INRIX Identifies Top U.S. Cities for Shared Highly Autonomous Vehicle Deployment

Deployment of highly autonomous vehicles (HAVs) is expected to deliver societal benefits, including reductions in traffic congestion and vehicle-related emissions. In addition, as shared-use vehicles replace single occupancy travel, the cost of mobility per trip is expected to decrease substantially and provide opportunities previously too cost-prohibitive to many segments of the country's population. HAV deployment could also work in conjunction with transportation service providers by providing first- and last-mile trips. Further gains in cost reductions for consumers should arise as autonomous vehicles reduce collisions and related medical claims.

However, gains in these areas could be limited due to a number of factors, including induced vehicle travel from lower costs and an increase in average commute distances as travel time becomes more productive. To avoid these possible effects, it is crucial for public officials to proactively plan for shared and personal autonomous vehicle deployment based on a data-driven approach aimed at tackling specific urban area needs.

Central to successful public planning is leveraging big data to understand travel patterns and urban- and city-specific mobility needs. To facilitate the planning process, INRIX has identified two key insights delivered from the hundreds of millions of data points collected about population movement, congestion and parking in downtown cores and urban areas across the U.S.

In this report, INRIX ranked the top cities for HAV deployment based on current travel habits, with New Orleans taking the top rank, and created a framework to analyze and visualize areas in a city that are best suited to benefit from HAV deployment. INRIX applied this framework to Austin, New York City and San Francisco, and outlined how city planners could use this insight to proactively leverage HAV technologies.

What are the top cities in the U.S. for HAV deployment?

When it comes to travel habits, not all cities are created equal. Highly autonomous vehicles are expected to scale through shared-use fleet deployment that will prioritize electric and hybrid vehicles. Securing America's Future Energy found that "58 percent of autonomous light-duty vehicle retrofits and models are built over an electric powertrain, while a further 21 percent utilize a hybrid powertrain. By comparison, in the larger light-duty vehicle market, only 14 percent of domestically available 2016 models were either electric or hybrid."

While the upfront cost of highly autonomous and electric vehicle (EV) technologies is greater than traditional internal combustion engine passenger cars, the per-mile cost to operate these vehicles is projected to be substantially lower. The cost savings alone make these technologies ideal for the high-mileage usage that will be indicative of HAV deployments, before even considering the reduction in other externalities of modern day travel.

While less expensive to operate per-mile, range capabilities, EV infrastructure and refueling time remains limited. Electric and shared-use vehicles will be most effective when used to deliver shorter, intra-city trips where occupancy is maximized and vehicles are less likely to be stranded from charging infrastructure or limited in their utility by range limitations. To see what urban areas could have the greatest proportion of vehicle travel replaced by HAVs, INRIX Research looked at one year's worth of travel – nearly 1.3 billion trips – in the top 50 U.S. cities by population.

Combining INRIX data and StreetLight InSight, an industry-leading mobility analytics online platform from partner StreetLight Data, INRIX Research analyzed trips that began and ended within a 25-mile radius of each downtown and compared this to aggregate regional trips (including outbound, inbound, and passing-through trips) to establish a percentage of intra-city travel. All data was anonymized, contextualized, normalized and aggregated to protect consumer privacy.

INRIX then analyzed StreetLight's aggregate trip distance Metrics and provided a score with more points awarded for shorter trips. A maximum of 50 points was awarded for the percentage of aggregate intra-city trips and a maximum of 50 points was awarded for the percentage of aggregate trips 10 miles or less, for a total maximum score of 100.

INRIX Highly Autonomous Vehicle City Evaluation

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The results of this study were as follows:

RANK	CITY	INRIX CITY SCORE	RANK	CITY	INRIX CITY SCORE
1	New Orleans, LA	90.33	26	Indianapolis, IN	85.25
2	Albuquerque, NM	89.85	27	Phoenix, AZ	85.01
3	Tucson, AZ	89.35	28	Columbus, OH	84.92
4	Portland, OR	89.32	29	Houston, TX	84.84
5	Omaha, NE	89.20	30	Jacksonville, FL	84.65
6	El Paso, TX	89.12	31	Minneapolis, MN	84.50
7	Fresno, CA	89.07	32	New York, NY	84.30
8	Wichita, KS	89.06	33	Boston, MA	84.26
9	Las Vegas, NV	88.99	34	Mesa, AZ	83.98
10	Tulsa, OK	88.09	35	Washington, DC	83.92
11	Colorado Springs, CO	87.46	36	Philadelphia, PA	83.89
12	Austin, TX	87.30	37	Milwaukee, WI	83.76
13	Memphis, TN	86.75	38	Raleigh, NC	83.69
14	Miami, FL	86.67	39	Atlanta, GA	83.34
15	Los Angeles, CA	86.60	40	Chicago, IL	83.31
16	Kansas City, MO	86.60	41	San Diego, CA	83.05
17	Louisville-Jefferson, KY	86.53	42	Dallas, TX	83.00
18	Seattle, WA	86.41	43	Oakland, CA	82.38
19	Oklahoma City, OK	86.35	44	San Jose, CA	81.80
20	Denver, CO	86.14	45	Arlington, TX	81.73
21	Charlotte, NC	86.00	46	Long Beach, CA	81.57
22	San Antonio, TX	85.92	47	Detroit, MI	81.35
23	Virginia Beach, VA	85.62	48	San Francisco, CA	81.16
24	Nashville-Davidson, TN	85.35	49	Baltimore, MD	78.55
25	Sacramento, CA	85.27	50	Fort Worth, TX	77.86

How do Cities Leverage Data to Plan for HAVs?

As cities prepare for autonomous vehicles, planners have the opportunity to prioritize deployment strategies that maximize benefits for constituents. The mobility goals of cities vary, such as reducing congestion and emissions, expanding mobility to underserved and lower-income populations, and reducing cost-intensive capital infrastructure improvements. A data-driven approach to smart city planning will allow city officials to identify what areas are best suited for HAV deployment and be strategic during rollout phases.

Leveraging anonymous, aggregated INRIX trip data from millions of connected cars, parking availability and restrictions, and U.S. Census demographic data, INRIX created a scalable and customizable scoring system to analyze three cities at the census tract level and smaller, and visualize priority corridors for HAV deployment.

TRIPS

Electric and shared-use vehicles are best designed to fill shorter travel needs in more heavily trafficked areas. In these environments, the upside of electric drivetrains is maximized while range and charging infrastructure limitations are minimized. Additionally, high-trip concentration increases the opportunity for ride-sharing by pairing users traveling along the same route, while minimizing travel with empty seats.

INRIX tabulated the total number and length of trips and calculated the average for weekday travel, then provided a score that rewards shorter trips by census zone, normalized for the total volume of trips in the city. On the city-level analysis, total trips were adjusted to trip density on a per-square meter level. Trip density allows a more accurate comparison between zones as various census boundaries differ in size.

PARKING

An estimated 30 percent of urban traffic is caused by drivers looking for parking. HAVs deployed in shared-use fleets can operate continuously and don't require parking, making them ideal for areas where parking is scarce. Leveraging proprietary INRIX information on parking availability, a higher score was awarded to areas with greater parking utilization (i.e. lower likelihood of parking availability).

While HAVs don't require parking spaces, they do benefit from restricted parking areas for pick-ups and drop-offs. With this in mind, the INRIX parking utilization measure was combined with the total number of parking spaces to get an estimation of curb space available for HAV loading and unloading.

DEMOGRAPHICS

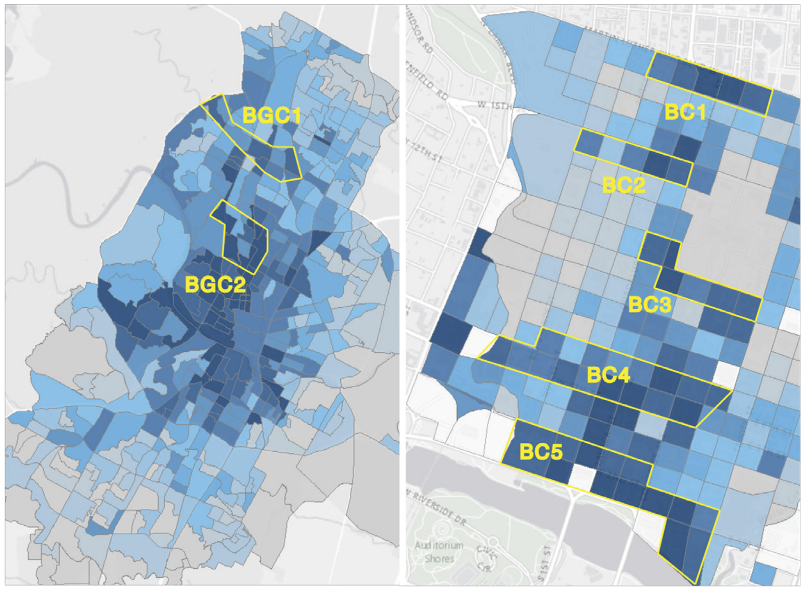
Beyond moving people from A to B, HAVs can be leveraged to deliver expanded, cheaper and faster mobility options to target populations. A city could identify lower-income areas with fewer vehicles per capita or more college students as a priority to deliver cost-effective, on-demand, shared-use autonomous vehicles.

INRIX identified three key demographic indicators for its census block scoring: percentage of residents younger than 17 or older than 65, percentage of households under 200 percent of the federal poverty income level and auto commute mode share. Each demographic indicator was given equal weight and averaged to ensure consistency between cities.

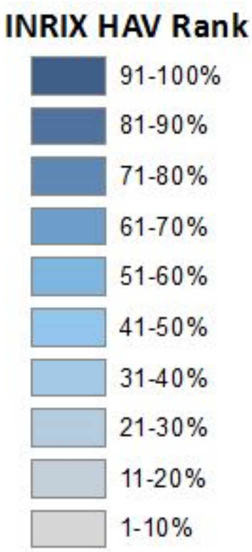
To demonstrate these evaluations, INRIX ran analysis for three cities currently considering autonomous vehicle deployment – Austin, Texas; New York City, New York; and San Francisco, California – and constructed heat maps to visualize this scoring. This model is structured in such a way that city planners can adjust the weight of each factor to account for individual priorities.

For example, a city looking to support a new business district could give greater weight to trip volume or length; a city that wants to decrease congestion in a commercial downtown area could give extra weight to parking utilization; or a city that wants to leverage HAVs to expand mobility options for seniors could give extra weight to areas with higher concentrations of residents 65-years and older. Once areas have been identified, city planners can facilitate private sector deployment through proactive policies – regulatory support for deployment, dedicated HAV lanes or established pickup/drop off zones – or public deployment of HAVs for shared-use as a supplement to existing public transit.

Austin Analysis



MAP A MAP B



The city of Austin, TX has established itself as a hub for HAV research and testing, including its place as one of the four cities where Google's self-driving car project, recently renamed "Waymo," is testing on public roads. The two maps above visualize millions of data points on travel patterns, parking scenarios and demographics, with darker shading denoting an area likely to benefit most from HAVs. The map on the left includes trip and demographics data only. The map on the right adds parking data.

Looking at the full city map for Austin (Map A) there is a clear concentration of high-scoring census block groups in and around downtown, where unsurprisingly the concentration of origin and destination trips per zone is high. However, there are several areas outside of downtown that would be worth further exploration for HAV deployment. This includes Spicewood Springs Road from the North Capital of Texas Highway toward Crestview (Block Group Chain 1), and Rosedale, just north of Central Austin (Block Group Chain 2).

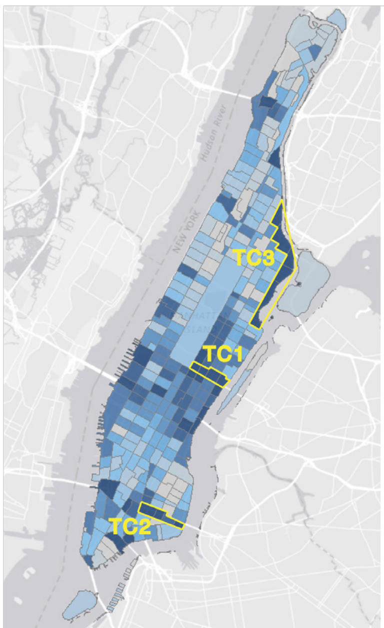
BGC1 has a trip density twice the study-area average at 0.029 trips per square meter, while BGC2 has a trip density over three-times the study-area average at 0.044 trips per square meter. However, BGC2 has a lower percentage of people under 17 years of age and over 65, in addition to a lower percentage of households making less than $40,000 per year.

A closer look at the downtown civic district at the census block level (Map B), accounting for parking utilization and supply, yields several areas where corridors of high-scoring zones are well positioned to benefit from HAVs.

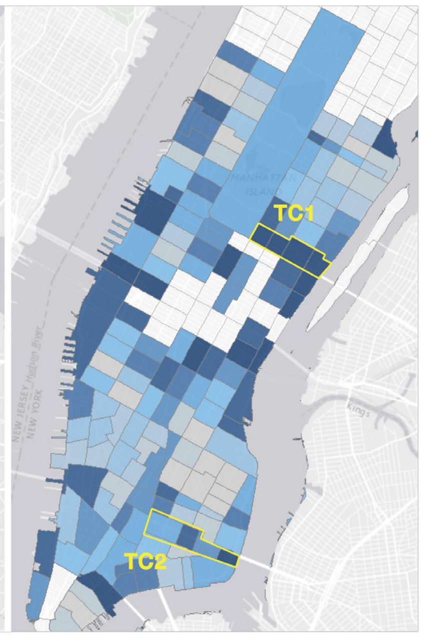
This includes the southern boundary of the University of Texas Austin (Block Chain 1); West 15th Street (Block Chain 2); 11th Street south of the State Capitol (Block Chain 3); 5th and 6th Streets (Block Chain 4); and along the Colorado River in Downtown (Block Chain 5).

Block Chains 1-3 exhibit similar characteristics with trip densities on par with the downtown area as whole. Yet BC4 and BC5 stand out with above average trip densities. BC5's trip densities are about three times the downtown average at 0.41 trips per square meter, with BC4's densities doubling the downtown average at 0.31 trips per square meter. In addition, parking availability in these two block chains is below the downtown average. Despite the trip density advantage over BC1-3, BC4 and BC5 have a higher auto commute mode share, fewer people younger than 17 and older than 65, and fewer households making below $40,000 a year.

New York City Analysis



MAP A



MAP B

City officials in New York have expressed interest in the testing and deployment of autonomous vehicles as part of broader smart cities efforts. Trip, parking and demographic data can help target deployment to areas where these vehicles will be most immediately effective. From this visualization, several corridors stand out as candidates for additional exploration for initial HAV deployment, highlighted in yellow on Map A. These areas score high marks for travel patterns and demographics, and their linear layouts are optimal for HAV deployment along set, straight routes. This includes E 59th-63rd Streets between 5th Avenue and the East River (Tract Chain 1); the Lower East Side (Tract Chain 2); and the northern portion of First Avenue and the Harlem River Drive toward east Harlem (Tract Chain 3).

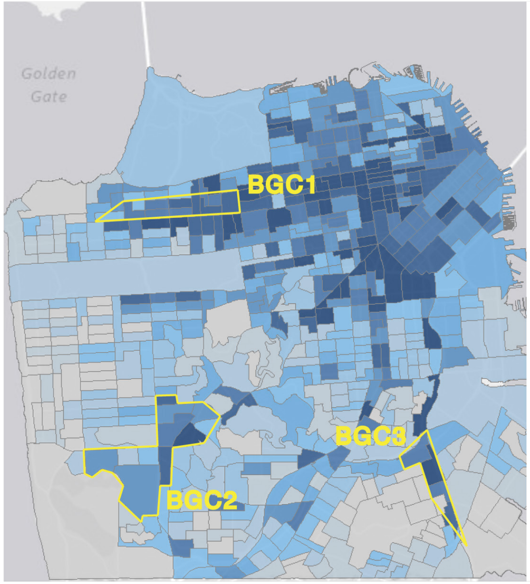
When INRIX parking data is added to the visualization in Map B, some of the high-scoring zones in Map A see their scores fall due to consideration of below-average city parking utilization and/or lower incidences of restricted parking for HAV pick-up/drop-off. However two corridors standout as well-suited for HAVs: the Upper East Side between E 59th and E 63rd and Lower East Side.

TC1 covers four census tracts with a trip density of 0.77 trips per square meter during the average weekday, over double the downtown-area average of 0.34 trips per square meter. The percentage of households making below $40,000 in this area is lower than the downtown-area average, yet the area shows little reliance on automobiles, as mode shares range from 4.4 percent to 10.5 percent auto commute share. On average, the study-area tracts have 27 percent of their population under 17 or over 65 – yet this chain's population ranges from 26 percent to over 50 percent of total residents below 17 or over 65. Parking availability worsens as tracts move toward Central Park.

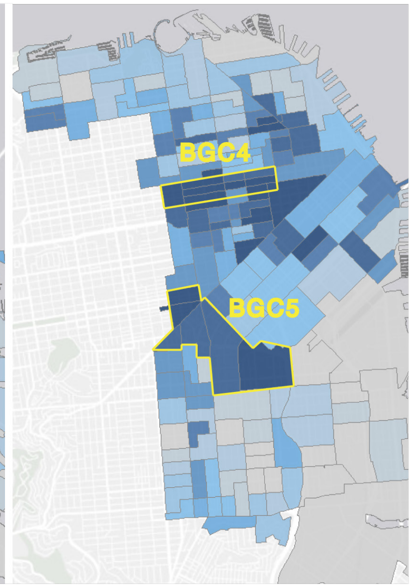
TC2 also covers four census tracts but displays different characteristics than TC1. Trip density is closer to the study-area average, at 0.35 trips per square meter. However, travelers in TC2 generally choose to travel shorter distances than in TC1 and in the downtown zone has a whole. 73 percent of trips in the downtown zone analyzed were less than 10 miles – yet 86 percent of trips beginning or ending in TC2 were less than 10 miles.

TC3 shows further deviations from other areas. For example, all six census tracts in this zone have more than 31 percent of residents either below 17 years old or more than 65 years of age, higher than the New York County average of 28 percent. In addition, household incomes below $40,000 are higher than the New York County average of 33 percent, ranging from 43 percent to 76 percent. Although roughly 75 percent of trips in the county were less than 10 miles, nearly 88 percent of the trips beginning or ending in this tract chain were less than 10 miles.

San Francisco Analysis



MAP A



MAP B

While receiving a low INRIX city score based on the length and centrality of trips, the San Francisco Bay Area is already a leader in HAV testing with more than a dozen operators testing vehicles on public roads. As these vehicles move from testing to commercial deployment, city officials have the opportunity to promote deployment in areas where constituent mobility needs are best served. Using U.S. Census Block Group boundaries, Map A (trip and demographic data) shows many of the highest scoring zones are in and around downtown neighborhoods, however several areas outside of downtown standout as particularly high-value and worthy of further consideration for HAV deployment. This includes the Outer and Inner Richmond Districts along Geary Boulevard (Block Group Chain 1), near the West Portal along 19th Avenue (Block Group Chain 2) and the neighborhoods of Portola and Vistacion Valley (Block Group Chain 3).

An analysis on BGC1 shows an average trip density of 0.154 trips per square meter, far higher than the study average of 0.099 trips per square meter. The chain also has a slightly lower per-block group average of car commuters (43 percent versus 45 percent) and contains a wide range of income levels by block group, from three to 29 percent of households earn below $40,000.

BGC2 shows a lower 0.117 trips per square meter on the typical day compared to BGC1, but the average census block group had 39 percent of residents younger than 17 and over 65, versus a per-group average of 28 percent. Other demographic trends, like household income, also trend lower than the average for San Francisco County. BGC3 has a similar 0.111 trips per square meter as BGC2, yet has fewer people below 17 years of age and older than 65, though it boasts a lower auto commute mode share than BGC2. When focusing on the downtown region and including INRIX parking data, two areas standout as most likely to benefit from HAV deployment. These areas combine high volumes trips and shorter average distances with high parking utilization and populations likely to most benefit from a HAV-based mobility option. This includes Bush and Pine Streets west of the Financial District (BGC4) and the area extending southeast from San Francisco City Hall (BGC5).

BGC4 incorporates the downtown San Francisco area and has a higher-than-average trip density, with 0.397 trips per square meter average between the seven Census block groups analyzed – compared to a 0.218 trips per square meter average among downtown block groups. BGC4 also has a higher-than-average percentage of trips shorter than 10 miles per block group than the typical downtown zone. The probability of finding parking in BGC4 is about 50 percent lower than in the average downtown parking zone, leading this chain to one of the highest scoring in San Francisco.

BGC5 has similar trip density as BGC4, at 0.367 trips per square meter. While this chain has a higher percentage of residents under 17 years of age and over 65, it has fewer households with incomes under $40,000 and a higher auto commute mode share than BGC4.

Conclusion

Many cities are currently considering deployment of HAVs on public roads within their footprint. While this technology brings promises of transformative public benefits, these gains are not guaranteed. Big data analytics and increased-understanding of mobility will help public sector stakeholders strategically plan to bring this technology to market in a way that benefits constituents and solves key mobility challenges.

By leveraging hundreds of millions of trips, parking availability and restrictions and demographic data, INRIX has identified the top markets for autonomous vehicle deployment by current travel patterns. Using these data-driven insights to inform public planning will allow cities to proactively leverage HAVs to address key mobility and societal challenges rather than reactively dealing with possible impacts of this technology.

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