THE OHIO STATE UNIVERSITY
COLLEGE OF ENGINEERING

SMART CITIES: THE MOBILITY COMPONENT

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XXVI FIG Congress 2018, Istanbul, Turkey ♦ May 6-11, 2018

- **Smart City**
  - Mobility → Smart Mobility
  - Positioning and Navigation (PNT), GEOINT
  - Autonomous Vehicle (AV) technologies
- **Technology Trends**
  - Geomatics field
  - Sensor technologies
- **Crowdsourcing/Crowdsensing**
  - Smart devices
  - Autonomous vehicles
- **Conclusion**

Smart Cities:

The deployment of technology and data…

…to improve people's lives.

Connectivity Spatial/temporal context Big Data

Smart City

- 26 smart cities are expected by 2025, 50% of which will be in Europe and North America
- At present: smart communities projects in many cities worldwide (global spending of $1.5 trillion by 2020)
- No smart city yet…Amsterdam, Barcelona, Dubai , NYC, London, Nice, Singapore

Smart Columbus Overview

Smart Columbus

LOGISTICS DISTRICT

Truck Platooning

Oversize Vehicle Routing

Interstate Truck Parking Availability

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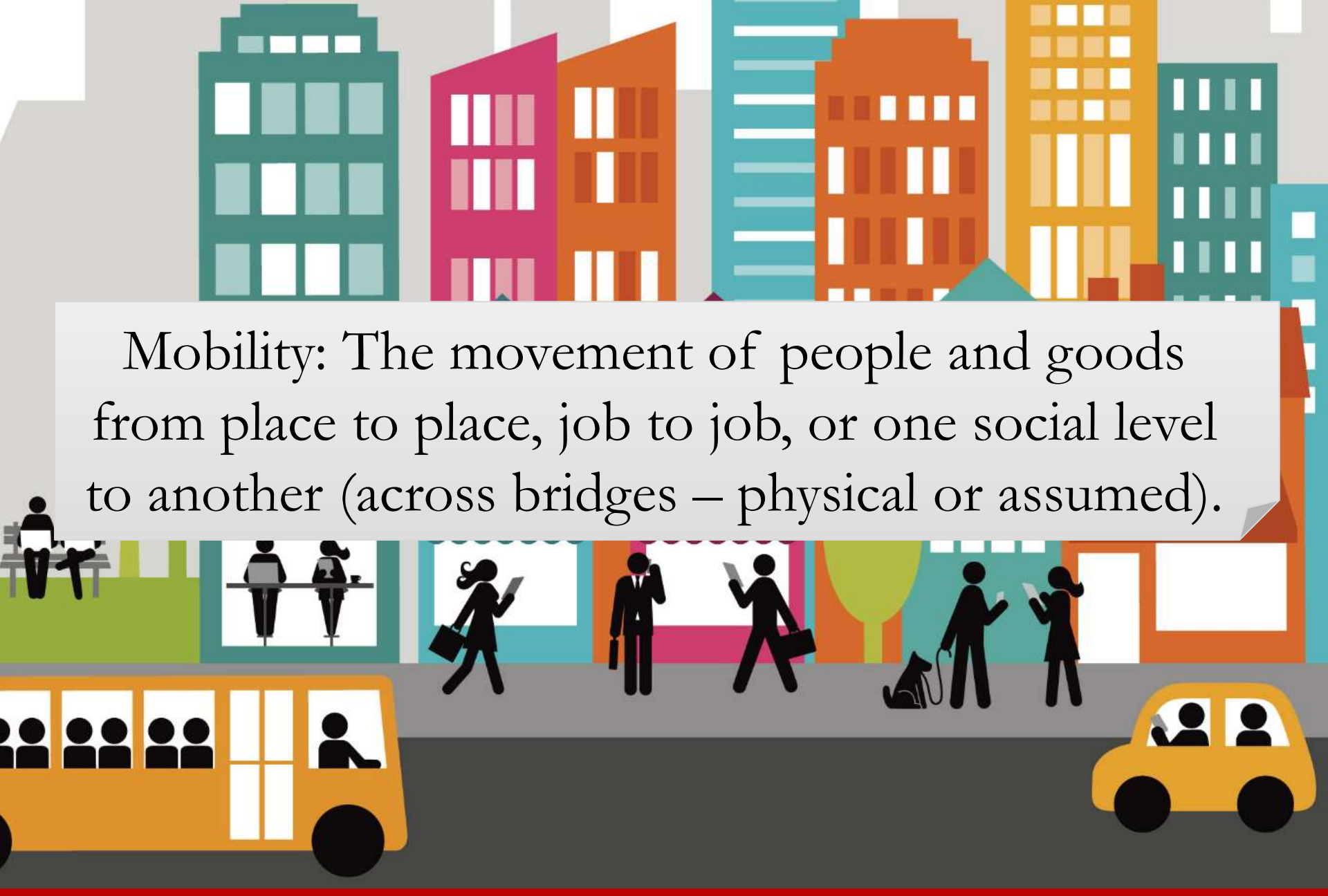
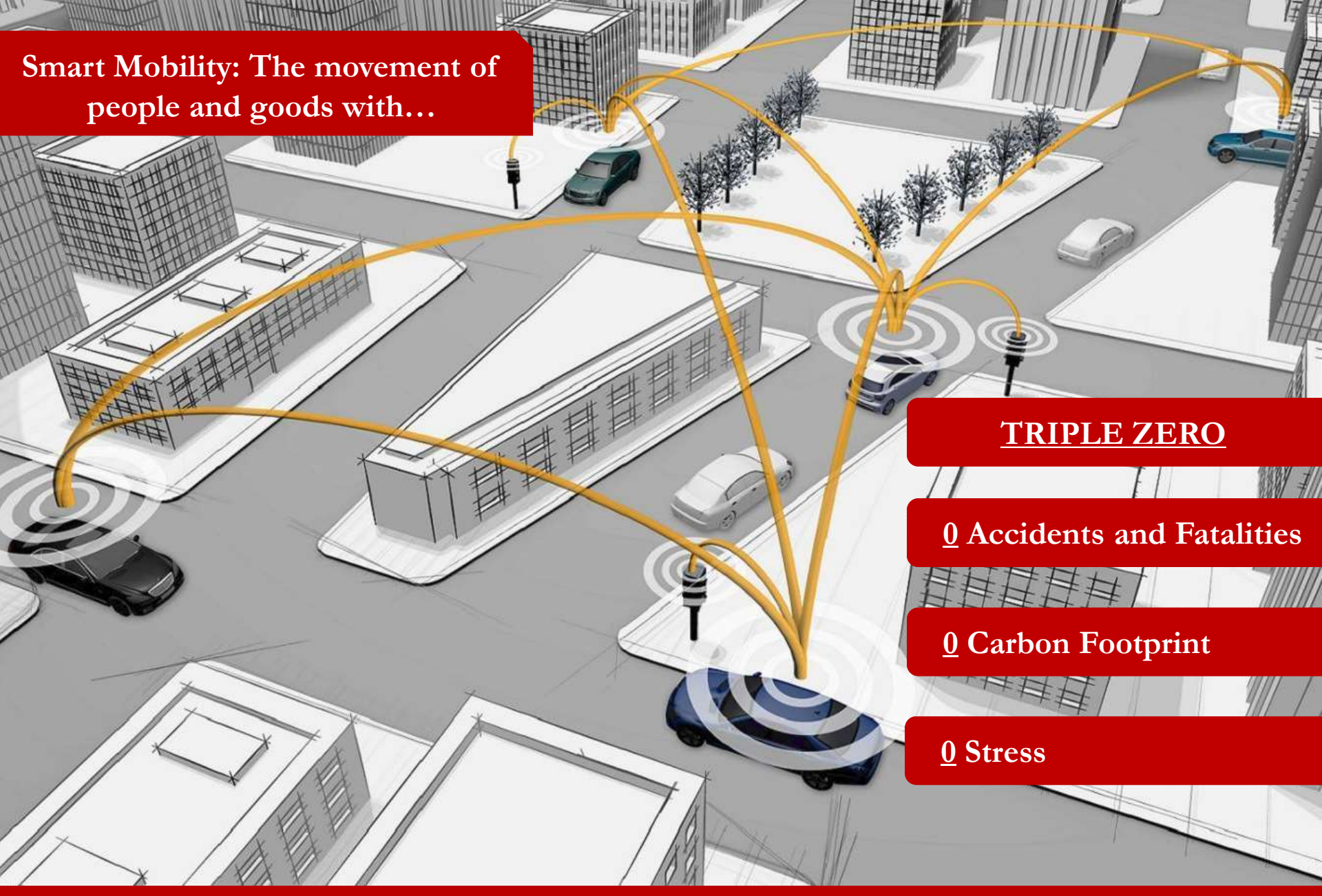
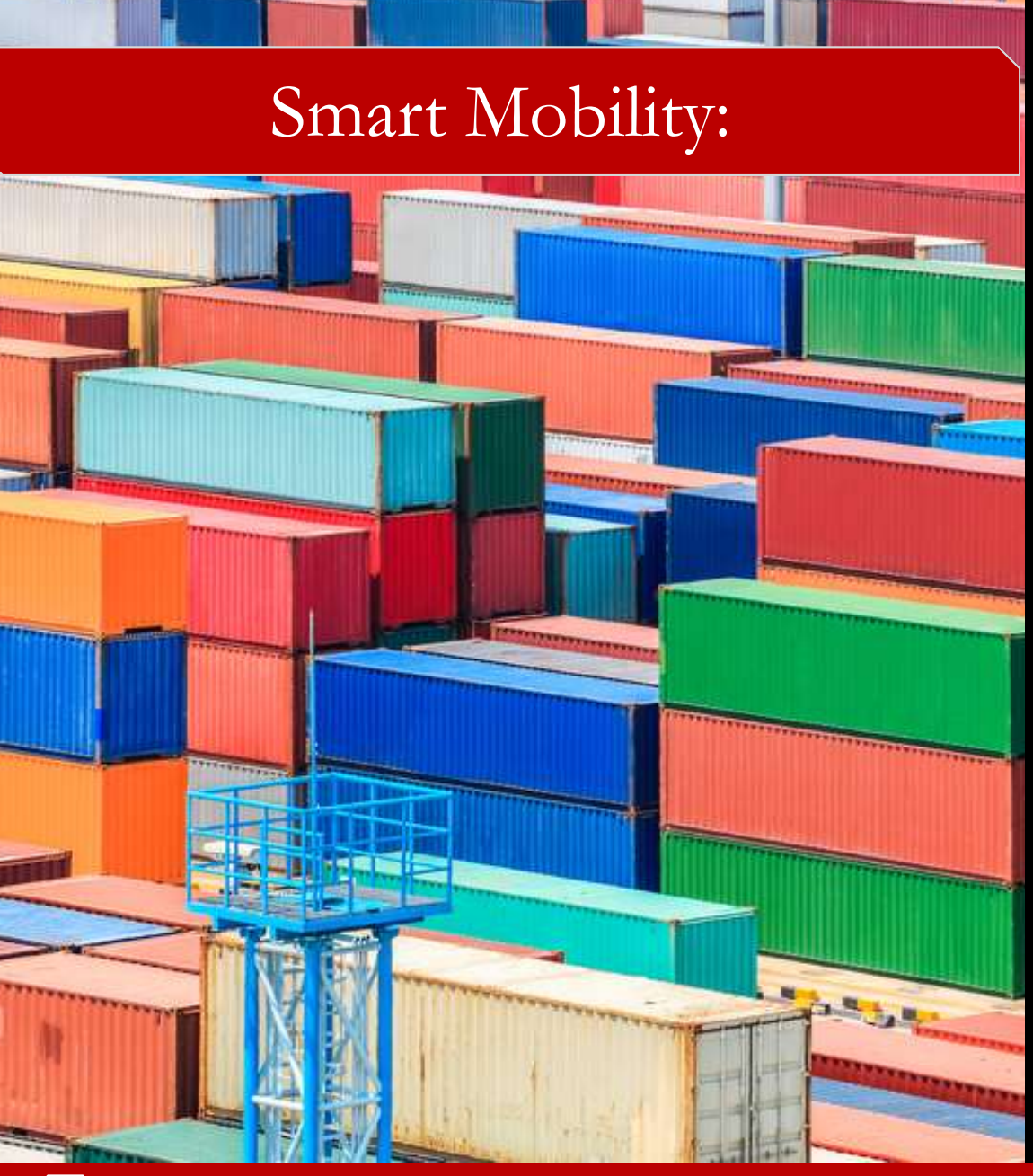


Mobility: The movement of people and goods from place to place, job to job, or one social level to another (across bridges – physical or assumed).

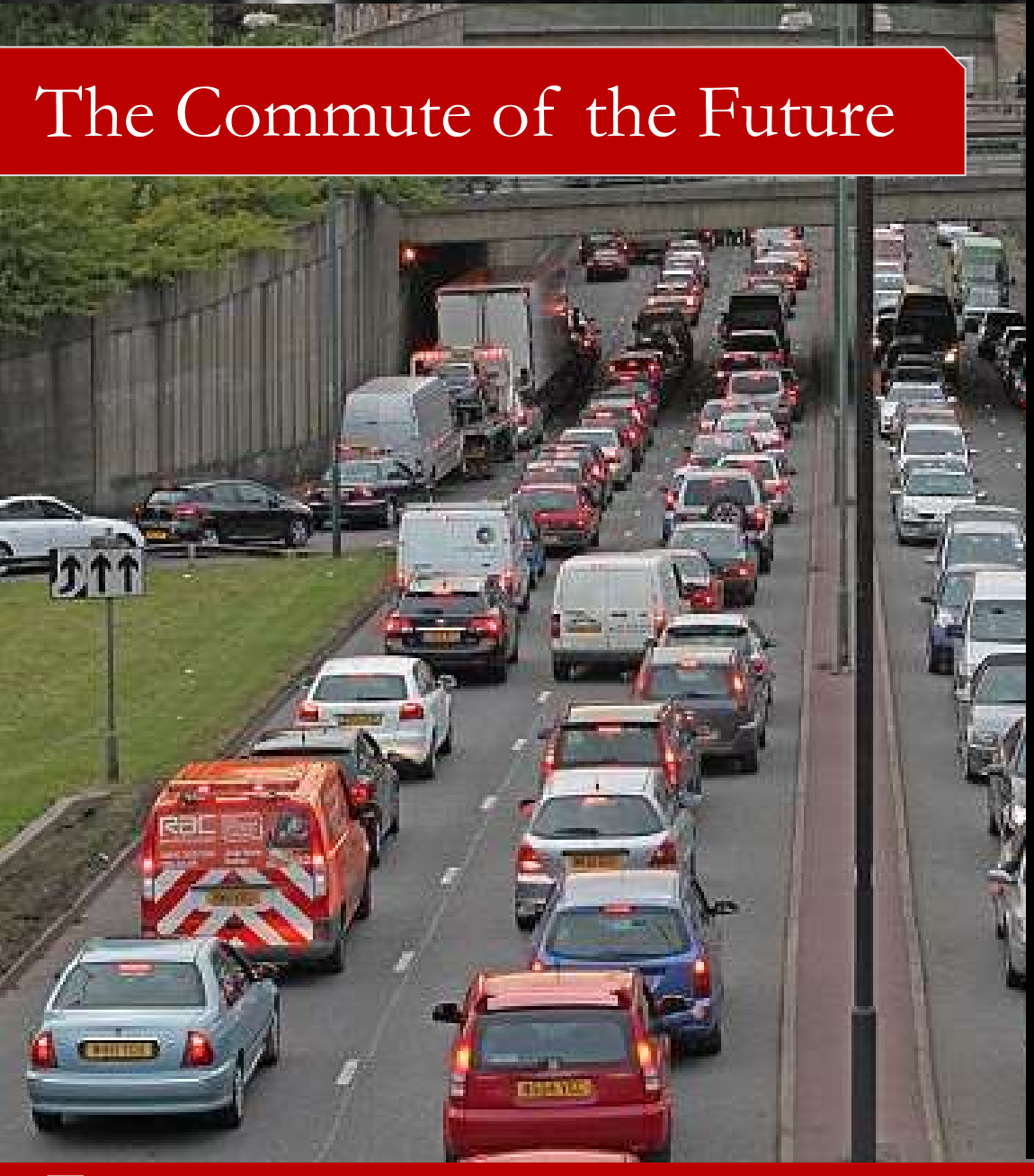

Smart Mobility: The movement of people and goods with…
TRIPLE ZERO
0 Accidents and Fatalities
0 Carbon Footprint
0 Stress

Smart Mobility:



- Saves Lives
- Improve Lives of Older Adults and People with Disabilities
- Transportation in an Era of Urbanization
- Environmental Sustainability
- Economic Sustainability

The Commute of the Future



Challenges

- Increasing VMT/VKT
- Pollution
- Urban Sprawl
- Inequity
- Segregated Roadways

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Position, Navigation, and Timing in an Autonomous Future

PNT Applications in Smart Cities

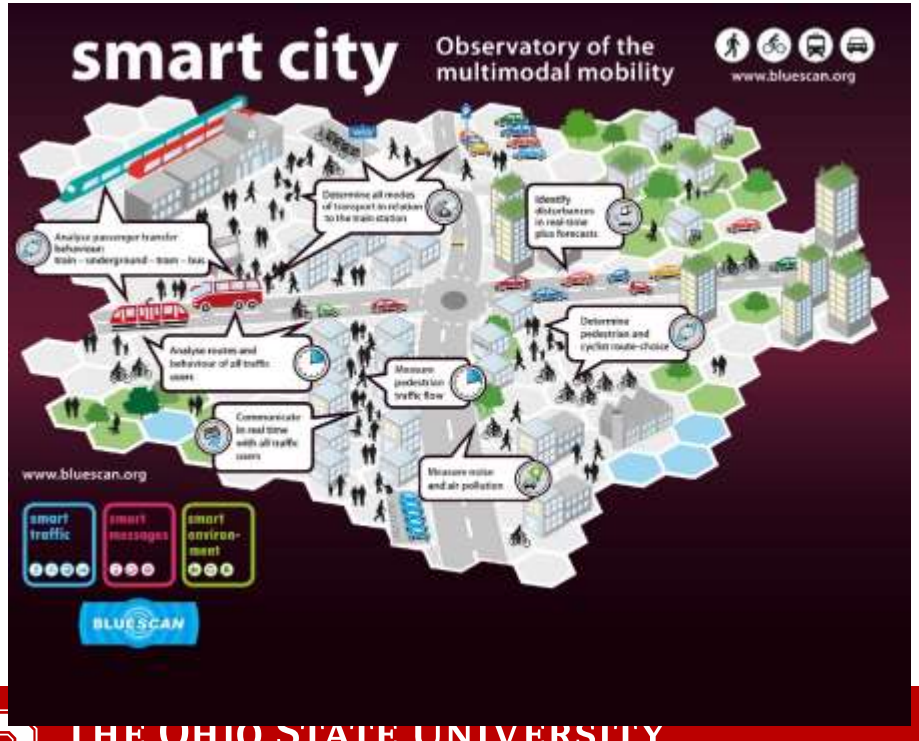
Courtesy of Prof. Dorota Brzezinska, OSU

- V2V & V2I (V2X) Communication
- Autonomous Navigation & Collision Avoidance
- Location Based Services
- Smart & Resilient Infrastructure

Positioning and Communication

- Location-based services
- Autonomous navigation and collision avoidance
  - Connected vehicles – cooperative mobility; vehicle-2-vehicle (V2V) and vehicle-2-infrastructure (V2I) cooperation, and V2X
  - Geodetic infrastructure needed (e.g., CORS)

https://www.google.pl/#q=connected+vehicles



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Motivation for Autonomous Driving (Self-Driving Cars)

- Driving by human beings is found to be dangerous and has led to countless deaths over the years. Worldwide, per the Global Road Crash Data [1], traffic crashes are the major cause of death and injuries, specifically estimated at 1.3 million fatalities each year, on average 3,287 deaths per day.
- In the United States, there are over 37,000 deaths and an additional 2.35 million injuries in road crashes each year. Of these, 94% are caused by human error [4], reported by USA's National Highway Traffic Safety Administration (NHTSA) research.
- The cost of traffic crashes is incredibly high, reaching USD $518 billion globally and $230.6 billion in United States. Unless action is taken, traffic crashes are predicted to be the fifth leading cause of death by 2030.

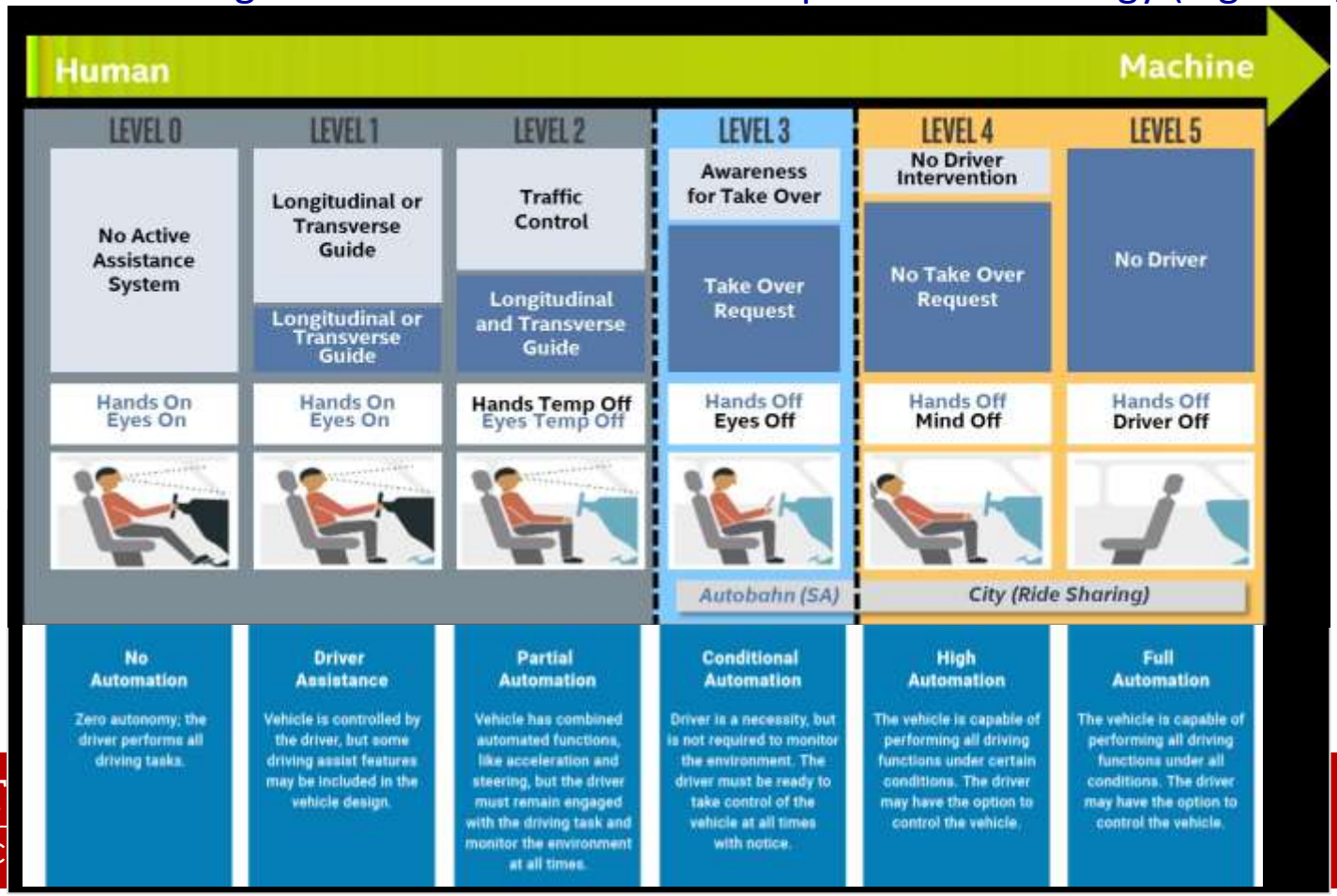
Traffic in Cities

- Most of the accident happen close to our homes (urban areas)
- An average American driver spends nearly
- Traffic congestion and parking are painful

Picture credit: pixabay

Autonomous Vehicles (AV)

- Driverless technology is rapidly evolving
- High-definition geospatial/GIS data is an enabling component to improve localization and, subsequently, safety
- Huge amount of GIS data is already available, the question is how to access it, and then the communication (organizing data, and V2X)
- Crowdsourcing will be the dominant data acquisition technology (Big Data, Big Geo Data)



Rapid AV Developments

DARPA Urban Challenge 2007

Google Driverless Car 2017

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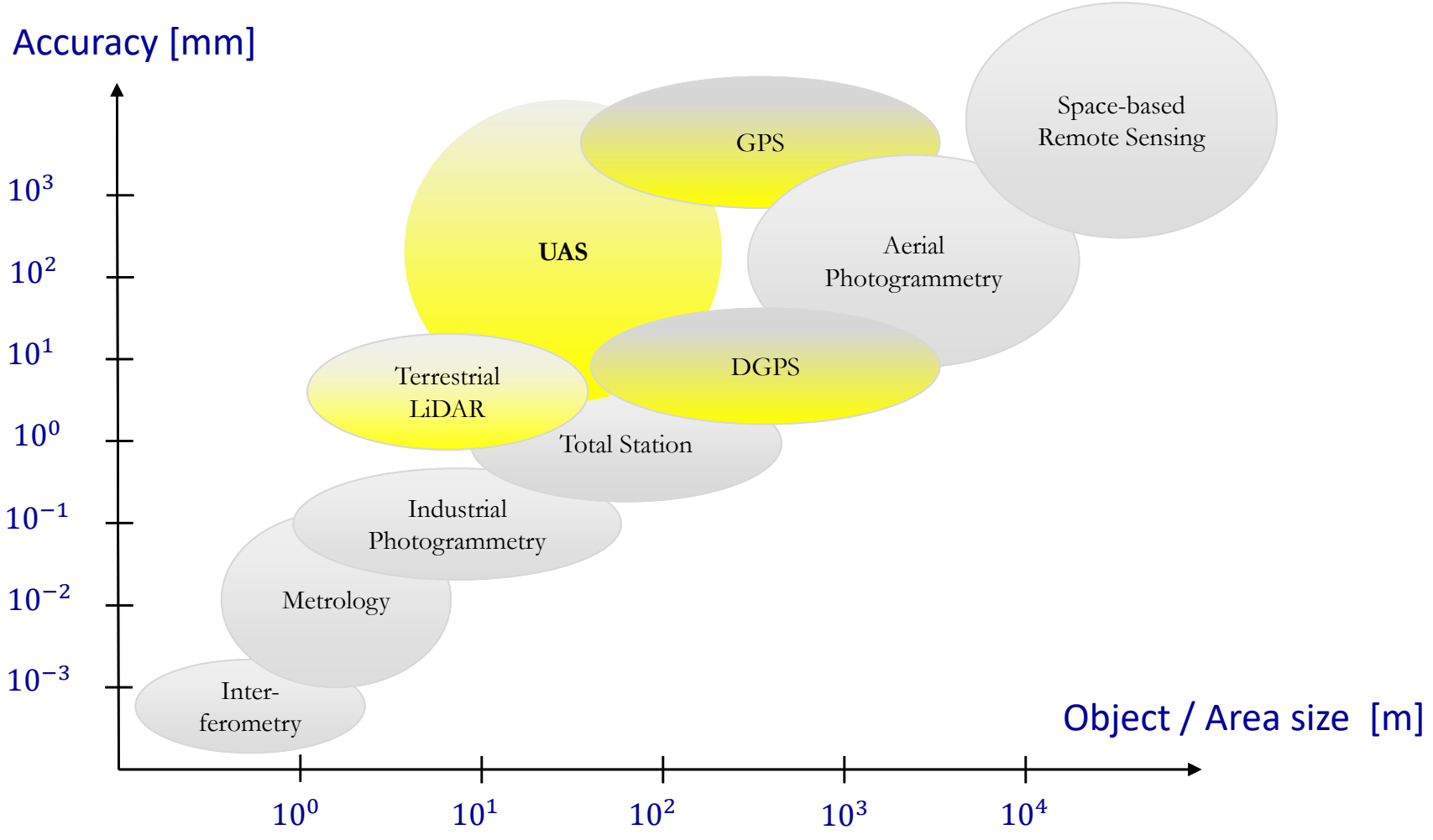
Smart Mobility → Autonomous Driving → Geomatics

Surveying

Mobile Mapping → Autonomous Driving

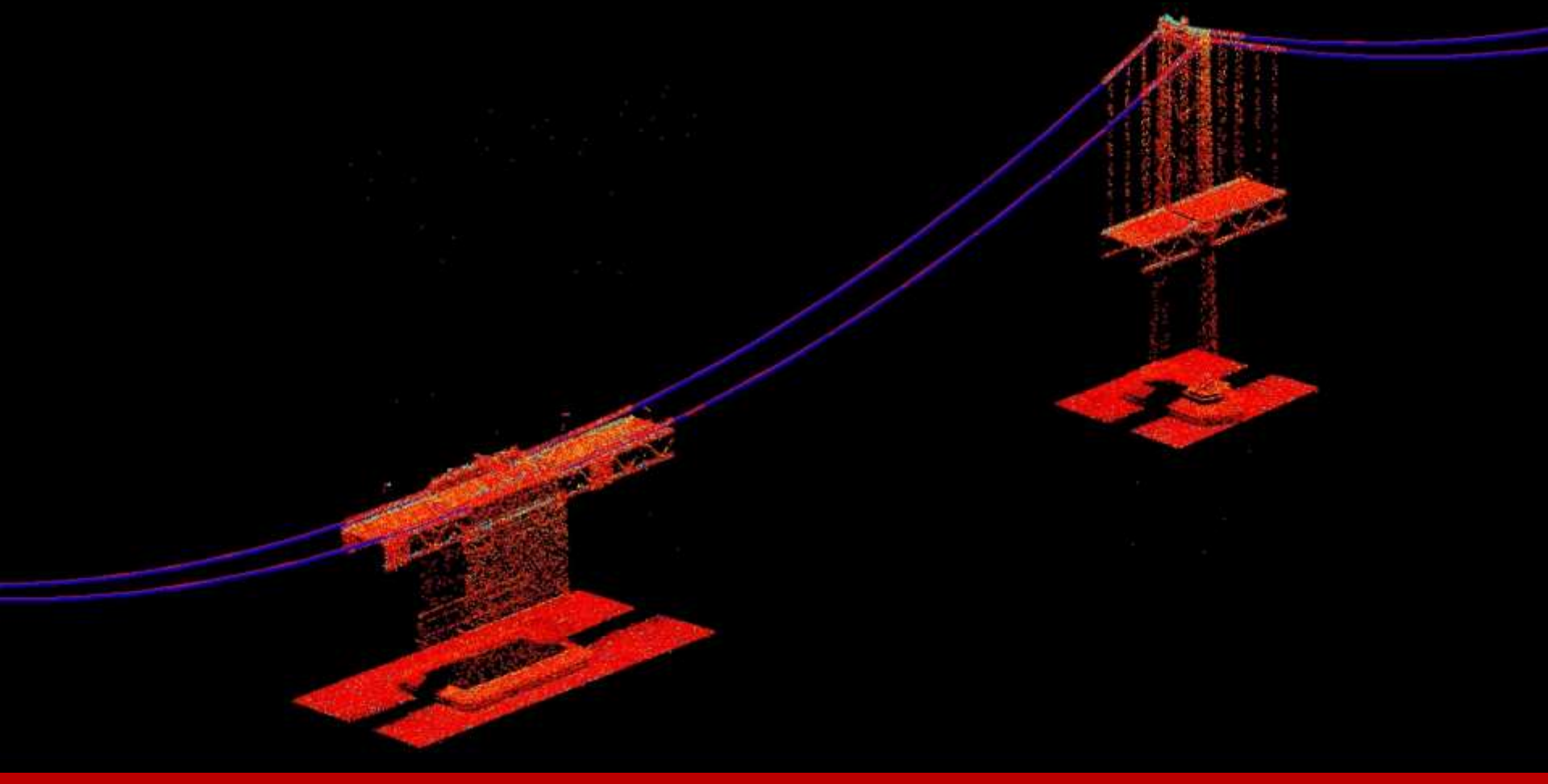
Airborne Surveying

Geomatics Technologies

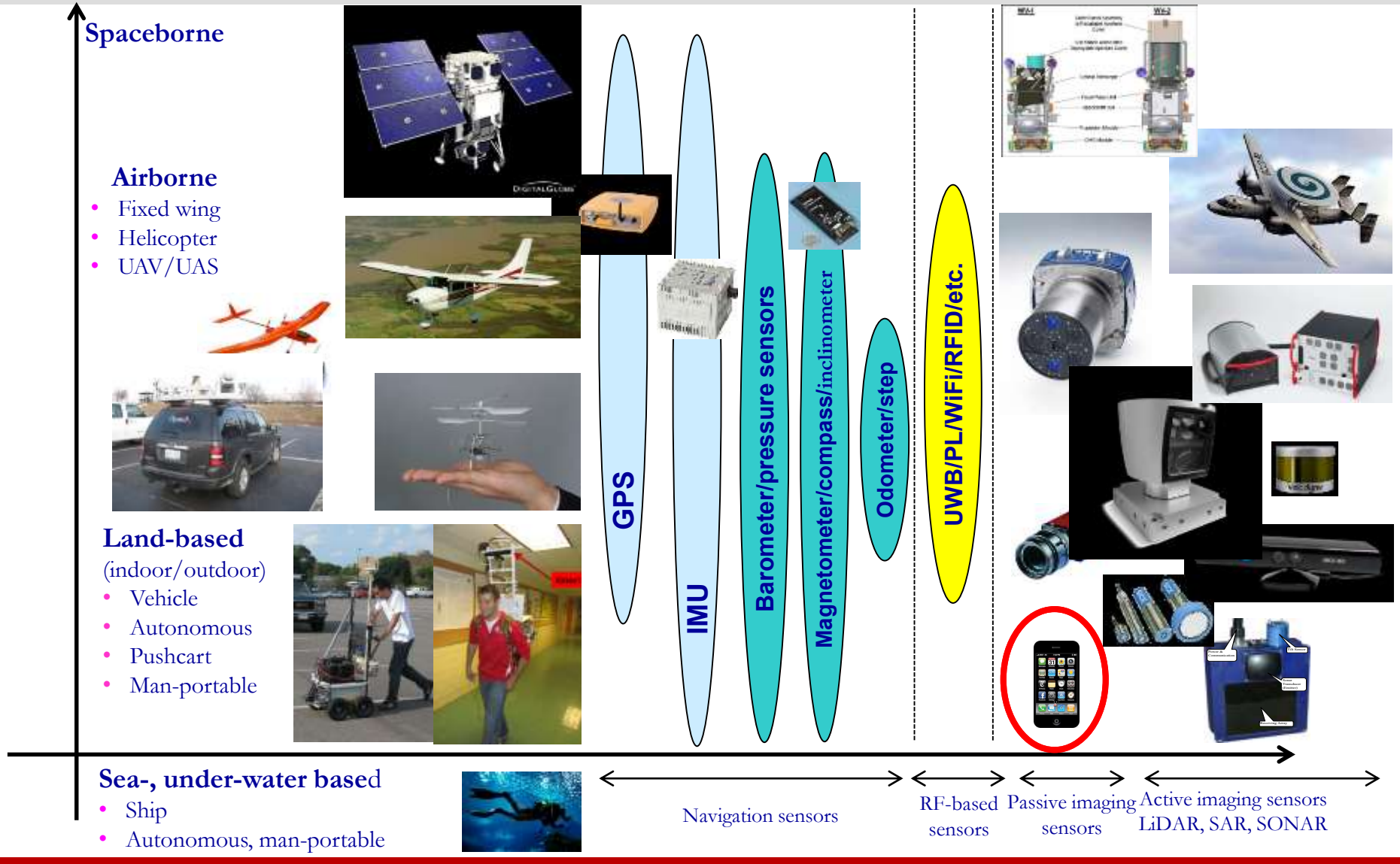


How Was the Bridge Surveyed?

Bay Bridge, San Francisco



Platforms and Sensors



Smart Devices

- GPS
- Wi-Fi
- 4G/GPRS
- 3-axis accelerometer
- 3-axis gyro
- 3-axis magnetometer

- Microphone
- Ambient light sensor
- Bluetooth
- Proximity sensor
- FM radio
- Cameras

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Crowdsourcing and Crowdsensing

Check what's in your pocket…a powerful geospatial technology!

Device	Navigation Sensors	Imaging Sensors	Communication Capability
Smartphone Smartwatch	GPS/IMU/ Compass	CMOS (2) (still and video)	3G/4G/WiFi/BT/etc.
Digital camera	GPS	CMOS (still and video)	WiFi
Recreational GPS Wearable technology	GPS/Compass/ IMU/HRM/etc.	No	WiFi, BT
Car navigation	GPS	CMOS (rear, etc.)	3G/4G/BT/etc.
Social networks (virtual)	Access point location	Webcam, etc.	Internet

- People leave digital footprints wherever we go
- We're continuously georeferenced, and provide other information too, including increasing volumes of imagery (voluntarily or involuntarily)

What is Mapped?

Iphone

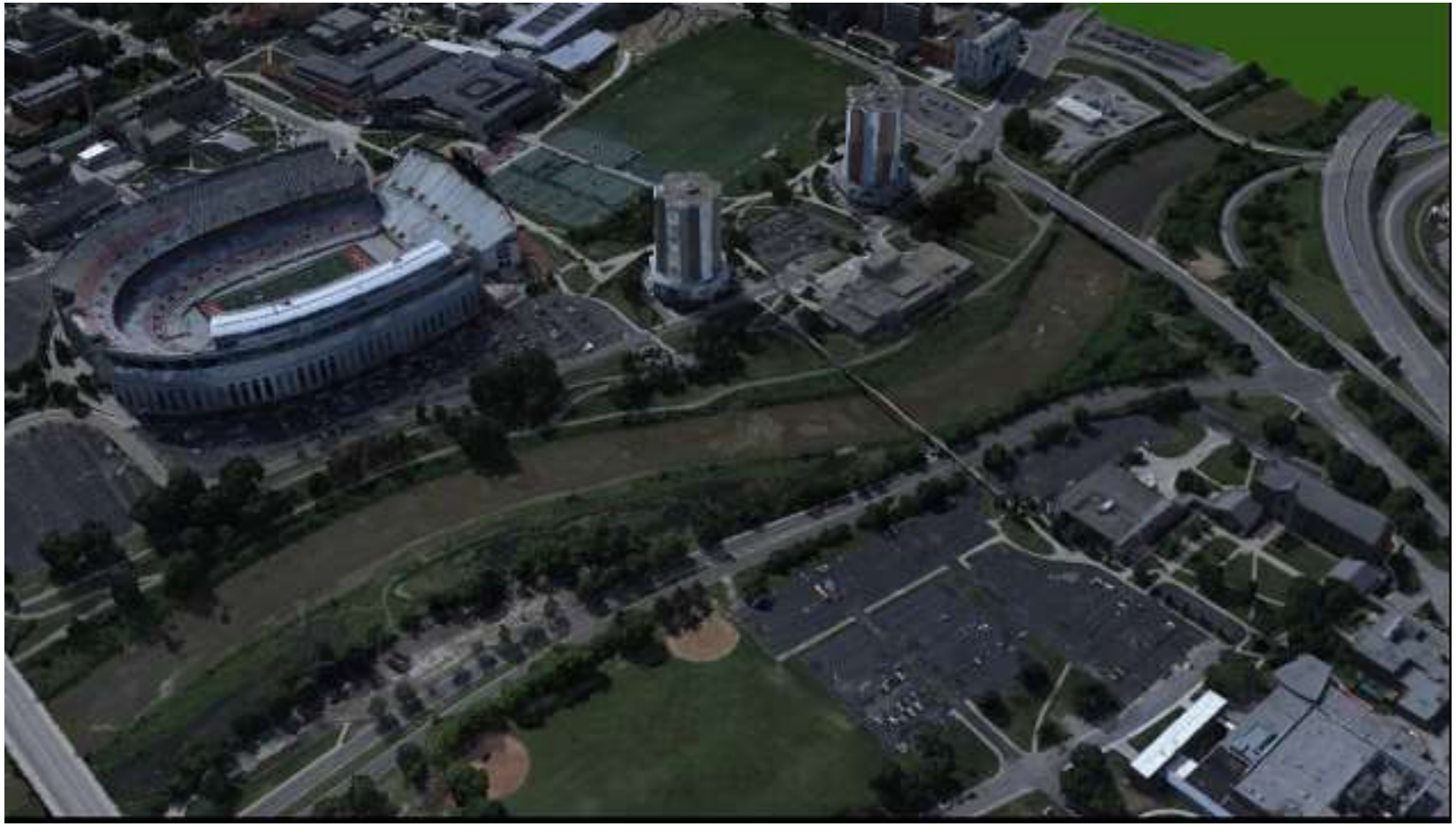
Android

What is Mapped?

Running

Bicycling

UAS is a Flying Smart Sensor

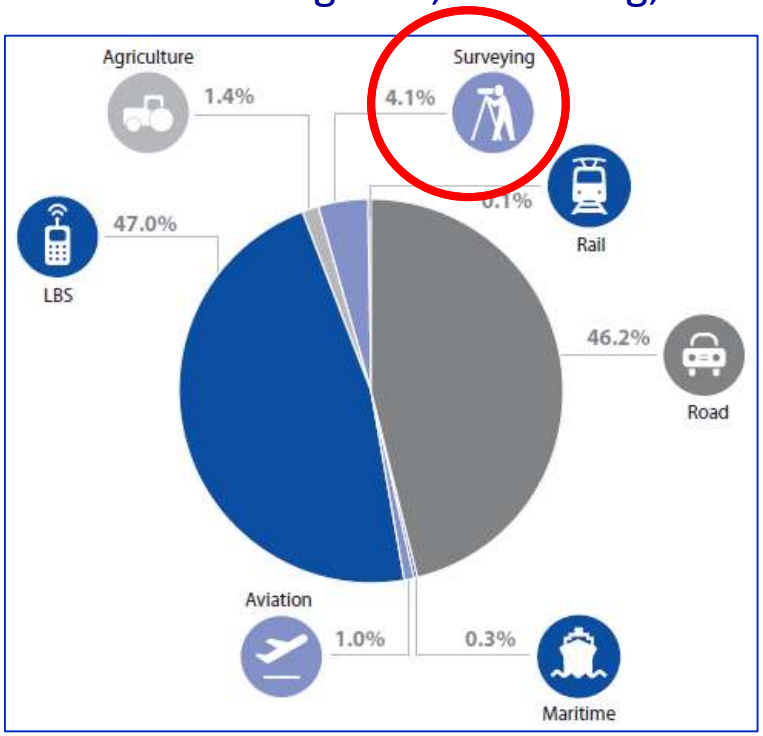


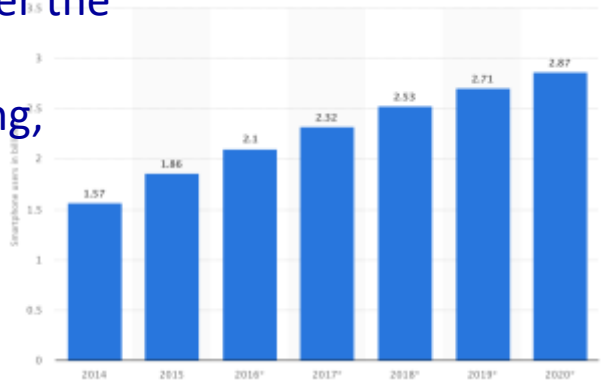
Power of crowdsourcing: Building Rome in a day (2009)

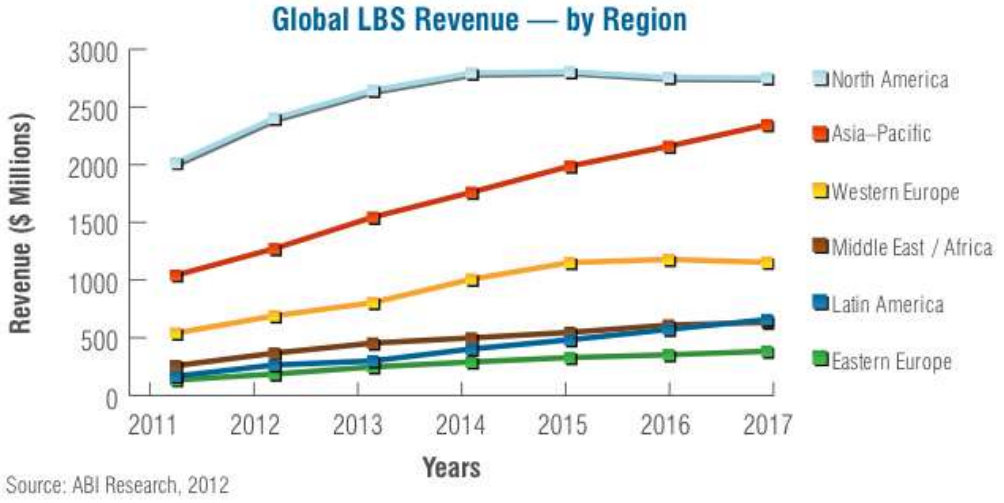
- Website: https://grail.cs.washington.edu/rome
- Videos: https://www.youtube.com/watch?v=qYaU1GeEiR8&list=PLDFDB5B8C80DB3AD6

Smartphone and GNSS Growth

- By the end of 2017 there were 2.4 billion smartphones in use, 7+ billion by 2030; LBS – the primary driver!
- Fastest growing GNSS+ market with revenues expected to reach over $88 billion USD by 2020; market growth at a CAGR of ~21% over the period 2012-2017
- IoT, Big Data, augmented reality, smart city, autonomous driving, multimodal logistics, mBanking, mHealth, asset mng't, etc.







Source: ABI Research, 2012

http://www.navipedia.net/index.php/GNSS_Market_Report

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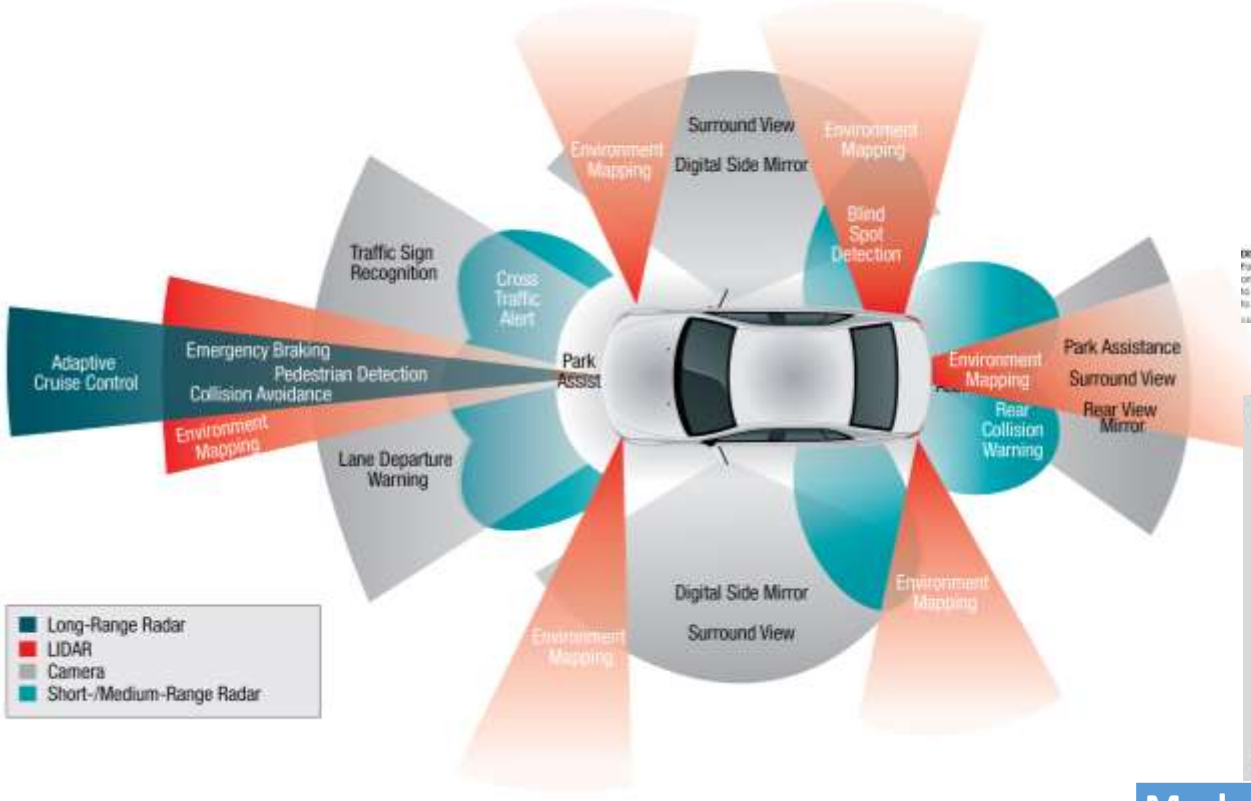
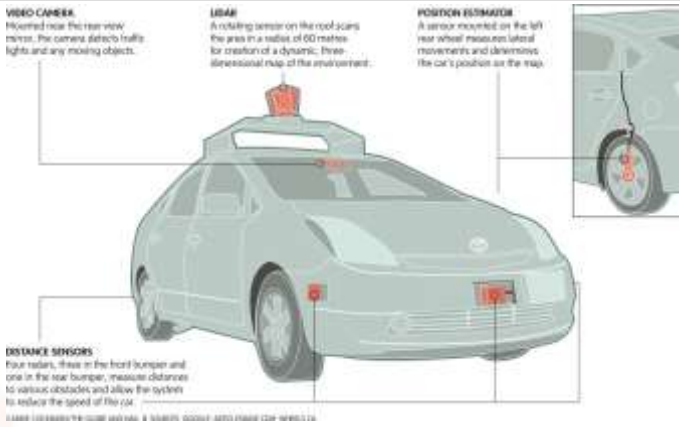
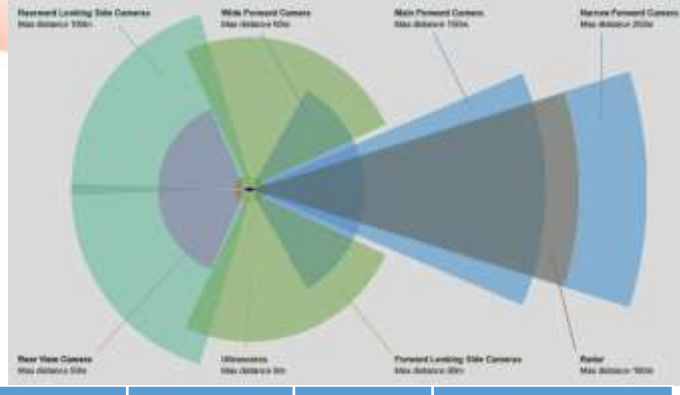
What Does AV See?







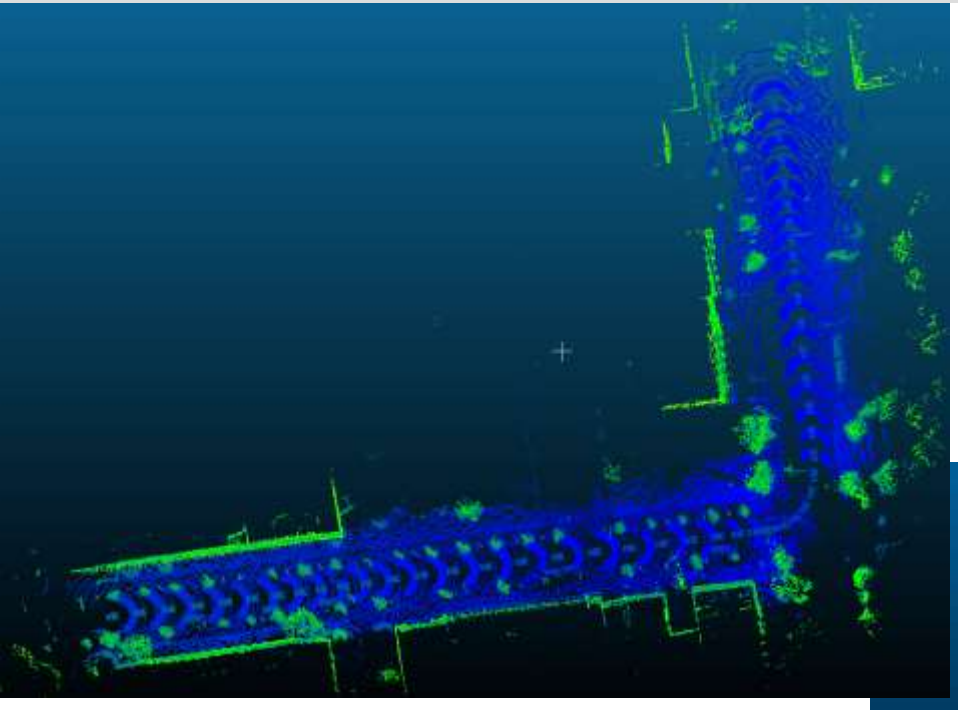
Model	Cameras	LiDAR	Other
Tesla M3	7	0	
Cadillac ST6	8	0	HD map, RTK
Waymo	1	1	Route info

Image Streams

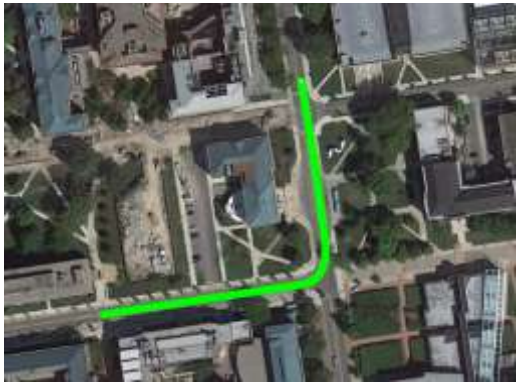
Image-based Collaborative Navigation and Mapping

OSU Campus, SPIN Lab CDD/SLAM solution (smartphone imagery)

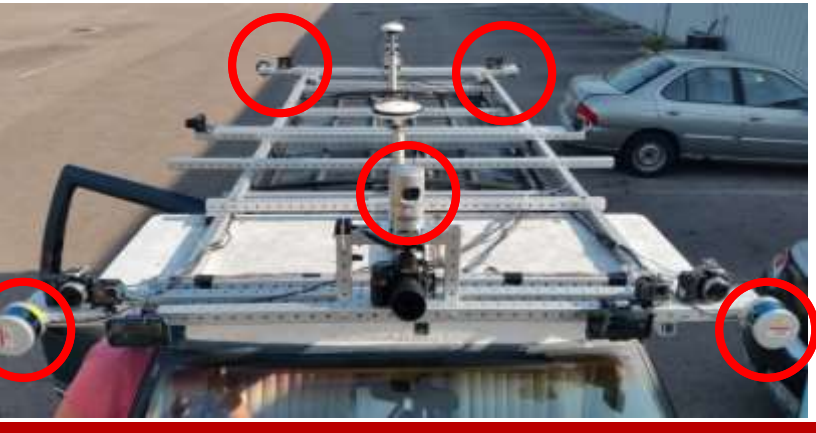
Lidar Point Clouds

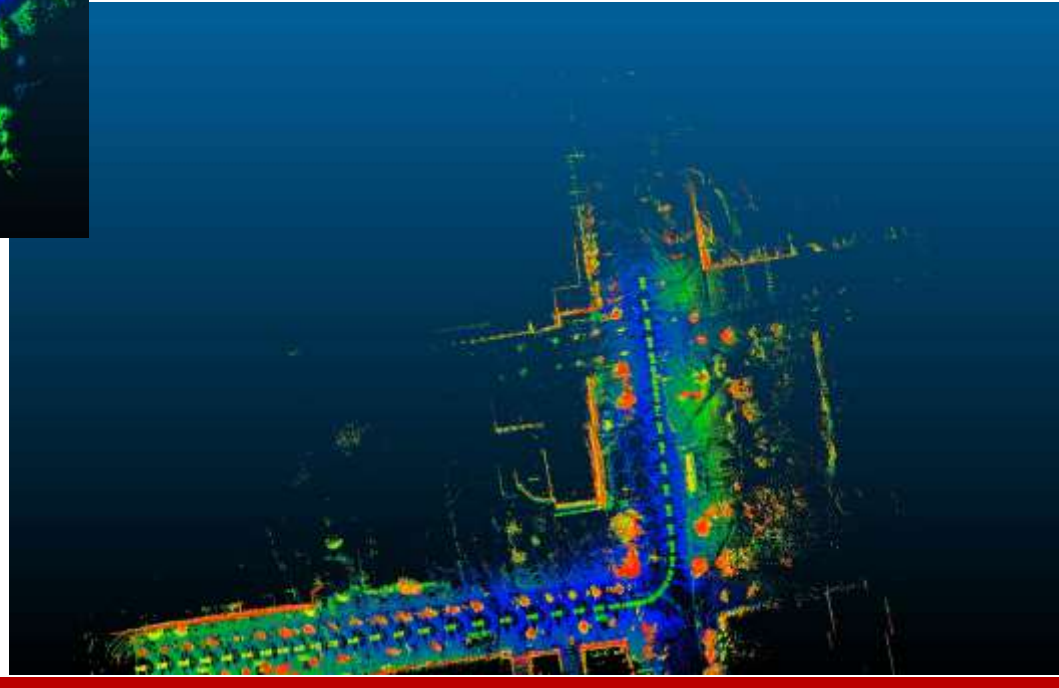


Central front LiDAR sensor, Velodyne HDL-32



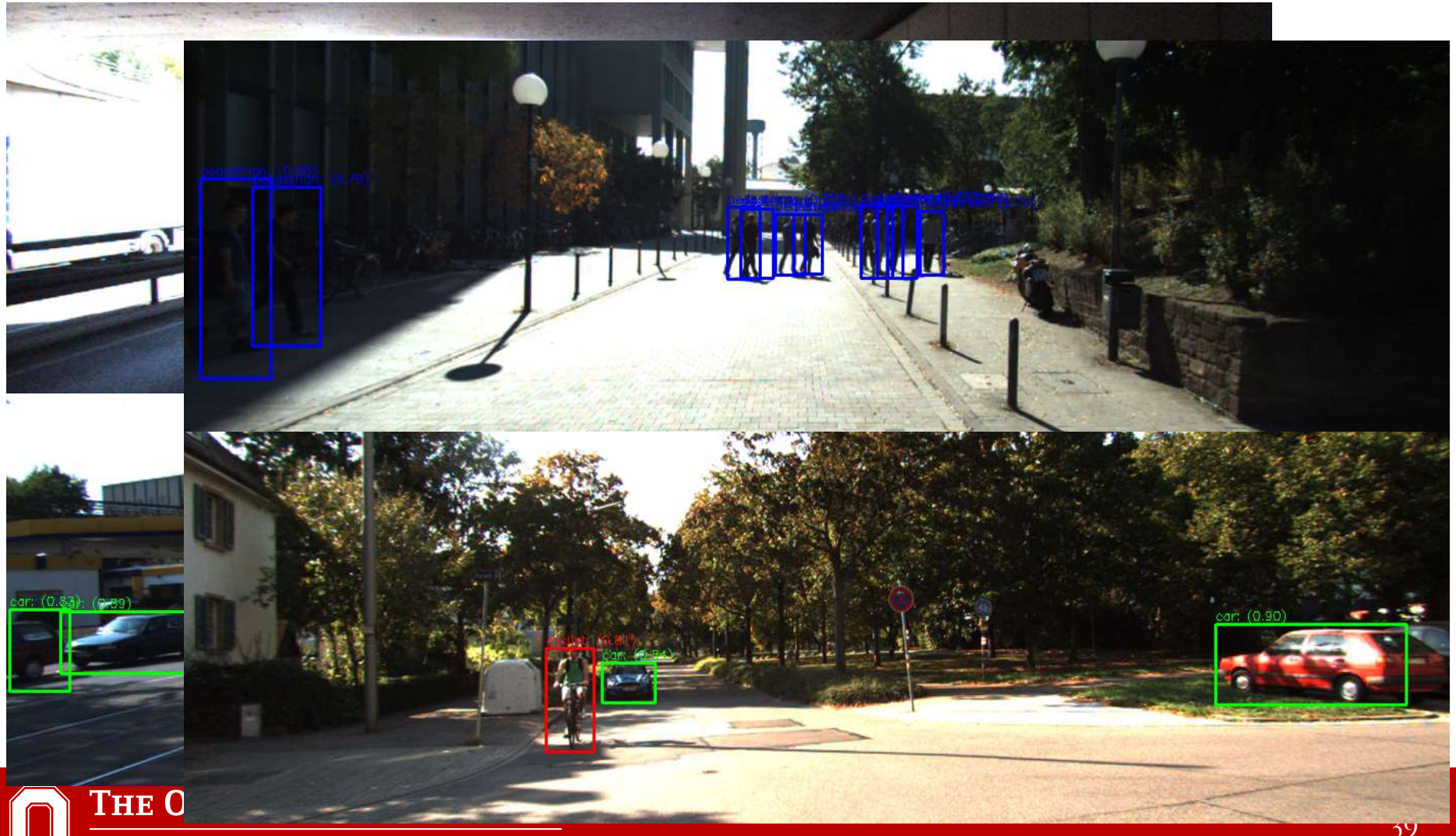
All LiDAR sensor data combined





Collision Avoidance

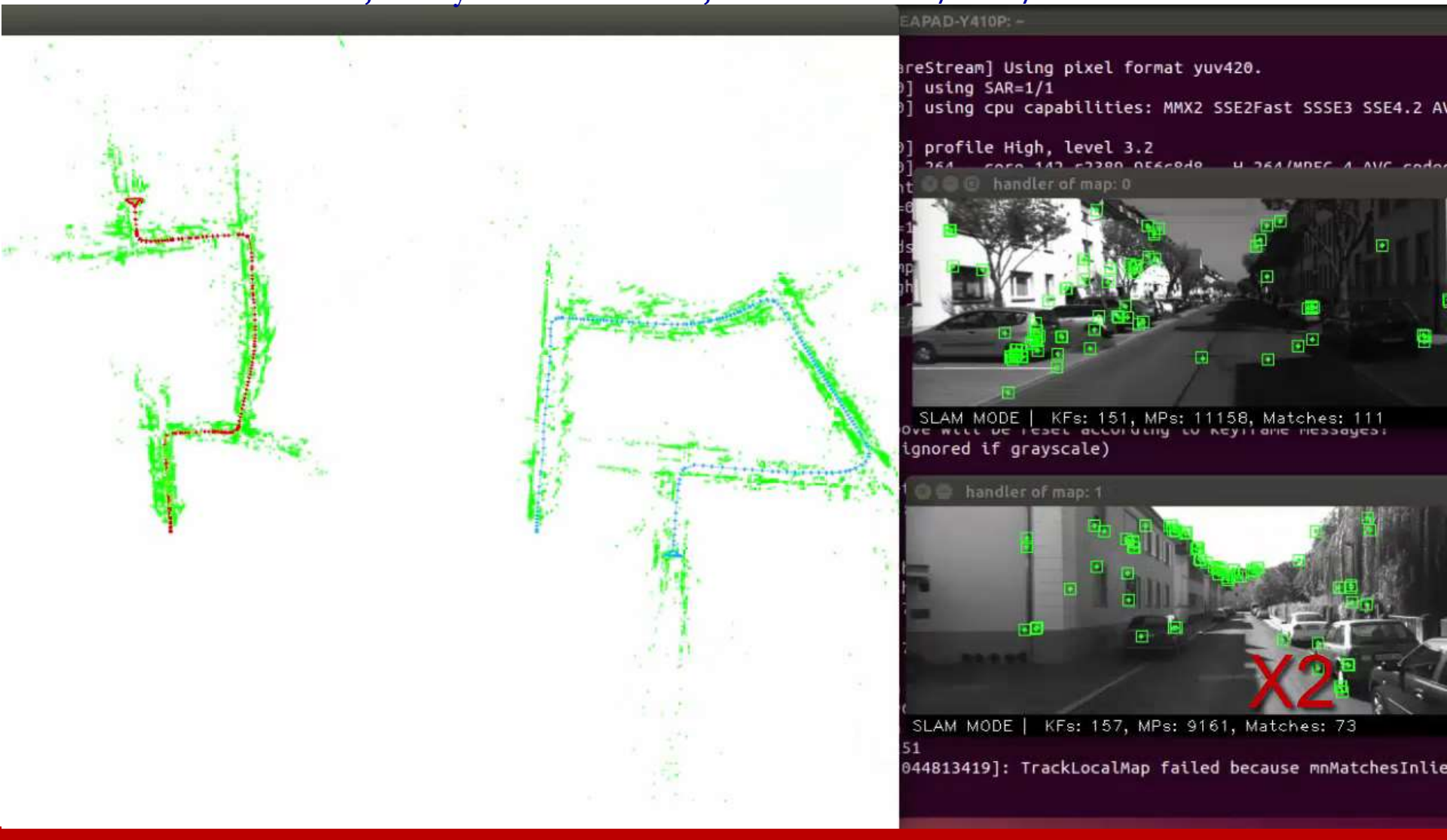
Tracking Moving Objects



Tracking Moving Objects

Creating Maps

KITTI data, widely used benchmark, SPIN Lab CDD/IMU/SLAM solution



Conclusion

- Smart Cities are relying on connectivity and sharing data/information with spatial/temporal context (every piece of information is geotagged)
- Handling the huge amount of sensor data requires new methods, Data Science, and within that discipline Data Analytics and Deep Learning (AI)
- Smart mobility is an essential part of Smart Cities, and driverless vehicles will play a growing role in the future
- Sensor proliferation will continue, seriously affecting both professional and crowdsourcing/crowdsensing based geospatial data acquisition and processing (accuracy and privacy are important questions)
- Autonomous vehicle technologies need high-definition and accurate 3D geospatial data to improve robustness and safety
- Autonomous vehicle technologies will likely be the prime provider of geospatial data along transpiration network in the future (mobile mapping platforms), and create a live transportation system (smart CAD/GIS)

THANK YOU!