Data Collection and Uses at International Border Crossings

Technology Options

Juan Carlos Villa

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Texas A&M Transportation Institute

Background

The border crossing process

- Stakeholders from 2 countries,

- Private and public sectors

- With different objectives

➢ Multiple and diverse data needs!

Data Needs and Use

Enforcement

- ✓ Credentialing, vehicle weight, immigration, customs duties, user fees, etc.

Planning and operations

- ✓ Crossing and wait times, lane usage, staffing, tolling, vehicle volumes, etc.

Technologies for Wait Time Measurement at LPOEs

- Inductive Loop Detectors

- Bluetooth

- Radio Frequency Identification (RFID)

- Global Positioning System (GPS)

- Connected Vehicles

- LED Sensors

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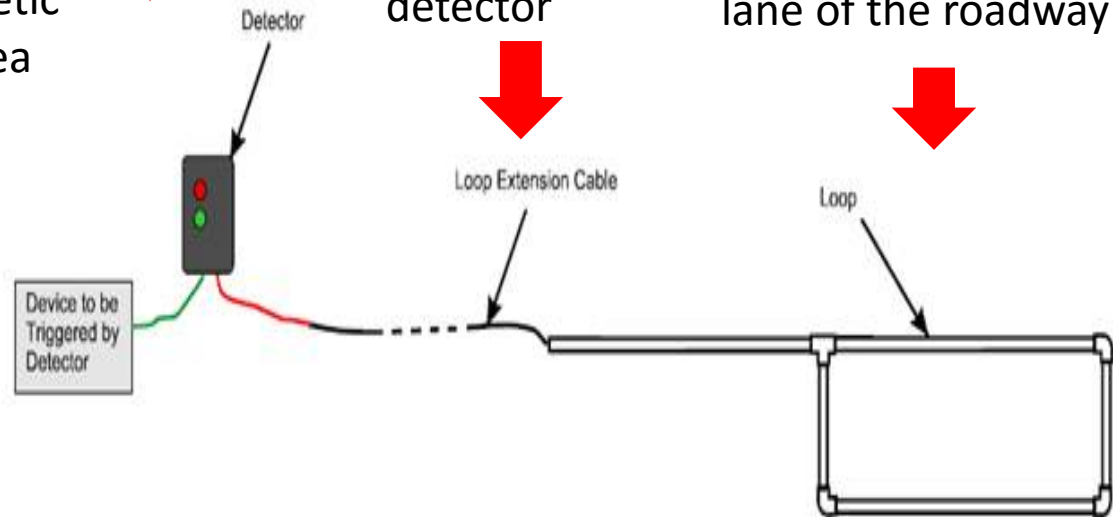
Inductive Loop Detectors

Elements:

Powers the loop and causes occurrence of magnetic field in the loop area

Connects the loop with the vehicle detector

Turns of isolated wire are placed under each lane of the roadway

Detector

Device to be Triggered by Detector

Loop Extension Cable

Loop

How it works:

A large metal object (vehicle) moves over the loop

Resonate frequency increases

The detection is made

Inductive Loop Detectors

Benefits:

- Mature technology (50 years on the market)

- No on-board equipment required

- Low installation and maintenance costs per detector

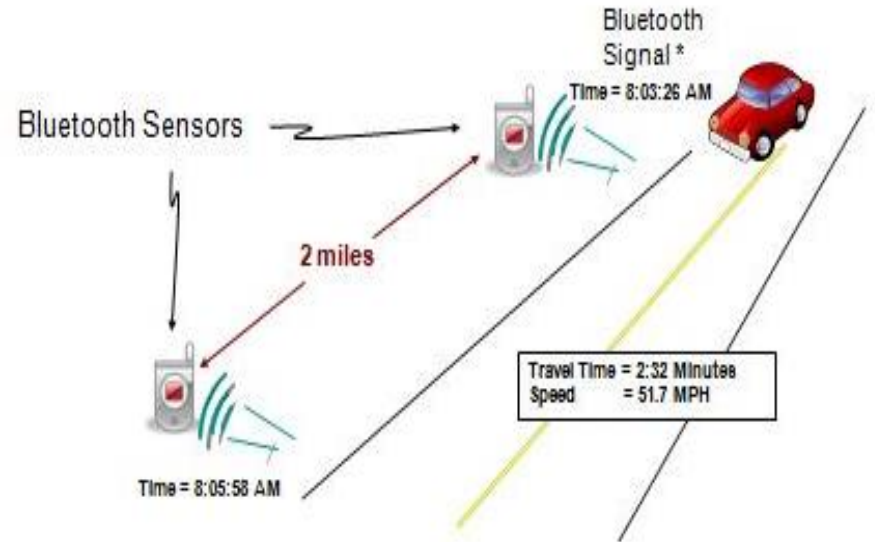- Accuracy can be increased if combined with technologies that have good spatial coverage (Bluetooth, GPS, RFID)

Concerns:

- High errors (traffic conditions are not captured between detectors)

- Low reliability of detectors (25% of installed detectors fails every year)

- Implementation of loop detectors has lower value added in comparison to implementation of more innovative technologies
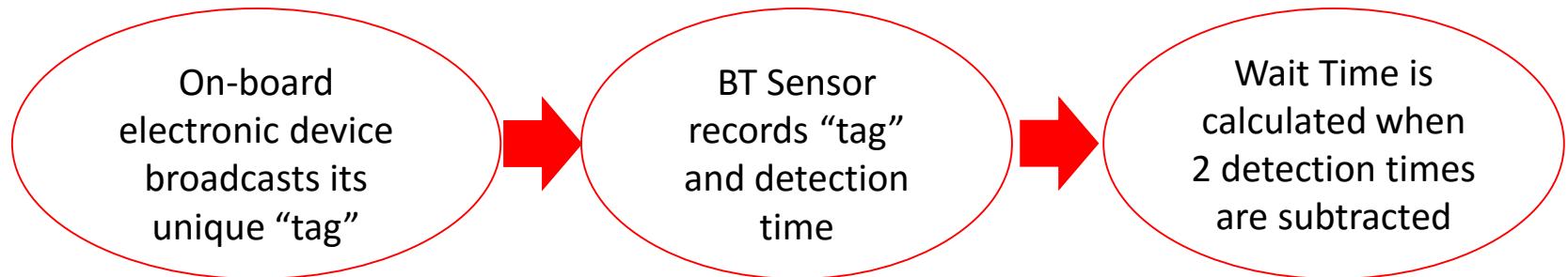
Bluetooth® (BT)

Elements:

- A wireless technology- allows radio frequency communication between BT enabled devices

- BT-devices: cell phones, computers, tablets, headsets, car navigation systems

How it works:

On-board electronic device broadcasts its unique "tag"	→	BT Sensor records "tag" and detection time	→	Wait Time is calculated when 2 detection times are subtracted

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Bluetooth® (BT)

Benefits:

- Mature technology (20 years on the market)

- Easy implementation

- Cost-effective

- Almost absent privacy violation

- Technology might bring more powerful devices and higher accuracy

Concerns:

- Complex algorithms are required

- Low penetration rate and match rate

- Overestimation of travel time (due to low sample rate and occurrence of multiple detections)

- Substitute technologies perform better

Radio Frequency Identification (RFID)

Elements:

- Uses electromagnetic fields for "tag" identification and tracking

  - In the vehicle- RFID tag (microchip and antenna)

  - Above traffic lanes- Reader unit (transmitter/receiver and antenna)

- Used at NEXUS, SENTRI, and FAST programs and tolls, user fee programs
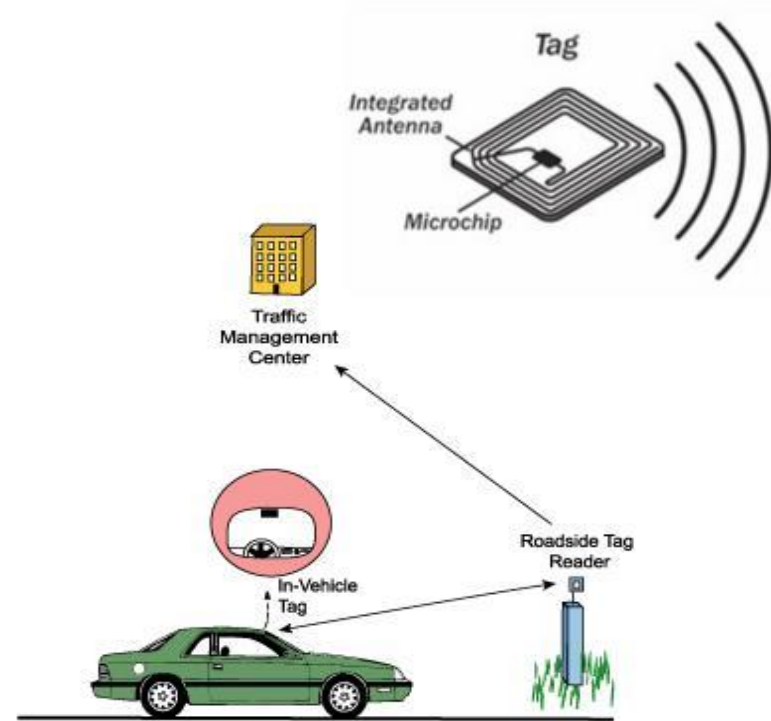
How it works:

A reader generates electromagnetic field and activates the "tag" → The "tag", when activated, sends requested data (serial number, location, etc.) → Wait Time is calculated when 2 detection times are subtracted

Radio Frequency Identification (RFID)

Benefits:

- Mature technology (40 years on the market)

- Easy implementation

- Low operating cost

- Precise data collected

- Performs well for freight wait time measurement at the border

Concerns:

- High investment for roadside infrastructure

- Possible data loss and multiple detection

- Low penetration rate for POVs

- Insufficient technology for wait time measurement

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Global Positioning System (GPS)

Elements:

- A satellite-based navigation system

- A probe vehicle- a vehicle that has an on-board data collection device

- The stored data is extracted by a reader using Bluetooth® technology when the probe comes within detection range.

GPS Satellites

Traffic Management Center
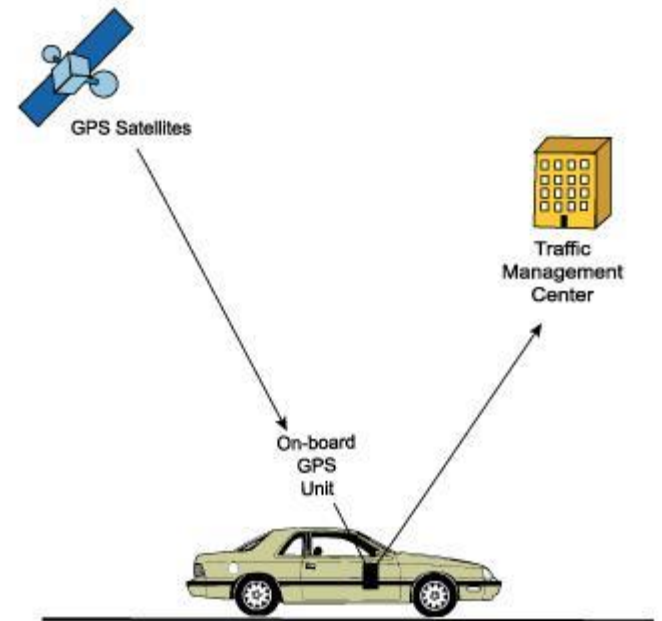
On-board GPS Unit

How it works:

On-board GPS unit determines its coordinates and time stamp while moving ➡ The stored data is extracted by a reader ➡ Wait Time is determined

Global Positioning System (GPS)
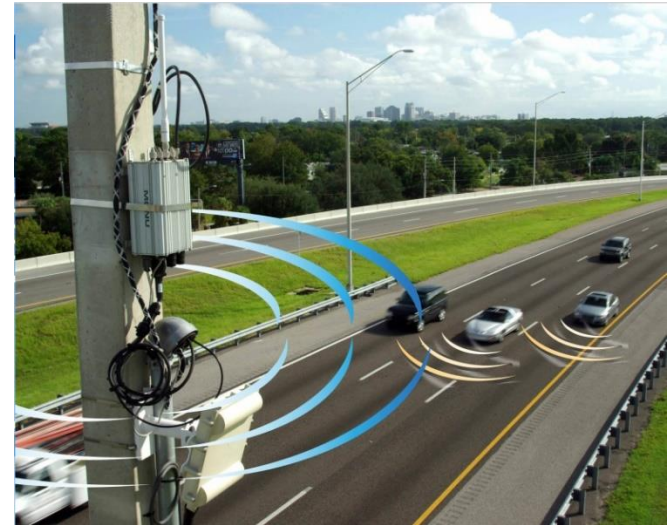
Benefits:

- Wide geographical coverage

- Low operating cost

- High data availability

- Potentially high accuracy

Concerns:

- Insufficient number of GPS-equipped vehicles

- Privacy concern

- The ability to gather data is completely dependent upon the willingness of carriers to share their information

- Enough crossing data may not be collected for reliable analysis

Connected Vehicles (CV)

- The Federal Communication Commission (FCC) assigned 75 MHz of wireless spectrum denoted as the 5.9 GHz band to be applied for Dedicated Short Range Communication (DSRC), particularly for CV usage.

- V2I communication allows data collection from a probe vehicle

- Basic Safety Message (BSM)- a data package: identification, vehicle position, speed, heading, etc.

How it works:

DSRC-equipped vehicle frequently broadcasts BSM while moving (10 times per second) → The stored data is extracted by the road infrastructure equipment → Wait Time is determined
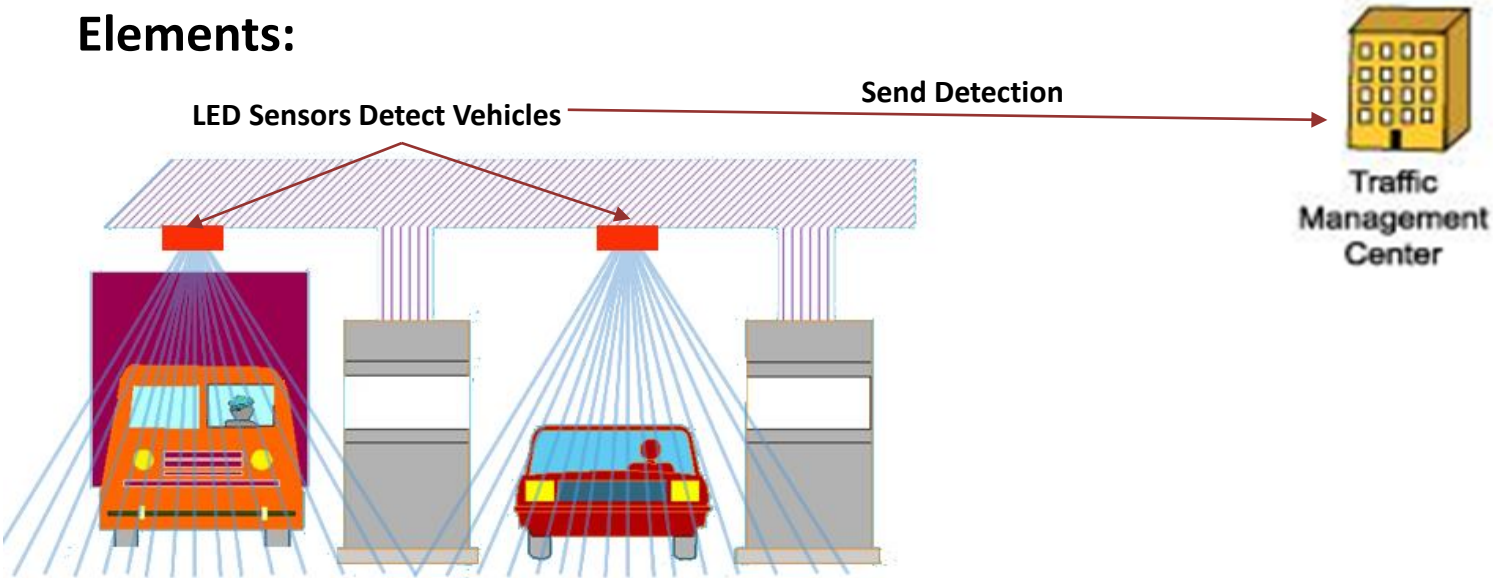
Connected Vehicles (CV)

Benefits:

- Reliable and fast

- Efficient and secure

- No interference in message transmission

- Wait time forecast

- Potential market growth (The CV market is expected to grow at a 10 times faster rate than the overall car market)
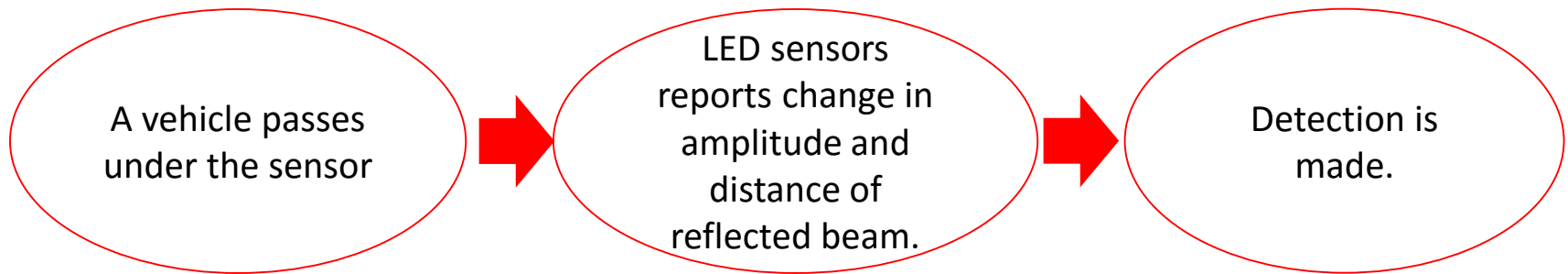
Concerns:

- Immature technology

- High per device cost

- Licensing fees

- Low market penetration in the next few years

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LED Sensors

Elements:

LED Sensors Detect Vehicles

Send Detection

Traffic Management Center

How it works:

A vehicle passes under the sensor ➡ LED sensors reports change in amplitude and distance of reflected beam. ➡ Detection is made.

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LED Sensors

Benefits:

- Accurate vehicle counts.

- Accuracy is independent of environmental (visibility, lighting, temperature ,etc.) conditions.

- Low operational and installation cost.

- No on-board equipment required.

- Can be used with RFID or Bluetooth for better wait time estimation.

Concerns:

- Unable to differentiate between loaded and empty trucks.

- Not tested under high speed conditions.

Summary

Technologies in operation

- ✓ RFID mainly for CV BWTC. Tolling, fess, credentialing are other uses

- ✓ Bluetooth for POV BWTC. WiFi as an alternative

- ✓ LED vehicle detector

Emerging technologies

- ✓ Connected vehicle. Provides much more information for multiple purposes.

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Contact Info

Juan Carlos Villa

j-villa@tti.tamu.edu

979.862.3382

Rajat Rajbhandari

Rajat@tti.tamu.edu

972.994.0433

Swapnil Samant

s-samant@tti.tamu.edu

915.532.3759

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