

# The Big Shift: Rethinking Cities in an Age of Intelligent Machines

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# TOYOTA

## Toyota Research Institute



- **Established** Jan 2016 - CEO Dr. Gill Pratt
- Initial \$1B investment

# TRI Office Locations

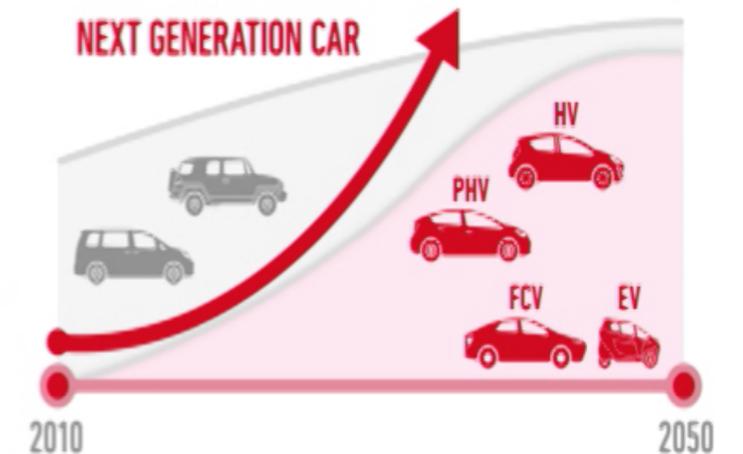


# Key R&D Focus Areas

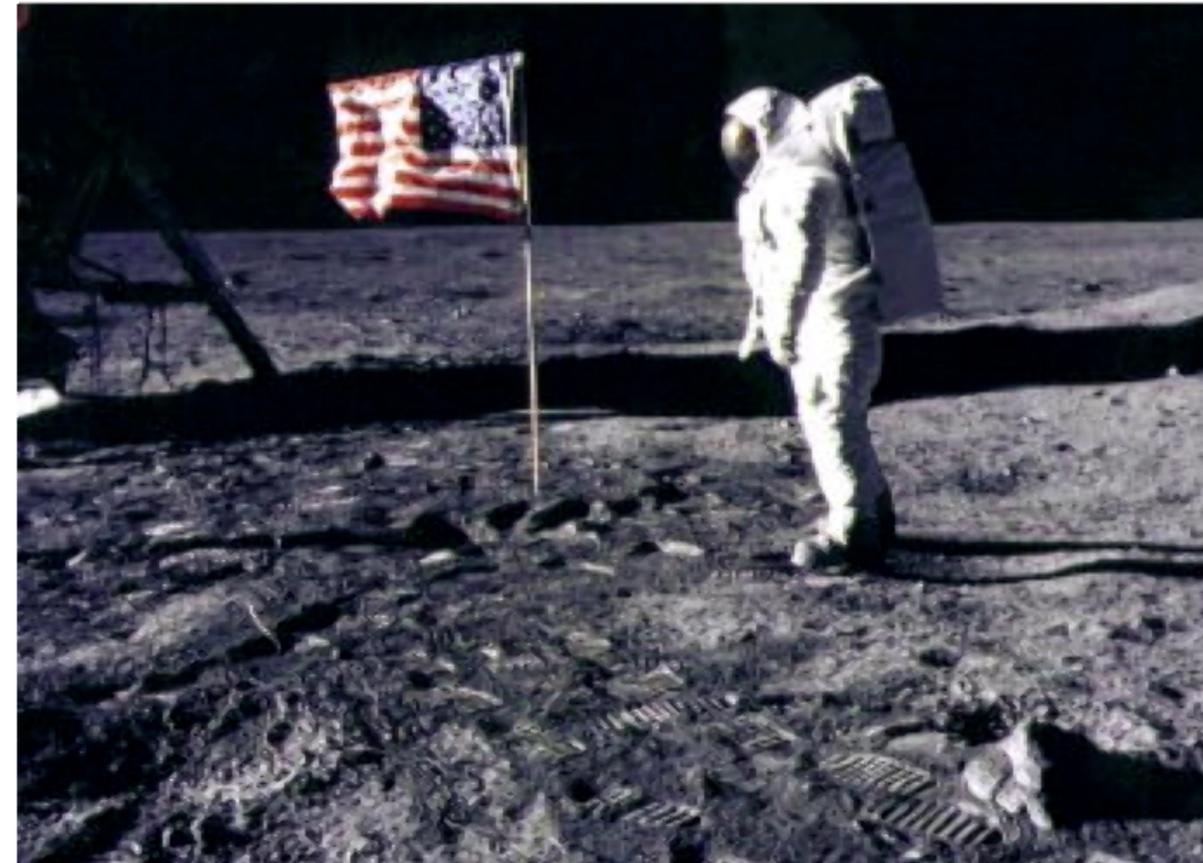
- Automotive Safety & Advanced Autonomy
- Mobility: Outdoor & Indoor (robotics)
- Scientific Discovery (Materials Science)



Toyota HSR:  
Human Support Robot



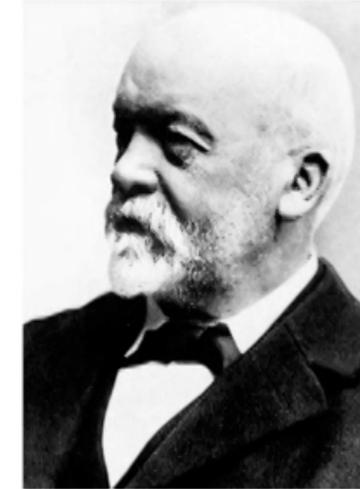
# “Moonshot” Research



Focus on Transformative  
Technology “Leaps”

# Historical Precedence : The Automobile

- 1885-1886  
Gottlieb Daimler and Kari Benz develop first gas-powered cars
- 1890-1915  
Rapid advancement in engine/transmission design and manufacturing technology
- 1910-1915  
Ford Model-T becomes first widely affordable automobile



# Historical Precedence: The Computer

- 1945-60  
Early computer protoypes
- 1960-75  
Rapid advancement in hardware (transistors, storage, displays)
- 1980-90  
Personal Computers (PCs) become widely affordable



**DEC PDP-1**



**Apple II**



**NEC PC-8801**

# Historical Precedence: The Mobil Phone

- **1983**  
Motorola DynaTAC cellular phone sold publicly for \$4000
- **1985-2000**  
Rapid technology advances (size, transmission speed, reliability, network coverage, cost)
- **2000-2015**  
Mobil phones evolve into “smartphones” and overtake desktops worldwide

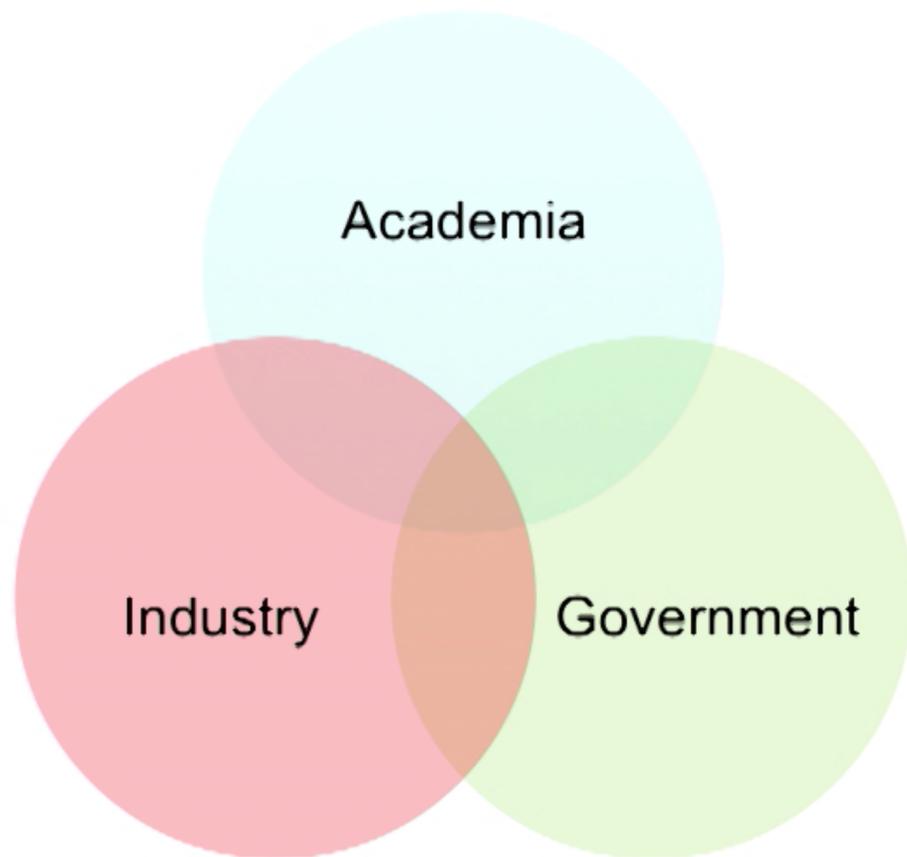


# Cloud-Connected Intelligent Vehicle and Robots

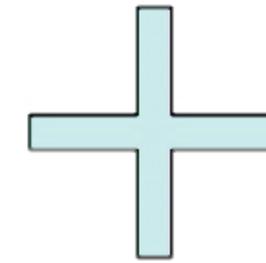
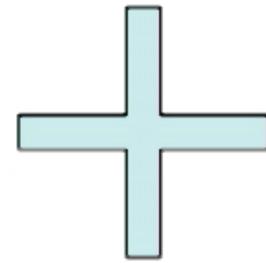


# Ingredients for Disruption and Transformative Technology

Strong Partnerships



Critical Mass of Talent



Investment



# Example: DARPA Grand Challenge

2004



- No winner
- CMU Sandstorm traveled furthest (~7 miles completed)

2005



- \$1M Cash Prize
- Stanford Racing (Stanley)

2007

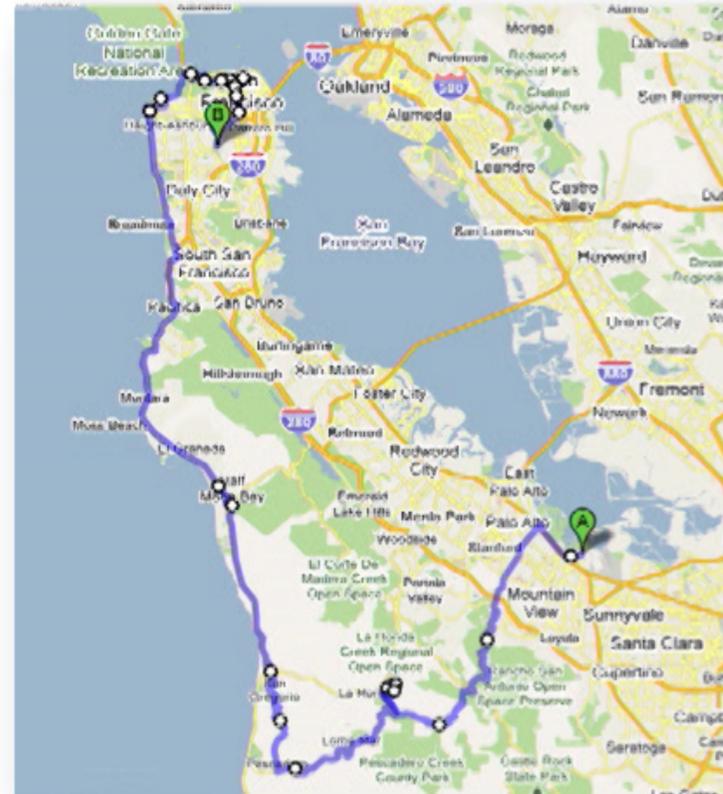
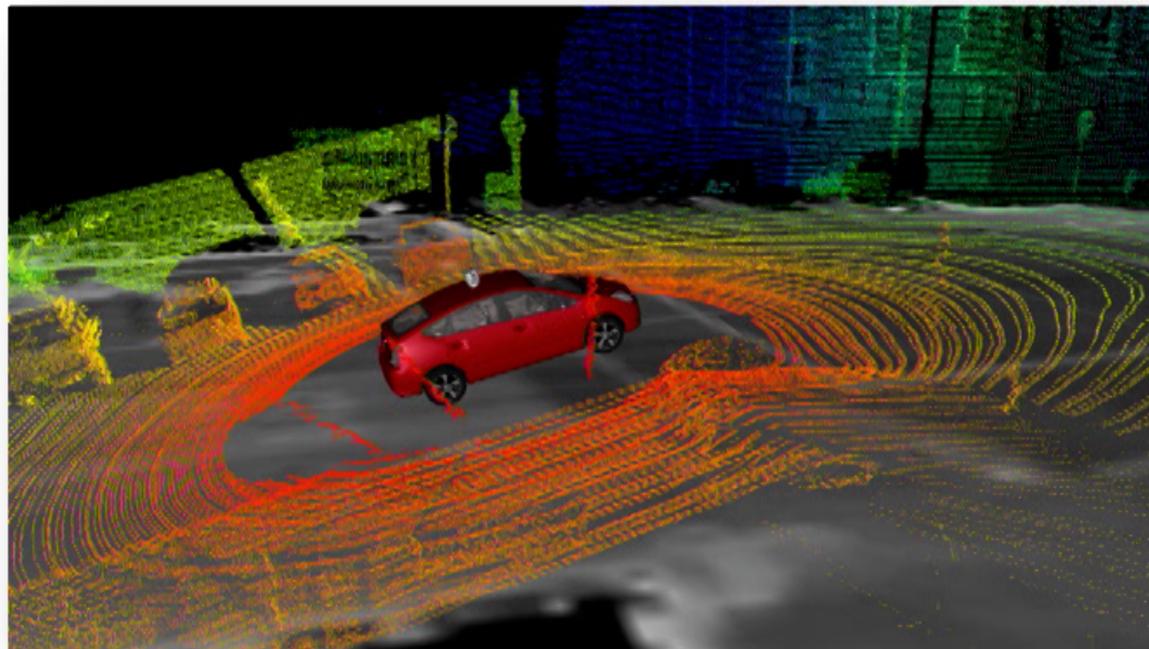


- \$2M Cash Prize
- CMU Tartan Racing

# Google Self-Driving Car Project (2009- )



Google™



# TODAY = An Explosion of R&D Activity

AUGUST 11, 2016

## 33 Corporations Working On Autonomous Vehicles



# How might intelligent vehicle technology impact the design of future cities?

- Enable true “driverless cities”:
  - Transportation on demand / mobility as a service (MaaS)
  - Dramatic reduction in:
    - Traffic
    - Noise
    - Pollution
  - Land dedicated to parking lots converted to:
    - Residential
    - Commercial



Singapore

# PARKING: Today's Reality

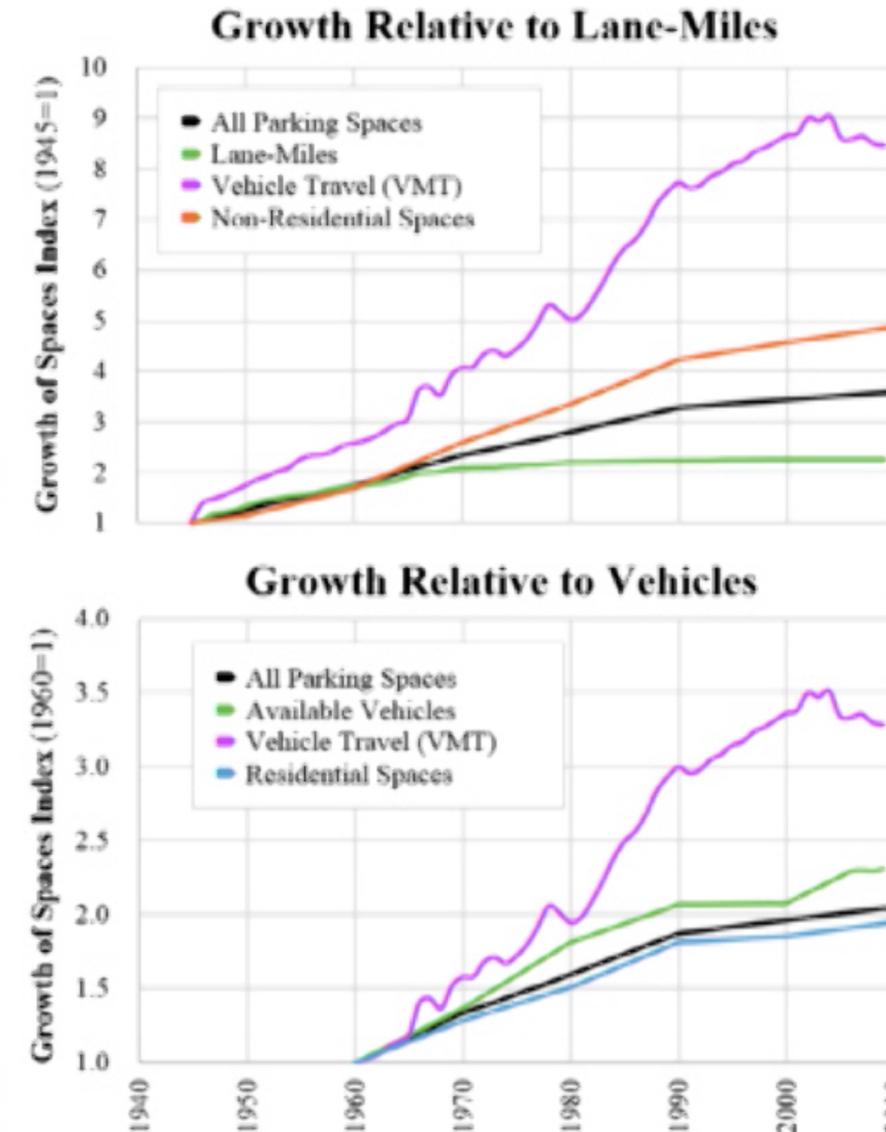
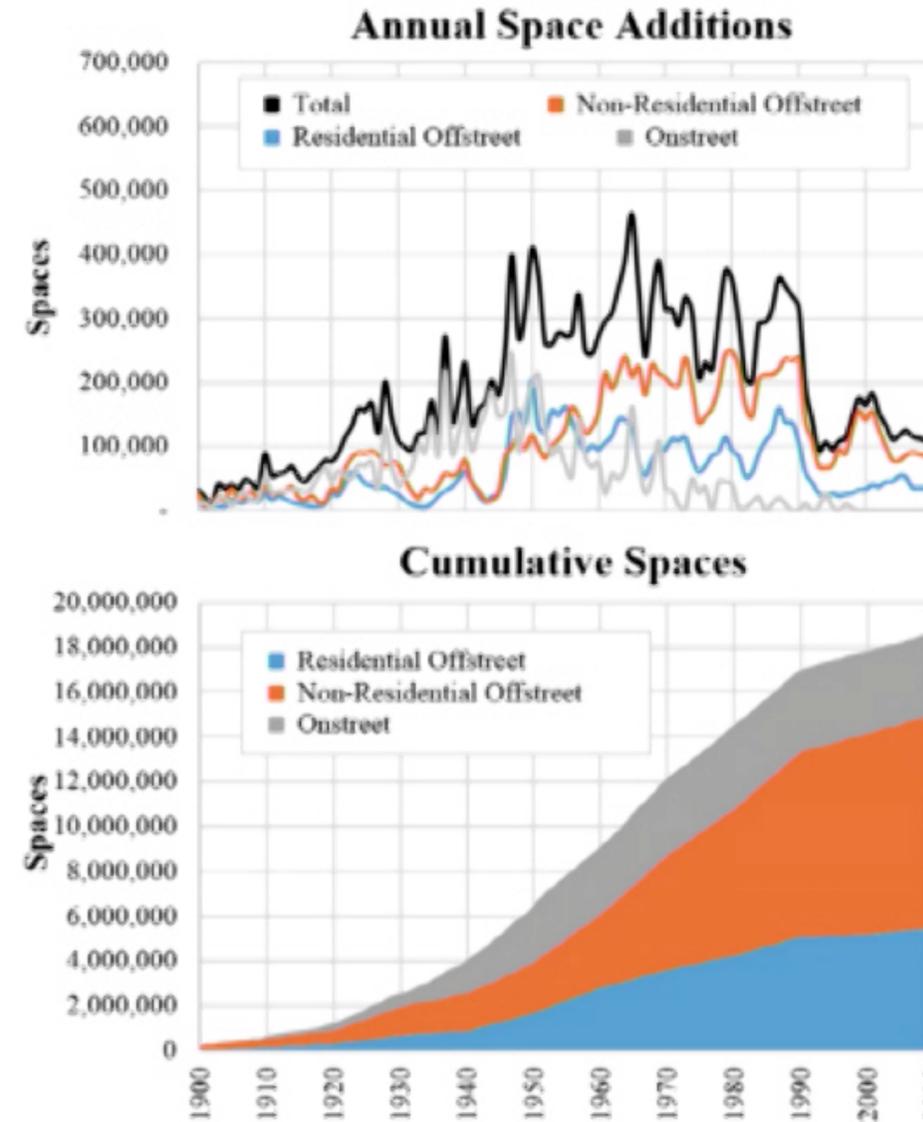
- The average car is **parked 95%** of the time, with only **5%** on-the-road time.
- Worldwide, urban drivers spend an average of **20 minutes** per trip *looking for parking*.
- The United States has **~1 billion** parking spots for only **253 million** cars and trucks (**4x** more parking spaces than vehicles).



# PARKING: Today's Reality

## 2015 study of Los Angeles County:

- 200 sq. miles of land dedicated to parking
- 18.6 million spaces
- 14% of all land area



Mikhail Chester, Andrew Fraser, Juan Matute, Carolyn Flower, and Ram Pendyala, 2015, Parking Infrastructure: A Constraint on or Opportunity for Urban Redevelopment? A Study of Los Angeles County Parking Supply and Growth, *Journal of the American Planning Association*, 81(4), pp. 268-286, doi: 10.1080/01944363.2015.1092879. Additional project information is available at [www.transportationca.org/losangelesparking/](http://www.transportationca.org/losangelesparking/)

# PARKING: Tomorrow's Future

- Driverless cars will enable:
  - Relocation of parking structures away from urban center
  - More dense, efficient, packed parking spaces managed robotically
  - No requirement for parking structures to contain stairs, elevators, or wide alleyways for vehicle access
  - Data-driven dispatch of on-demand transportation and dynamic load-balancing of vehicle supply according to demand patterns



Source: <http://www.roboticparking.com/>

# PARKING: Tomorrow's Future

- Parking lots will double as **charging stations** and replace traditional gas stations
- Car cleaning, repairs and **maintenance** can be performed at centralized parking lot facilities
- Parking lots full of connected cars will serve as **logistics hubs** — new shipping ports for the on-demand economy



Source: <http://www.greencarreports.com/>

# Urban Center Re-design

- Convert parking lots and gas stations to green spaces
- Curbside parking spaces become bike lanes and/or expanded sidewalks



# Radical Urban Center Re-design

- Move all vehicle traffic **underground**
- Convert all above-ground streets and roads to **Fußängerzone** (pedestrian-only zones)
  - Less noise
  - Better air quality
  - Safer



# Ongoing Broad Initiatives



<http://transportationforamerica.org/>



<https://www.sidewalklabs.com>



SMART CITIES

Why Chicago is a Smart City King

Chicago — Array of Things

<https://arrayofthings.github.io>

# Personal Mobility: New Vehicle Platforms

## Toyota iRoad



- Zero-emissions electric vehicle
- Compact, three-wheel design
- Active Balance and stability control
- Strong, lightweight, composite frame
- Powered by lithium-ion batteries that average 50km on a single charge



*Trial in  
Grenoble,  
France*

# Fuel-Cell Vehicle : Toyota Mirai

## Toyota Making 5,600 Hydrogen Fuel Cell Patents Free To Use

January 8th, 2015 by [James Ayre](#)

Toyota will be making more than 5,600 of its hydrogen fuel-cell technologies patents free to use for a large number of companies in the industry/sector — absolutely no charges, including no royalty payments — according to recent reports.

Seemingly taking a move from [Tesla's recent playbook](#), the move is certainly an interesting one — but you can't help but wonder if the primary reason for it is simply as a means of generating good PR.



- **Zero-emissions** hydrogen fuel-cell vehicle
- **312** EPA-rated miles per tank
- **5** Minutes to refuel
- \$8000 federal tax credit + \$5000 CA rebate + 3 years' worth of complimentary fuel

[http://www.toyota-global.com/innovation/personal\\_mobility/i-road/](http://www.toyota-global.com/innovation/personal_mobility/i-road/)

# Connected Cars and Vehicle Intelligence

- **Big Data and Deep Learning**
  - Powering tremendous advances:
    - Speech / NLU / Translation
    - Object recognition (ImageNet)
  - Connected cars will:
    - gather novel data
    - upload new exemplars
    - train updated models in the cloud
    - download / broadcast updates to the entire vehicle fleet



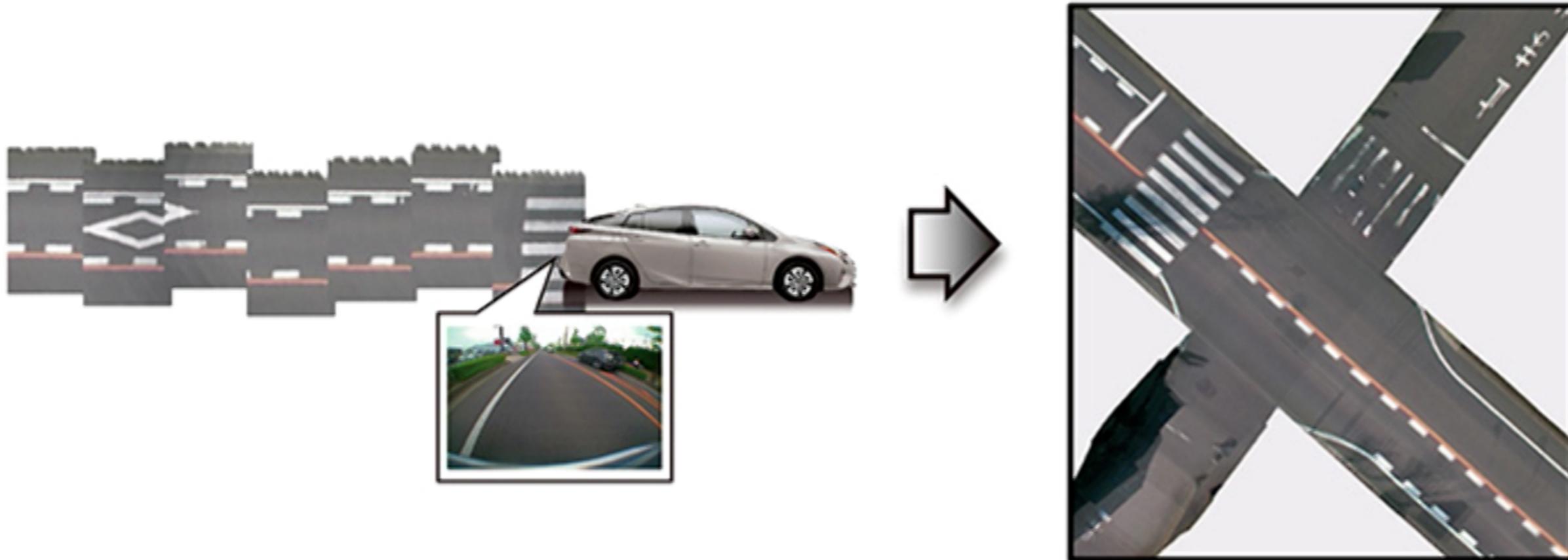
# Toyota Distributed Map Generation

Jan 4, 2016  
CES announcement

Toyota develops high-precision map generation system ...

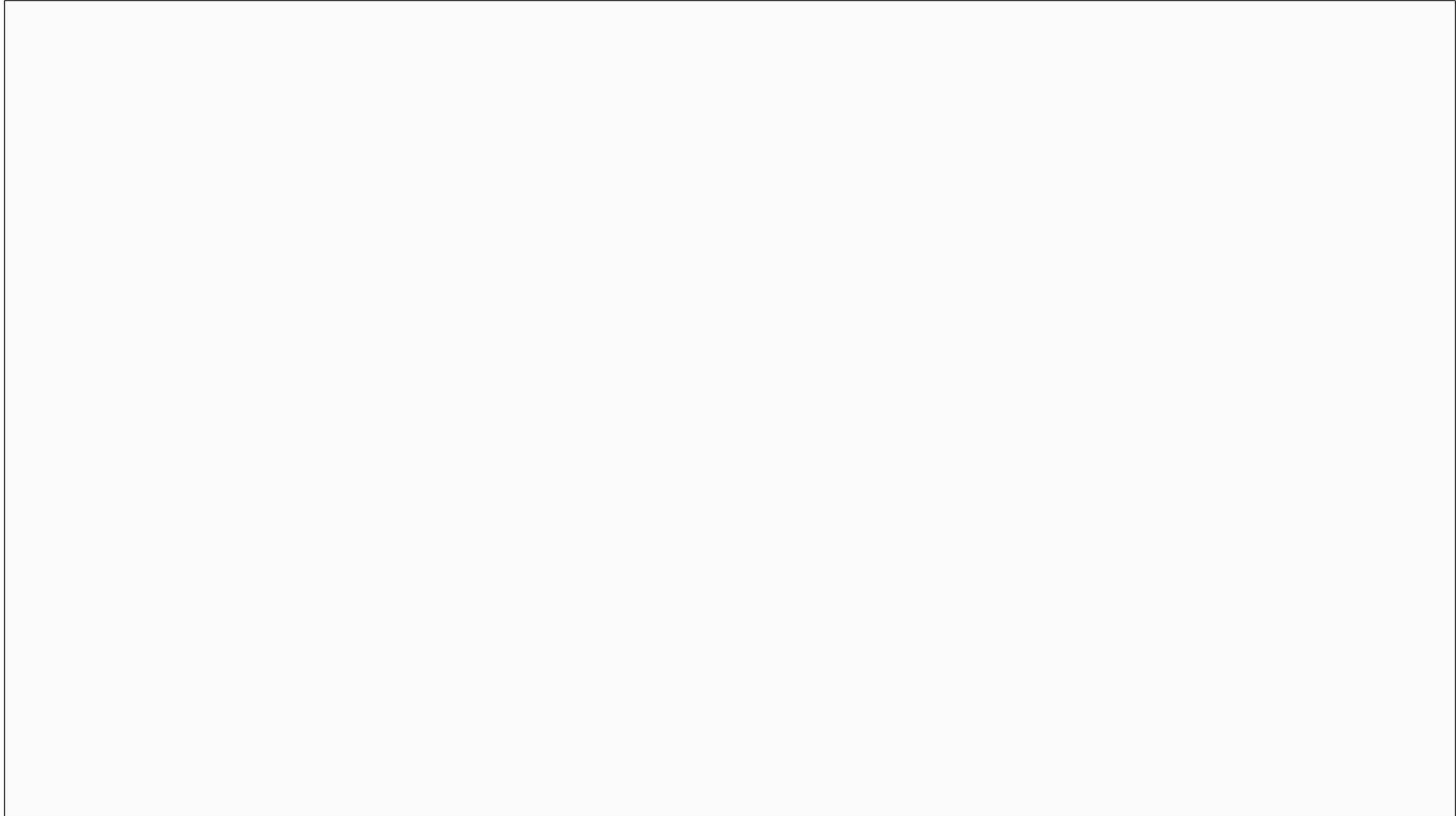
[www.roadtraffic-technology.com/.../newtoyota-develops-high-precision...](http://www.roadtraffic-technology.com/.../newtoyota-develops-high-precision...)

Jan 4, 2016 - Toyota has developed a high-precision map generation system that will make use of data from on-board cameras and GPS devices installed in ...



<https://www.youtube.com/watch?v=56RNDP3hD-8>

# Toyota Distributed Map Generation



# Closing Thoughts

- The next generation of intelligent autonomous vehicles will enable a **complete rethinking** of how our urban centers are designed and built
- Cloud Computing, Big Data, and Ubiquitous Connectivity will dramatically advance vehicle autonomy for improved safety and accessibility
- Strong **government, industry, and academic** partnerships are key



Toyota "Robina" Partner Robot

# We are hiring — join us!



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