Potential Impacts of Autonomous Vehicles on Real Estate Development

Interviews with Professionals in the Washington D.C. Area

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VIRGINIA TECH™

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Cover Photo: Ford Motor Company (n.d.), Ford Autonomous Vehicle

Introduction

Transportation and the built environment have always been closely linked. As new transportation technologies are created, new development patterns form to take advantage of increased mobility. History tells of streetcar suburbs, automobile induced sprawl, and transit oriented development (TOD) are examples of the historic links between transportation and development. These are all instances of advancements in transportation technology and infrastructure impacting growth and the types of buildings that are produced.

As the end of the first quarter of the 21st century approaches, a new transportation technology is yet again poised to disrupt the existing transportation and mobility paradigm and potentially the way the built environment develops. Autonomous vehicles, also known as AVs, may offer an exciting opportunity to reshape today's transportation and development patterns. This study will explore the impact AVs could have on the real estate industry and the development professionals helping to shape the built environment.

LITERATURE REVIEW

Previous literature has laid the foundation for understanding the connection between AVs and real estate development, but many of these sources are written by consulting firms or are interviews of one or two individuals from across the country. There appears to be a lack of studies focusing on this topic from a more rigorous academic perspective. Similarly, there are no identified studies that focus entirely on developers in a particular region, such as the Washington, D.C. metro area. This study looks to extend previous work while also filling the gap in the academic literature and focusing exclusively on developers in a single geographic region.

Parking

One of the most frequently cited impacts of AVs on real estate development is the potential of lowered parking requirements. Even before the emergence of AVs, parking had been a major area of concern for planners, transportation professionals, and many other groups. The overproduction and supply of parking and the reduction of parking ratios is a constant conversation when new developments are proposed. An analysis by Ben-Joseph found that surface parking alone covers more than a third of the land in many US cities. There are nearly two parking spaces for each car in the country.[1] Similarly, Bragg and Pazzano found that between 15 and 30 percent of urban land is occupied by parking. The same authors find that services like Uber and Lyft have already cut into the demand for parking, and they expected that demand could diminish by 90 percent as a result of widespread AV adoption. A more realistic projection is a reduction in 50 percent of parking in the next 30 years.[2]

Academic models have also attempted to better understand parking requirements in an autonomous future. A simulation model of Atlanta in which only 5 percent of vehicle trips were replaced by shared AVs resulted in a 4.9 percent reduction in parking needs.[3] A second modeling exercise looked at the efficiencies in parking created through automated parking (e.g. saving space through parking AVs closer together). This study found that AV parking could decrease parking demand by 11 to 49 percent.[4]

To prepare for a potential decline in parking

demand, many developers and designers are already starting to consider retrofitting existing garage space or building new garages that can be converted to other uses in the future. This means ensuring that ceiling heights and the slope of floors are appropriate for future office or residential use. These structures could also include exterior ramps that can be removed as the need for redevelopment arises.[5] The up front cost to design these new parking structures can be prohibitive, but the long term pay offs may be worthwhile.[6]

Public Realm

Removing cars and parking from urban areas will have a significant impact on the public realm. Cohen predicts that the space cars vacate will become vibrant, human-centric locales with more outdoor amenities like cafes and more mixed use projects that bring "new vibrancy to the already vibrant cityscape."[7] Others speculate that developers will look to maximize the value of this space and the new vibrancy created by adding additional amenities and experiences to draw tenants and customers to their locations.[8]

Development Locations and Asset Classes

Previous research also suggests that autonomous vehicles could have an impact on land values and development locations. One report expects TOD locations to diminish in value while more suburban areas not serviced by existing public transportation to increase in value.[9] The changing geography of development value could impact where developers choose to build as they search for a better return on investment. The same report expects assets such as commodity-focused retail, self storage, and billboards to decline in value. At the same time, offices, hotels, experiential retail, and suburban residential is likely to increase in value. Large mixed use structures and data centers, which will facilitate the communication needs of AVs, are also predicted to increase in value as a result of AV deployment.[10]

The idea that suburban locations will benefit from AVs is also held by others in the industry. The idea of Marchetti's Constant supports the prediction that AVs will increase sprawling development patterns. The Marchetti Constant states that as investments are made in infrastructure to save travel times, individuals actually move further from their commuting targets. Instead of saving time, they add distance.[11] AVs are projected to decrease travel times and make transportation far more efficient. Instead of diminishing travel times on average, this could create more sprawling development patterns. Developers could capitalize on this shift by turning their focus to more suburban and exurban locations where new development opportunities may grow.

Schlecter does not expect development patterns to change, but instead believes that existing land use patterns will have a greater impact on AV adoption. Land use patterns are relatively static and will not be altered quickly. Technology on the other hand can evolve faster. Given this line of thought, AVs will not change development patterns so much as they will reinforce and cater to them. In rural, sprawling developments, AVs will likely be adopted in an ownership model. In denser areas, AVs will be shared and will complement walkable environments.[12]

STUDY OBJECTIVES

The purpose of the present study is to understand the potential impacts of AVs on the real estate and property development industries. Development companies may play a significant role in shaping the urban environment to incorporate AVs. As such, this study aims to understand the impacts of AVs from the perspective of property developers. The main goals of the study are to:

1. Understand developers' knowledge of AVs

2. Understand the perceived pros and cons of AVs

to the real estate and property development industry

3. Understand the potential impacts of AVs on existing developments and future projects

4. Understand, from the developers' perspective, what role governments can play in preparing for AV deployment and how governments at all levels can work with developers to maximize the potential offered by AVs

These questions were explored through interviews with developers throughout the Washington, D.C. metro region.

FOOTNOTES

1. Schwartz & Kelly, 2018, p. 58

2. Bragg & Pazzano, 2017, p. 13

3. Zhang, Guhathakurta, & Ross, 2016

4. Kong, Vine, & Liu, 2018

5. Rusch, 2016

6. Kiger, 2018

7. Cohen, 2017

8. CBRE, 2018

9. Brookfield, 2017, p. 4

10. Brookfield, 2017, p. 5

11. Donkers, n.d., p. 5

12. Schlecter, 2018

Study Methodology

SAMPLE

This study focused on the opinions of real estate and property developers who work in and around Arlington, VA. As such, developers with existing or forthcoming properties in the County as well as those with properties in the broader Washington, D.C. metro area with the potential to build in the County were targeted. A number of public sources were used to construct the study's sample. Most large scale development projects in Arlington County go through a site plan review process, which gives the development company flexibility to build at a "form, use, and density" beyond what is traditionally allowed by-right.[1] The Arlington County website maintains a list of developments that have successfully navigated the site plan review process between 2012 and 2018. Using this list of approved projects, development companies that have built or were approved to build in Arlington County were first identified.[2] The membership directory of the Housing Association of Nonprofit Developers (HAND), an association of affordable housing and community development agencies in the Washington, D.C. area, was also consulted to ensure that active nonprofit and affordable housing development companies were captured.[3] Finally, additional publicly available information on bisnow.com, bizjournals.com, and arlnow.com was consulted to find any development companies not captured by the formal Arlington site plan review process or the HAND directory.

The initial company list was reviewed for thoroughness by MobilityLab, the Property and Development Services Department of the Arlington Transportation Partners, and a local developer known by the researcher. A number of additional development companies were suggested and

included in the sample.

After finalizing the list of development companies, individuals within each company were identified and contacted directly by email. This was done by reviewing publicly available site plans and company websites to find individuals working in a development capacity. In total, 256 individuals were identified from 73 unique companies. A mix of experience levels and company roles were present in the sample.

INTERVIEW PROCESS

Each potential participant was contacted via email on March 7, 2019 or March 8, 2019. The engagement email included: a description of the study; a rationale for contacting the developer; a general outline of the questions; a description of who was conducting the study; a description of the studies format (a 45-minute telephone or Zoom interview); and a request to record the interview for future analysis. Developers who responded to the initial email were scheduled for an interview and provided with consent information required for their participation.

All but one interview was conducted over the phone. Two participants asked to schedule a joint in-person meeting. Each interview began by reviewing the consent material provided to the participants. Participants were given the opportunity to ask any questions regarding the research including but not limited to the research's purpose, how data would be presented, and where the findings would be published. Importantly, participants were informed that any identifying information of their person or company would not be included in subsequent publications. When no further questions were

raised, the participants provided their consent to conduct the interview and consent for the interview to be recorded. Four interviews were not recorded, but this was due to technical difficulties and not a lack of participant consent. Each interview followed the same semi-structured interview protocol, which included general questions and follow-up questions covering topics such as: 1) general information about the developer's and company's role; 2) knowledge of AVs; 3) perceived pros and cons of AVs; 4) impact of AVs on current and future developments; and 5) how developers and local governments can maximize the potential benefits of AVs. Interviews lasted between 30 and 45 minutes. Participants were not compensated for their participation and were informed that they could receive a copy of the final report when it was complete. Notes were recorded throughout the course of each interview along with a memo reflecting on each discussion.

DATA ANALYSIS PROCEDURE

Descriptive statistics about the development company and participants' roles were compiled from the interviews and publicly available sources. Interview notes, memos, and recordings were reviewed to identify common responses to the question probes. The same material was reviewed to identify broader themes that emerged from the research. In the process, relevant quotes were transcribed from the interview recordings to provide additional context to the observations.

No qualitative data analysis programs were used to analyze interview audio or transcripts.

FOOTNOTES

1. Arlington County, n.d.

2. Arlington County, 2019

3. Housing Association of Nonprofit Developers, n.d.

In total, 17 different developers from 14 development companies were interviewed. Participants had a wide range of experience and work tenure, and they represented companies of varying sizes, geographic scopes, and asset classes. Participants and their companies were classified by the individual's position, the asset classes each company developed, and the broad locations they targeted for development.

First, each participant's role within their company was identified. It can be challenging to classify roles between different companies as titles and responsibilities are not always transferable. For purposes of classification, participants were divided into upper-level management, mid-level management, and non-management positions. Upper-level management includes presidents, vice presidents, directors, etc. who oversee entire development functions or asset classes. Mid-level management focus more on individual projects than overall company strategy. Non-management includes individuals such as development analysts who do not have managerial responsibilities over any one project. In total, seven individuals classified as upper-level management, six as mid-level management, and four as non-management were interviewed.

Second, the type of asset classes each development company held was determined. Asset classes were divided into Residential – Single Family, Residential – Multifamily, Office, Retail and Restaurant, Retail – Big Box and Mall, Affordable Housing, Mixed-Use, and Other. These classes are not mutually exclusive, with all development companies (excluding the lone affordable housing developer) having a presence in more than one class. Mixed-Use developments are projects that have two or more asset classes in the

same development (which could mean multifamily residential and office, or office and retail, or any other combination). Some developers may develop multifamily residential but not do so in a mixed-use development. The Mixed-Use designation is used to differentiate between those developers who mix asset classes in this way and those that do not. The classification of Other was used to capture developments such as hotels, self-storage, data centers, etc. These assets are often commercial in nature but do not fall neatly into office or retail uses. In total, 3 of the 12 development companies develop single family residential, all 14 develop multifamily residential, 10 develop office, 13 develop retail or restaurants, 5 develop malls or big box retail space, 4 develop affordable housing, 12 develop mixed-use developments, and 7 develop an asset class defined as other. Of the four developers who reported building affordable units, only one is a true non-profit affordable housing developer. The other three companies develop affordable housing as one piece of their residential developments, often related to required affordable housing contributions or density bonus incentives.

Third, each company's geographic footprint was determined as either: D.C. Metro only; regional; and national. D.C. Metro only includes cities and counties in proximity to the beltway such as Arlington County, the City of Alexandria, the City of Falls Church, Fairfax County, Montgomery County, Prince George's County, and the District of Columbia. The designation of a regional footprint is slightly less concrete and includes developments in the D.C. area, but also properties into other cities such as Baltimore, MD, Philadelphia, PA, and Richmond, VA. Finally, a national footprint is used to designate those companies that are in different

cities and regions across the country. A number of developers had a global footprint. These companies were included in the national designation to protect the anonymity of their organizations. In total, four development companies operate exclusively in the D.C. Metro area, three companies have a more regional footprint, and seven operate nationally.

Figure 1 summarizes information about each participant and development company. A code (D01, D02, etc.) is provided for each participant in order to protect participant and company identities. A letter following the initial code is included if two or more participants were interviewed from the same company. Codes will be used throughout the preceding sections to reference respondent information and direct quotes.

Description of Participants

Developer Code	Residential - Single Family	Residential - Multifamily	Office	Retail/ Restaurant	Retail - Big Box/Mall	Affordable Housing	Mixed-Use	Other	Footprint
D01	X	X		X		X	X	X	National
D02		X	X	X	X		X	X	National
D03		X		X					Regional
D04		X	X	X	X		X		National
D05		X	X	X			X	X	D.C. Metro
D06		X	X	X	X		X		D.C. Metro
D07a D07b	X	X	X	X	X		X	X	Regional
D08		X	X	X			X	X	National
D09	X	X		X		X	X		D.C. Metro
D10a D10b		X	X	X			X	X	Regional
D11a D11b		X	X	X			X		National
D12		X	X	X	X		X		National
D13		X	X	X		X	X	X	National
D14		X				X			D.C. Metro

Figure 1: Description of participants: Developer ID; Asset Classes; and Development Geographic Footprint

A number of findings emerged from the interviews. First, the 17 respondents described their general knowledge of AVs. The discussions focused on their company's knowledge and levels of internal discussion regarding AV technology, and perceived pros and cons of AVs to their industry, company, or tenants.

As previously stated, direct quotes or information provided by an individual respondent will be referenced using a code (ex. DO1) in order to protect the identity of the developer and company.

COMPANY KNOWLEDGE AND DISCUSSIONS

Many publications and reports prognosticate about the potential benefits of AVs to real estate developers, giving the impression that the development community is well aware of the topic and considering it in great detail. This study did not find this to be the case. Developers are aware of AVs and attempt to stay current on the technology, but for the most part, they are not considering AVs as an influential factor in current or future development decisions.

Four respondents indicated that their companies have not considered AVs at all. These developers did not indicate any general internal discussions regarding AVs nor any projects in which they planned to incorporate AVs. D05's company focuses on the development, construction, and quick sale of transit oriented development exclusively in the D.C. metro area; she noted that her company is "four steps removed from considering AVs," and that they only consider "what is in front of their nose". Similarly, D03, whose firm mainly focuses on the investment side of development, noted that e-commerce is a bigger concern at this point than integrating AVs into plans. To D03, understanding the market impact to retailers and the physical changes at residential properties due to e-commerce is more pressing than confronting AVs.

Thirteen of the 17 participants noted that their companies have general discussions about AVs. These discussions do not focus on AV implementation for a specific project. Instead, discussions are framed as a way to stay up to date with the technology. This is done by sharing documents and articles related to AV technology with co-workers and attending conferences where AV technology is discussed. D01 and D09 both described attending Urban Land Institute events that covered the topic of AVs and development. D03 spoke about an experience speaking on an AV panel, even though D03's firm is not internally discussing AVs at this time. Beyond conferences, developers also invited external experts to inform them about the technology. D06 and D12 both attended internal company events to learn more about AVs. D06 also described the project of a graduate intern who studied the potential impact of

"From a defensive perspective, we don't want to be the last guy to think about AVs but have other issues we really need to consider in three to five years" — D11b

"[we are] four steps removed from considering AVs" — D05

AVs on their company and said that "to ignore AVs would not be doing their job as developers." D11b summed up the topic of AVs for many developers by noting that, "from a defensive perspective, we don't want to be the last guy to think about AVs but have other issues we really need to consider in three to five years." The impact of AVs on real estate is certainly an area of concern, but it is not something to be worried about today and is secondary to more pressing, market driven concerns.

Even though the majority of developers only focus on AVs in a general sense, five participants did detail internal discussions specifically related to AV integration at current properties or upcoming projects in addition to more general discussions about the technology.

PERCEIVED PROS AND CONS

When asked about the perceived pros and cons of AVs, developers often began by answering from a consumer perspective. They all exhibited an understanding of the impacts of the technology to society as a whole. For example, they identified the alleviation of congestion and the tediousness of personal automobile transportation. They described how AVs could allow for more productive commutes and the potential positive impacts on transportation costs. They even displayed an understanding of the various forms AVs could take and how vehicles could be purpose-built for different needs. In city centers, AVs could be smaller and shared while AVs built for cross-country transportation could look more like a recreational

vehicle (RV). On the other hand, developers also identified increased sprawl and the possibility of induced demand as potential negatives. Some respondents were concerned about mixing AVs with personal automobiles, and the challenges this could create for human drivers in the future. Finally, some even identified the potential impacts on employment as automation cuts in to the shipping and public transportation industries.

Parking

Turning to the direct benefits to development companies and the real estate industry, the participants identified a reduction in parking supply as one of the most significant changes AVs could bring. This is a consistent theme throughout this report and is a concern for most developers. Parking is very expensive to provide and some developers, like D01, can't always recoup the costs of building parking structures. The developers noted that parking spaces cost anywhere between $40,000 to $100,000 a space, with any reduction helping to make projects more feasible. The developers consistently emphasized the importance of the bottom line to themselves and their investors. Decreasing the amount of required parking could increase project feasibility. On AVs' impact on parking, D13 said that "they make projects more feasible because you don't ultimately have to provide that much parking. In every project, the amount of parking can make or kill a deal. When you're looking at different projects and you're looking at parking ratios, it [AVs] makes the projects work." D07b said that "anything AVs can do so that we don't need to create as many parking spaces for commercial and residential will let us deliver more

"In every project, the amount of parking can make or kill a deal." — D13

product. As sites get tighter and the land becomes more expensive, having to go underground is enormously expensive."

Beyond return on investments, developers also highlighted the potential benefits to residential consumers. D03 noted that without strict parking requirements, projects could be denser, which was seen as beneficial by the developer. D07a and D07b both believed that the cost savings could be passed on to residential tenants either through a lower [cost of] rent that is not bundled to parking, or through an increased supply of housing that is not restricted financially or by parking requirements. Finally, D11a and D11b noted that underground parking in condo buildings can cost up to a fourth of the overall cost of producing each unit. Not being required to provide this parking could save the developer, and in turn the condo owner, a significant amount of money.

Interestingly, some developers saw decreases in parking requirements as both an opportunity and a challenge. Developers like D02, who builds big box retail, described that some tenants still demand parking. Even in an autonomous future in which parking is less necessary, these developers may have to build parking to satisfy a demand that is slowly diminishing. Their long term returns could be negatively impacted because they have to build to meet immediate tenant demands. Taken one step further, D04 described the legal complications of retail leases, which often require certain levels of parking throughout the lease term. If a developer or property owner attempted to remove existing parking, they could face legal challenges or be pushed by the tenant to decrease rents. So while removing parking is generally seen as a positive, it is not without potential complications.

Accessibility

Many developers, particularly those that develop retail and office properties, were conscious of the way AVs could attract more customers and visitors to their properties. In the past, many developers built around transit oriented development (TOD) sites because of the number of passengers TOD could transport. Developers such as D02 and D07b believed that AVs could expand the catchment areas of these locations. They do not expect to change where they build, but do believe that AVs can make their locations accessible to people further away than the traditional quarter mile radius of TOD. Ubers and Lyfts are already helping in this regard. D07b believed that taxis were avoiding one of his company's large, more suburban properties. Ubers and Lyfts helped address this challenge. AVs would function in much the same way and could ensure broader accessibility to developers' sites.

Liability

Most developers expected AVs to have a positive impact on development, but one concern beyond the previously stated issues related to parking, is the topic of liability. This is especially true for commercial developers who own and operate parking structures. D02 described how commercial developers understand how to design and stripe parking lots to protect pedestrians and limit their own liabilities. AVs could complicate this for the developer. While AVs are meant to be safer than human driven automobiles, there is still uncertainty as to how developers need to react from a liability perspective. Over time, this concern will be ameliorated with experience and conversations with insurance companies and local jurisdictions.

Findings—Impact on Developments

In the future, AVs could impact both existing properties and future developments. Developers may need to address the need to retrofit or repurpose existing developments to accommodate AVs. More likely, developers will need to consider how to build future "ground-up" developments with AVs in mind. The developers provided their thoughts on both scenarios below.

EXISTING DEVELOPMENTS

The majority of respondents were not considering changes to existing properties. This is likely due to the uncertainty of AV adoption compared to the certainty of these developments, which were built to meet market demand. Going one step further, D05 noted that her company's business model did not incentivize this kind of thinking. D05's company develops properties and looks to sell within three years. This type of business model does not lend itself to considering retrofits or redevelopments.

Six interviewees described previous thinking about how to adapt existing properties. Collectively, these developers identified the need to consider adding pickup and drop off zones to developments, repurposing garages, and accommodating electric charging.

Six developers noted that pickup and drop off zones would be needed in an AV future. Many of these developers, like D06, D10a, D10b, and D13 are already considering such zones to accommodate Ubers and Lyfts. These six respondents believe that the trend towards pickup and drop off zones could continue in a future of AV transportation. D06 said, "the whole drop off sequence needs to be totally rethought and probably rethought at almost all [of our] buildings." D01 and D09 also see the need to

> *"The whole drop off sequence needs to be totally rethought...at almost all [of our] buildings"*
> — D06

include pickup and drop off zones in their developments, but they both believe that developers should not provide the infrastructure. Instead, they believe that local governments can more easily convert street parking to pickup and drop off zones at a much lower cost.

Two developers described repurposing garages to better utilize the space when it is not needed for parking. One developer also noted the potential for additional charging infrastructure, under the assumption that AVs will be electric vehicles (EVs). These respondents did not provide specifics plans for implementation.

FUTURE DEVELOPMENTS

The developers expressed many more opinions regarding the design of new developments than they did the repurposing or redeveloping of existing developments. The main issues or opportunities identified by the developers were: potential changes to development locations; changes to parking; the need for more pickup and drop off zones; changes to delivery infrastructure; and the inclusion of electric charging.

Fifteen of the 17 developers interviewed responded that the location of developments could be impacted in an AV future. D10a said that "any new mode of transportation or approach to transportation opens up new areas of the city, and any time that happens, it opens up opportunities for development." Some, like D01, believed that AVs could open up more suburban development locations. Similarly, D08 believes that AV implementation will be easiest in campus-like locations where developers can better control the implementation of the technology. D08 described how dense locations would lack the horizontal area needed to pilot AV deployment and funding the infrastructure improvements would prove challenging. Others, like D04, think that infill developments will be more attractive given the redevelopment potential of existing parking structures. Still others, like D09, expect AVs to make inner suburb locations, specifically those not well served by transit, more attractive to developers.

While the developers did not agree on the geographic impact of AVs, they were all in agreement that AVs will not change where they develop. The respondents' comments highlighted the importance of local markets, their professional networks, and a grasp of the local regulatory environment as more important than any potential geographic opportunities created by AV technology.

D14, the sole non-profit affordable housing developer, noted that many of their acquisitions come through personal contacts or donations. AVs might open up more geographic areas, but they acquire properties, based on their limited funding streams, in different ways from their market rate contemporaries. D09 summed up the question of location by saying that "AVs won't turn a bad deal into a good deal." Just because AVs could open up a potential new market or geographic area does not mean it will be a profitable venture for a developer who is comfortable and successful in their current market(s).

Six developers noted a need for less parking at future projects. Declines in parking is a common refrain when predicting the impact of AVs on future developments, but the interviewees provided some interesting additional information. D06 singled out the inefficiencies of parking below ground and how the need for such structures would continue to decrease with the increased ability of AVs to park in more suburban or rural parking structures. D07b predicted that safety requirements and ventilation standards would be reassessed as humans would no longer be present in parking structures. D07b expected this to simplify developing parking structures, leading to further cost savings. Other developers were cautious as to how quickly parking would be

"Any new mode of transportation or approach to transportation opens up new areas of the city, and any time that happens, it opens up opportunities for development" — D10a

"AVs won't turn a bad deal into a good deal" — D09

reduced, especially for big box retail and office properties. The provision of parking in these asset classes is driven by tenant and brokerage firm demand. According to D04, a developer who focuses on retail projects, big box tenants such as large grocery stores often measure potential profitability by the number of cars they can bring to their locations. When dealing with this type of tenant, more parking often allows the developer to exact higher rents. Similarly, D11a and D11b, note that brokerage firms, entities that assist office tenants find space, often require certain levels of parking regardless of whether potential tenants utilize the supply. Not having "enough" parking is a quick way to be overlooked in the site selection process. According to D11a and D11b, this leads many office developers to provide the parking even if they know it won't be needed. This situation illustrates the need to inform potential tenants and brokers of the realities of parking demand and to have the data to support providing less parking.

Related to parking, three developers also identified the need to repurpose parking garages in an AV future. This is separate from the need to repurpose existing parking structures. In this context, new garages would be purpose built and prepared for a future with less cars. These developers, like D13 are focusing on how to design future structures to adapt to changing parking requirements. This means designing with taller ceiling heights and designing internal columns to maximize the potential repurposed space. D13 did not expect to convert these purpose built garages into residential or commercial uses. Instead, D13 thought these spaces could be used most effectively for storage.

Seven developers expected an increased need for pickup and drop off zones at future developments. Much like those developers who wanted to add these zones to current developments to prepare for AVs, these seven developers also saw that pickup and drop offs were related to Uber and Lyfts. Pickup

and drop off zones are something they were already considering for future developments, with AVs being a logical extension. D08 described how pickup and drop off zones are the "low hanging fruit" that all developers will be considering in an AV future. What they really need to be thinking about is the sequencing of pickups and drop offs from an operational perspective, instead of only thinking about the physical space needed. Similarly, D12, who develops malls and big box retail as part of her portfolio, questions how AVs will be managed between drop offs and pickups. Will they circle D12's property endlessly waiting to pick up the same passenger they dropped off? Will they need to park or would they move back to the larger street grid? Thinking about the physical space for these zones is only half the concern.

The need to address deliveries was identified by D03. D03 described how his firm was more interested in e-commerce at this time, so it is not surprising that deliveries were a consideration. No other respondent had the same concerns about e-commerce, potentially leading them to overlook this aspect of AV deployment. D03 called for reconsidering delivery areas, with automated delivery vehicles opening up space for additional building amenities as loading docks decrease in size. D03 also raised the question of verticality and whether deliveries would take place by drone requiring new infrastructure and amenities. No other developer moved from AVs as a ground-based vehicle to AVs as drones or other air-based device in the same way as D03.

Again, only D01 identified electric car charging as a feature in future developments. No other developer identified the need for electric charging, potentially pointing to uncertainty surrounding how AVs will be powered.

One aspect of future buildings that the developers did not address was the public realm. Literature and futuristic renderings of AV implementation show a

more pedestrian friendly public realm that includes additional public space and increased ground floor activity. Developers in this study did not volunteer ideas about potential changes to the public realm at their projects. One reason for overlooking changes to the public realm could be their focus on activity within the physical walls of their properties, limiting considerations of what happens on street level. This does not mean that they fail to see the benefits but may think it's for the jurisdiction to manage, much like the addition of pickup and drop off zones. Another reason could be that these developers are already creating walkable, mixed-used developments, with plentiful ground level activation. AVs would not change this strategy, so it was not included in their responses.

While developers are a major player shaping the built environment, they are not alone. Governments at all levels, but especially at the local level, will play a significant role in shaping development patterns in response to AVs. Respondents held many opinions about the types of regulatory, zoning and infrastructure changes governments will need to make to prepare for AVs. Some were hopeful about government's ability to adapt to the changing technology, while others were more pessimistic. The developers' thoughts coalesced around parking ratios, infrastructure needs, incentives, and costs associated with developers' transportation system obligations.

Parking was once again the most often cited concern about local government's involvement. Nine of the developers identified the need for local governments to lower parking ratios or to remove them entirely to let the market dictate the amount of parking required. This was a common call from the interviewees, in relation to both the present development climate and any potential AV future. As D01, D11a, and D11b describe, parking can cost developers between $40,000 and $100,000 a spot depending on the way in which it is provided. In an AV future, governments will need to lead the way by allowing developers to react to the demands of the market instead of being locked in to predetermined parking ratios.

The need for infrastructure improvements was mentioned throughout the interviews, but two developers specifically called on governments at all levels to play a significant role in ensuring AVs have the appropriate infrastructure to be deployed. Without seeing this investment, many of the developers would be reluctant to plan for AVs at their properties. The developers identified the need

for permanent infrastructure like roadways and pickup and drop off zones, as well as the need for technological infrastructure like 5G communication and sensors. D11a compared the life cycle of a building to that of major transportation improvements. Buildings can be developed and stabilized in 4 to 5 years, with a lifespan of 40 or 50. Major infrastructure investments take much longer to complete and last for decades. D11a believed that governments were already falling behind and were failing to provide the necessary infrastructure. He was also not confident that governments would build the appropriate infrastructure to support an AV future.

Six of the developers also noted the need for governments to incentivize developers to install AV technology. For the most part, developers are meeting current demand and producing buildings that will satisfy customers today. Systems must be put in place for developers to begin to think of designing and building for AVs. Speaking about developers, D11b said that "you won't play nice in the sandbox unless you are made to." Local governments must find a balance between requiring developers to provide AV oriented infrastructure while still allowing them to respond to market demands. D04 and D12 described their views that governments need to remain nimble and allow

"You won't play nice in the sandbox unless you are made to" — D11b

developers to react to changing technology. D12 described seven year planning, development, and building cycles for some of her major projects. In that time, technology and the way developers hope to include it can change rapidly. Governments need to recognize the speed of technological advancement and be flexible. They need to allow for changes in the design process, which as D12 noted, could impact entitlements and zoning approvals.

Finally, two developers identified the potential impacts of AV technology on transportation demand management (TDM) agreements and transportation studies. D07b outlined his general experience with TDM, which he saw as penalizing developers if traffic levels did not fall within the TDM agreed upon range. D07b believed that AVs have the potential, through impacting peak travel periods and roadway capacity, to completely change traffic patterns and the demand created by a development. Developments in an AV future would generate less traffic, leading D07b to call for a reassessment of TDM policies and penalties in light of these efficiencies. Similarly, D12 suggested the need to reassess local government traffic studies to consider how AVs could lower developers' infrastructure contributions.

Findings—Broader Themes

A number of broader themes emerged from the developer discussions, which were note related to the existing literature. Broader themes included the uncertainty of AV deployment compared to the need to meet present market demand, and the common characteristics of developers who are already implementing AV technology, which included the desire to be forward thinking, viewing AV deployment as part of an overall customer experience strategy, and the need for sufficient development scale.

UNCERTAINTY AND PRESENT DEMAND

A common theme running throughout the interviews was the element of uncertainty. AV deployment, compared to the relative certainty of meeting present market demand, was seen as highly uncertain and risky. One of the most uncertain aspects of AVs is the timing of widespread adoption. Timing could impact decision making as developers are building structures that last 40 to 50 years, if not longer. If AVs are adopted relatively quickly, this could have a significant impact on today's developments, creating the need for AVs to be planned for in the present. If adoption is farther into the future, developers have less need to consider AVs at this time.

Fifteen of the interviewees said they were unsure of when AVs would be adopted or had no opinion on the matter. Factors contributing to uncertainty included: the slow growth of 5G (D06); the challenges of implementing AVs in all locations including those that are inhospitable or lack quality infrastructure (D08); and an overall skepticism after hearing about AV technology for many years without seeing concrete results (D07a and D11a).

On the other hand, D01 was the most bullish in his projection, stating that AVs could be ready for adoption in the next five years but that the speed of government regulation could slow the process. D03 was the most pessimistic or cautious, believing that AVs may never be widely adopted. D03 noted the technologic and economic cost associated with preparing the nation's infrastructure for AV adoption, which could hinder widespread deployment.

In addition to timing, respondents were also uncertain about how AVs would be adopted and used. They were unsure if AVs would be shared or owned. The specific form of adoption will likely have a significant impact on the type of infrastructure that developers need to provide. For instance, a shared model could mean much less parking and the need for more pickup and drop off areas, while an ownership model may not see much change in how developers, especially on the retail and residential side, choose to design their properties. Without this kind of information, it is difficult for developers to make any decisions.

Even in the face of this uncertainty, many respondents still had a desire to stay on top of the technology and looked to incorporate AVs into their plans. This desire is complicated by the need to meet market demand. In almost all cases, meeting market demand in the present, which was seen as much more certain compared to AV adoption in the future, won out over any potential inclusion of AV infrastructure. This is a rational decision and necessary to compete in today's market. D04, D11a and D11b all spoke about the need to meet current demand for parking in their properties, which also raised the issue of brokerage firms in site selection. One developer brought investors into the discussion

"We're willing to take a little bit of risk, but not to the extent that we can't get the project financed."

by noting that "we are driven by investors and banking institutions that look at past trends in order to justify their investments. We need to be able to justify, in trends, that a project has worked in the submarket for us to be able to do that [incorporate AVs into project designs]." Summing up the conflict between present demand and uncertainty, the same developer said, "We're willing to take a little bit of risk, but not to the extent that we can't get the project financed."

COMMONALITIES AMONG DEVELOPERS IMPLEMENTING AND CONSIDERING AV TECHNOLOGY TODAY

Five respondents described current developments and ongoing plans that incorporate AV technology. These developers and developments share a number of similarities including: a desire to be innovative and forward thinking; prioritizing customer experience; and developing at sufficient horizontal scales.

Innovative and Forward Thinking

Most developers aspire to be innovative and forward thinking, with many achieving these goals, but the companies that are actively incorporating AV technology into their developments seem to prioritize innovation more than other developers. These developers have taken steps, such as creating internal working groups to look at all types of technologies, to ensure that they can maximize the benefits of these innovations. AVs are just one type of technology that these developers are considering.

One interviewee described the aspiration to create a "digital master plan" in which all aspects of a large development including AVs, parking, elevator use, utility use, safety, pedestrian foot traffic, and many others are tracked to optimize operations and to provide data needed to attract tenants. The concept of a "digital master plan" is not only about AVs, but AVs will likely play a more and more significant role as adoption levels increase. A second developer did not mention a "digital master plan" but expressed AV integration as part of broader technology strategies.

Other forward-thinking developers are implementing pilot projects as a way of better understanding the technology and how it could be utilized in their developments. Two developers described the opportunity to showcase the technology and to use their properties as a type of incubator space for AVs. A third respondent said that "We as a team collectively realized that we needed to get smart about AVs, and the way to do that was to touch and feel the product." Speaking of their pilot project, the same developer continued by saying, "you also get to understand how you would design your roads differently to accommodate AVs, how you would design your parking garages differently." This developer concluded by saying, "We can try to prognosticate or try to read tea leaves and predict the future, but the technology is here so we might as well try it and grow with the times." Similarly, another respondent said that "The more pilot programs you have going, the better chance you have of finding something that really works, getting a really quick answer to what doesn't." Adopting pilot projects in this way seems like a good strategy to overcome some of the

"We can try to prognosticate or try to read tea leaves and predict the future, but the technology is here so we might as well try it and grow with the times."

uncertainty surrounding the technology. Pilot projects do not necessarily shed light on the timing of AV development, but they do provide some information on how the technology can be adopted in the future. This gives these developers an advantage over those not taking the same steps.

Customer Experience

The developers seriously considering AVs and those looking to integrate AVs as part of a pilot project often saw AVs as a means of enhancing customer experience at their properties. The technology in these cases was not implemented solely to understand its capabilities as part of a forward-thinking approach, but was adopted to serve an identified function at their sites. One developer who noted a desire to be at the forefront of technology also wanted to be "at the forefront of providing value to people who use our real estate," with the introduction of AV technology being one source of value. For these developers, implementation was mainly seen as a way of increasing mobility at their sites and providing connections between parking areas and other retail and office locations. As one respondent described, "it's primarily being thought of as an internal people mover to solve our mobility issues." This seems to be the predominant strategy at the moment as the regulatory environment does not allow for easy integration outside a developer's development footprint.

AVs implemented to increase custom service can also evolve with a project. These five respondents are all looking to implement AVs at properties today

to run in fixed loops. As growth occurs at the project sites, the same AVs can be repurposed to run variable routes or act in an on-demand fashion. This flexibility allows the developer to constantly adapt and cater to tenant and customer use patterns.

Developing at Scale

The final characteristic that unifies these five developers is their implementation of AV technology across a large horizontal scale. They are all implementing this technology in large, campus like developments where they own many properties and have control over the transportation system within the bounds of their larger development. There is no minimum size for these developments, but they often are greater than 50 or 60 acres and can reach into the hundreds of acres. In most but not all cases, these are ground-up, greenfield developments. These developments are often in suburban or urban-adjacent locations, where land is more plentiful and less expensive.

There are a number of reasons why AV implementation, particularly in the form of a pilot project, seems to work best in larger developments. First, smaller developments do not present a use case for AV integration in the form of a people mover. Only in large developments, where parking and amenities are more spread out geographically, does there appear to be a need for AVs in the form of a shuttle service. This can be compared to more urban developments where a developer generally owns a single building with the necessary parking included directly in the structure. A single developer

is also unlikely to take on the cost of implementing a pilot project when adjacent developers can benefit from the improved mobility without paying the upfront cost to implement the service. Second, the concept of a "digital master plan" is most powerful when it integrates more contiguous land. Large sites offer horizontal scale and allow AVs to be part of a broader data collection effort over the extent of an entire development. Third, the technology needed for AV pilots including the sensors and data collection efforts are easier to integrate into large developments, especially those that are being built from the ground up. It can be challenging and costly to retrofit existing buildings to accommodate the necessary sensors. Additional challenges are created when buildings are owned by different developers or property management companies . This adds another level of coordination when trying to install and manage the sensor technology associated with AVs. Having control of all the buildings and the surrounding infrastructure alleviates many of these concerns and supports more effective implementation.

Conclusions and Next Steps

CONCLUSIONS

This study focused on the potential impacts of AVs on the real estate and property development industry. Through interviews with developers that have a footprint in the Washington, D.C. region, this study explored the level of developer knowledge regarding AVs, the potential pros and cons of AVs to the development industry, the potential impacts of AVs on existing properties and future developments, and the role government can play in ensuring AVs are successfully adopted from a development perspective.

A number of key findings emerged from the interviews:

1. Most developers are considering AVs, but only in a general fashion. Only a minority of developers are considering AVs at specific projects. The uncertainty surrounding AVs seems to be a main reason for not considering the technology, which is a rational response given the need to meet current market demand.

2. Developers find the cost savings associated with parking and the potential for increased customer access to their sites as the most appealing benefit of AVs. There are still concerns over tenant demand for parking at big box store developments and uncertainty in regards to liability.

3. Most developers are not considering how they would retrofit, repurpose, or redevelop current properties. They are more interested in changes to future developments such as decreases in parking requirements. Some also note AV's potential to change development locations, though most do not expand to change their strategies at this time.

4. Government can play a role in AV adoption through lowering parking minimums and building out the infrastructure that AVs will require. Governments can also incentivize developers to consider AV technology and must likely do so if they expect to see developers take the lead on designing for the technology.

5. Arlington and the surrounding jurisdictions are most likely to see developers deploying AV infrastructure and including AVs in their building designs as part of larger, campus-like developments where AVs are provided as part of an overall customer service or customer experience strategy. There are a limited number of suitable development locations in the area. Local jurisdictions should consider what role they can play in building a framework that mirrors that of a "digital master plan" or other means of integrating the technology across a wider area.

LIMITATIONS

The present study suffered from a number of limitations:

1. The participants predominantly came from for-profit companies and mainly focused on commercial and market rate development. The opinions of affordable housing developers may differ but only one non-profit affordable developer was included in the study. It is impossible to generalize from the experience of this single developer.

2. There is still a significant amount of uncertainty surrounding AVs. Developers are not ready to make decisions with AVs in mind, which can be

seen in their responses. Subsequent studies could uncover better information as the future of AVs becomes more clear.

3. The participants came from various levels throughout each company, ranging from entry-level analysts to presidents and vice presidents of entire companies or divisions. It was a benefit to understand the perspective of respondents at different levels, but these individuals may not be the decisionmakers within their respective firms. Future studies should focus on and ensure that the views of those making strategic decisions are more thoroughly included.

NEXT STEPS

Subsequent research should focus on a broader section of the development industry. This could mean reaching out to more companies in this geographic region and/or companies that operate in completely new areas. Using the findings from these 17 interviews, a survey could be developed to better measure perceptions and the potential impacts of AVs in a more quantitative fashion. Case studies could also be conducted to find examples of AV deployment in larger, controlled, campus like developments, which could inspire and inform developers in the Washington D.C. region.

One participant also suggested that Arlington County hold roundtable discussions between developers, planners, transportation officials, and the broader community. These roundtables could help identify future opportunities for investments and create a better understanding of the opinions and priorities of each regional actor.

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