

TRANSPORTATION RESEARCH BOARD

Advancing Innovative Automated Vehicles and Shared Mobility Research

November 9, 2020

@NASEMTRB
#TRBwebinar

PDH Certification Information:

- 2.0 Professional Development Hour (PDH) – see follow-up email for instructions
- You must attend the entire webinar to be eligible to receive PDH credits
- Questions? Contact Reggie Gillum at RGillum@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Providers Program. Credit earned on completion of this program will be reported to RCEP. A certificate of completion will be issued to participants that have registered and attended the entire session. As such, it does not include content that may be deemed or construed to be an approval or endorsement by RCEP.



REGISTERED CONTINUING EDUCATION PROGRAM

#TRBwebinar

Learning Objectives

1. Identify innovative research methods used in the private and public sectors
2. Discuss how to apply these approaches and methods

#TRBwebinar





Innovative Research Methods in Public and Private Sectors

(or, How to Do It Faster)

Dr. Katherine Kortum
Transportation Research Board



Public, private, and research organizations discuss critical issues for deployment of AVs and shared mobility. Identify and facilitate research for policies so that deployments happen how and when they will:

- Increase safety
- Reduce congestion
- Enhance accessibility
- Increase environmental and energy sustainability
- Encourage economic development and equity

Workshop: May 3, 2019

In coordination with TRB's Conduct of Research Committee, answer this:

In an era of rapidly evolving transformational technologies, **can research projects and processes provide needed answers in a timely manner while still protecting the credibility of research, and if so, how?**



Getting It First vs. Getting It Right

November 7, 2000



Getting It First vs. Getting It Right

- What is the ultimate research objective?
 - What is the urgency?
 - What is acceptable risk?
 - How much evidence will we need to move forward?
 - What are the barriers?
 - Can we provide transparency and balance stakeholder influence?
 - Can we ensure that the research results are objective, without necessarily being neutral?
- 

In General

- As with any project, **management matters**
- Constantly build and nurture support from leadership
- Constantly seek any and all opportunities to reduce administrative burdens
- Test rapid response models used by others (e.g., National Science Foundation)



Typical Research Lifecycle



Identify Research Priorities

- **Dynamic research roadmaps** for priorities and individual problem statements
 - **Scenario planning** for emerging needs
 - **Continuous calls** for proposals
 - Continuous and **visible approaches** (e.g., a research needs dashboard)
 - Input to understand “**real world**” needs
 - **Meta-analyses** of research done on a policy topic, targeted to specific audiences
- 

Problem Statements

- Pursue strategic level research—focus on broad research program areas rather than on individual discrete projects
- Align the need for more applied research with desired objectives and outcomes
- Clearly define the objective of the research at the outset of each project
- Break research questions into small pieces/phases



Research Project Selection

- Prioritize and select individual discrete projects from broader program areas or roadmaps
- Balance larger, complex projects with other smaller and shorter projects



Contracting

- Prepare Requests-for-Proposals (RFPs) that focus more on the outcomes rather than on prescribed, specific research processes
 - Consider relying on Requests-for-Qualifications (RFQs) as opposed to RFPs
 - Prequalify contractors in subject areas
 - Use indefinite delivery/indefinite quantity contracts
 - Award projects with shorter phases
- 

Conducting the Research

- Accomplish tasks in parallel, not in series
- Provide researchers and staff with flexibility to achieve the desired outcomes
- Use interim reporting periods to determine if directional changes are needed
- Enforce deadlines
- Avoid scope creep



Conducting the Research

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YES, I KNOW.



Publication

- Release phased results as they are completed
- Release interim results and/or pre-publication findings in advance of final editing. **It doesn't always have to be pretty.**
- Partner with public affairs and communications experts to package the findings for specific audiences



Implementation

- Include technology transfer as an integral part of the research project life cycle
- Take advantage of scheduled field tests and demonstrations when scheduling and designing research projects
- Use pilot projects to test “laboratory” results
- Use stakeholders and partners to deploy results



Peer Review

- Standing pools of peer reviewers
- Peer review research in phases
- Enforce deadlines



Peer Review

- Standing pools of peer reviewers
- Peer review research in phases
- Enforce deadlines **YES, I KNOW.**



Collaboration Across Sectors

- Work with universities to attract the best and brightest into the transportation profession.
- Address misperceptions on “duplication” of transportation research. In transportation there are rarely enough resources to validate earlier research.



Collaboration Across Sectors

- Work with universities to attract the best and brightest into the transportation profession.



Collaboration within state DOTs

- Build and/or enhance relationships between research office and other divisions to share research efforts across the agency
 - Develop processes for state DOT research offices to work with other divisions to identify and address emerging issues on an ongoing basis
 - Prepare divisions DOT-wide for the implementation of research results
 - Inspire all state DOT research offices with a sense of responsibility for policy research
- 

Reduce competition

- Form advisory groups and engage them frequently
- Use confidentiality agreements to facilitate the sharing of data
- Pursue collaboration through tools such as pooled fund studies and shared research roadmaps



Communicate

- Communicate accurate research results with the media and general public
 - Work closely with public affairs and communications experts
 - Target results packages to specific audiences
 - Ensure communications experts' messages are accurate



Communicate

- Communicate across media and generations
 - Work closely with communication
 - Target results
 - Ensure communication accurate



Results with the
and
specific audiences
messages are





trb.org/AVSMForum

E-Circular 253. Transformational Technologies in
Transportation: Impacts on Traditional Research
Processes and Programs (October 2019)

Katherine Kortum (kkortum@nas.edu)

Future of Mobility - How autonomous vehicles will impact cities across the globe

Autonomous mobility: First (over)hype, now skepticism

In 2017

“

Fully self-driving cars are here

-John Krafcik, Waymo CEO

“

There's going to be no steering wheel. There's not going to be a gas pedal. There's not going to be a brake pedal...

-Mark Fields, ex-Ford CEO

“

GM will deploy its fully driverless cars, without steering wheel or pedals, for commercial ride-hailing use as early as 2019

-GM Company Releases

In 2019

“

It's really, really hard...Autonomy always will have constraints

-John Krafcik, Waymo CEO

“

We overestimated the arrival of autonomous vehicles

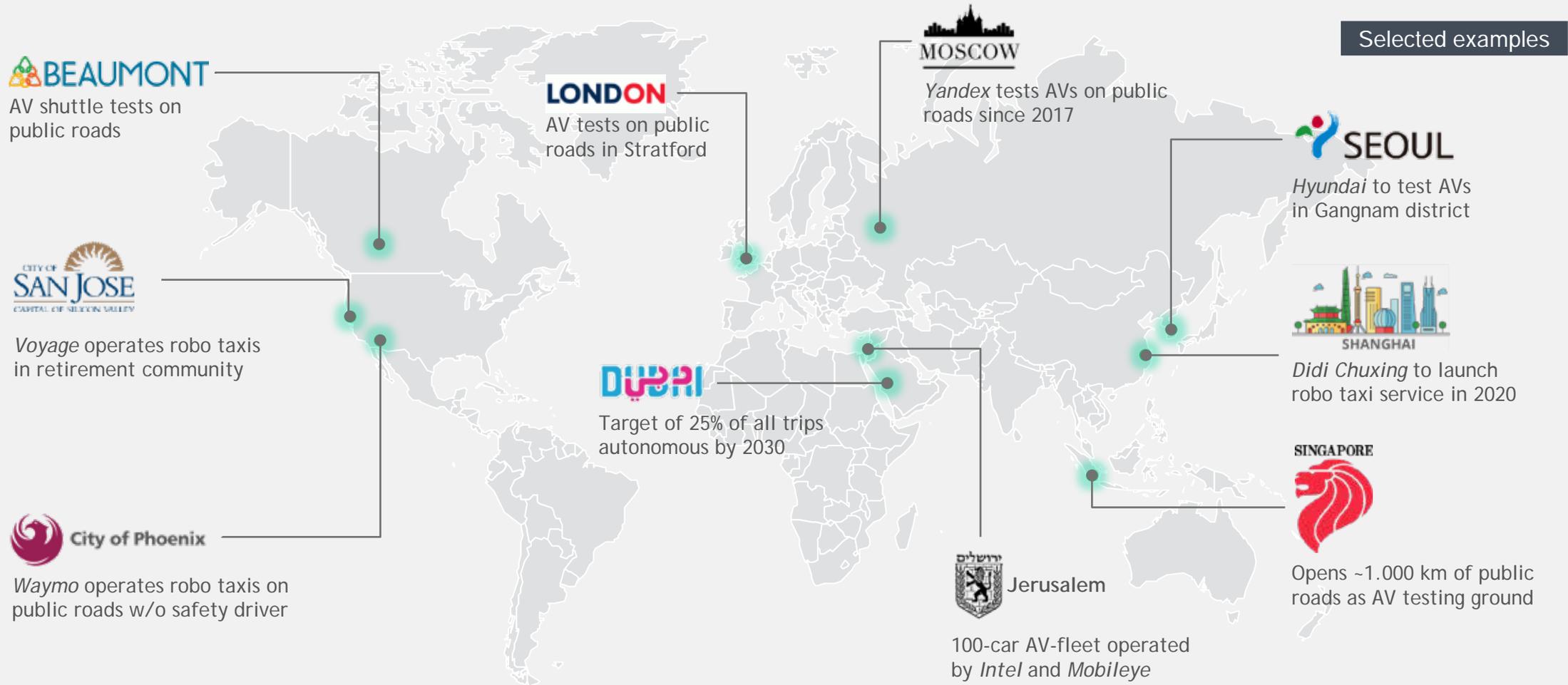
-Jim Hackett, Ford CEO

“

There's quite a bit more work to do on Level 3....we're not quite there yet

-Artur Seidel, VP at Elektrobit (Continental)

Many cities already testing autonomous mobility



Key objective of this study

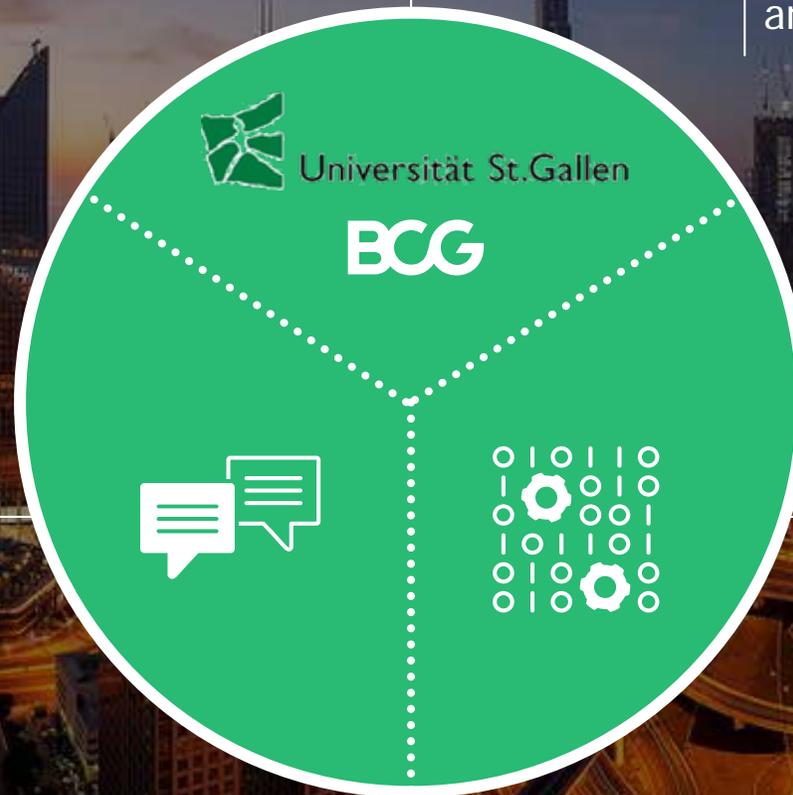


What impact does the implementation of autonomous vehicles have on cities in future?
Based on a distinct set of KPIs



Three sources leveraged for joint research project

Existing IP, research, and insights from one of the world's leading universities and strategy consultancies



Insights from 30+ qualitative interviews with industry experts, policy makers and researchers

Big data travel demand model simulating more than 1.7 billion daily trips in total



Interviews: AMoD success will depend on players navigating multiple challenges



Key success factors

- 100%** say that AMoD operators will need to closely **collaborate with city governments**
- 90%** think an AMoD-friendly **infrastructure** must be in place (separate AV lanes, smart signals, kerb space management)
- 85%** believe a **legal** framework is essential early on to ensure a smooth transition from conventional traffic to AMoD



Potential roadblocks

- 80%** believe that **acceptance can be a barrier** if citizens are not involved with AMoD integration
- 64%** think that a lack of **technological standards** could significantly slow down AMoD adoption
- 60%** say **safety** will be a key criterion for AMoD operators, with poor safety significantly increasing the risk of failure



Required capabilities

- 87%** think cities will need to acquire **data analytics capabilities** if they are to properly orchestrate urban transport systems in future
- 70%** believe that AMoD needs to be **seamlessly integrated** into the **public transport network**
- 45%** expect **technology companies** will be the first operators of AMoD



Simulation: Complex model developed to determine impact of AMoD

Input



City archetypes (city size, density, current modal split, ...)



Future modal split (based on WEF study and on distinct drivers per city archetype)

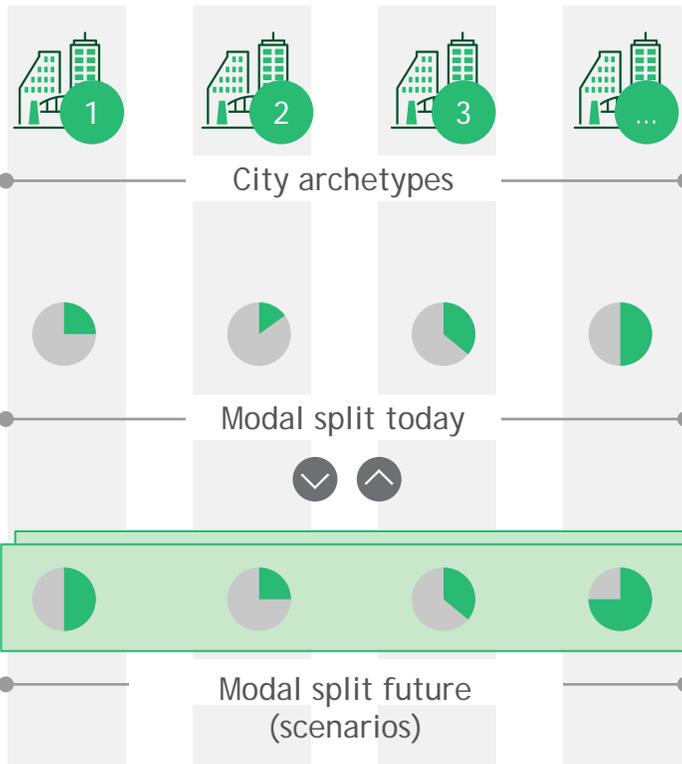


Robo-vehicle types (costs, energy consumption, ...)



Further assumptions (parking space, speed dependency on congestion level, ...)

Simulation



Simulate modal split today vs. future for each city archetype, run different hypothetical scenarios

Output

Per archetype:



Mobility Index (comparing KPIs today vs. future, e.g. journey time, fatalities)

Across archetypes:

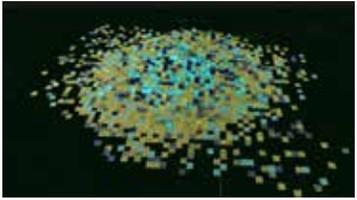
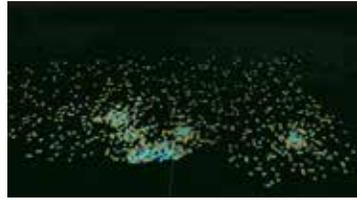
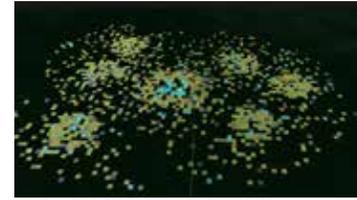
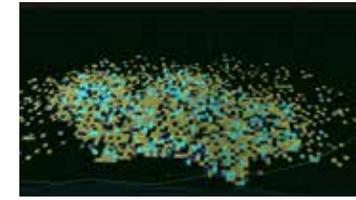
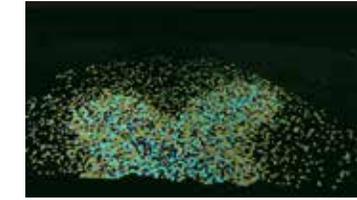


Which cities **benefit most** from AMoD integr. along scenarios



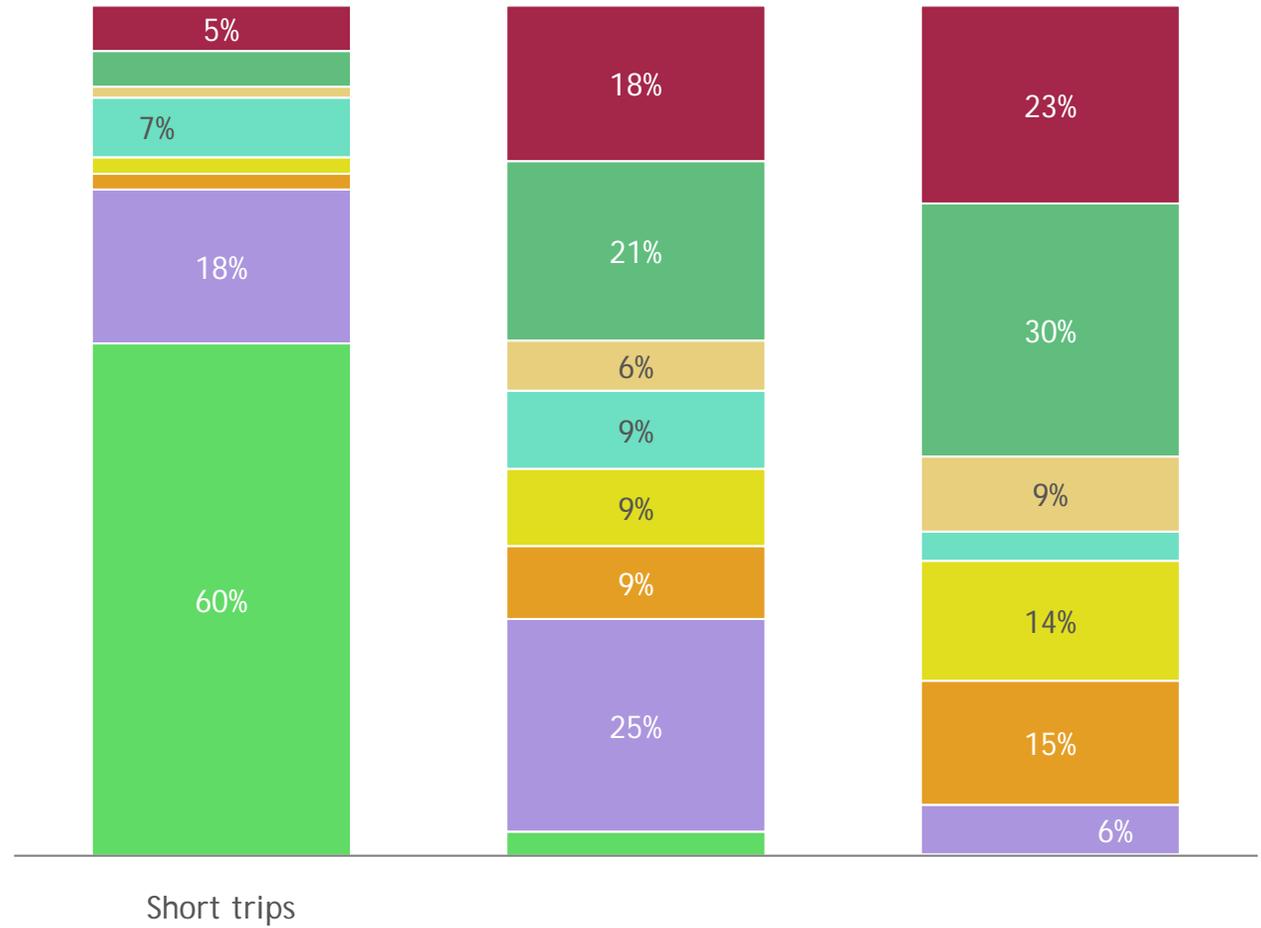
What are concrete **recommendations** for cities and stakeholders? (qualitative analysis)

5 city archetypes derived from data of >40 global metropolises

					
	The high-compact middleweight	The car-centric giant	The prosperous innovation center	The developing urban powerhouse	The high-density megacity
Examples	Berlin, Seattle	Los Angeles, Toronto	London, San Francisco	Bangkok, Buenos Aires	New York City, Shanghai
Size ¹	<2,000 km ²	3,000 - 6,000 km ²	4,000 - 8,000 km ²	3,000 - 6,000 km ²	6,000 - 13,000 km ²
Population ¹	<5 M	3-7 M	2-8 M	7-15 M	15-27 M
Topography	Inland with central river or on a coast Highly compact area	Natural boundary Dispersed area Widely distributed small hubs	Next to a river or on a coast Several medium-density "towns"	Typically on a coast Dense cluster along a natural boundary	Typically on a coast or alongside a river Large central dense cluster & "satellites"
Simulation result					

1. Includes urban area and periphery; outliers possible
Source: BCG analysis

8 different mobility options considered for simulation





Future base case modal split for each archetype estimated with 20-30% AV share



The high-compact middleweight



The car-centric giant



The prosperous innovation center

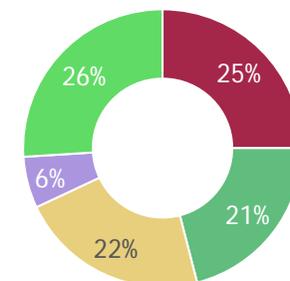
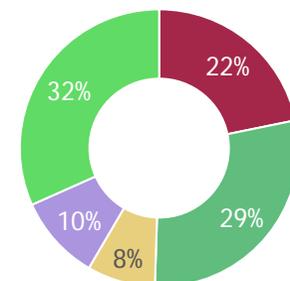
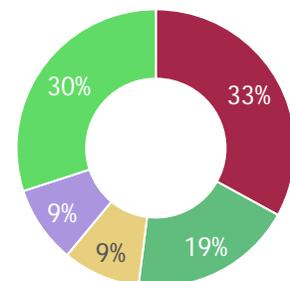
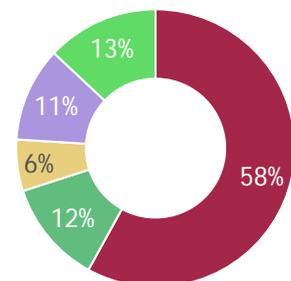
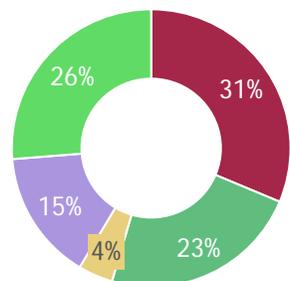


The developing urban powerhouse

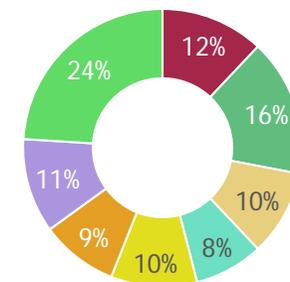
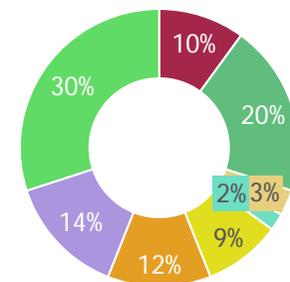
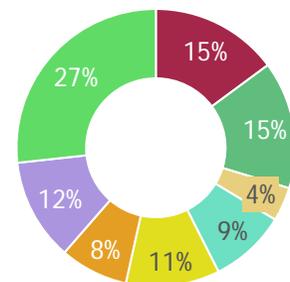
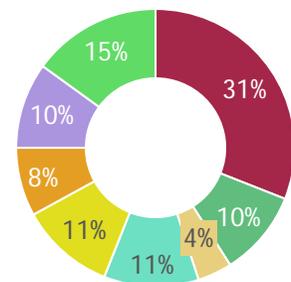
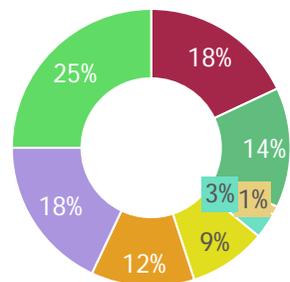


The high-density megacity

Current modal split "base case"



Future modal split "base case"



■ Private Car
 ■ Public Transit
 ■ Taxi / Ride hailing
 ■ Robo-pod
 ■ Robo-taxi
 ■ Robo-shuttle
 ■ Micromobility
 ■ Walking



Simulation insights: Improvement along all six KPIs observed

Current modal mix "base case" today vs. future modal mix "base case"



Traffic volume



Decreases as people either switch to smaller vehicles or vehicles with higher occupancy



Annual fatalities



Most traffic accidents are based on human errors and involve private cars - heavily reduced by AV's and other modes of transport



Energy consumption



Shift to more efficient electric vehicles, the increase of shared mobility modes, and the rise of micromobility, which consumes little energy



Total parking area



Shift away from private cars towards increased usage of shared autonomous vehicles and micromobility require much less parking space



Transportation cost



Today's taxi rides and private cars are the most expensive transport modes; due to driverless taxis and sharing the price per trip will decrease



Avg. journey time



Reduced traffic volume and more flexible journeys as multi- & intermodal usage of different transport modes increases

Future urban
mobility could
take different
paths...





Shift from private cars to non-AV modes

Cities restrict the use of private cars in city centers and encourage green modes; AVs are still in their infancy

Public transit 
Micro-mobility
Private cars 
AV modes



4
future
Scenarios
developed



Strong push for robo shuttles

Cities promote larger semi-flexible robo shuttles (up to 15 PAX), a hybrid between mass transit and more personal transport modes

 Robo Shuttles
 Robo Pods

Dominance of micro-mobility

Cities promote the use of micro-mobility options such as e-scooters, bikes, and e-bikes and other green shared modes

Micro-mobility 
Private cars 
AV modes



Strong uptake of robo pods

Cities promote small flexible robo pods (up to 2 PAX) because they provide on-demand travel while also accounting for individual preferences

 Robo Pods
 Robo Shuttles



The mobility index gives an overview of the model's results



The high-compact middleweight



The car-centric giant



The prosperous innovation center



The developing urban powerhouse

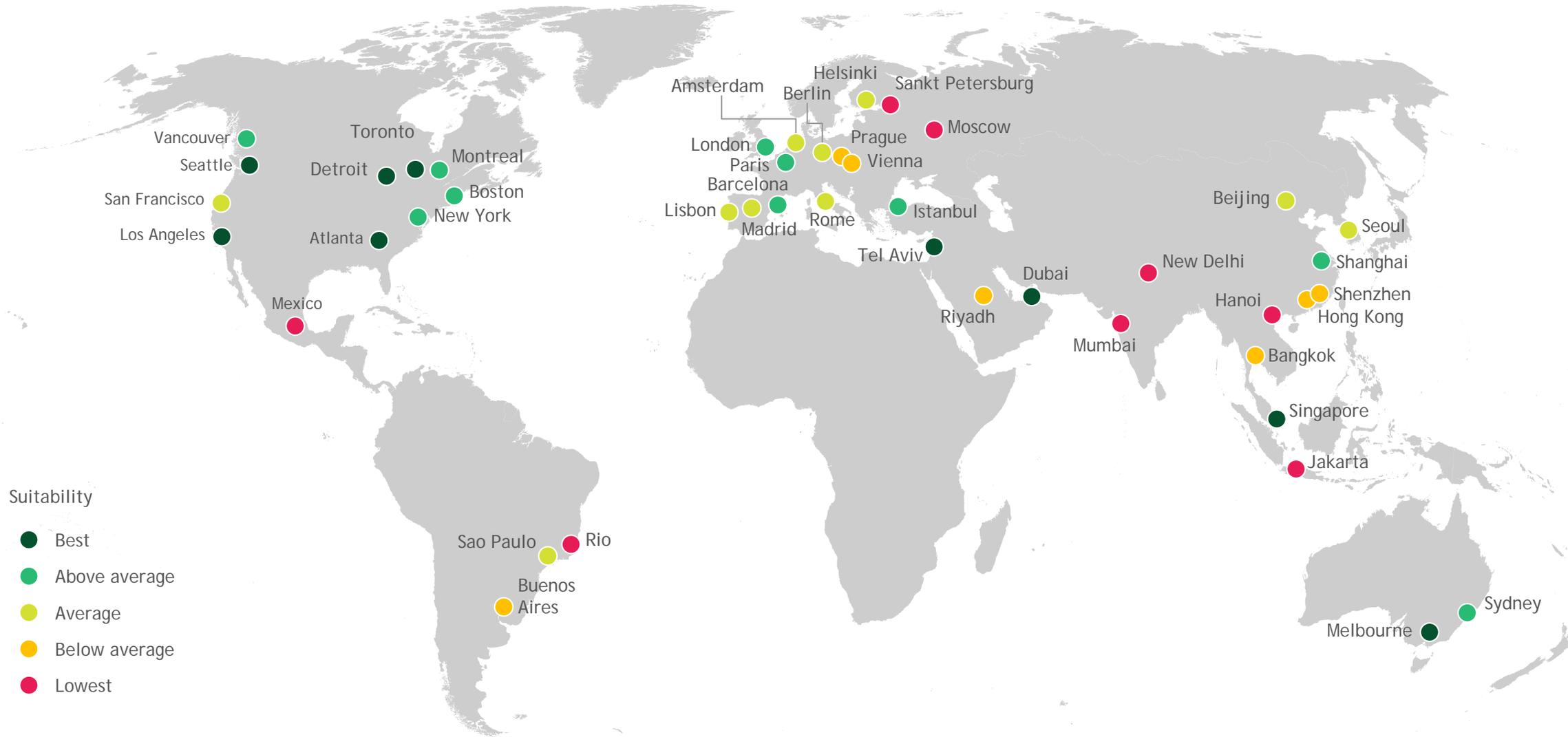


The high-density megacity

	The high-compact middleweight	The car-centric giant	The prosperous innovation center	The developing urban powerhouse	The high-density megacity
Future base case scenario	7	0	25	28	37
Shift from private cars to non-AV modes	82	42	67	67	46
Dominance of micro-mobility	71	19	61	84	74
Strong push for robo shuttles	66	71	75	76	100
Strong uptake of robo pods	18	20	22	20	37



AMoD suitability assessed for 44 metropolises across the world





Cities gain significant real-world benefits by choosing the best-case scenario



The high-compact middleweight



The car-centric giant



The prosperous innovation center



The developing urban powerhouse



The high-density megacity



Saved annual household budget in Berlin



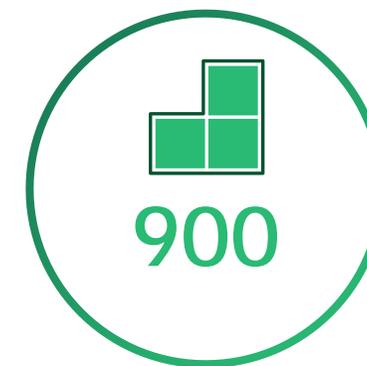
Metric tons of CO₂ emissions avoided p.a. in Los Angeles¹



Less annual traffic-related fatalities in London



Hours saved in traffic per commuter p.a. in Hong Kong



Freed-up blocks in terms of public space in New York City

1. This excludes additional effects from electrifying public transit, taxis, and private cars; mt = metric tons
Source: BCG analysis

Key takeaways



Each city is different - there is no "one size fits all" approach for the future of urban mobility



Autonomous mobility on demand - if shared - will massively improve the mobility situation, esp. for highly congested megacities



But also pushing both active mobility & public transit is highly beneficial for compact cities with good existing public transit infrastructure



Creating seamless intermodal connections between different mobility modes incl. first & last mile and incentivizing public acceptance of new mobility are key



Whatever the desired target scenario for a city will be, public-private partnerships need to be established to create a sustainable mobility ecosystem



Please reach out to us if you want to learn more



CENTER FOR
Mobility Innovation

Next steps in piloting the most appropriate and promising approaches

Alex Lybarger – Assistant Director of Advanced Mobility
Transportation Research Center Inc. (TRC Inc.)

TRB Webinar

Advancing Innovative Automated Vehicles and Shared Mobility Research

November 09, 2020, 01:00 PM - 03:00 PM

*“AVs—**if developed properly**— have the potential to make our roadways safer by reducing crashes caused by human error,…”*

National Science & Technology Council, U.S. Department of Transportation, *Ensuring American Leadership in Automated Vehicle Technologies, Automated Vehicles 4.0*, January, 2020.

History of Vehicle Technology

1950 - 2000

Cruise Control
Seat Belts
Antilock Brakes

2010 - 2016

Rearview Video Systems
Automatic Emergency Braking
Pedestrian Automatic Emergency Braking
Rear Cross Traffic Alert
Lane Centering Assist

2025+

Highway Autopilot

2000 - 2010

Electronic Stability Control
Blind Spot Detection
Forward Collision Warning
Lane Departure Warning

2016 - 2025

Lane Keeping Assist
Adaptive Cruise Control
Traffic Jam Assist
Self-park

<https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety>

New Roadway User, New ITS Technologies.



The introduction of a new driver!



Source – U.S. Department of Transportation

New Infrastructure!



THEA CV Pilot, Pedestrian Crosswalk Warning.

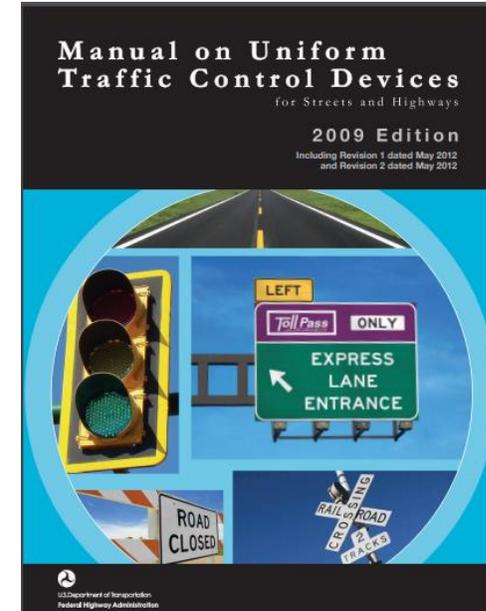
Roadways – Evolved through time!

- Infrastructure.
- Evolved over time.
- Designed for humans.



Source – Charlotte, NC. Source FHWA: Complete Streets

What happens when traditional and “new” roadway users navigate a shared space?



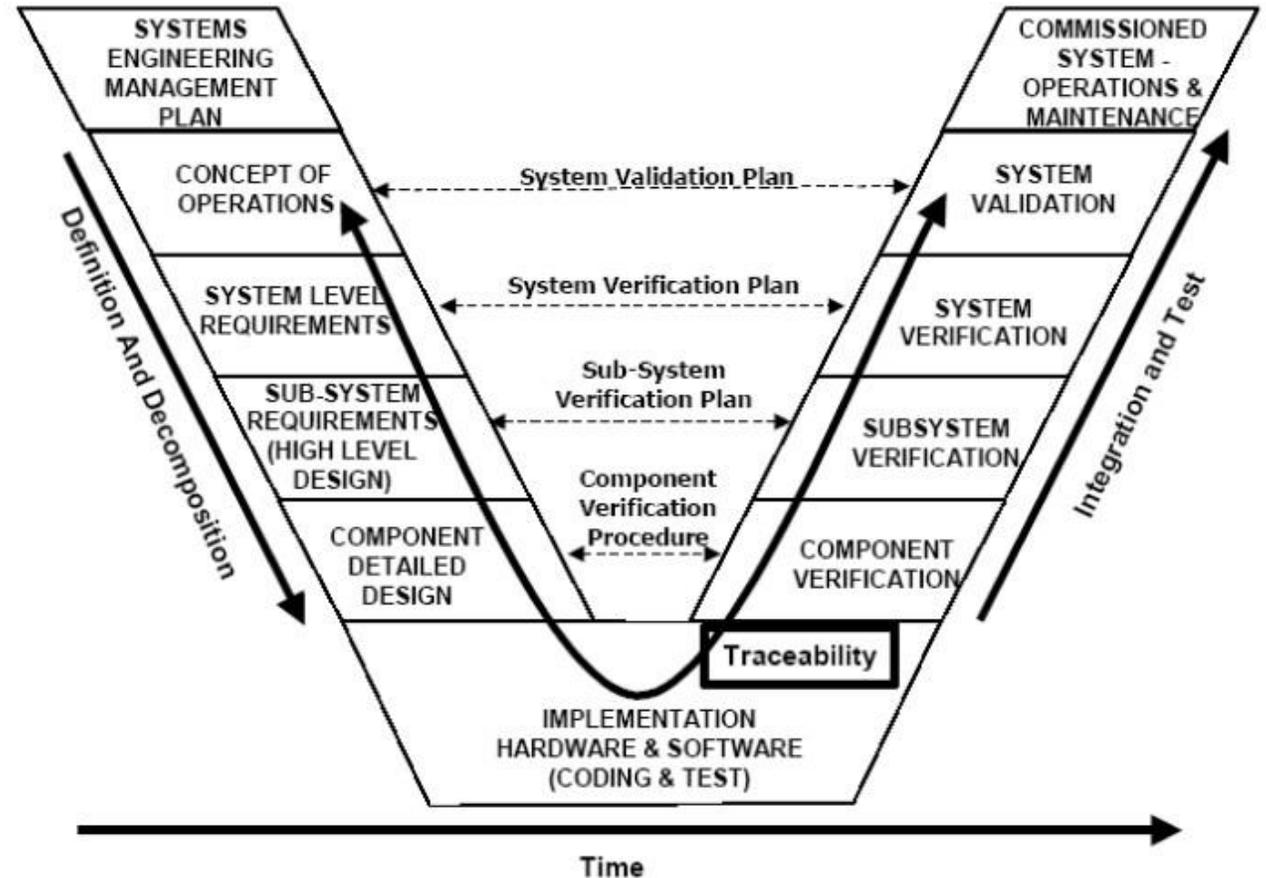
History of MUTCD

Early 1900s – 1935: First Steps
1935 – First MUTCD Published.
1935 – 2010s – Evolution.
Current – 2009 MUTCD with Rev 1 and Rev 2, May 2012.

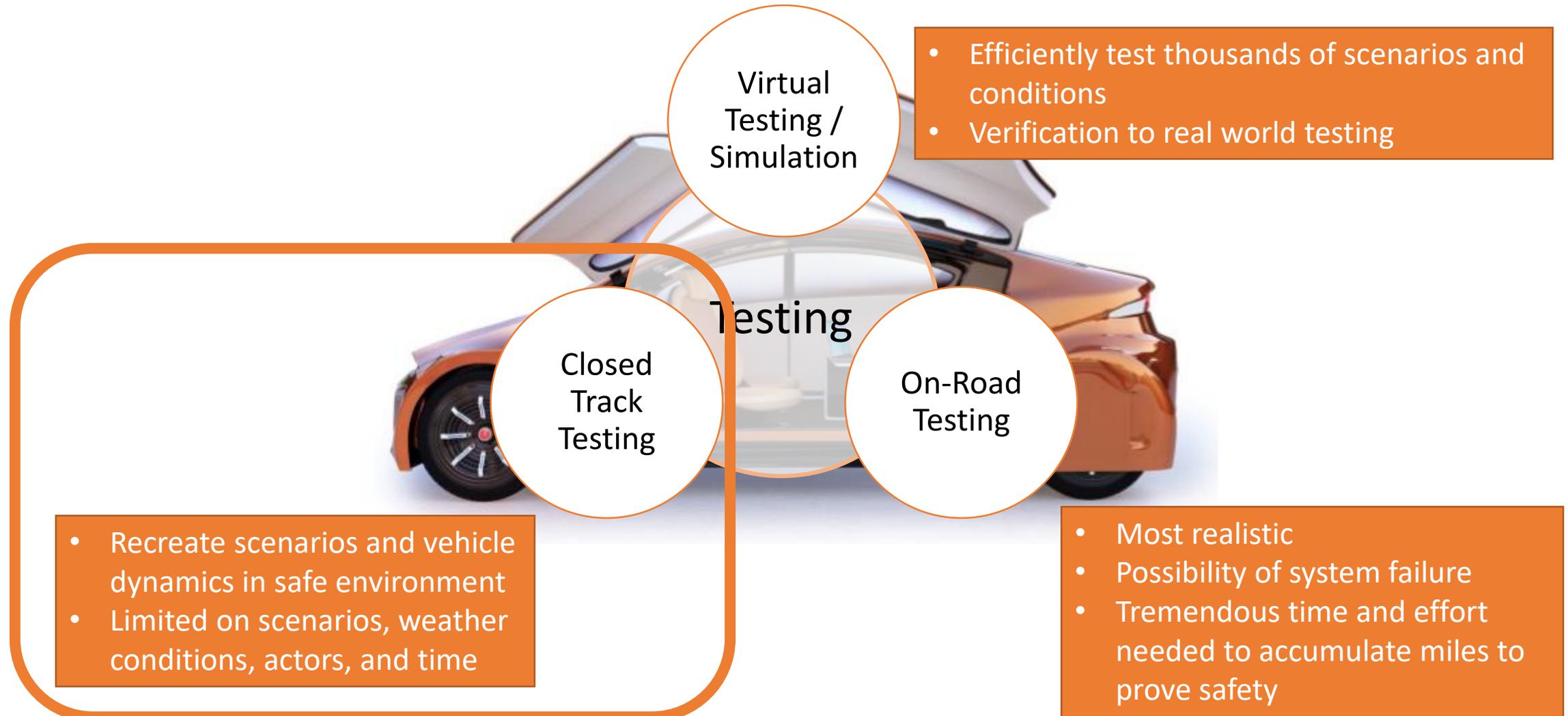
MUTCD, 2009 Ed., FHWA.

Development Process Changes

- No longer Linear
 - V-Model -> W-Model
- Iterative Approach
- Blended Approach



Evaluation Approaches



TRC Inc. Facilities and Services



Road Performance Evaluation



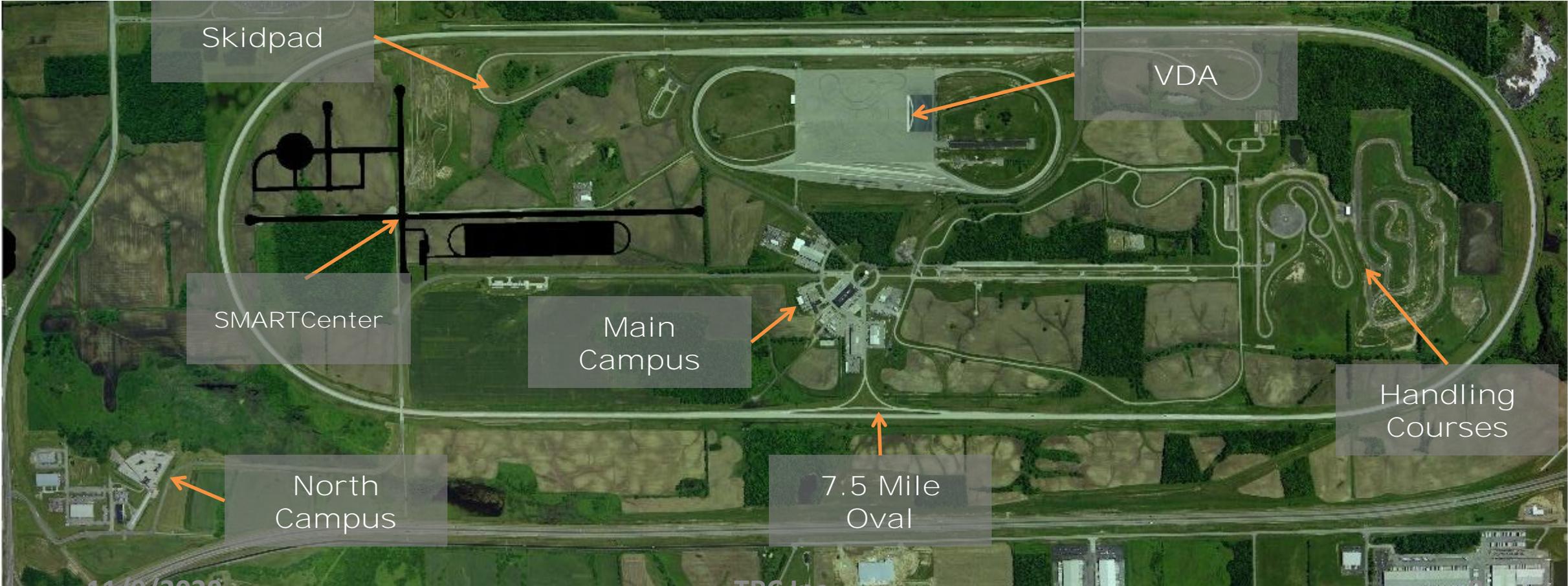
Laboratory Evaluation



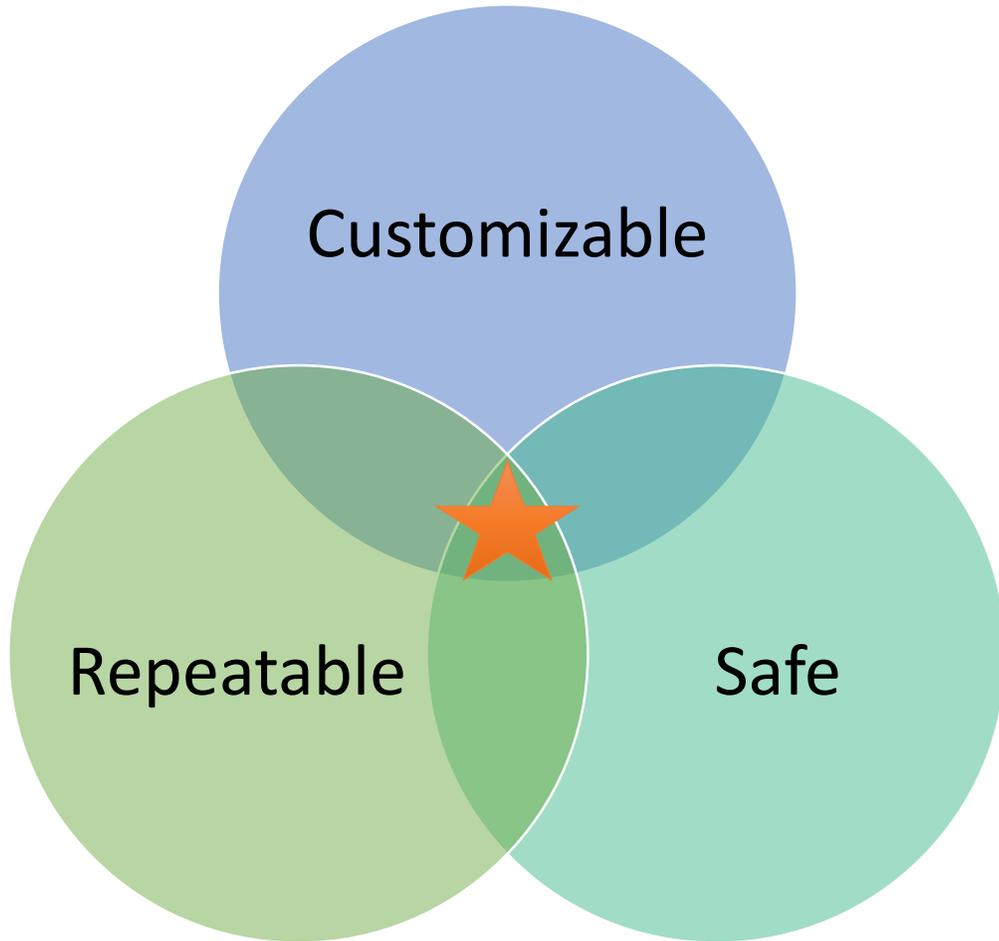
Advanced Mobility



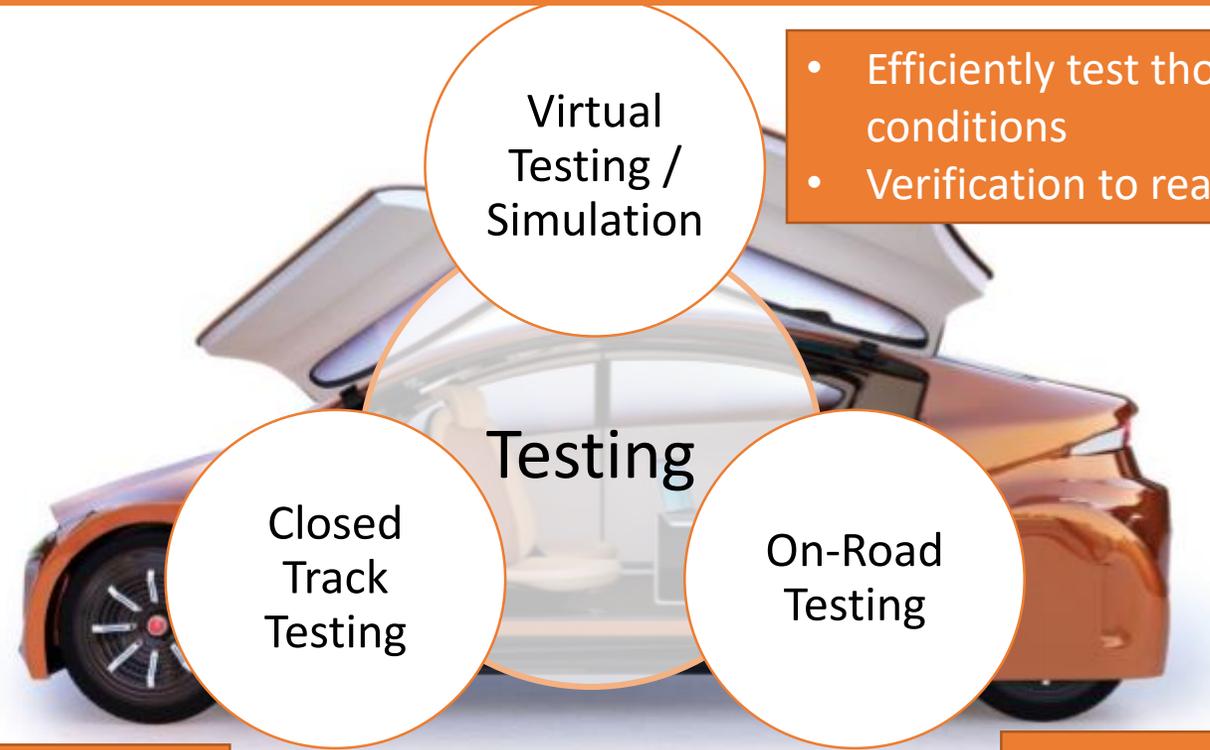
Technical Services



TRC Inc. SMARTCenter



Evaluation Approaches

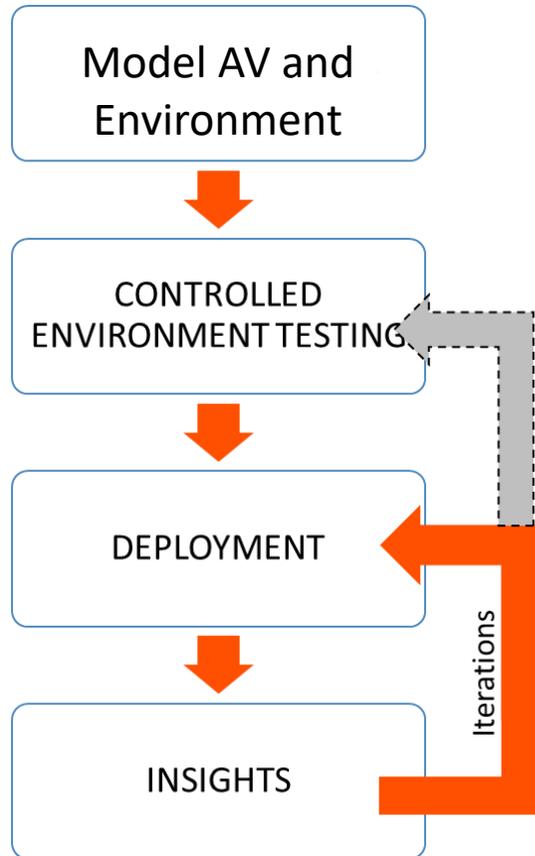


- Efficiently test thousands of scenarios and conditions
- Verification to real world testing

- Recreate scenarios and vehicle dynamics in safe environment
- Limited on scenarios, weather conditions, actors, and time

- Most realistic
- Possibility of system failure
- Tremendous time and effort needed to accumulate miles to prove safety

Method for AV Evaluation



Step 1 - Understand the “Job”

Step 2 - Configure your “tool”

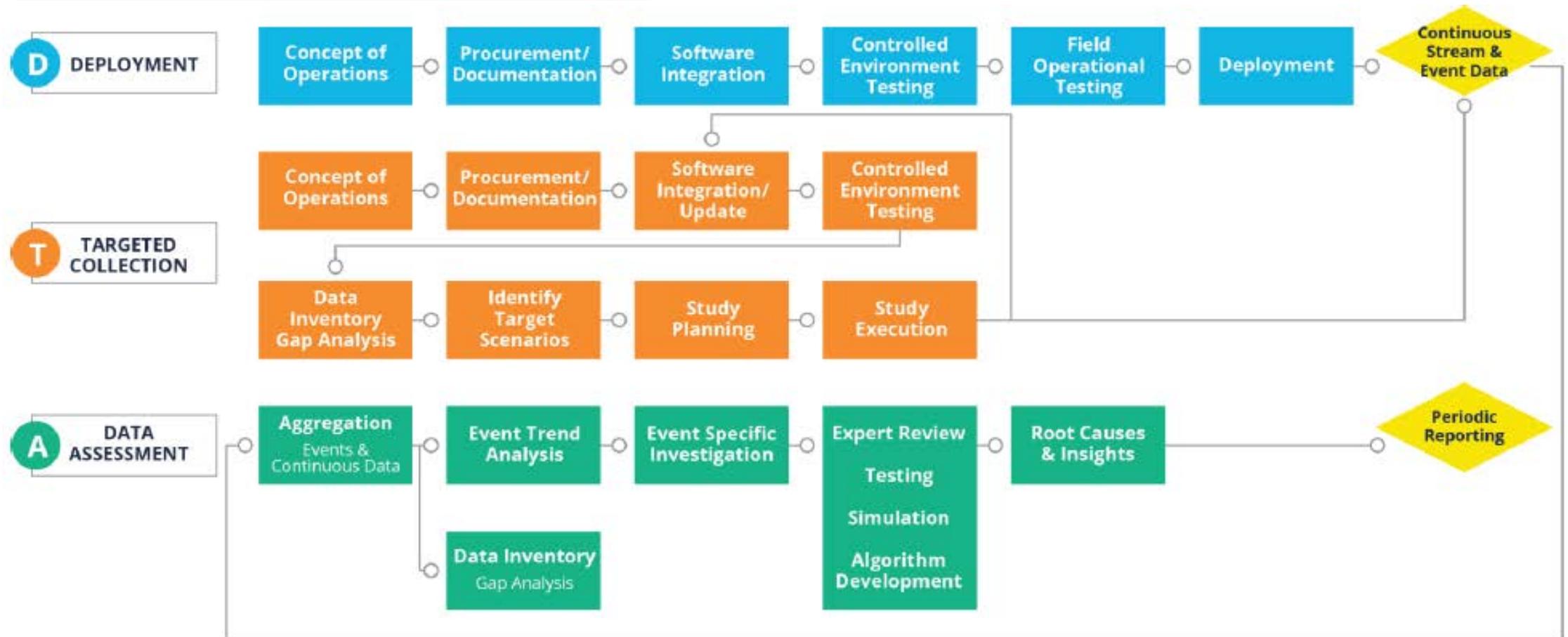
Step 3 - Trials (Controlled Environment)

Step 4 - Deploy. Learn. Update. Iterate.



Project - D.A.T.A. in Ohio

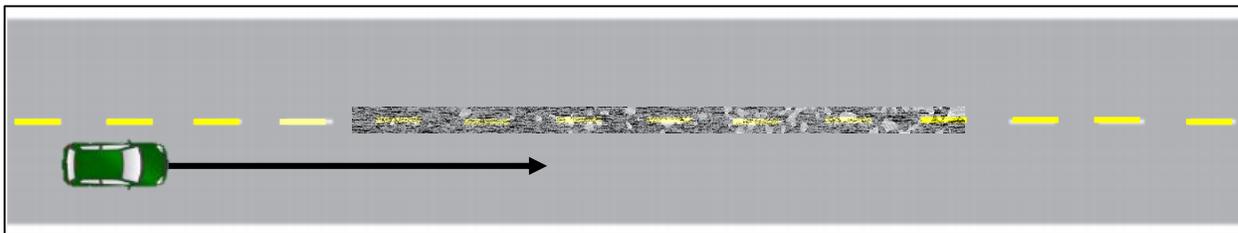
Iterative Deployment Concept



Project – ROADMAP

Performance of Production (L1-2) in Rural Environments

- Scenario - An AV encounters gravel covered lane lines, on a two-lane bi-directional road.
- Executed test scenarios in a controlled environment



Two Lane, Bi-directional Road

Sector 1 – Good lane lines

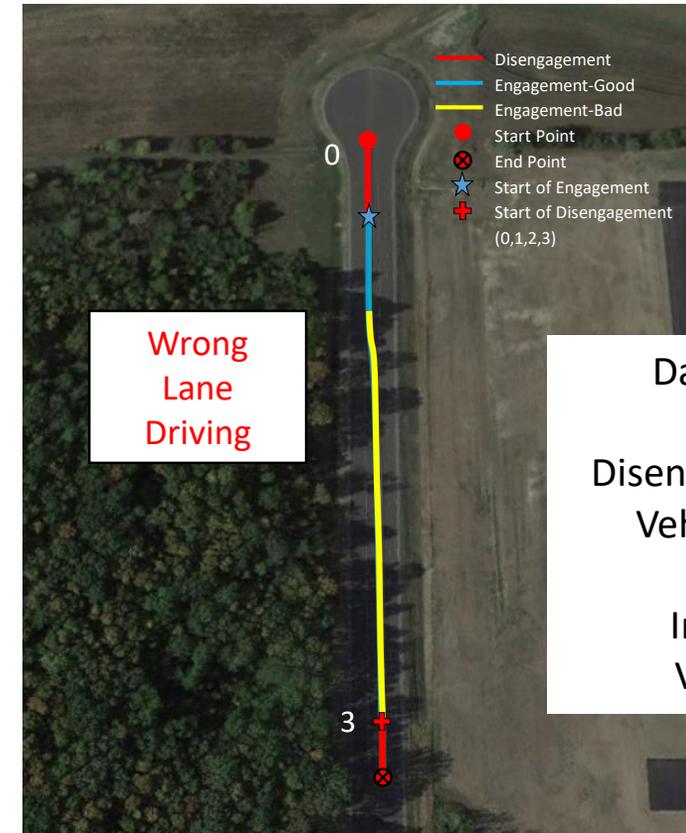
Sector 2 – Gravel covers lane lines

Sector 3 – Good lane lines

A sample of ADS/Infrastructure Insights

- AV performance linked to Infrastructure elements.
- Controlled Environment Testing as a part of AV Deployments produce insights.
- Insights can help evaluate possible infrastructure solutions

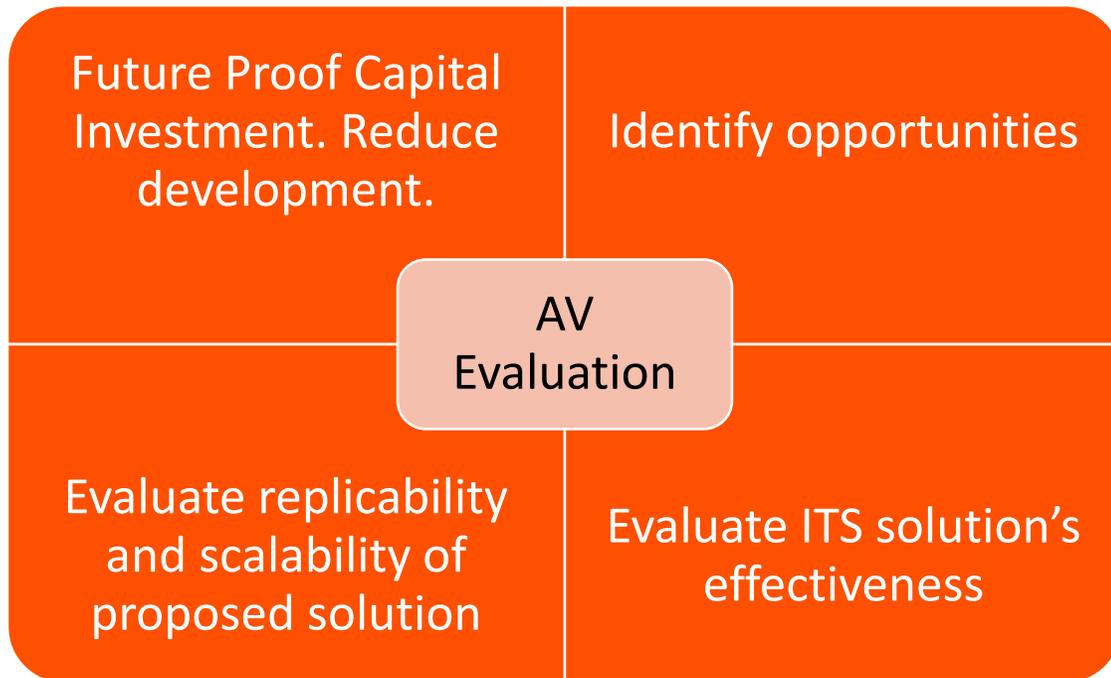
Map based Insights



AVs and Infrastructure

Well structured AV Evaluation -> Insights -> Convergence of AVs and Infrastructure

- Integrated AV Evaluation is a powerful, and configurable tool.



- Both the AVs and Infrastructure landscape is evolving



Q&A

Contact Information

Alex Lybarger

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LybargerA@trcpg.com

Collaborations for Deployment and Evaluation: Some Perspectives from the Las Vegas Ecosystem

Advancing Automated Vehicles Webinar

Shashi Nambisan, Ph.D., P.E.

Director, Transportation Research Center

Professor of Civil Engineering

Transportation Research Board

Washington, DC

November 09, 2020

UNLV Transportation Research Center

Las Vegas Metropolitan Area

- Resident Population: ~ 2.3 million

- Annual Visitors: ~43 Million

Key Public Sector IOOs

- Nevada DOT

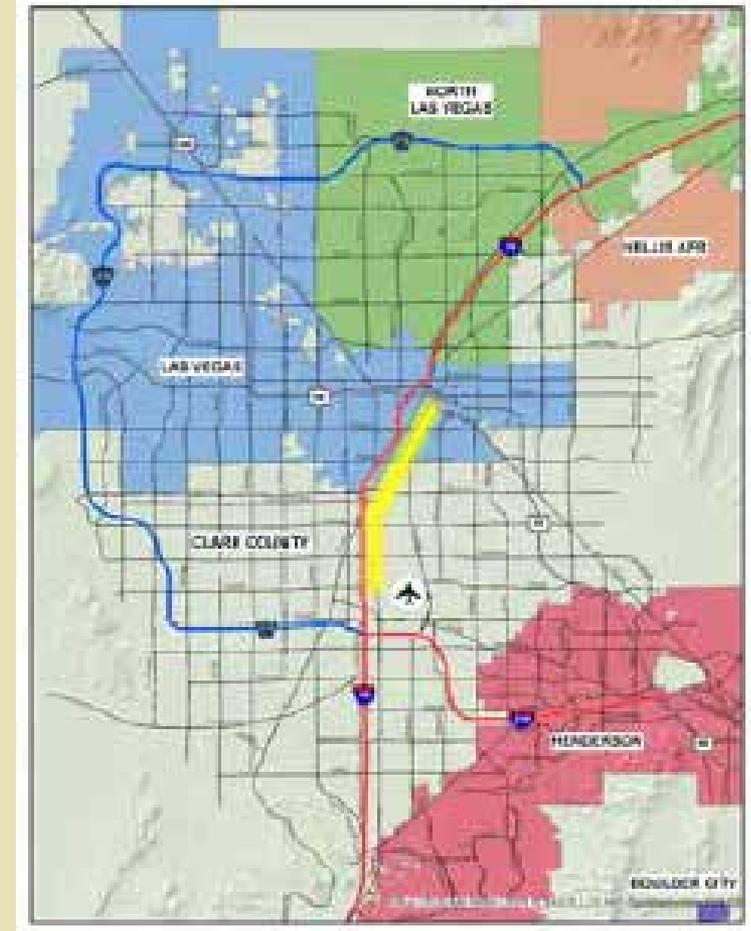
- RTC of Southern Nevada

- Clark County

- City of Henderson

- City of Las Vegas

- City of North Las Vegas



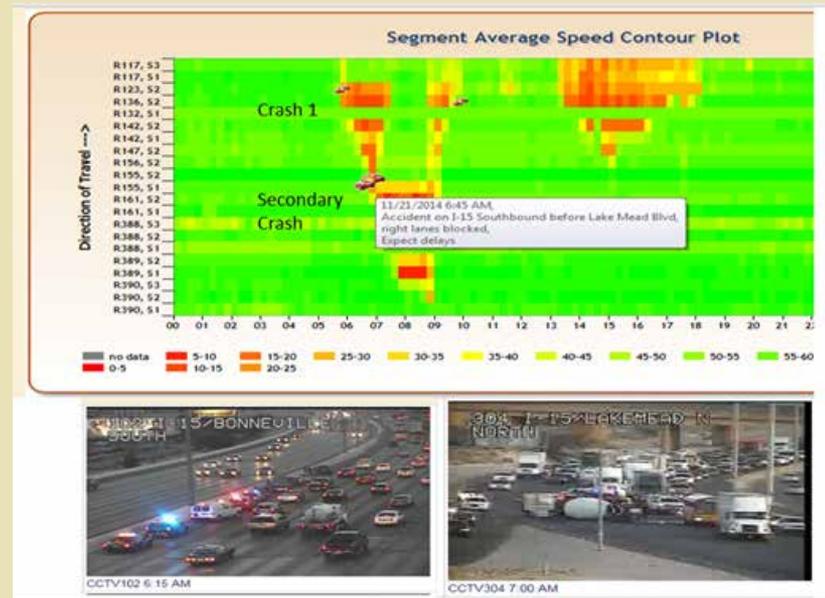
Environment

- Entrepreneurship
- Risk tolerance
- Joint investments
 - Cooperation
 - Collaboration
- Technological
- Legislative



Key Goals and Activities

- Enhance safety
 - Minimize incident frequency
 - Improve emergency response
 - Proactive / strategic positioning
 - FAST, law enforcement, responders
- Improve travel time reliability
- Leverage technologies
 - Data analytics
 - Connected & automated vehicles
 - Communications: wayfinding, route information



Technology Implications

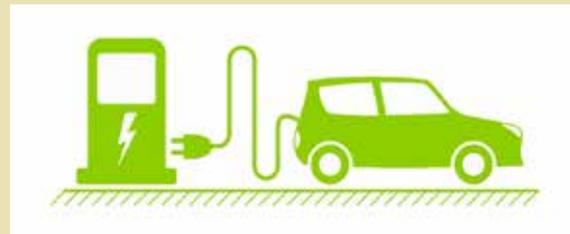
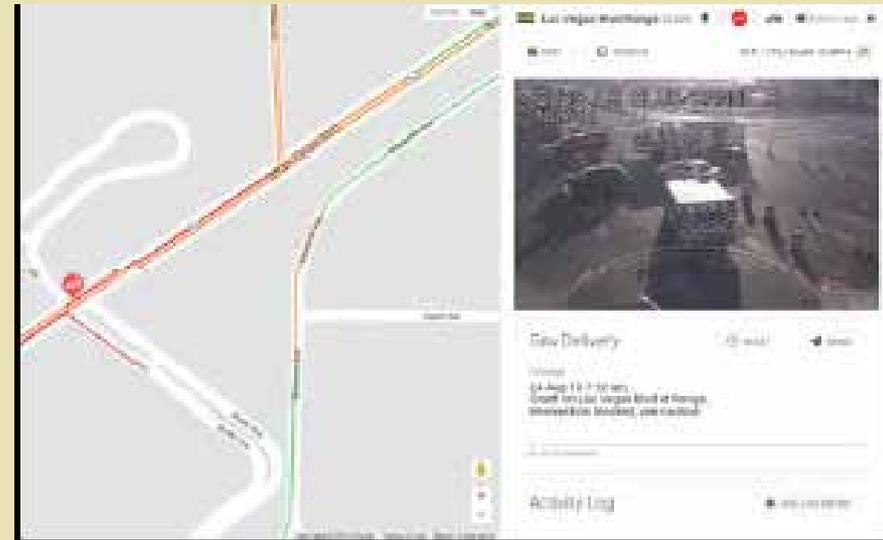
- Smart Communities: **CAVIS, ACES**
 - Connected, Automated Vehicles & Infrastructure Systems
 - Automated, Connected, Electric & Shared
- Automation
 - Vehicle Operations
 - Infrastructure Operations
- Data and Sensor Systems
- Efficiency
 - Vehicles; People & Goods
 - Personal
 - Societal
- Concerns
 - Safety and Security
 - System Vulnerability, Hardening
 - Resiliency
 - Complacency
- **Transition from Legacy Environment to CAVIS**



Source: USDOT ITS Joint Program Office <https://www.its.dot.gov/index.htm>

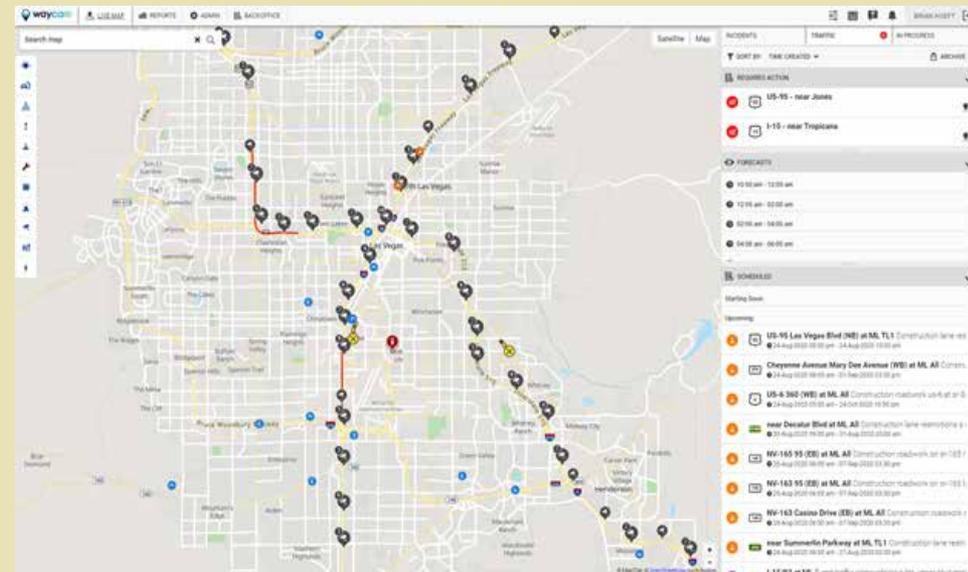
Collaborators and Partners

- Across disciplinary areas
 - Cross- / Inter- / Multi-disciplinary
- Across sectors
 - Public sector
 - Private Sector
 - Academe



RTC FAST (Established 2004)

- Freeway and Arterial Operations
 - Active Traffic Management
 - Incident Management
 - Identification, Response, Recovery
- Safety
- Travel Time Reliability
- Partners / Collaborators
 - NDOT, RTC, county, cities
 - Law Enforcement Agencies
 - Private Sector
 - Academe



Integrated Data Platform and Interface

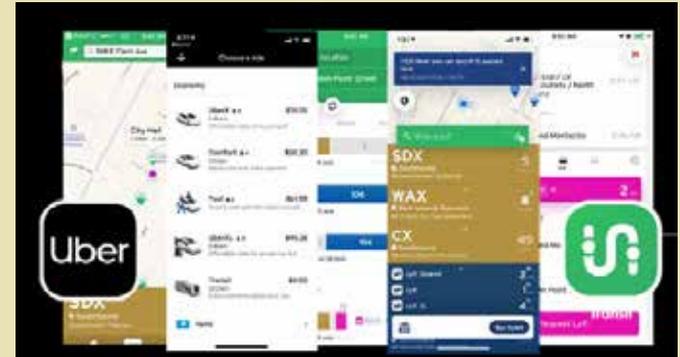
CAVs

- Downtown Las Vegas shuttle
- Resort corridor
- GoMed shuttle
 - US DOT BUILD grant
- Automated people movers
 - Tunnel network
 - Automated passenger vehicles
 - Resort corridor



Transit

- Integrated Trip Planning
 - Transportation Network Companies (TNC)
 - Mobile phone based applications
 - Fare Payment mechanisms
- Bike share programs
- Extending network accessibility
 - Public-private partnership
 - Employer, TNC, RTC Transit
- Low or No Emissions Buses
 - Hydrogen fuel cell buses & fueling infrastructure
 - US DOT grant



Smart Work Zones

- Smart work zones
 - Safety
 - Operations
 - Public-private partnerships



Connected Intersections

- Las Vegas Innovation District
- Signalized intersections (24)
 - Sensors: RSU / RSE
 - In-vehicle
 - V2x Communications
 - Data analytics
 - Computing
- Public agency
- Manufacturers & vendors
- Universities



UNLV Transportation Research Center: *A Resource for Nevada and Beyond...*

Shashi Nambisan, Director

E-mail: shashi@unlv.edu

Today's Panelists

#TRBWebinar



Katherine Kortum,
TRB



Moderator: Cynthia
Jones, *DriveOhio*



Alex Lybarger



Rich Davey, *BCG*

Shashi Nambisan,
*University of Nevada,
Las Vegas*



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