Emerging Technologies & the Future of Street Design
the big picture

Todd Juhasz, City of Beaverton
Karla Kingsley, Kittelson and Associates, Inc.
Mollie Pelon, NACTO
Hermanus Steyn, Kittelson and Associates, Inc.
What evolving technologies will impact street design?

Karla Kingsley
Kittelson & Associates, Inc.
Need photo of modern designed roadway – not futuristic.
Emerging Technologies are ACES... AUTOMATED CONNECTED ELECTRIC SHARED
AUTOMATED CONNECTED ELECTRIC SHARED
**Level 0**  
No automation: the driver is in complete control of the vehicle at all times.

**Level 1**  
Driver assistance: the vehicle can assist the driver or take control of either the vehicle’s speed, through cruise control, or its lane position, through lane guidance.

**Level 2**  
Occasional self-driving: the vehicle can take control of both the vehicle’s speed and lane position in some situations, for example on limited-access freeways.

**Level 3**  
Limited self-driving: the vehicle is in full control in some situations, monitors the road and traffic, and will inform the driver when he or she must take control.

**Level 4**  
Full self-driving under certain conditions: the vehicle is in full control for the entire trip in these conditions, such as urban ride-sharing.

**Level 5**  
Full self-driving under all conditions: the vehicle can operate without a human driver or occupants.
New-vehicle market share of autonomous vehicles, %

High-disruption scenario
- Conditionally autonomous
- Fully autonomous

Low-disruption scenario
- Conditionally autonomous
- Fully autonomous

- Commercial introduction by new tech players and premium OEMs
- Gradual ramp-up of manufacturing capacity by tech players
- Commercial introduction by mass-market leaders
- Availability in popular consumer models
- Technical/regulatory barriers delaying commercial-scale introduction
- Low perceived value or negative publicity following critical incidents, causing slow consumer uptake

AUTOMATED
CONNECTED
ELECTRIC
SHARED
AUTOMATED
CONNECTED
ELECTRIC
SHARED
Overtaking Lane
Electric vehicle sales will surpass internal combustion engine sales by 2038

Source: Bloomberg New Energy Finance
AUTOMATED
CONNECTED
ELECTRIC
SHARED
Photo of Chariot microtransit or low-speed shuttles.

Source:: Chariot
How Will Connected Cities/Vehicles Be Supported?

Todd Juhasz, Transportation Division Manager
City of Beaverton, OR
Small Cells Mounted on Buildings, Utility Poles and Other Infrastructure Work in Concert w/Macro Cell Sites
Anatomy of a 5G Connected City

- Macro cell (Base station - massive MIMO)
- Fixed wireless access (FWA) (beamforming)
- Small cell (Base station - beamforming)
- Smart office (Pico cell - massive MIMO)
- Smart home
- Industry 4.0
- Smart street lighting
- Smart car (SOTA)
- Fibre

Base station (Macro cell, massive MIMO) ≤ 6 GHz
Small Cell (Beamforming) > 6 GHz
SOTA (Software over the air)
Improved coverage and capacity - requirements are for 5G to support up to a million connections per square kilometer; millimeter wave, small cell and massive MIMO (multiple-input, multiple-output) technologies will help 5G support billions of connected devices.

Increased speed/throughput - 5G promises data rates of at least 10Mbps almost everywhere and up to 10Gbps in dense environments.

Reduced latency - end-to-end latency on a 4G network typically is about 50-100 milliseconds but on a 5G network it will be 1 millisecond or less.

Ultra-high reliability and availability - 99.9999 percent availability is anticipated in 5G networks.

Improved efficiency - Sharing mobile and fixed infrastructure increases efficiency and improves utilization. And base station energy efficiency is expected to increase 30-60%.
Collison Avoidance and Vehicle to Vehicle Comms Enabled w/5G
Small Cell Anatomy

**Omni Antenna**
- Pole top slimline solution
- Connects with end users
- 360 degree propagation

**UE Relay**
- Wireless backhaul solution
- Eliminates need for fiber for most sites
- Communicates with existing infrastructure

**AC Distribution**
- Control Power to the site
- On and Off Switch

**Radio Unit**
- Converts radio frequencies
- Increases network capacity
Local Examples of Small Cell Installations
Envisioning Great Cities with AV Technology

Mollie Pelon
Major shift in US cities: Singular goal of vehicular movement is giving way...
... to streets that serve many purposes.
AVs carry many promises

...what does the path look like?

Reduce traffic violence?
Decrease carbon footprint?
Free up public space?
Decrease travel costs?
Decrease vehicle ownership?
Decrease congestion?
Do “driverless” cars mean a people-less city?
1. Improving Safety Today
How do we get there?

www.nacto.org/blueprint
How do we get there? Policies

Safety is the Top Priority

20 is Plenty
Collect Better Data for Safety
Set Operating Principles that Prioritize People

Mobility for the Whole City
Create a Citywide AV
Invest in Active Modes
Collaborate Regionally to Promote Interoperability

Rebalance the Right-of-Way
Stop Expanding Roads
Take a Lane for Transit
Pavement for the People

Manage Streets in Real Time
Street Management with Data
Price the Curb
Code the Curb for Optimum Access

Move More with Fewer Vehicles
Prepare for a Future without Parking
Incentivize Electrification
Invest Strategically in Transit
How do we get there? Phasing

TODAY
PARTIAL AUTOMATION
FULL AUTOMATION
Making Automated Vehicles Work for Cities

- Design for Safety
- Move more People with Fewer Vehicles
- Data Foundations
- Coding the Curb
1. Improving Safety
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1. Improving Safety
2. Expanding Transit
2. Expanding Transit
2. Expanding Transit

- Local Bus
- Rapid Bus
- Metro or Subway
- Light Rail
- Regional Rail

Fixed Route
2. Expanding Transit

Micro-transit and Delivery

Flex Route
2. Expanding Transit

Bike Share | Microcar Share
Scooter Share

Hub-to-Hub
2. Expanding Transit

Flexible

Personal Bike | Walking | For-Hire Vehicle | Point-to-Point Car Share

Door-to-Door
2. Expanding Transit
Manage Streets in Real Time

www.SharedStreets.io
4. Coding the Curb

12 a.m - 6 a.m
6 a.m - 11 a.m
11 a.m - 4 p.m
4 p.m - 12 a.m
4. Coding the Curb

12 a.m - 6 a.m
6 a.m - 11 a.m
11 a.m - 4 p.m
4 p.m - 12 a.m
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11 a.m - 4 p.m
4 p.m - 12 a.m
Making Automated Vehicles Work for Cities

- Improving Safety
- Expanding Transit
- Sharing Data
- Coding the Curb
www.nacto.org/blueprint
Emerging Technologies & the Future of Street Design:

How might our design approach and standards change?

Hermanus Steyn, Pr.Eng., P.E.
March 6, 2018
Presentation Outline

▪ Vision
▪ Geometric Design Elements
▪ Opportunities created by Connected Vehicles and Autonomous Vehicles (CV/AV)
▪ Challenges for CV/AV
▪ Discussion
The Vision!

- Reality…

…and how will extra vehicles get into a city at the exit ramp terminal intersections?

...Does this support multi-modal objectives?
Geometric Design Elements (3 dimensions)

- **Horizontal Alignment**
  - Curve dynamics and forces
  - Horizontal offset sight distance

- **Vertical Alignment**
  - Sight distance at crests
  - Fewer issues with sags

- **Cross Section**
  - Lane width
  - Shoulders
  - Offsets to physical elements

*Geometric design is based designing for humans...*

... We apply “standards” to select design values...

... But how much do we know about the standards we use?
CV/AV Safety Benefits

- **User to user**
  - Vehicle to vehicle
  - Vehicle to pedestrian or bicyclist
  - Vehicle to motorcyclist

- **User Types**
  - Operational performance between small and large vehicles
CV/AV Safety Benefits

▪ Vehicle to roadway
  – Intersection conflicts
  – Prudent speed

▪ Land use contexts
  – Rural
  – Urban

...Creating significant opportunities to reduce the type, number, and severity of crashes...
Let’s explore how CV/AV Might Change our Practice…

Is a 499 foot radius curve substantially less safe than a 500 foot radius curve?

Nominal Safety is an Absolute

Substantive Safety is a Continuum

Crash Risk

Greater

Design Dimensions

(Lane Width, Radius of Curve, Stopping Sight Distance, etc.)

Greater
In reality, we have the chance to shift the continuum...
CV/AV affects on Multi-modal Geometric Design

- The impending evolution in Geometric Design

- Consistency (not safety)
- Designing for *humans*
- Designing for *vehicles*

  - Stopping Sight Distance
  - Horizontal Sight Distance
  - Lane Widths
  - Roadside
CV/AV affects on Multi-modal Geometric Design

- Stopping Sight Distance
  - Reducing break reaction time

\[ SSD = 1.47Vt + 1.075 \frac{V^2}{a} \]

where:

- \( SSD \) = stopping sight distance, ft
- \( V \) = design speed, mph
- \( t \) = brake reaction time, 2.5 s
- \( a \) = deceleration rate, ft/s\(^2\)

...Reduced reaction time means shorter distances....
CV/AV affects on Multi-modal Geometric Design

- **Horizontal Sight Distance**
  - No straight line of sight needed

...Objects closer to the roadway...

...Stronger land use integration...

...Less right-of-way needs...

Source: AASHTO Green Book Figure 3-23
C/AV affects on Multi-modal Geometric Design

- **Current Lane Widths**
  - Guidance: 9-12 feet
  - Maneuvering space
  - Buffers between users

- **Future Lane Widths?**
  - Less buffer between vehicles?
  - Do we need recovery areas?
  - Buffers between motorized users?

...Less pavement and less drainage?

...More space for non-auto users.

...What about large trucks?

Source: Kittelson & Associates, Inc.
C/AV affects on Multi-modal Geometric Design

- **Current Roadside Design**
  - Clear zone
  - Recovery area
  
  Protecting vehicles from objects or other vehicles

- **Future Clear Zone?**
  - Need for guardrail and attenuators?
  - Steeper cut/fill slopes?
  - Trees closer to the roadway?

Source: AASHTO Roadside Design Guide Figure 10-1
Adapting to non-motorized users of all types

▪ Vulnerable Users:
  – Pedestrians
  – Young
  – Older
  – Special needs
  – Bicyclists

▪ Challenges
  – Inconsistent and unpredictable user behavior
  – CV/AV detecting variable behavior

Source: Kittelson & Associates, Inc.
Adapting Temporary Traffic Control Conditions

- Work zone signing
  - Placement consistent with permanent devices
  - Advance warning of non-standard conditions
  - Using flaggers

- Temporary Pavement Markings
  - Completely removing existing markings is needed to avoid conflicting messages

...these conditions are often difficult for actual drivers...
...they could be especially challenging for CV/AV...
Other Transitional Considerations

- Redundancy to support CV/AV
  - Markings not visible due to weather
  - Inadequate reflectivity
  - Poor wireless and/or satellite signal

- Magnetic particles in markings?
1: Major Transit Street/Multiway Boulevard – Intersection of 162nd and Stark Street, Portland
Karla Kingsley, Hermanus Steyn and Michael Corrente

2: Major Transit Street/Downtown Street – Broadway and 6th Avenue, Portland
Denver Igarta and Radcliffe Dacanay

3: Multiway Boulevard – Intersection of Farmington Rd and Murray Blvd, Beaverton
Todd Juhasz, Anna Slatinsky and Erin Wardell
Phase 1 – Present

Automated features continue to improve and become less expensive, while car ownership declines.

Phase 2 – Five years from now

Fully autonomous vehicles are on the market, but AV and legacy vehicle mix results in uneven traffic improvements.

Phase 3 – Ten years from now

Fully autonomous vehicle are on the market, but AV and legacy vehicle mix results in uneven traffic improvements.

Phase 4 – Twenty years from now

Land use planning is permanently altered to make way for pedestrians, cyclists, and public spaces, in both urban and suburban streets.
reflect back discussion

What themes emerged?

How can we use what we learned today to influence how emerging technologies influence safe, green, people oriented street design?