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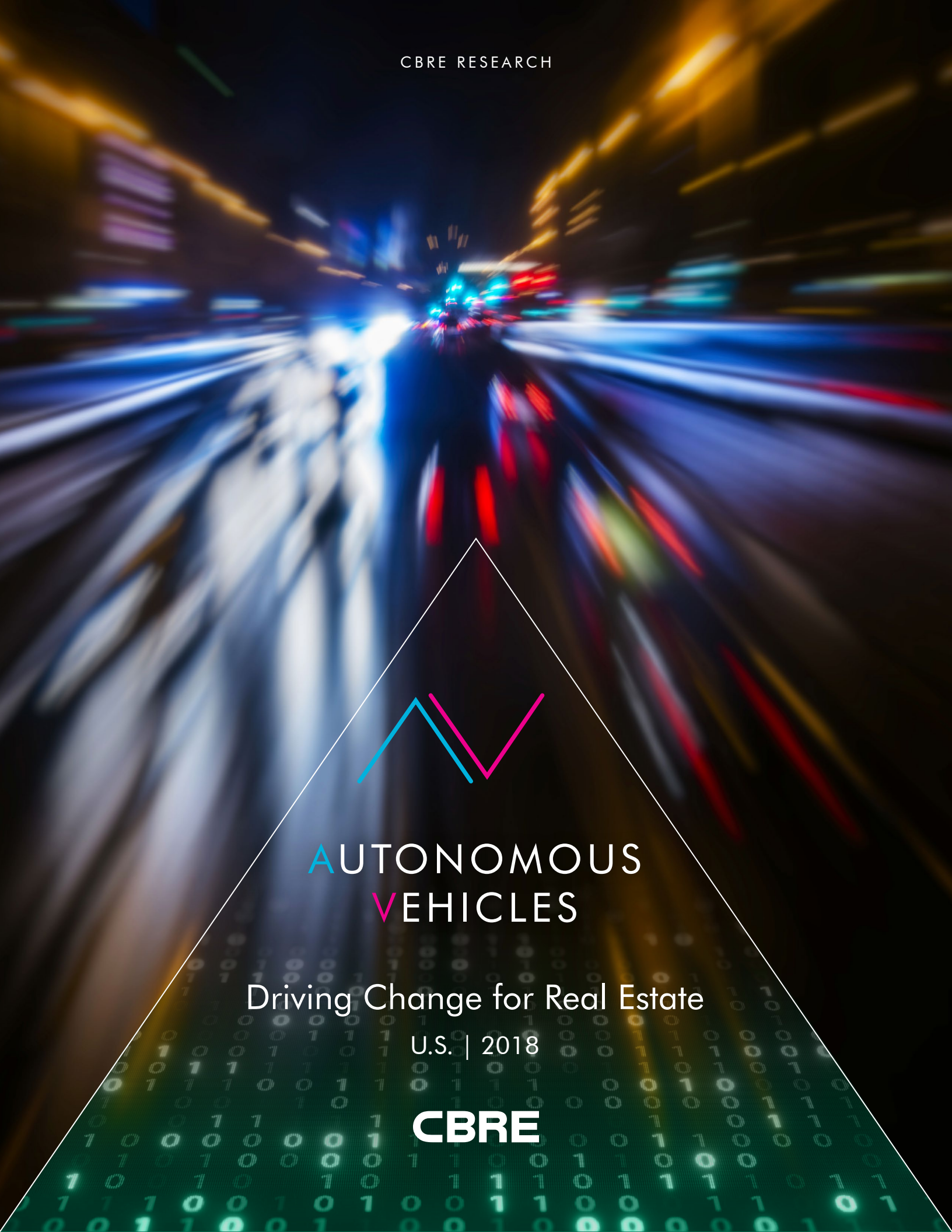

AUTONOMOUS VEHICLES

Driving Change for Real Estate

U.S. | 2018

CBRE

AUTONOMOUS VEHICLES

Autonomous vehicles (AVs) may have the greatest imp

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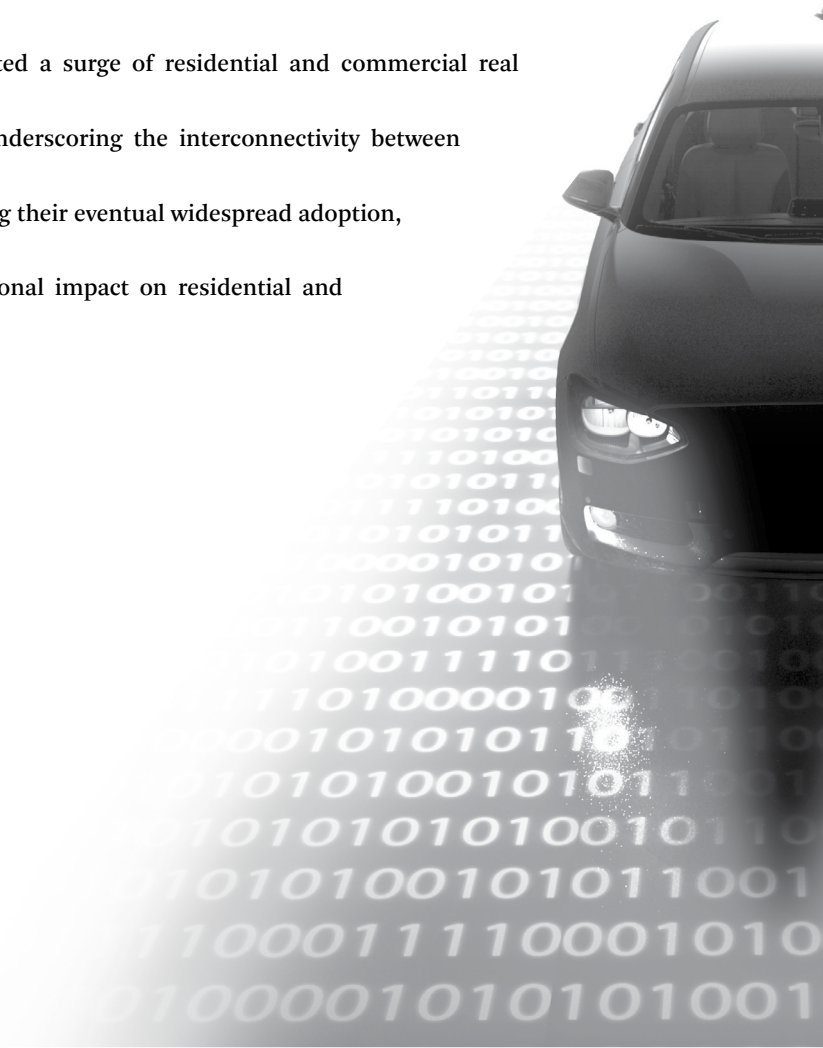
These transformational events facilitated a surge of residential and commercial real estate development in the suburbs, underscoring the interconnectivity between transportation and real estate. Assuming their eventual widespread adoption, AVs may have a similarly transformational impact on residential and



Driving Change for Real Estate

act on U.S. real estate markets since mass adoption

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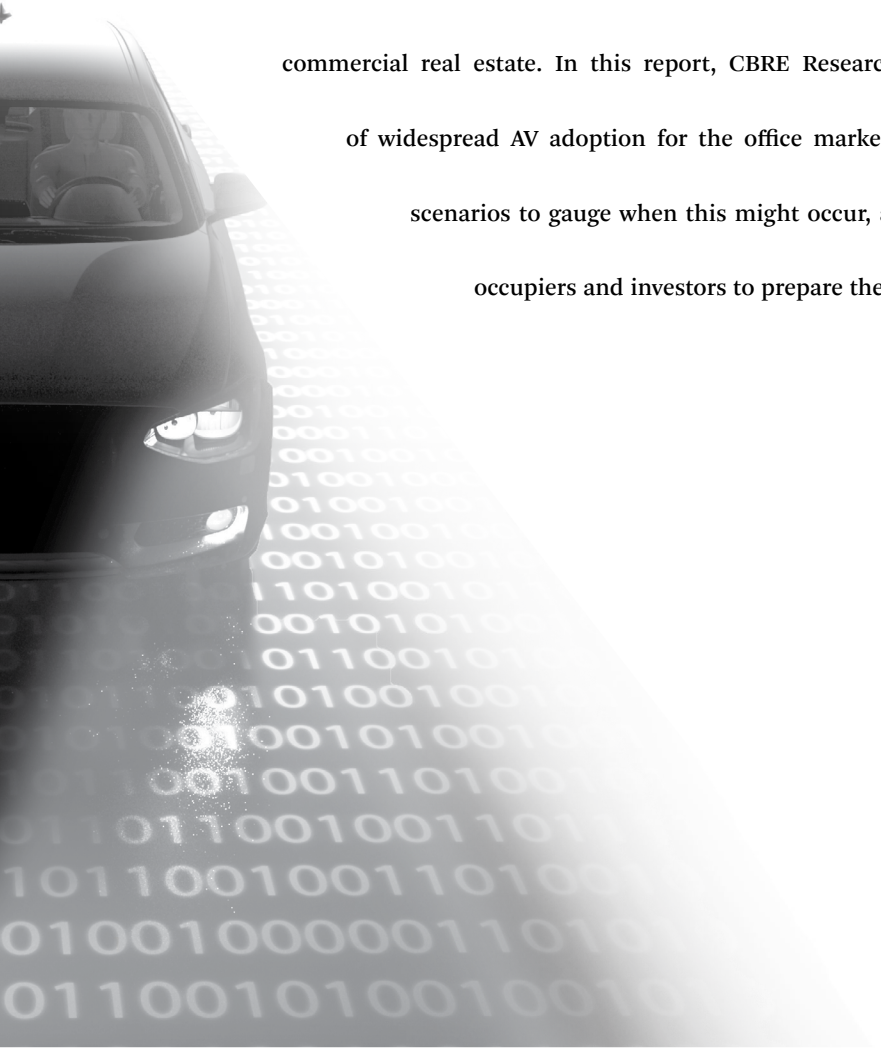


commercial real estate. In this report, CBRE Research examines the implications of widespread AV adoption for the office market, presents several AV rollout scenarios to gauge when this might occur, and offers strategies for office occupiers and investors to prepare themselves for the impact of AVs.

Implications for Office Market

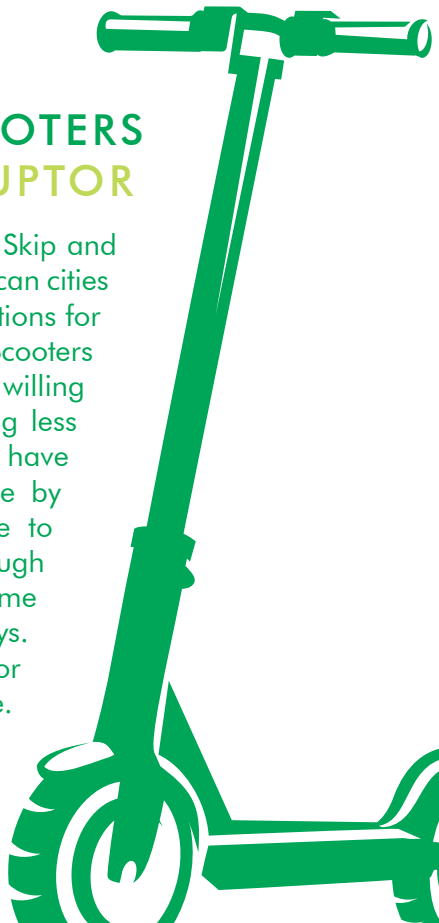
Given the inextricable link between transportation and how and where people live and work, widespread adoption of AVs likely will have a profound impact on the office market. CBRE partnered with 99MPH, a firm that specializes in analyzing how mobility impacts real estate, to examine the likely effect of AVs on office markets. The analysis incorporated the following hypotheses:

- **Outlying locations and those that are unserved or underserved by public transit may become more accessible and thus more desirable.** Similar to what has occurred with corporate tech shuttles transporting employees between San Francisco and Silicon Valley, workers may be more willing to travel long distances due to the less stressful journey and the ability to work while commuting. Vehicle amenities may include beds for sleeping, which may also make private transportation preferable to public transport.
- **Access to nearby talent may be less of a driver of location decisions.** As AVs extend the distance that workers are willing to commute, immediate proximity to the target workforce may be a lower priority in choosing an office location. This will open a broader range of options for tenants and investment opportunities for owners. Advances in communications technology, including virtual reality, and a cultural shift to a more dispersed workforce could accelerate this trend.
- **Walkable locations may become more valuable.** Dense, walkable areas may attract an even greater premium due to the replacement of existing car infrastructure—parking lots, garages and on-street parking spaces—with parks, urban retail and other pedestrian-friendly areas. Also, micro-mobility options, such as eScooters and shared bike services, will continue to improve mobility within walkable cores. Based on an average eScooter trip of 1.6 miles[1] versus a half-mile average walking trip[2], eScooters allow access to up to 10 times more amenities in a single trip, increasing the range of services accessible without a car. Thus, locations on the periphery of walkable areas also will benefit from the growth of micro-mobility options. Less-dense and less-walkable areas will not benefit as much from these quality-of-life enhancements and will fall in relative value.

[1] https://qz.com/1325064/scooters-might-actually-have-good-unit-economics/
[2] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3377942/

eSCOOTERS
THE NEW DISRUPTOR

eScooters from companies such as Lime, Bird, Skip and Spin appeared virtually overnight in many American cities during the past few years, providing low-cost options for riders to travel greater distances than by foot. eScooters essentially expand the "last mile" that riders are willing to travel, with approximately 38% of trips covering less than two miles. The result is that walkable places have become even more walkable and more valuable by increasing the area that is considered reasonable to access via foot, eScooter or in combination. Although providers are facing regulatory challenges in some locations, these likely will cause only short-term delays. Similar to ridesharing services, consumer demand for eScooters likely will be too strong for regulators to ignore.

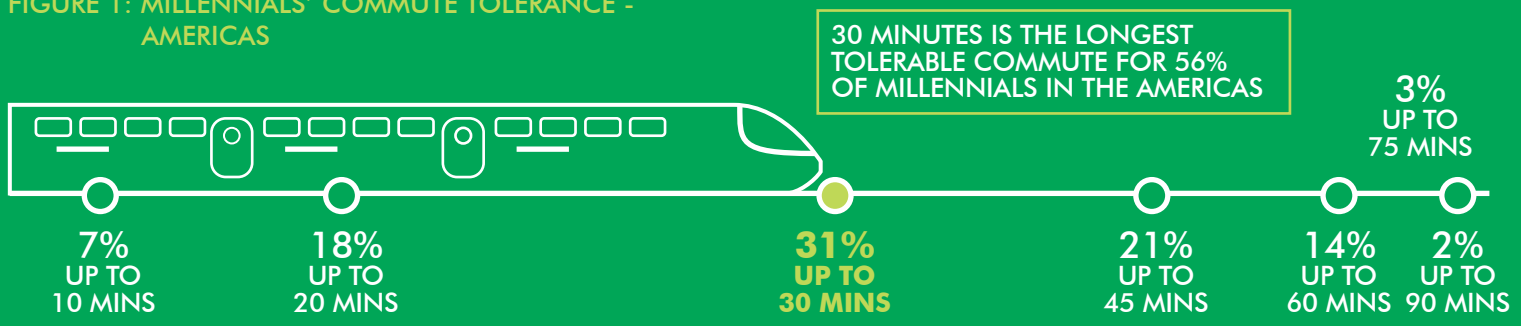


CURRENT COMMUTING TRENDS
DON'T GIVE UP YOUR STEERING WHEEL YET

Despite the emergence of alternative forms of transportation such as rideshare, bikeshare and eScooters, the car remains the dominant mode of commutation in the U.S. As detailed in CBRE Research's recent *U.S. & Canadian Mobility 2018* report, 86% of workers commute via car, truck or van. Even in relatively transit-rich metros such as Boston, Washington, D.C. and Chicago, more than 75% of workers drive a vehicle to work. Despite their relatively low use currently, alternative modes of transportation provide a glimpse of how workers may commute once self-driving cars become widespread.

According to research conducted for CBRE's 2016 report *Millennials: Myths and Realities*, 56% of millennials in the Americas are willing to tolerate no more than a 30-minute commute to work (see Figure 1). In most of the largest office markets, the mean commuting time is at least 30 minutes and has increased by more than the national average during the current economic expansion. As commute times have worsened, office tenants have focused on locating in commercial centers and along transit lines and freeway corridors to ease the commutation burden on their workforce.

FIGURE 1: MILLENNIALS' COMMUTE TOLERANCE - AMERICAS



Source: Live Work Play: Millennials Myths and Realities, CBRE Research, November 2016.

FIGURE 2: MEAN COMMUTE TIME BY METRO AREA - LARGEST U.S. OFFICE MARKETS

Mean Travel Time to Work (# of Minutes)

Metro Area	2016	2013	% of Change 2016 vs. 2013
San Francisco-Oakland	32.1	29.6	8.4
Seattle-Tacoma	29.6	27.9	6.1
Boston	30.6	29.3	4.4
Houston	29.5	28.2	4.6
Los Angeles-Orange County	29.6	28.5	3.6
New York-Northern NJ	35.9	34.9	2.9
Dallas/Ft. Worth	27.8	26.8	3.7
Atlanta	31.0	30.3	2.3
Philadelphia	29.2	28.5	2.5
Chicago	31.3	30.8	1.6
Denver	27.3	26.8	1.9
Washington, D.C.	34.4	34.0	1.2
United States	**26.1**	**25.5**	**2.4**

Source: Census American Community Survey 5-Year Estimates, 2016.

FIGURE 3: SHORTEST MEAN COMMUTE TIME BY METRO AREA

Metro Area	# of Minutes	Metro Area	# of Minutes
Rochester	21.2	Memphis	24.0
Buffalo	21.3	Norfolk	24.2
Grand Rapids	21.7	Las Vegas	24.4
Oklahoma City	22.4	Tucson	24.4
Salt Lake City	22.5	Cincinnati	24.6
Kansas City	22.9	Cleveland	24.6
Milwaukee	23.1	Indianapolis	24.8
Columbus, OH	23.5	Richmond, VA	25.0
Louisville	23.7	Minneapolis/St. Paul	25.2
Hartford	23.8	San Diego	25.3
United States	**26.1**		

Note: Table includes metro areas with total populations of 1,000,000 or greater
Source: Census American Community Survey 5-Year Estimates, 2016.

AV Rollout Obstacles & Timing Scenarios

With AVs already tested on the road, what is preventing them from being widely used by consumers, public and private transit providers and others? At this point in the development cycle, three primary obstacles to broad adoption remain:

- **Regulations:** One of the biggest regulatory obstacles to AVs likely will be the backlash from crashes that have occurred during testing and that will inevitably occur after full implementation of this new technology. Nevertheless, state and city governments, particularly in business-friendly municipalities like Phoenix, have already welcomed self-driving service companies. As of this publication, test users in Chandler, Arizona, for example, can hail a self-driving Waymo vehicle.
- **Software:** Although current software systems are sufficient for self-driving cars to operate in relatively benign conditions, further development is needed for navigation in more challenging conditions, specifically inclement weather and more complex urban roadway layouts. Full implementation of AVs will vary by location depending on these two factors (see Figure 4). In general, development of software systems capable of handling these more complex situations will likely not be complete until at least the early to mid-2020s.
- **Hardware:** Vehicle manufacturing capacity likely will be the biggest constraint to mass adoption of AVs. Factories for manufacturing truly integrated self-driving vehicles capable of handling extreme utilization with an array of sensors have yet to be built. In order to justify the increased cost of building fully autonomous cars, these vehicles must be capable of driving 1 million miles versus 200,000 for a conventional car. Some industry experts predict that it could take five years and between $3 billion and $5 billion to build new factories for custom vehicle programs and an additional two to three years to ramp up production, meaning that a program started today would not be fully operational until the mid-2020s. Without newly tooled factories built for custom self-driving vehicles, the industry must rely on costly post-market retrofits and will not realize the cost savings that could drive mass adoption of AVs.

FIGURE 4: AV DEPLOYMENT TIMELINE BY LOCATION

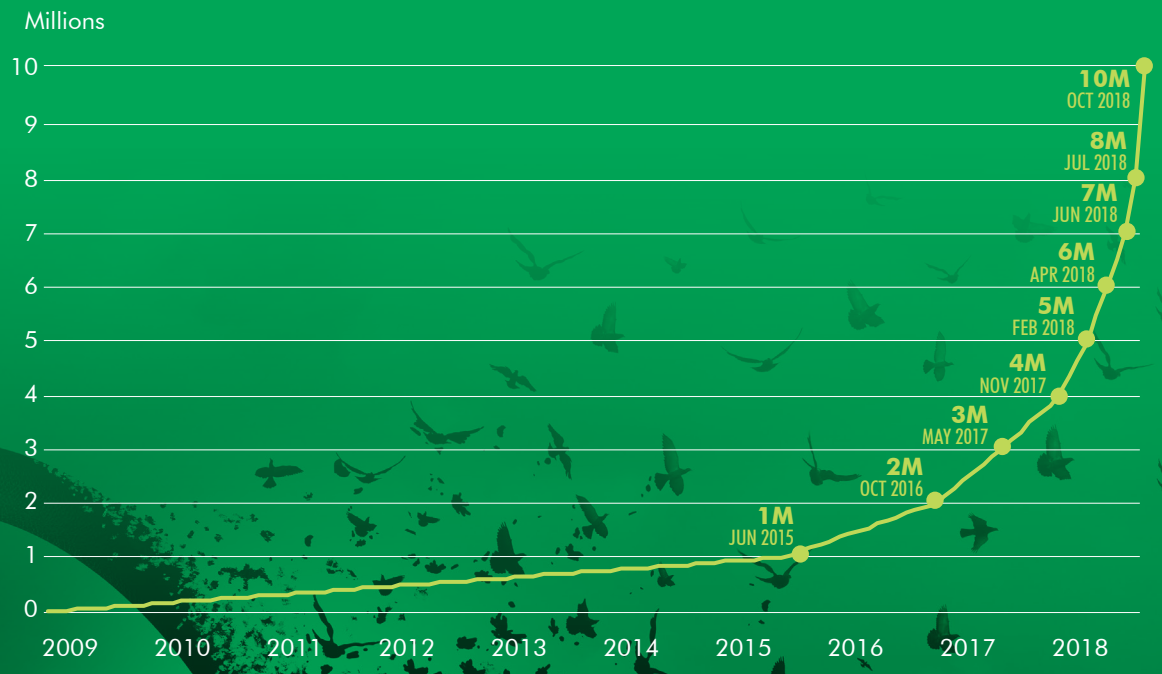
Source: 99MPH, July 2018.

AVs ARE ALREADY HERE

Although AVs may seem like a futuristic phenomenon unlikely to disrupt transportation patterns anytime soon, the reality is that they already are here, fueled by aggressive investment from technology, automotive and other companies. The Brookings Institution conservatively estimates that investment in self-driving cars totaled $80 billion between August 2014 and June 2017. This statistic is based on English-language reports only, and thus potentially excludes a significant amount of investment in Asia, one of the most active regions in the world for AV investment and testing.

Self-driving cars now are being tested on public roadways in several American cities, especially in warm locations with relatively little hindrance for the vehicles to navigate, such as suburban Phoenix and Las Vegas. Moreover, the pace of development and testing is accelerating with the surge in investment in recent years. Google's Waymo unit tested its driverless cars for six years before reaching a cumulative total of 1 million miles driven in June 2015; in contrast, it took the company only one month in 2018 to go from 7 million to 8 million total miles driven. Waymo testing has occurred in diverse environments that pose unique challenges, including California, Arizona and Michigan.

FIGURE 5: WAYMO CUMULATIVE AV MILES DRIVEN



Source: Waymo, July 2018.

Given the major impact that AVs may have on commuting patterns and office usage and preferences, gauging exactly when this disruptive event might occur is critical. To estimate how much mileage-share AVs may capture by 2030, CBRE and 99MPH modeled three scenarios based on the following insights from leading AV companies:

- The rate at which the cost of a mile driven by an AV decreases.
- The amount of time required for the development of software capable of navigating inclement weather and complex urban roadway layouts.
- The rate at which AVs are rolled out in different markets across the country (see Figures 6 and 7).

At first glance, the vehicle-mile-traveled (VMT) shares for these three scenarios may seem relatively low. For comparison, the major ride-share services have had a profound impact on transportation patterns, yet currently account for only about 2% of VMT in the U.S. Thus, even the 11% share of VMT in the bear case implies substantial disruption to the way that people travel by 2030.

It is important to underscore that these projections are for the U.S. only. AV adoption could occur sooner in other countries with centralized government control and highly controlled environments and housing communities. It also is possible that AV adoption could occur faster in a U.S. market that bans all non-AVs within its city limits to eliminate the challenge of interacting with human-operated vehicles.

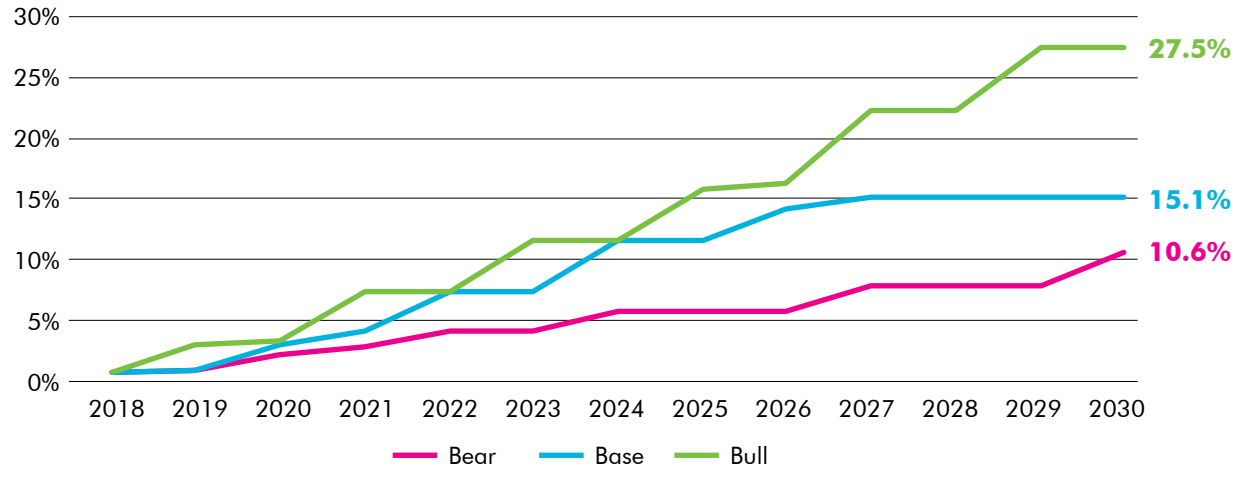
FIGURE 6: AV ROLLOUT SCENARIOS

	KEY LEVERS DETERMINING ROLLOUT			
SCENARIO	PRICE POINT	SOFTWARE TIMING	ROLLOUT SCHEDULE	2030 VMT* SHARE
BEAR CASE	- Longer to decrease than expected - Never beats personal car prices	- Longer than expected to handle weather and urban areas	- Slower - Focused on smaller cities	**10.6%**
BASE CASE	- Nears personal car prices by 2026	- Consistent with current expectations	- Aggressive but on par with announced company plans	**15.1%**
BULL CASE	- Below personal car prices by 2028	- Complex urban environments and inclement weather solved faster than expected	- More aggressive than expected	**27.5%**

*Vehicle Miles Traveled
Source: 99MPH, July 2018.

FIGURE 7: AV ADOPTION PROJECTIONS

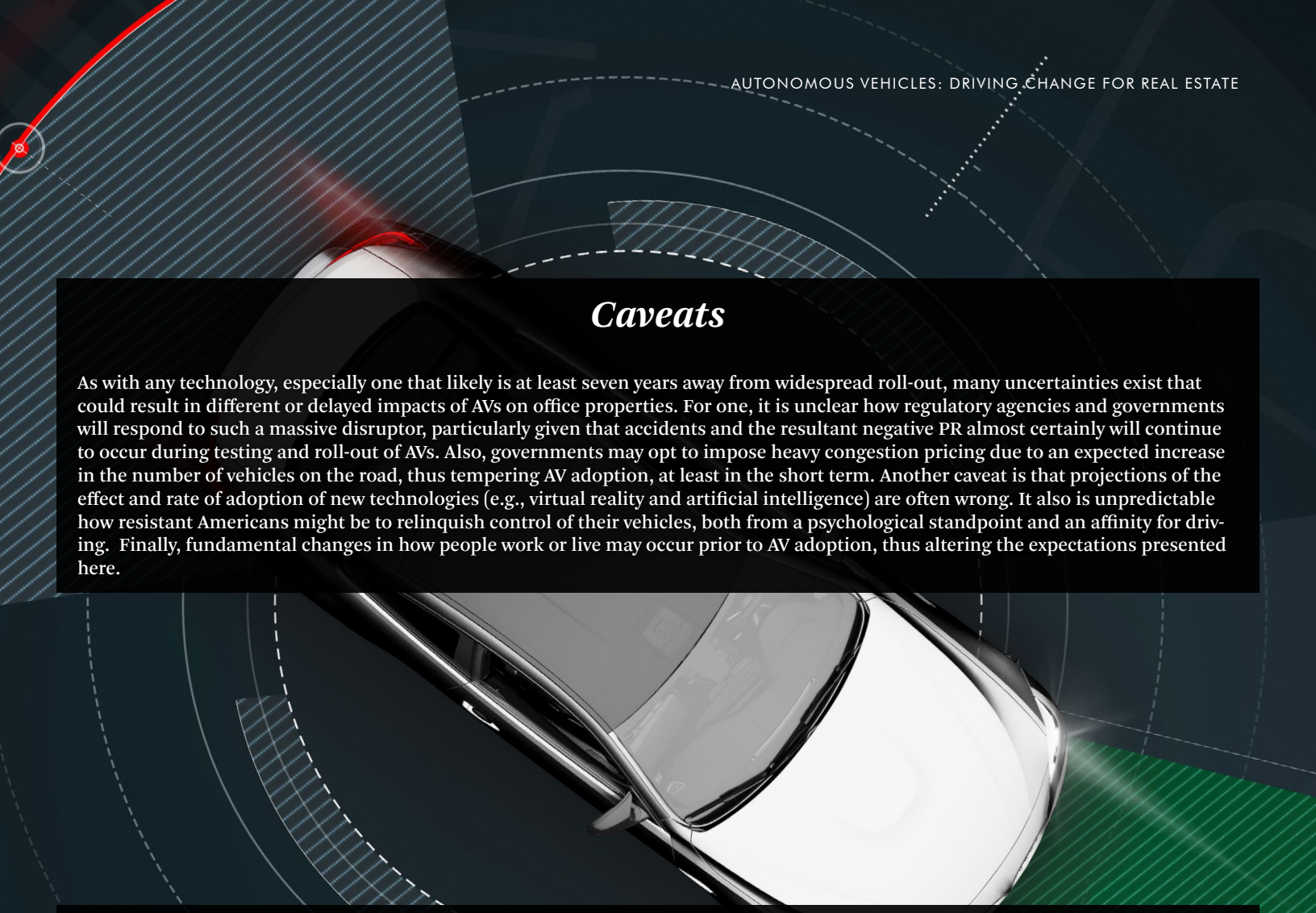
% of Vehicle Miles Traveled (VMT) in Autonomous Vehicles



Source: 99MPH, July 2018.

Caveats

As with any technology, especially one that likely is at least seven years away from widespread roll-out, many uncertainties exist that could result in different or delayed impacts of AVs on office properties. For one, it is unclear how regulatory agencies and governments will respond to such a massive disruptor, particularly given that accidents and the resultant negative PR almost certainly will continue to occur during testing and roll-out of AVs. Also, governments may opt to impose heavy congestion pricing due to an expected increase in the number of vehicles on the road, thus tempering AV adoption, at least in the short term. Another caveat is that projections of the effect and rate of adoption of new technologies (e.g., virtual reality and artificial intelligence) are often wrong. It also is unpredictable how resistant Americans might be to relinquish control of their vehicles, both from a psychological standpoint and an affinity for driving. Finally, fundamental changes in how people work or live may occur prior to AV adoption, thus altering the expectations presented here.



Strategies for Owners & Occupiers

CBRE and 99MPH analyzed a proprietary CBRE database of more than 12,000 lease transactions in three metro areas to create a model that explains the level of office rents based on observable factors (a "Hedonic Model" of real estate lease rates). The five factors analyzed that contributed most to office rents were: proximity to nearby talent, proximity to commercial centers (including transit), grade of office, walkability and local demographics. Based on the expected impact of AV adoption on each of these factors, we modeled the anticipated effect of AVs on office rents in various types of locations across these metro areas.

Based on the results of this analysis, we propose the following strategies for owners and occupiers to position themselves not only to prepare for the impact of AV adoption, but also to benefit from it:

Focus on creating the most attractive building and work environment possible. *If AVs render location less important than it is today, the building itself, including its amenities and workspaces, will increase in importance. Given uncertainty regarding the timing of AVs, property differentiation is one element that owners can control, and it also can be incorporated across all locations. Furthermore, with occupiers already placing a premium on highly amenitized buildings, investing in assets will increase their value to tenants both now and in the future.*

Target walkable areas. *Walkable areas are already popular among many workers and likely will become even more valuable with AV adoption, the repurposing of parking infrastructure in urban cores and the continued growth of micro-mobility. Similar to building quality, this is another characteristic that differentiates a property and will benefit owners and occupiers both now and following implementation of AVs. The downtowns and adjacent locations of San Francisco, Los Angeles, Seattle and Bellevue all could benefit from the increased importance of walkability.*

Consider a broader geographic range of opportunities for office locations and acquisition opportunities once full AV rollout becomes likely during your lease term or hold period. *With AVs expected to increase the range of where workers are willing to commute, there may be attractive opportunities for occupiers and investors to target outlying locations that currently are not considered easily and widely accessible. Examples of areas that may stand to gain from this are suburban and exurban locations east of Oakland, CA that are not accessible via public transit, as well as the Inland Empire region east of Los Angeles.*

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