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The Future of the Electric Take-Off and Landing Industry

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The Future of the Electric Vertical Take-Off and Landing Industry

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Abstract

An analysis was done to find the emerging location(s) for the electrical vertical takeoff and landing (eVTOL) industry. The VTOL and eVTOL industries are aiming to replace short private jet travel as helicopters will have the ability to cut out some of the driving. For instance, it can bring a client to the top of a skyscraper because heliports and vertiports can be positioned almost anywhere making them more accessible than private jets. Initially, a numerical analysis was done to see how the past could predict the future, which showed electric vehicle (eV) charging stations have been exponentially rising while heliports have been declining. This was used in the analysis when choosing the criteria to analyze. It was determined that the final recommendation for the emerging location of the eVTOL industry would use the following: 25% Flexjet data, 25% eV charging stations, 25% population density, and 25% median household income. The Flexjet flight data reflected the busiest airports for flights 30 minutes or less for departures and arrivals. The eV charging station data showed which states have the largest number of charging stations at parking lots or garages, since they can be converted to vertiports in the future. The population density and median household income showed the top 10 cities in the US for each, respectively. This led to a final score given for every state and showed New York would be the emerging location for the eVTOL industry based on the data and scoring. This led to recommendations given to OneSky for New York.

Introduction

A. Statement of Purpose

The purpose of this report is to give an introductory analysis for OneSky on the future of the electrical vertical take-off and landing (eVTOL) industry as part of a summer research project funded by the National Science Foundation (NSF).

B. Scope of the Problem

OneSky wants an analysis on where emerging locations in the United States of America (USA) could be for the eVTOL industry. This analysis will use previous private jet flight records provided by OneSky and data from any websites that may be of use for this analysis. There are no restrictions on the cities recommended for the eVTOL emerging locations, but they will be narrowed down to at least one emerging city after an analysis is completed. The final recommendations will use the following percentages from the data analysis to come to a result for the emerging locations in USA: 25% Flexjet data, 25% electric charging (eV) stations, 25% population density, and 25% median household income.

C. Background

OneSky is a company that supplies technological support to private aviation companies, such as support to their websites, research, and financial departments, that are comprised and known as Kenn Ricci's Directional Aviation Group. The companies comprising Directional Aviation Group own either private jets or vertical take-off and landings (VTOLs), but OneSky does not own either. One of the companies in Directional Aviation is AAG Heli. They already own VTOLs and heliports located in the northeastern USA, but no eVTOLs yet, so this is important to keep in mind during the recommendations.

To help predict how vertiport growth may occur, two things were analyzed: eV stations, and

heliport growth in the past. First, for eV station growth, shown in Figure 1, there has been an exponential increase in recent years. Heliports on the other hand have been declining in most states, as seen in Table 1. The reason for eV stations' massive growth could partly be the government's support (U.S. Department of Transportation Federal Highway Administration), while heliports have not had the same support. In places such as New York City, citizens have proposed laws on locations on where VTOLs can fly and also where heliports can be located because of the loud noise that VTOLs can produce when flying (Tremayne-Pengelly). The takeaway is that OneSky should first pursue vertiports which are politically supported and in prime locations, such as next to a sports arena, concert hall, or just areas of interest of high-net-worth individuals.

State Name	USPS Abbreviation	1960	1973	1975	1977	1981	1984	Predicted 2020	Actual
Alabama	AL	2	11	27	55	75	75	167	48
Alaska	AK	1	38	71	57	74	49	183.4	14
Arizona	AZ	0	40	55	42	62	94	198.24	63
Arkansas	AR	0	10	12	4	5	10	25.5	42
California	CA	69	413	528	585	440	365	1305	62
Colorado	CO	4	41	69	73	94	109	252.4	50
Connecticut	CT	15	24	46	50	45	55	112.56	66
Delaware	DE	0	13	13	12	15	22	49.8	11
District of Colmbi	DC	2	12	24	23	23	22	63.32	11
Florida	FL	4	67	126	96	113	166	370.72	62
Georgia	GA	4	27	43	42	51	61	141.1	34
Hawaii	HI	0	1	18	19	28	18	57.36	13
Idaho	ID	1	19	28	26	27	23	76.42	25
Illinois	IL	107	120	171	181	335	250	481.34	59
Indiana	IN	14	28	40	28	63	74	129.68	36
Iowa	IA	1	9	11	13	32	48	79.96	47
Kansas	KS	0	12	17	12	20	25	57.708	7
Kentucky	KY	1	9	19	17	33	28	70.36	62
Louisiana	LA	22	59	108	104	123	145	312.76	65
Maine	ME	0	15	19	16	13	12	46.344	21
Maryland	MD	6	31	50	41	54	64	146.46	63
Massachusetts	MA	1	41	47	57	67	66	181.3	92
Michigan	MI	5	41	47	41	53	51	139.88	34
Minnesota	MN	3	18	13	14	21	19	48.66	23
Mississippi	MS	1	18	24	26	30	31	82.9	35
Missouri	MO	4	22	21	32	54	80	139.48	34
Montana	MT	0	26	25	16	15	15	58.62	24
Nebraska	NE	0	37	21	25	24	30	86.28	23
Nevada	NV	8	26	27	20	21	21	54.164	28
New Hampshire	NH	0	9	14	16	17	20	50.682	95
New Jersey	NJ	18	344	472	478	355	413	1268.28	97
New Mexico	NM	0	5	9	9	14	13	33.846	32
New York	NY	7	111	103	114	139	118	361.6	45
North Carolina	NC	0	14	29	23	44	43	104.58	34
North Dakota	ND	0	7	8	6	4	7	19.944	6
Ohio	OH	0	101	124	127	230	230	553.482	58
Oklahoma	OK	0	26	33	26	23	26	84.06	31
Oregon	OR	0	41	66	62	76	90	223.5	33
Pennsylvania	PA	17	126	109	203	233	262	594.92	61
Rhode Island	RI	1	2	11	12	12	5	24.892	10
South Carolina	SC	1	7	23	20	15	15	49.036	21
South Dakota	SD	0	5	7	5	9	6	20.754	32
Tennessee	TN	4	26	37	46	65	58	147.7	54
Texas	TX	14	122	185	205	258	370	750.8	84
Utah	UT	1	12	19	18	23	22	59.86	54
Vermont	VT	0	3	6	13	14	14	34.59	15
Virginia	VA	3	30	39	45	64	78	133.44	46
Washington	WA	3	58	106	98	116	112	280.92	46
West Virginia	WV	1	3	5	4	37	40	65.56	34
Wisconsin	WI	0	17	29	20	37	35	92.226	29
Wyoming	WY	1	7	9	9	12	15	32.8	25

Table 1: Number of heliports in the past years

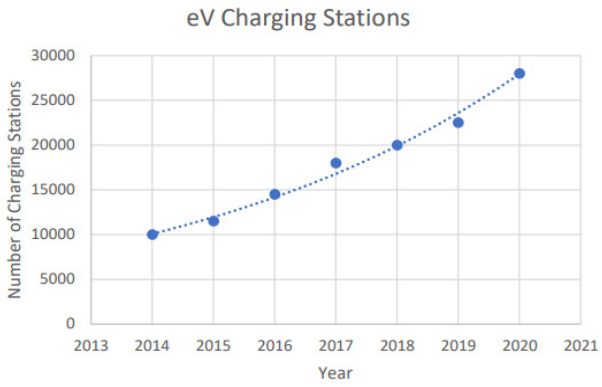

Figure 1: eV charging stations growth in the past years

D. Research Methodology

Data was provided by OneSky on Flexjet's flights from 2017-2021. The data was filtered to flights lasting 30 minutes or less, and to the most recent years of 2020-2021. This was used to make a map using ArcMap, and to find the busiest airports in the US for arrivals and departures using an Excel sheet to filter the numbers used in the final score for every state. Next, for eV charging station growth throughout the years, information was used from Shahan's article [6]. The data was put in Excel and graphed to add a trendline to predict how they might look in the next years. For analyzing the change of heliports throughout the years, the book written by the Aerospace Industries Association of America [1], was used. Data was used on a state-by-state basis to see change over the years. In Excel the data was graphed and the trendline was used to obtain a predicted number for heliports in 2020 that was then compared to the actual number of heliports in 2020. The website City-Data [2] was used to get all of the current heliports in the USA plotted on a map to give a visual on their location in U.S. using latitude and longitudes on ArcMap. The Department of Energy's website article [3] was used to make a map using ArcMap latitude and longitudes. Before plotting, the data was filtered to those listed as parking lots or garages in Excel. Afterwards, it was filtered into states so a total number of eV stations could be found for every state to be used to find the states' final scores. In Heacock's article [5], the population density was analyzed, and the top 10 most densely populated cities were put into a table in Excel to

be used when calculating the states' finalscores. In Duffin's article [4], the median household income was analyzed, and the top 10 median household income cities were put into a table in Excel to be used when calculating the states' final scores. Lastly, the background of the U.S. Department of Transportation Federal Highway Administration's article [8] was used to support the claim on politics and eV charging stations, while Tremayne-Pengelly's article [7] was to support the claim of how VTOLs have been getting backlash from their loud noise.

Data Analysis

A. Data Acquisition

When finding the emerging locations for the eVTOL industry, several topics of interest were analyzed: private jet flight data, eV stations, population density, and median household income. During 2017-2021, there were approximately 37,000 flights. The flights were then narrowed down to private jet flights only thirty minutes or less. A visual of the flights thirty minutes or less can be seen in Figure 2.

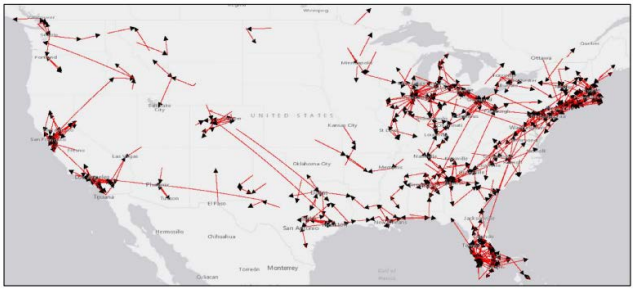

Figure 2: Flights thirty minutes or less

After analyzing the figure, it appears that there are locations of interest that could be where eVTOLs emerge. The Flexjet flights were narrowed down to only 2020-2021 to look at the most recent flight travel to analyze where the busiest airports are located for flights thirty minutes or less. Table 2 shows all the flights' travel patterns to show how Flexjet's flights distances could be replaced by eVTOLs in the future. In Table 3, the busiest airports are shown, which could have eVTOLs located at or near them to allow for faster travel from or to the airport. A score was then given to the busiest airports, where the lowest number of departure and arrivals was given a score of 1. While the other ones were bigger than the score of 1, they were given their respective score off that base as seen in Table 4.

Rank	Depature	Arrival	Number of Times	DEP	ARR	Distance (miles)
1	Chicago, Illinois	South Bend, Indiana	18	KMDW	KSBN	74.39
2	South Bend, Indiana	Chicago, Illinois	13	KSBN	KMDW	74.39
3	Freeport, Florida	Miami, Florida	11	MYGF	KMIA	112.14
4	Boston, Massachusetts	Nantucket, Massachusetts	10	KBOS	KACK	90.88
5	White Plains, New York	Westhampton Beach, New York	8	KHPN	KFOK	58.37
6	Houston, Texas	Austin, Texas	8	KHOU	KAUS	128.93
7	Westhampton Beach, New York	White Plains, New York	7	KFOK	KHPN	58.37
8	Miami, Florida	Freeport, Florida	7	KMIA	MYGF	112.14
9	Nantucket, Massachusetts	Boston, Massachusetts	7	KACK	KBOS	90.88
10	Reading, Pennsylvania	Atlantic City, New Jersey	7	KRDG	KACY	156.66

Table 2: Flight routes that were the most traveled for flights 30 minutes or less

Rank	DEP	Times Departed	Name
1	KPBI	247	West Palm Beach, Florida
2	KDAL	203	Dallas, Texas
3	KIAD	191	Naples, Florida
4	KPBI	174	Teterboro, New Jersey
5	KPBI	132	White Plains, New York

Rank	ARR	Times Arrived	Name
1	KDAL	204	Dallas, Texas
2	KTEB	193	Teterboro, New Jersey
3	KPBI	176	West Palm Beach, Florida
4	KAPF	173	Naples, Florida
5	KHPN	169	White Plains, New York

Table 3: Airports with the most departures and arrivals for flights 30 minutes or less

State	City	Times Departed/Arrived	Score
Indiana	South Bend	59	2.95
Illinois	Chicago	57	2.85
Florida	Naples	42	2.1
Massachuetts	Nantucket	38	1.9
New York	White Planes	23	1.15
Georgia	Atlanta	20	1

Table 4: Scoring for the busiest airports for flights 30 minutes of less

Now that the private jet flights have been analyzed, it is time for the eV stations. As seen in Figure 1, eV stations have been exponentially growing recently, meaning the eVTOL industry could have the same type of growth. eV stations have the possibility to expand to vertiports since they will already have the eV chargers there. They were narrowed down to just those that are either a parking lot or garage, since the eVTOLs will need space to land. In Figure 3, a visual representation of all the heliports and eV charging stations in the USA was compiled on a map to give an idea of their locations, since heliports also can also be turned into a vertiport.

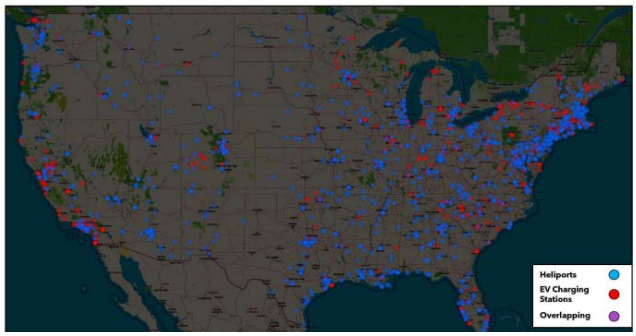

Figure 3: Visualization of where eV charging stations and heliports are in USA

Table 5 shows that places such as New York and California have been pushing for the eV industry to grow there. With political support at such places for the electrical industry, they could be potential spots for the eVTOL industry to emerge. Scores were given again, as seen in Table 6, with the number of charging stations by the found mean.

USPS Abbreviation	Number of eV Charging Stations	USPS Abbreviation	Number of eV Charging Stations
AL	0	MT	3
AK	7	NE	1
AZ	1	NV	0
AR	1	NH	4
CA	163	NJ	15
CO	28	NM	0
CT	45	NY	304
DC	14	NC	20
DE	4	ND	0
FL	20	OH	22
GA	14	OK	9
HI	20	OR	8
ID	2	PA	32
IL	17	RI	2
IN	17	SC	30
IA	2	SD	1
KS	0	TN	10
KY	2	TX	8
LA	9	UT	2
ME	11	VT	4
MD	43	VA	20
MA	23	WA	17
MI	27	WV	1
MN	11	WI	4
MS	1	WY	0
MO	2		

Table 5: Number of eV charging stations in every state

USPS Abbreviation	Number of eV Charging Stations	Score	USPS Abbreviation	Number of eV Charging Stations	Score
AL	0	0	MT	3	0.152847
AK	7	0.356643	NE	1	0.050949
AZ	1	0.050949	NV	0	0
AR	1	0.050949	NH	4	0.203796
CA	163	8.304695	NJ	15	0.764236
CO	28	1.426573	NM	0	0
CT	45	2.292707	NY	304	15.48851
DC	14	0.713287	NC	20	1.018981
DE	4	0.203796	ND	0	0
FL	20	1.018981	OH	22	1.120879
GA	14	0.713287	OK	9	0.458541
HI	20	1.018981	OR	8	0.407592
ID	2	0.101898	PA	32	1.63037
IL	17	0.866134	RI	2	0.101898
IN	17	0.866134	SC	30	1.528472
IA	2	0.101898	SD	1	0.050949
KS	0	0	TN	10	0.509491
KY	2	0.101898	TX	8	0.407592
LA	9	0.458541	UT	2	0.101898
ME	11	0.56044	VT	4	0.203796
MD	43	2.190809	VA	20	1.018981
MA	23	1.171828	WA	17	0.866134
MI	27	1.375624	WV	1	0.050949
MN	11	0.56044	WI	4	0.203796
MS	1	0.050949	WY	0	0
MO	2	0.101898	**MEAN**	**19.62745098**	**N/A**

Table 6: Scores for the eV Charging Stations

Next, population density will be taken into account. As seen in Table 7, the population densities are dominated by New York and California, just like the eV charging station, using the same scoring procedure as for the busiest airports.

State	City	Population Density	Score
New York	New York	27,747.90	3.273548
California	San Francisco	18,790.80	2.216837
Massachusetts	Boston	14,362.60	1.694422
Florida	Miami	13,000.50	1.533729
Illinois	Chicago	11,846.50	1.397586
Pennsylvania	Philadelphia	11,796.80	1.391723
District of Columbia	Washington	11,545.90	1.362123
California	Long Beach	9,122.70	1.076247
Washington	Seattle	8,937.00	1.054339
California	Los Angles	8,476.40	1

Table 7: Top 10 cities with the highest population density and corresponding scores

Lastly, the median household income was researched. It also was used to see if there are cities where there is a correlation between population density and median household income. This is shown in Table 8, and California yet again is standing out as a possible location, but New York is not showing up for the median household income. This means most likely many commuters live outside the city, since White Plains is a nearby airport which is one of the busiest airports according to Table 3. OneSky could thus target places like these to use an eVTOL instead of the city traffic.

State	City	Median Household Income	Score
California	San Francisco	$119,136	1.822794
California	San Jose	$117,324	1.79507
Washington	Seattle	$97,185	1.486941
District of Columbia	Washington	$90,842	1.389893
California	San Diego	$83,454	1.276856
Massachusetts	Boston	$76,298	1.167368
Texas	Austin	$75,752	1.159014
Colorado	Denver	$72,661	1.111721
New York	New York	$69,407	1.061935
North Carolina	Charlotte	$65,359	1

Table 8: Top 10 cities with the highest income and their corresponding scores

Results

Now that all the data has been acquired the final scores were calculated as stated before, final scores were calculated for every respective state, and if a

state showed up more than once in one category because of multiple cities being in the top 10, the highest score for that state was used. For instance, in Table 8, San Francisco, California and San Jose, California, both appear, so San Francisco's higher score will be used towards the final score. In Table 9 the final score for every state is listed, with New York and California standing out from the rest. This will be used when giving recommendations to OneSky.

USPS Abbreviation	Total Score	USPS Abbreviation	Score
AL	0	MT	0.038212
AK	0.089161	NE	0.012737
AZ	0.012737	NV	0
AR	0.012737	NH	0.050949
CA	3.086082	NJ	0.191059
CO	0.634574	NM	0
CT	0.573177	NY	5.243499
DC	0.866326	NC	0.504745
DE	0.050949	ND	0
FL	0.779745	OH	0.28022
GA	0.428322	OK	0.114635
HI	0.254745	OR	0.101898
ID	0.025475	PA	0.755523
IL	1.27843	RI	0.025475
IN	0.954033	SC	0.382118
IA	0.025475	SD	0.012737
KS	0	TN	0.127373
KY	0.025475	TX	0.391652
LA	0.114635	UT	0.025475
ME	0.14011	VT	0.050949
MD	0.547702	VA	0.254745
MA	1.483405	WA	0.851854
MI	0.343906	WV	0.012737
MN	0.14011	WI	0.050949
MS	0.012737	WY	0
MO	0.025475		

Table 9: Total scores for all of the states based off the four researched categories

Conlcusion

A. Reccomendations

There was a state based on the result's scores that stood out from the rest which would be recommended to OneSky for an emerging location of the eVTOL industry: New York. In New York, based off the data, it has Flexjet's customers already in the area, a high amount of eV stations, and a high population density in the city. Since the White Plaines airport is one of the busiest for short flights for Flexjet, according to Table 3, it could be an easy spot to start. The airport is represented by the white arrow in Figure 4 and has close proximity to the city. eVTOLs could replace taking taxis to and from the city to the airport nearby in addition to the short flights to nearby locations. Also, since AAG Heli is already located in the northeast, this could be a good preliminary designation to start with, since they already own heliports that could be converted to vertiports in the future, and it wouldn't be as risky as going all the way to California where there is no VTOL company already owned by Directional Aviation. To get the industry emerging, OneSky should attempt to get politically endorsed like the eV car industry was to allow it to quickly spread around the US.

Figure 4: New York City could be the starting spot for the eVTOL industry to emerge

Acknowledgement

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