILS
- RNAV RNP
- RNAV GPS
- non-precision



Preliminary Cargo Airports Classification

Preliminary Cargo-Focused Airports Classification

Airport Classification	Aircraft Type	Airspace Class	ILS CAT II-III*	Operating Environment	Example Airports
Major Cargo Hub	Heavy Jet	B, C	Yes	Low VFR %	Memphis, Louisville, Cincinnati, Indianapolis, Newark
Other Cargo Hub	Heavy Jet, Prop	C, D	Some	Mixed VFR %	Fort Worth Alliance, Ontario, Rickenbacker
Medium/Small Commercial	Mixed Jet, Prop	B, C	Some	Medium VFR %	Akron, San Antonio, Lubbock, Providence
Regional	Light Jet, Prop	D, E, G	No	High VFR %	San Angelo, Roswell, Bakersfield, Visalia

Conclusions and Future Work

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- These airports present **accessibility** challenges, for example:
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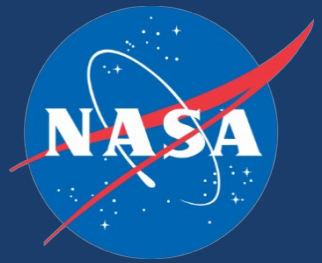
- **Future work**:
  - Quantitative cargo airport classifications using detailed traffic data to identify airspace metrics, such as throughput and VFR mix
  - Assessments of additional regions to support trade studies



For more details, please see the paper,

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Thank you for your attention.

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Backup Slides

Cargo airlines included in the analyses

ICAO Code	Airline
ATN	Air Transport International
ABX	Airborne Express
AIP	Alpine Air Express
AMF	Ameriflight
GTI	Atlas Air
BVN	Baron Aviation Services
CJT	Cargojet Airways
CSJ	Castle Aviation
CPT	Corporate Air
IRO, CSA	CSA Air, Inc.
CFS	Empire Airlines
FDX	FedEx Express
FRG	Freight Runners Express

ICAO Code	Airline
TSU	Gulf & Caribbean Cargo / Contract Air Cargo
IFL	IFL Group
LYM	Key Lime Air
MRA	Martinaire
MEI	Merlin Airways
MAL	Morningstar Air Express
MTN	Mountain Air Cargo
MBI	Mountain Bird
PAC	Polar Air Cargo
UPS	United Parcel Service
PCM	Westair Industries
WIG	Wiggins Airways

Airports by total number of cargo departures

ICAO ID	Total Cargo Departures	Total Departures	% Cargo	Class of Airspace	Airport Name	NPIAS Type
KMEM	121,188	164,494	76.67	B	MEMPHIS INTL	Medium
KSDF	91,112	135,476	67.25	C	LOUISVILLE MUHAMMAD ALI INTL	Small
KIND	38,998	129,676	30.07	C	INDIANAPOLIS INTL	Medium
KONT	29,704	61,205	48.53	C	ONTARIO INTL	Medium
KCVG	25,915	102,534	25.27	B	CINCINNATI/ NORTHERN KENTUCKY INTL	Medium
KOAK	19,326	86,133	22.44	C	METRO OAKLAND INTL	Medium
KRFD	18,165	23,340	77.83	D	CHICAGO/ROCKFORD INTL	Non-Hub
KEWR	16,345	301,574	5.42	B	NEWARK LIBERTY INTL	Large
KPDX	16,256	112,423	14.46	C	PORTLAND INTL	Medium
KLAX	15,294	406,289	3.76	B	LOS ANGELES INTL	Large

ICAO ID	Total Cargo Departures	Total Departures	% Cargo	Class of Airspace	Airport Name	NPIAS Type
KPHL	15,158	224,251	6.76	B	PHILADELPHIA INTL	Large
KDFW	14,734	474,252	3.11	B	DALLAS-FORT WORTH INTL	Large
KMIA	14,287	276,740	5.16	B	MIAMI INTL	Large
KPHX	14,010	283,518	4.94	B	PHOENIX SKY HARBOR INTL	Large
KAFW	13,047	28,177	46.30	D	FORT WORTH ALLIANCE	National
KDEN	12,348	443,006	2.79	B	DENVER INTL	Large
KSEA	10,716	265,669	4.03	B	SEATTLE-TACOMA INTL	Large
KBWI	10,556	151,893	6.95	B	BALTIMORE/ WASHINGTON INTL THURGOOD MARSHALL	Large
KSLC	8,876	211,560	4.20	B	SALT LAKE CITY INTL	Large
KJFK	8,765	312,259	2.81	B	JOHN F KENNEDY INTL	Large

Airports by number of prop cargo departures

ICAO ID	Prop Cargo	Total Cargo	Total	Prop Cargo %	Total Cargo %	Airspace Class	Airport Name	NPIAS Type
KMKE	3,893	5,548	62,535	70.17	8.87	C	GENERAL MITCHELL INTL	Medium
KLAN	3,821	4,389	10,655	87.06	41.19	C	CAPITAL REGION INTL	Non-Hub
KPDX	3,109	16,256	112,346	19.13	14.47	C	PORTLAND INTL	Medium
KCAK	2,740	2,747	20,772	99.75	13.22	C	AKRON-CANTON RGNL	Non-Hub
KPHX	2,650	14,010	283,450	18.92	4.94	B	PHOENIX SKY HARBOR INTL	Large
KSLC	2,599	8,876	211,505	29.28	4.20	B	SALT LAKE CITY INTL	Large
KDEN	2,500	12,348	442,990	20.25	2.79	B	DENVER INTL	Large
KBIL	2,475	5,052	18,447	48.99	27.39	C	BILLINGS LOGAN INTL	Small
KONT	2,255	29,704	61,204	7.59	48.53	C	ONTARIO INTL	Medium
KFSD	2,056	3,861	25,351	53.25	15.23	D	JOE FOSS FLD	Small
KIND	1,824	38,998	129,669	4.68	30.08	C	INDIANAPOLIS INTL	Medium
KEWR	1,791	16,345	301,569	10.96	5.42	B	NEWARK LIBERTY INTL	Large
KLBB	1,630	2,697	18,534	60.44	14.55	C	LUBBOCK PRESTON SMITH INTL	Small
KOMA	1,628	3,934	51,602	41.38	7.62	C	EPPLEY AIRFIELD	Medium
KGEG	1,576	5,660	30,604	27.84	18.49	C	SPOKANE INTL	Small
KDFW	1,570	14,734	474,224	10.66	3.11	B	DALLAS-FORT WORTH INTL	Large
KMEM	1,544	121,188	164,486	1.27	73.68	B	MEMPHIS INTL	Medium
KFAR	1,541	3,404	18,045	45.27	18.86	D	HECTOR INTL	Small
KSMF	1,490	8,505	73,791	17.52	11.53	C	SACRAMENTO INTL	Medium
KAFW	1,373	13,047	28,152	10.52	46.34	D	FORT WORTH ALLIANCE	National

Airports by percentage of cargo departures relative to total departures

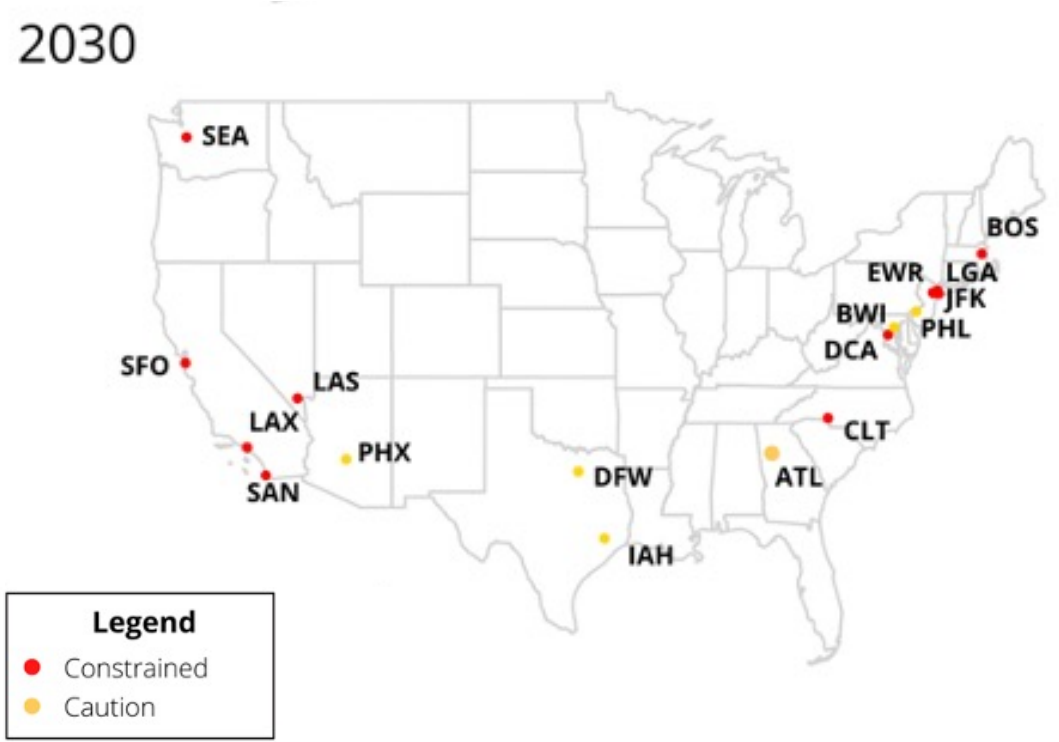
ICAO ID	Total Cargo Departures	Total Departures	% Cargo	Class of Airspace	Airport Name	NPIAS Type
KILN	8,243	9,463	87.11	D	WILMINGTON AIR PARK	N/A
KSBD	8,361	10,081	82.94	D	SAN BERNARDINO INTL	National
KRFD	18,165	23,340	77.83	D	CHICAGO/ROCKFORD INTL	Non-Hub
KMEM	121,188	164,494	73.67	B	MEMPHIS INTL	Medium
KSDF	91,112	135,476	67.25	C	LOUISVILLE MUHAMMAD ALI INTL	Small
KTVF	1,204	1,837	65.54	E	THIEF RIVER FALLS RGNL	Local
KIAB	66	101	65.35	D	MCCONNELL AFB	N/A
KCTB	125	223	56.05	E	CUT BANK INTL	Local
KAIA	345	672	51.34	E	ALLIANCE MUNI	Local
KONT	29,704	61,205	48.53	C	ONTARIO INTL	Medium
KPUC	144	309	46.60	E	CARBON COUNTY RGNL/BUCK DAVIS FLD	Basic
KAFW	13,047	28,177	46.30	D	FORT WORTH ALLIANCE	National
KIYK	213	472	45.13	E	INYOKERN	Basic
KMLC	223	502	44.42	E	MC ALESTER RGNL	Regional
KLDM	366	851	43.01	E	MASON COUNTY	Local
KATY	738	1,719	42.93	E	WATERTOWN RGNL	Regional
KESC	695	1,659	41.89	E	DELTA COUNTY	Regional
KSCK	2,474	5,948	41.59	D	STOCKTON METRO	Non-Hub
KLAN	4,391	10,696	41.05	C	CAPITAL REGION INTL	Non-Hub
KSUU	189	472	40.04	D	TRAVIS AFB	N/A

Median values by NPIAS classification

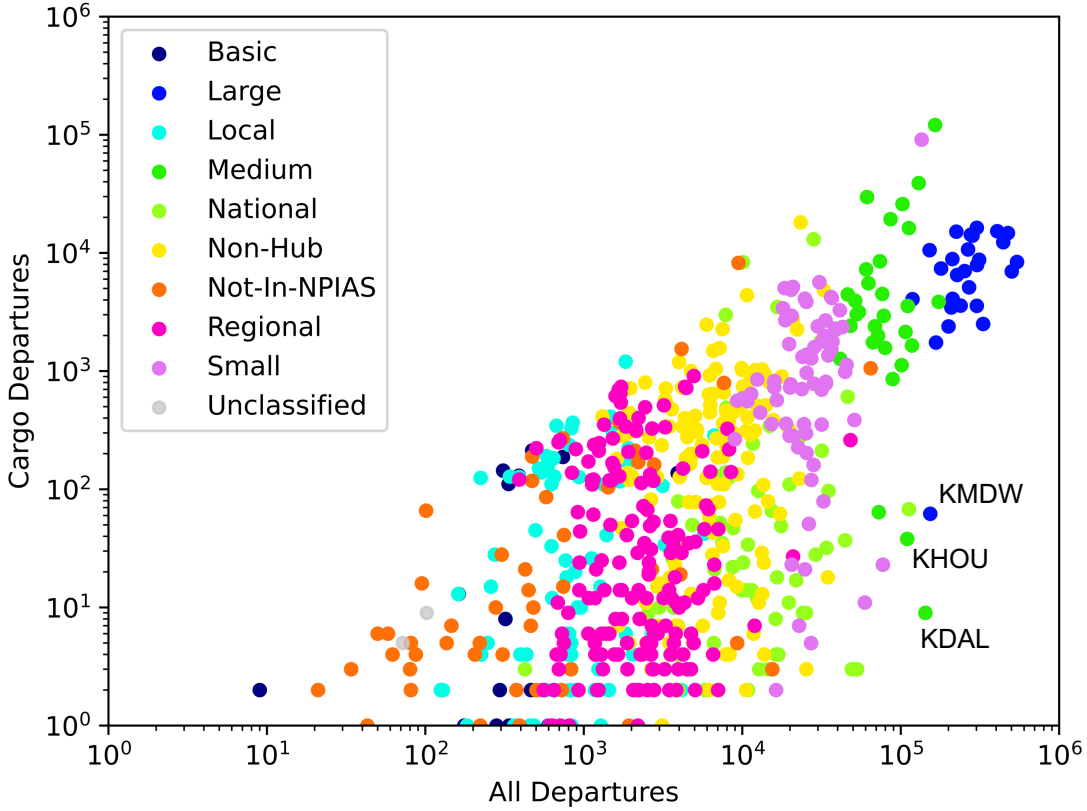
NPIAS Type	Airports	Cargo Departures	All Departures	% Cargo Departures
Large Hub	27	7,387.00	265,669.00	2.79
Medium Hub	30	3,094.00	77,282.50	4.40
Small Hub	70	798.00	25,337.00	4.05
Non-Hub	141	239.00	6,541.00	3.92
National	64	25.00	11,167.00	0.28
Regional	167	18.00	2,217.00	0.78
Local	178	12.50	812.50	1.36
Basic	17	8.00	337.00	2.50
Unclassified	2	7.00	87.00	7.88

Estimated Future Cargo Demand

- Air:
  - Increasing number of capacity-constrained airports
  - Shift to regional airports could help alleviate traffic
- Ground:
  - 2012 downtown traffic levels expected across the country by 2045



Cargo Departures vs All Departures



Airports with High Levels of Cargo