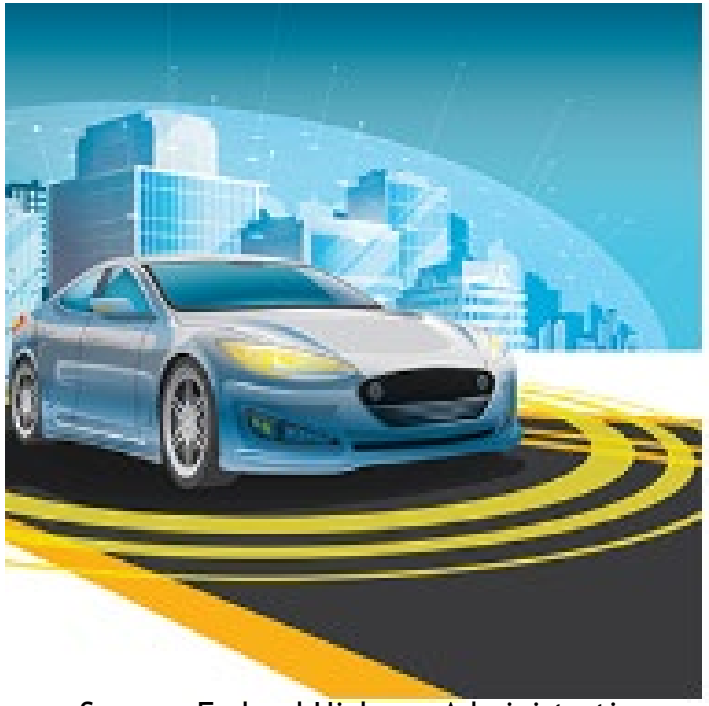
U.S. Department of Transportation
Federal Highway Administration



Source: Federal Highway Administration

BUILDING INFRASTRUCTURE FOR THE FUTURE

SOUTHERN TRANSPORATION AIR QUALITY SUMMIT
August 21, 2019

Why Do We Care? Automation and Safety

1. AVs that accurately detect, recognize, anticipate, and respond to the movements of all transportation system users could lead to breakthrough gains in transportation safety.

2. The voluntary guidance outlined in A Vision for Safety 2.0 on the design, testing, and safe deployment of Automated Driving Systems remains central to USDOT's approach.

3. AV 3.0 maintains USDOT's primary focus on safety, while expanding the discussion to other aspects and modes of surface transportation.

Safety by the Numbers

- An estimated **39,141** people lost their lives on all modes of our transportation system in 2017. The vast majority—37,133 deaths—were from motor vehicle crashes[A,B]
- *Driver Factors:* Of all serious motor vehicle crashes, **94 percent** involve driver-related factors, such as impaired driving, distraction, and speeding or illegal maneuvers.

  In 2017:
  - Nearly **11,000** fatalities involved drinking and driving.[B]
  - Speeding was a factor in nearly **10,000** highway fatalities.[B]
  - Nearly **3,500** fatal crashes* involved distracted drivers.[B]
- *Commercial Vehicles:* **13 percent** of annual roadway fatalities occur in crashes involving large trucks.[B]
- In 2017, **82 percent** of victims in fatal large truck crashes were road users who were not an occupant of the truck(s) involved.[B]
- *Professional Drivers:* Professional drivers are **ten times** more likely to be killed on the job, and nearly nine times more likely to be injured on the job compared to the average worker.[C]
- *Pedestrians:* **5,977** pedestrians were killed by motor vehicles in 2017, representing 16 percent of all motor vehicle fatalities.[B]
- *Highway-Rail Grade Crossings:* Over the past decade, highway rail grade crossing fatalities averaged **253** per year, representing about one-third of total railroad-related fatalities.[A]

Sources:
A U.S. Department of Transportation, Bureau of Transportation Statistics, special tabulation, September 8, 2018
B NHTSA 2017 Fatal Motor Vehicle Crashes: Overview (DOT HS 812 603)
C Beede, David, Regina Powers, and Cassandra Ingram, *The Employment Impact of Autonomous Vehicles*, U.S. Department of Commerce, Washington, DC: http://www.esa.doc.gov/sites/default/files/Employment%20Impact%20Autonomous%20Vehicles_0.pdf

* *This number is likely underreported.*

USDOT Automation Principles

USDOT has established a clear and consistent Federal approach to shaping policy for automated vehicles, based on the following six principles.

1. We will prioritize safety.

2. We will remain technology neutral.

3. We will modernize regulations.

4. We will encourage a consistent regulatory and operational environment.

5. We will prepare proactively for automation.

6. We will protect and enhance the freedoms enjoyed by Americans.

Automated Vehicles 3.0

PREPARING FOR THE FUTURE OF TRANSPORTATION

www.transportation.gov/av

Where we ARE…

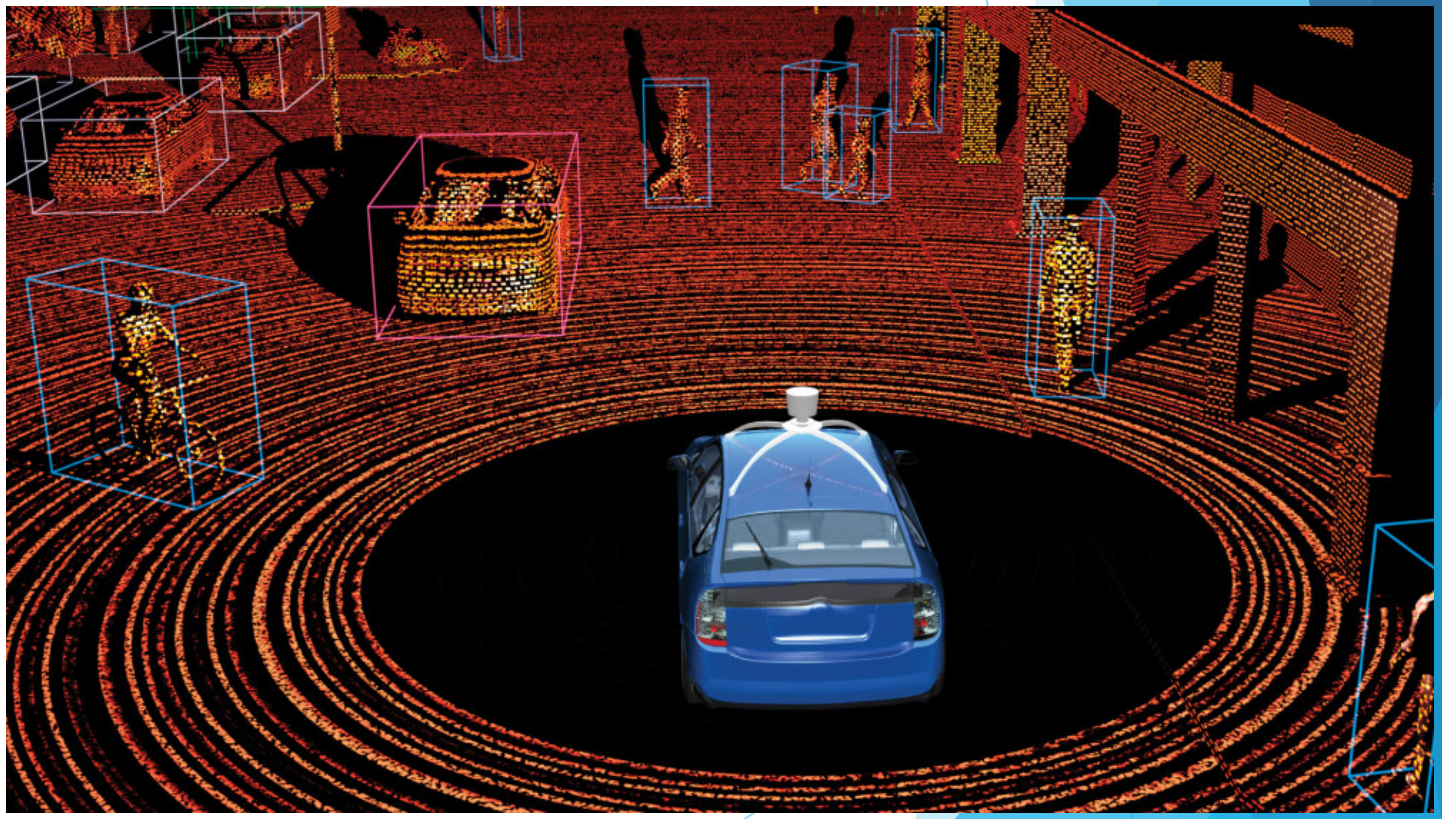
Monitored Driving			Both	Non-Monitored Driving	
Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**
No Automation (driver only)	**Driver Assistance** (driver assisted by automation)	**Partial Automation** (self-driving on occasion)	**Conditional Automation** (self-driving for specific uses)	**High Automation** (self driving under defined conditions)	**Full Automation** (driverless)
Driver has longitudinal AND lateral control	*Driver has longitudinal OR lateral control; System has the other* Example: Cruise Control	*System has longitudinal AND lateral control for specific uses* Example: Cruise Control and Lane Positioning	*System has longitudinal AND lateral control for specific uses; informs Driver to resume control if necessary*	*System has control in defined use case; assumes good weather conditions*	*System has control in all situations*

NHTSA & Society of Automotive Engineers (SAE) Automation Levels J3016

https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety#av-30 https://www.sae.org/standards/content/j3016_201806/ Table 1. p17

How Do Automated Vehicles Work?

- AVs may combine sensor and map data, can detect and classify objects in their surroundings, and may predict how they are likely to behave with:
  - Other moving vehicles.
  - Pedestrians and cyclists.
  - Stationary objects (e.g., signs, trees, traffic cones).
- Based on what an AV can "see" and what it predicts nearby objects are likely to do, it can make decisions about speed and steering inputs.



Source: Federal Highway Administration

Source: An Introduction to Automated Vehicles

Connectivity May Enhance Automated Vehicle Benefits

- Connectivity may enhance the safety and efficiency of AVs by providing greater situational awareness and efficiency.

- **What is Connectivity?**
  - The ability to transmit data and information to and from the vehicle.
  - May include the ability for a vehicle or driver to receive and use broadcasted information about traffic, travel, roadway condition, and other information.
    - (Example: vehicle is aware of work zone in advance.)
  - May include the transmission of critical information from the vehicle.
    - (Example: crash notification.)

Source: An Introduction to Automated Vehicles March 8, 2018

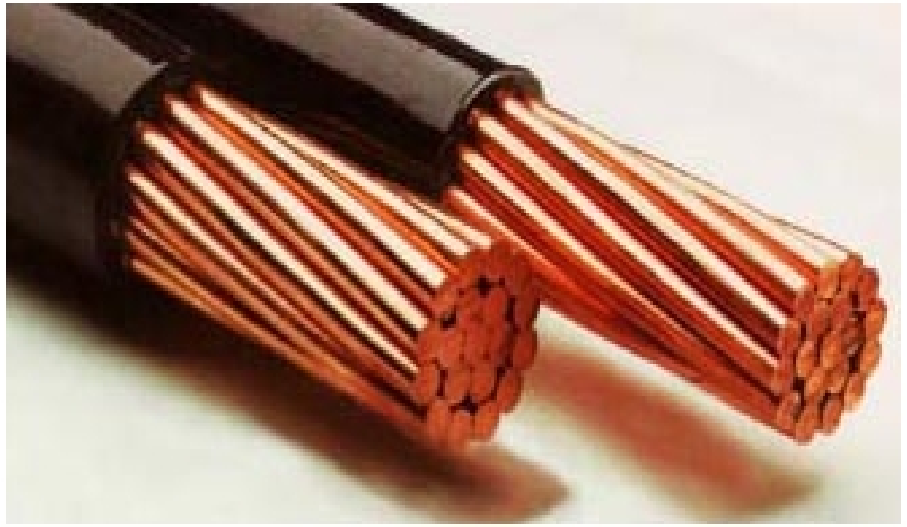
The BASICS

- **Infrastructure**
- **Technology**
- **Data Collection**

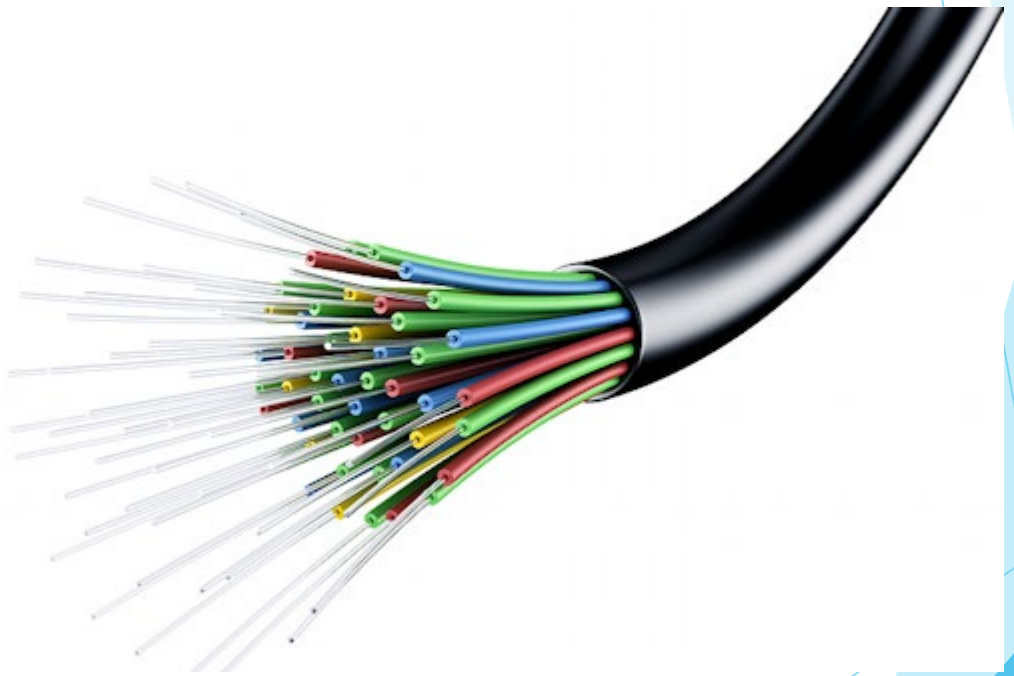
http://www.mujeresdeempresa.com

The BASICS: Infrastructure

Phone Lines OR Fiber Optic Cable



http://engineering.electrical-equipment.org

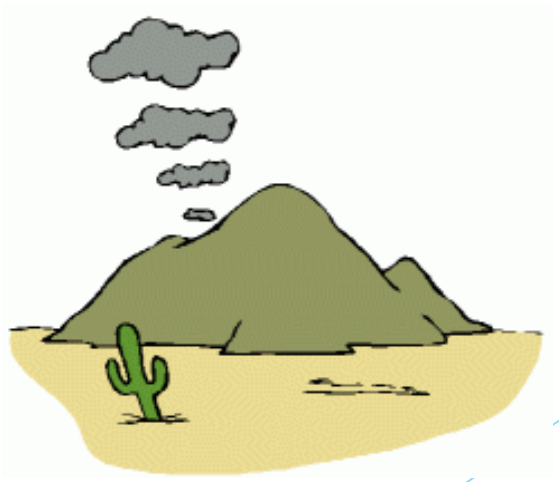


http://www.davidellis.ca

Infrastructure: Two Key Terms

- Bandwidth – How much data can be sent
- Latency – How long it takes to send the data

Shutterstock - 172029599



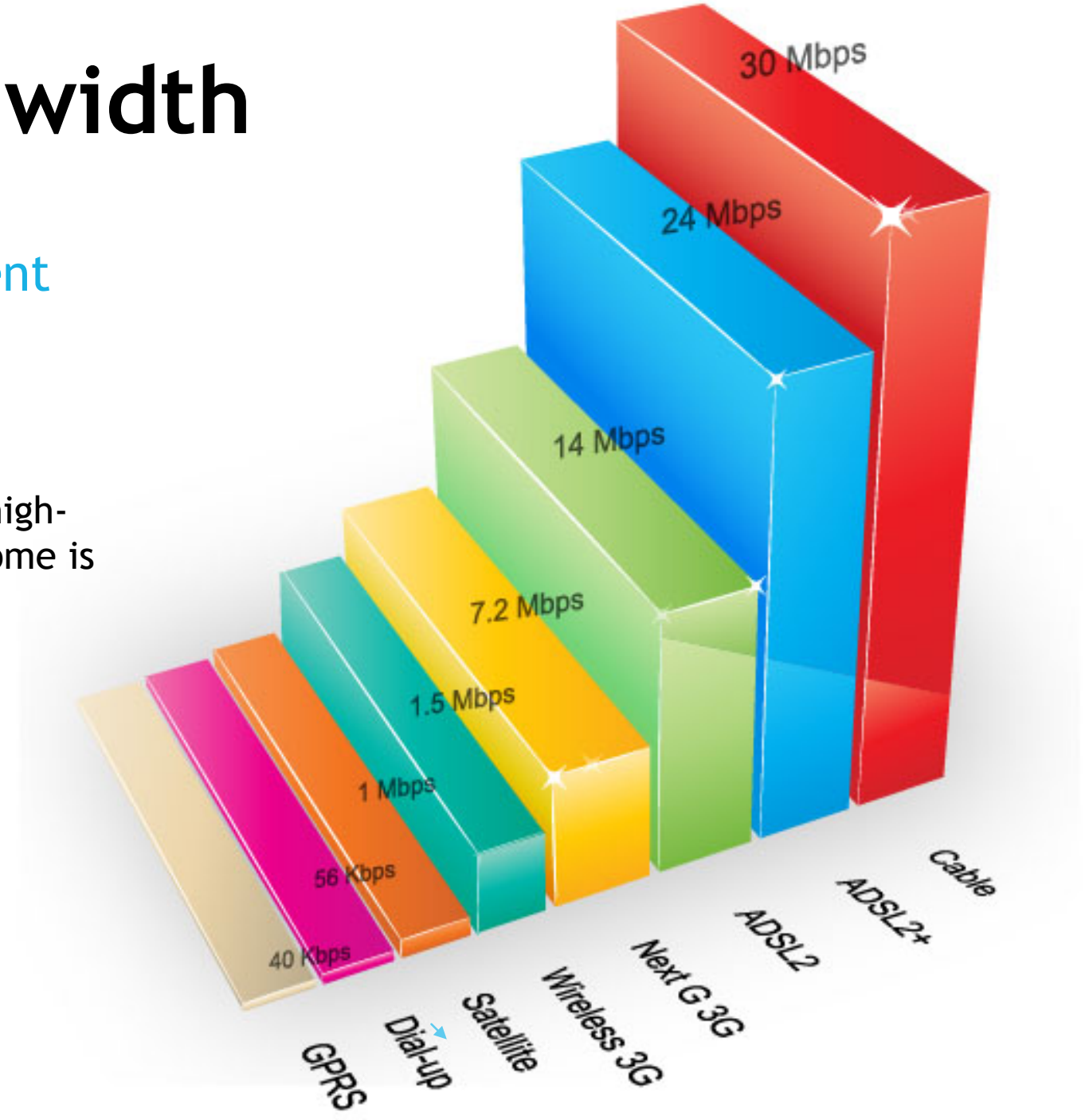
On-line Pictures

Infrastructure: Bandwidth

Bandwidth = How much Data can be sent

Data transfer rate is the average number of bits

Example: Data Rate for the modem that provides high-speed Internet connections for your computer at home is usually in Mbps



Infrastructure: Bandwidth

Dial Up
- Uses same phone line for internet and home phone
- Can't use both at same time
- Copper – usually 4-strand – since 1880s
- 56 Kbps

Cable Internet / "Broadband"/DSL
- Both phone and internet on same phone line but on different frequencies
- Slows down the further away from the switching station
- Coaxial cable – stranded copper
- 30 Mbps

Fiber Optic Cable
- Glass
- 1 Gbps (1000 Mbps)

To download a 2-hr (1 GB) movie :

10 minutes

8 seconds

Infrastructure: How We Use The Technology

- **Closed Circuit (CCTV) cameras are used for traffic surveillance.**
- **CCTVs relies on latency and bandwidth to operate effectively.**

  - **Latency**
    - Panning camera
    - Speed for humans shouldn't be > 250 milliseconds

  - **Bandwidth**
    - Resolution (pixels)
    - Frame Rate (requires Bandwidth)
      - HDTV – 30 frames/second
      - Computer – 60 frames/second

http://returntooza.tistory.com/1266

Infrastructure: Dial-Up Connections via Phone Lines

Source: David Filiatreau, Lexington Fayette Urban County Government (LFUCG)

http://suchismita-wwwsuchsimita.blogspot.com/2011/03/telephones-and-me.html

- **Low Bandwidth Capacity**
  - Cameras can NOT be added
  - Cannot collect much data
  - Signal change data takes ***5-10 minutes*** to download.
  - It takes hours or days to retime signal systems

http://energy-alaska.wikidot.com/current-costs-future-projections

- **Expensive**
  - 10 years ago in Lexington – phone bill was ***$300,000+/yr***

http://engineering.electrical-equipment.org

NOTE: Depending upon installation..

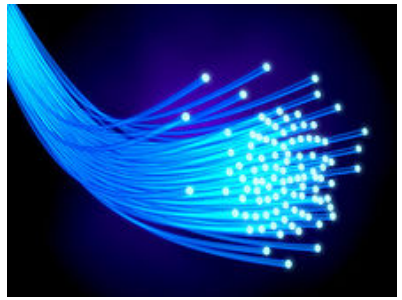
Range is associated with distance from main line.

The further away the less data.

Works at 11,000 – 15,000'

Infrastructure: Fiber Optic Cable Network

Source: David Filiatreau, LFUCG



www.sienanews.it/

- **High Bandwidth Capacity**
  - Operate High Definition Cameras
    - Used on busiest corridors to monitor congestion and traffic incidents.
    - Photo every 1/10 second
  - Collects traffic volumes, record phase timings, more….
  - Signal changes take ***1/5-1/10 second***
- **Low Latency** Connection
  - Required for Safety Critical Functions
  - Monitor Signal System in Near Real Time
- **Low Cost**
  - No overhead, ***$30,000/yr for entire network – includes maintenance costs***

NOTE: Lexington KY's Bandwidth for Fiber Network
2000 Mbps = 2 Gbps

How much isn't used???

http://energy-alaska.wikidot.com/current-costs-future-projections

Technology

- USDOT focus is on delivering benefits regardless of the technologies (technology neutral)

- Wireless Technologies enables connectivity to automated systems:
  - Safety Critical Applications
  - Non-Safety Applications

Source: Federal Highway Administration

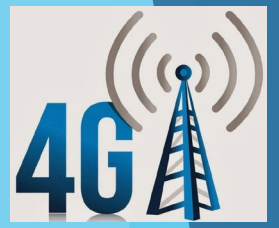
Technology

- **Safety Critical Applications**
  - Latency performance is absolutely critical
  - 5.9 GHz spectrum reserved for that purposes
  - One-To-Many
  - These are interoperable standards used by the CV Pilot sites.
    - IEEE 802.11p-2016 – wireless communication standards
    - IEEE 1609 – security and privacy standards
    - SAE J2735 – message/data standards

Source: Federal Highway Administration

Technology

Wi-Fi, Cellular - ONE TO ONE



https://www.navigaweb.net/2014/12/migliori-10-smartphone-4g-lte.html

- **Non-Safety Applications**
  - Latency not as critical
  - Can consider using other technologies, Wi-Fi, 4G Cellular, …
  - In the future, Cellular may play a role, but at this time the pathway is uncertain.

Twistedsifter.com

- **Non-Safety Shared Infrastructure**
  - Wi-Fi public or private service
- **Macro** and **Micro/Small Cells** to optimize the mix of capabilities.
  - Use different frequencies

Technology: Message Authentication Systems

- Cybersecurity component of Connected Automated Systems
- Messages should be authenticated
  - Between vehicles
  - Between vehicles and infrastructure

www.wired.it

- Authentication guarantees safety information is from a trusted source
- USDOT work on this is completed (secure credential management system – SCMS) and available on ITS JPO website
- Deploying agencies should apply available commercial solution to preserve message security

What's Going On In Kentucky?

Photos by Bernadette Dupont

CAV Peer Exchange

- Connected and Autonomous Vehicles (CAV)
- One day event held in Lexington on May 30, 2018.
- About 30 participants
  - MPOs: Lexington, Louisville, Cincinnati
  - KYTC
  - FHWA
  - UKTC

https://gustmees.wordpress.com

LEXINGTON

Lexington Fayette Urban County Government (LFUCG)

LFUCG Contact:

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Signal Systems Manager
Lexington-Fayette Urban County Government
101 E. Vine Street, Suite 300
Lexington, KY 40507
(859)258-3491

Advantages include:

- MPO provides a portion of their dedicated STP money on a regular basis
- CMAQ awards
- Consolidated Cities

Infrastructure - Fiber Optic Cable

Source: David Filiatreau, LFUCG

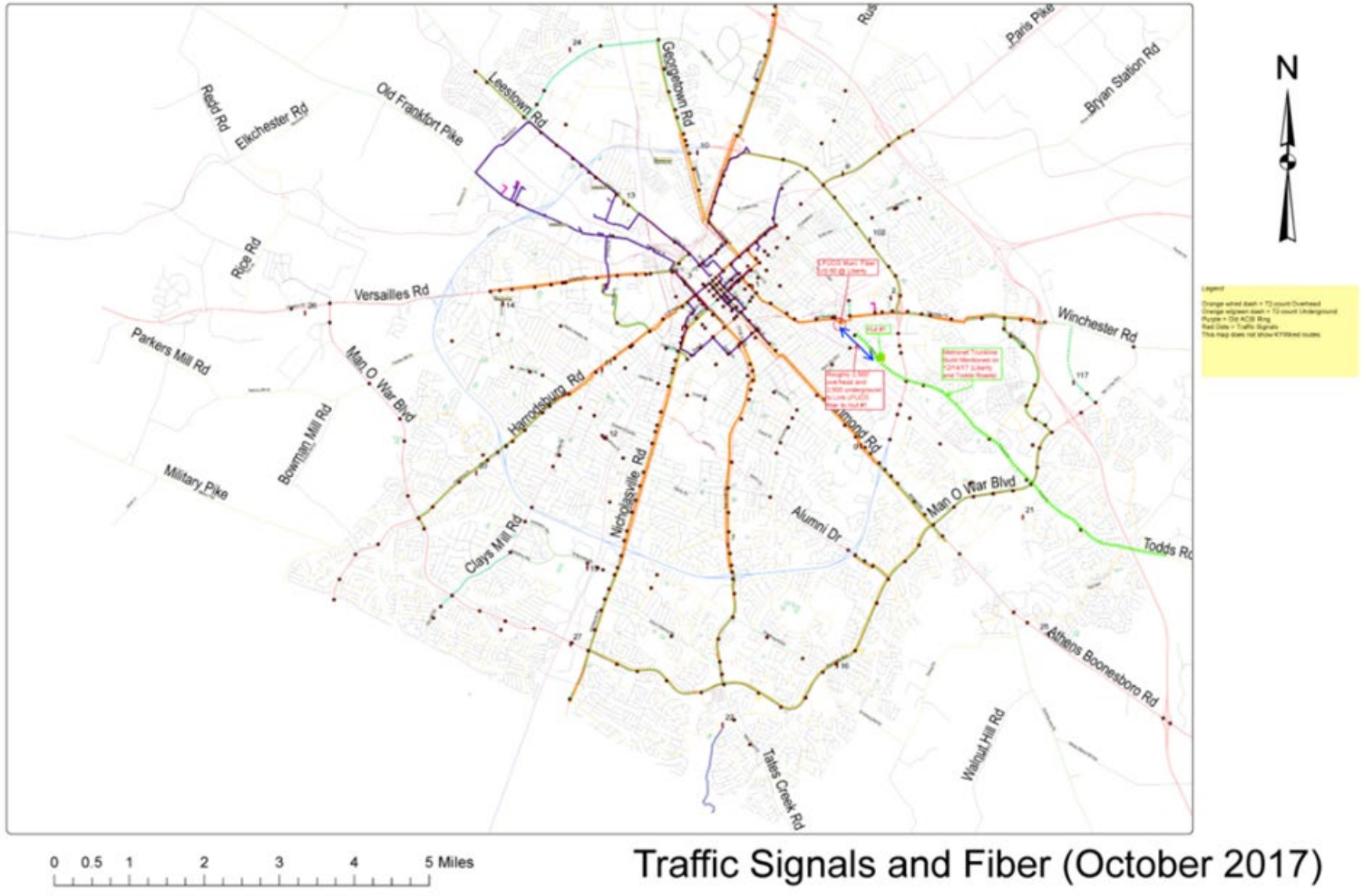
- 95% of city covered
  - 80% connected directly via fiber optic cable
  - 15% connected via high speed radio
    - Radios connections are “last mile connections”
    - Radio “hops” are installed at locations where
      - Fiber has not yet been installed
      - It wouldn’t make sense spend the money to get it installed.
        - (I-75 at Athens-Boonesboro Rd)

Infrastructure - Fiber Optic Cable

- 90 miles of cable connecting
  - 402 traffic signals
  - 24 fire and police stations

www.publicdomainpictures.net

www.leader-values.com



Traffic Signals and Fiber (October 2017)

Source: David Filiatreau, LFUCG

Infrastructure - Micro/Small Cell

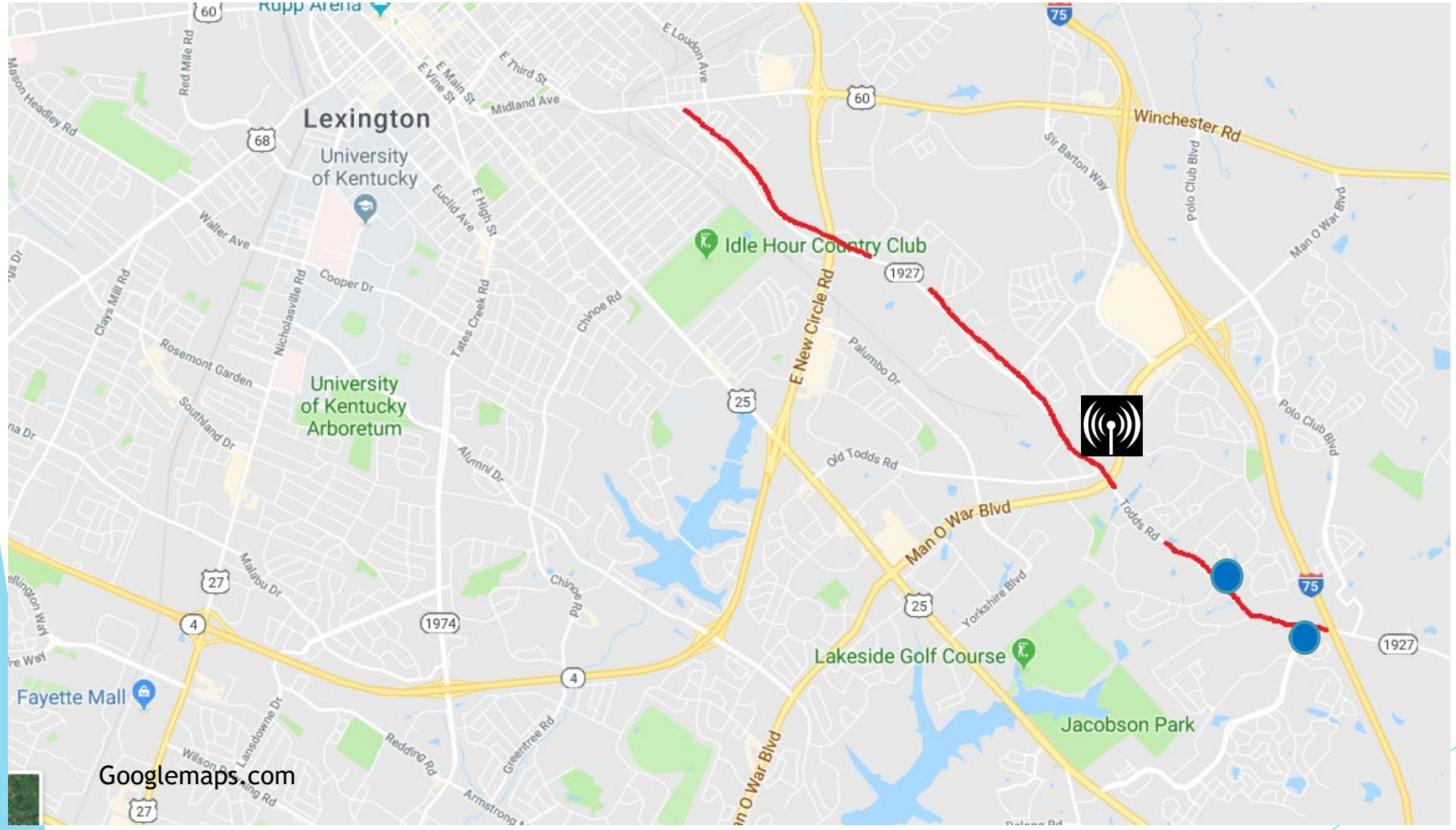
Lexington has 1
- Call it a “Sector Antenna”
- Located at Paul Laurence Dunbar High School

https://fr.Wikipedia.org

Source: David Filiatreau, LFUCG

HOW IT WORKS:

Lexington, KY has a HYBRID NETWORK - multiple technologies are employed.
Most of the road is connected with fiber, but there is a radio installed that interfaces with the fiber network. The radio transmits information from the intersections.



- Man-o-War at Liberty Road
- Todd's Rd/Hayes
- Todd's Rd/Autumn Ridge

KENTUCKY TRANSPORTATION CABINET

Source: Shane McKenzie, KYTC

www.rizomatica.net/empleabilidad-en-un-mundo-conectado/

CAV Initiatives

- Identified internal stakeholders and are developing a **"CAV Road Map".**
- Plans to launch an internal **CAV webpage** by the end of 2018.
- Commissioned **research project to identify any barriers**, regulations, or policies that might prevent implementation of CAV in 2017.
  - https://uknowledge.uky.edu/ktc_researchreports/1568/

KENTUCKY TRANSPORTATION CABINET

Source: Shane McKenzie, KYTC

www.pixapay.com

CAV Initiatives

- KYTC worked on a Mid America Association of State Transportation Officials (MAASTO) taskforce to research policy and regulatory issues related to truck platooning in an effort to define a framework or model for regulatory changes that might result in harmony among MAASTO States

- The Governor signed Senate Bill 116 to allow “Truck Platooning” on March 10, 2017

Next Steps…

writersally@blogspot.com

Deborah Curtis
Office of Operations R&D
Turner Fairbank Highway
Research Center

SAXTON LABORATORY
Driving Future Highways

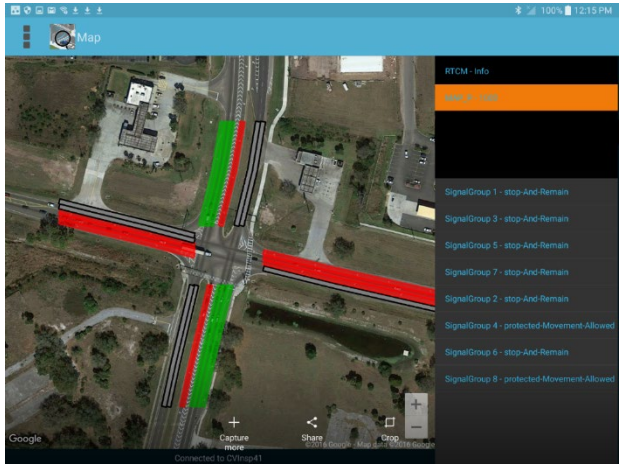
CAV Support Services

https://www.pcb.its.dot.gov/CAVSupportServices.aspx
CAVSupportServices@dot.gov

Business hours:
Monday-Friday, 8:00AM - 5:00PM EST
Toll-free #: 1-844-DOT-CVCS (1-844-368-2827)

Equipment Loan Program

- Roadside Units (RSUs) – Infrastructure DSRC radios
- Onboard Units (OBUs) – In-vehicle DSRC radios
- DSRC Sniffers – Device to validate wireless communications
- V2I Trailers – Self-powered trailers with radios and traffic signal controllers for mobile testing
- *V2I Test Device – Device with visual display to confirm transmission of SAE J2735-03 messages*



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QUESTIONS?

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