Cybersecurity Challenges in Transportation Systems

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In collaboration with the City of Tampa Transportation Management Center

Motivation: Transportation and Technology

- Current status
  - Adapt techn… …nprove usa…
- Emergi…
  - Conn…
  - Auton… …nology

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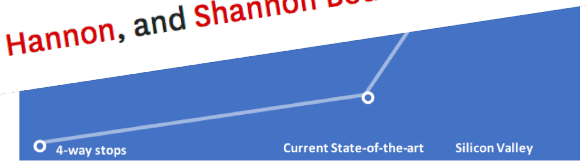
Technology Is Changing Transportation, and Cities Should Adapt

Harvard Business Review

by Stefan M. Knupfer, Eric Hannon, and Shannon Bouton



Tech and the future of transportation: From here to there

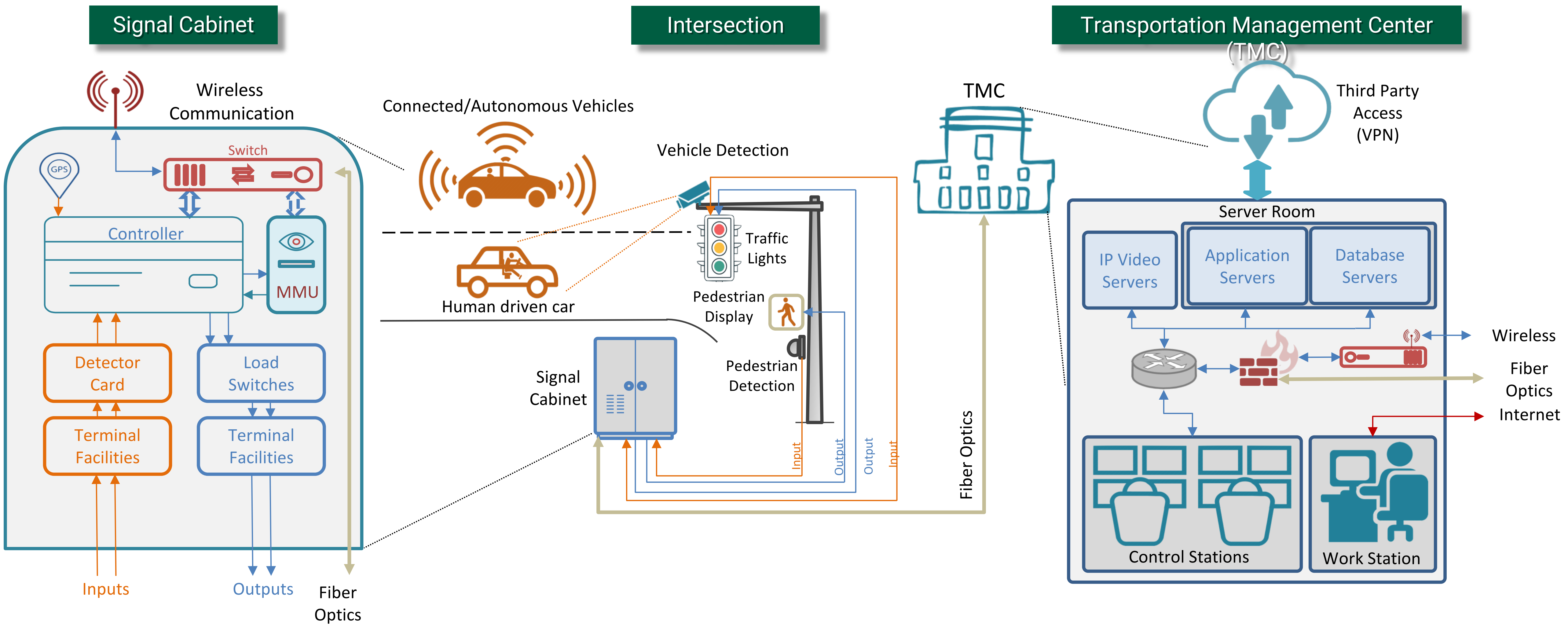
Transportation is about to get a technology-driven reboot. The details are still taking shape, but future transport systems will certainly be connected, data-driven and highly automated.

Transportation systems inherits the Cyber-security problem.

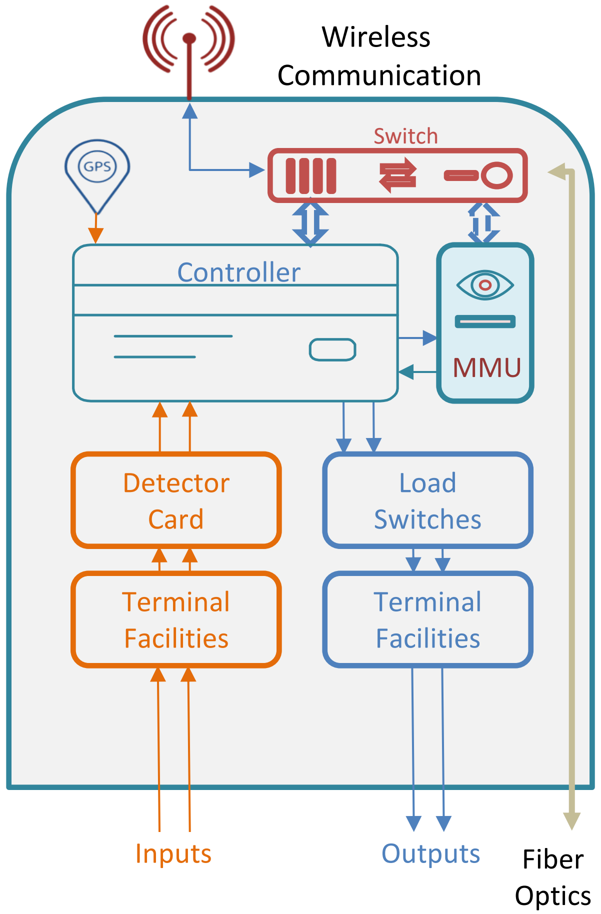
Outline

- Case study: City of Tampa Transportation Management Center
  - Overview of the current transportation system
  - Cyber risk analysis
- Demo
- Conclusion and Take away

Overview of the Transportation System

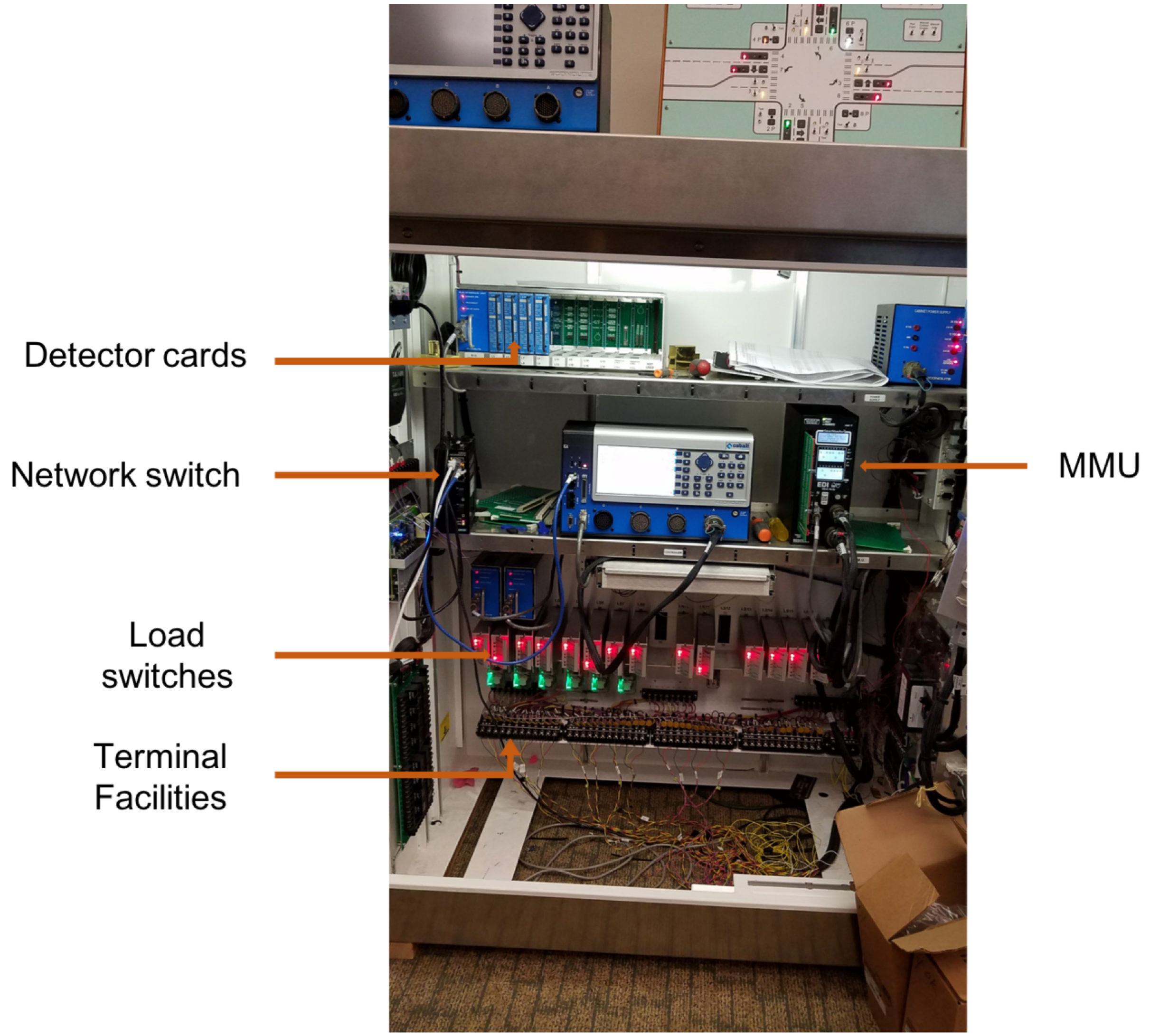


Signal Cabinet



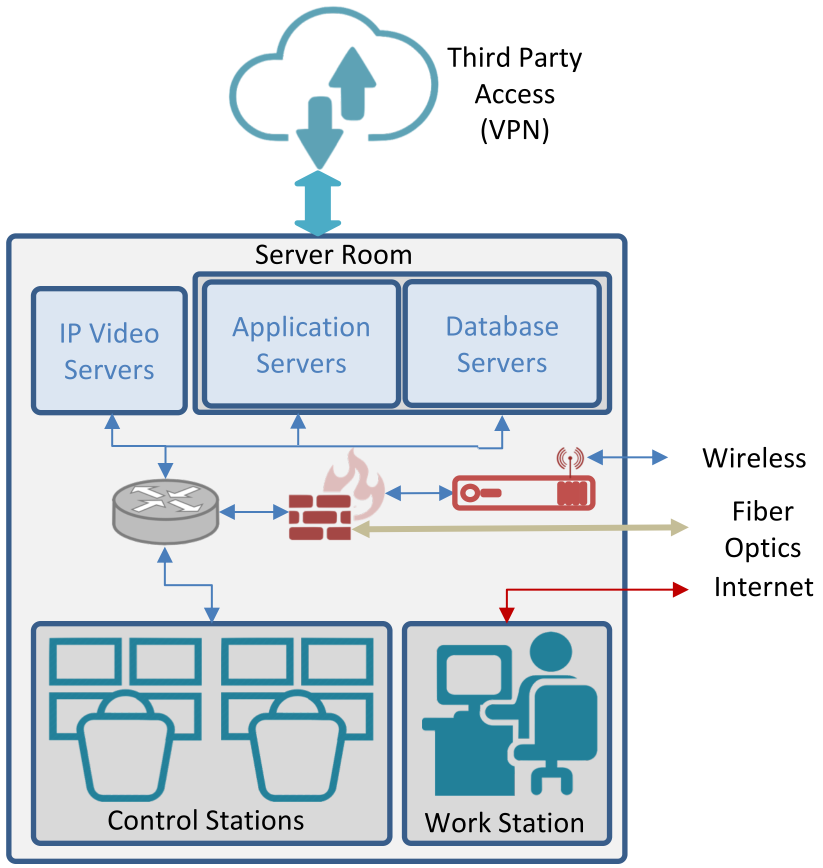
- Role: Control the intersection
- Brain: Controller
  - OS: Linux(2.6.3x or greater) based
  - Driven by:
    - Programmed signal timing
    - Detector inputs
    - External requests: Transit Signal Priority (TSP), pre-emption (trains)
  - Ways to program:
    - Direct: Front panel, LAN connection with laptop, data-key, USB
    - Wireless: Wi-Fi Connection with tablet
    - TMC: Centracs, client applications
- Watch dog: Malfunction Management Unit (MMU)
  - Role: Enforce the safety/conflict policies
  - Driven by: soldered circuit board
- GPS: Account for time drift to maintain coordination
- Communication: Fiber optics, wireless, twisted copper

Signal Cabinet: Safety features



- Controller:
  - Powered through MMU so that it cannot be taken out of the loop
  - Username and password (Not used).
  - 3 access levels: administrator, data change level, data display level (Default is admin).
  - Has a backup database.
- MMU:
  - Hardwired/soldered input.

Transportation Management Center (TMC)

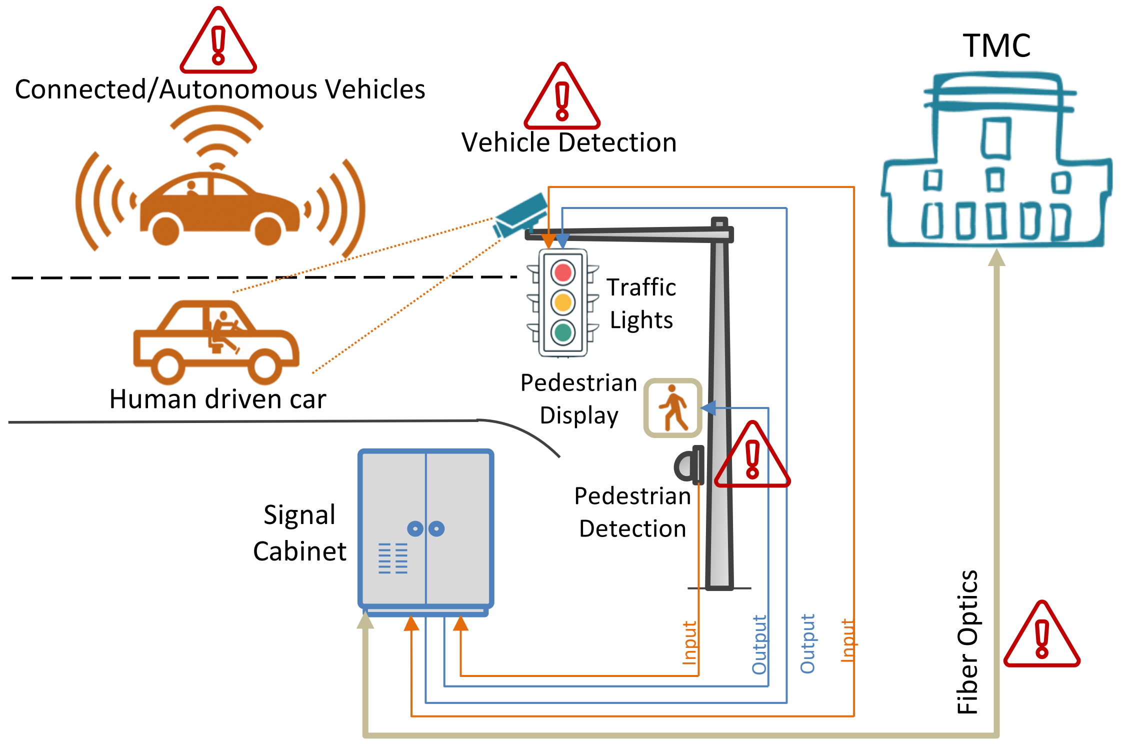


- Role: Monitor and control ALL intersections
- Communication:
  - Protocol: NTCIP level 2 compliant
  - Wireless: Mesh network, single hub in TMC can manage 20 spokes
  - Third party access through VPN
- Applications:
  - MTCS:
    - MS-DOS based (legacy twisted copper support)
    - Command and Control type system.
    - If command and feedback vary: Controller runs it’s stored timings.
  - Centracs 2.0:
    - Advice and Consent type system (Controller is stand alone)
    - Can view status of each controller, view reports for single controller or for a zone, check logs
  - Connected Signals:
    - Mobile app that shows signal timings (red light notifier).
    - Have a network sniffer in the main switch.

TMC: Safety features

- Transportation network is isolated from the outside world.
- Network:
  - Firewall
  - Virtual Private Network (VPN)
- MTCS:
  - Easy detection of command and feedback inconsistence.
- Centracs:
  - Username and password
  - Logs every change made to signal timing (version control like)
  - Provides alerts, logs and reports.

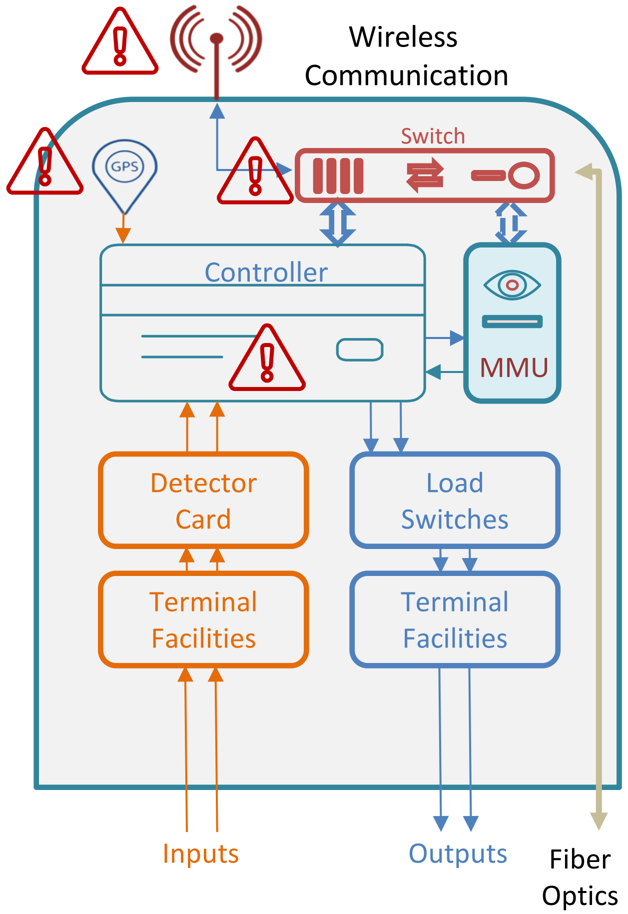
Risk Analysis: Intersection



- Vehicle detection:
  - Cerrudo (2015) and Ghena et al (2014) have shown that wireless vehicle detectors can be hacked.
  - Impact: Congestion
    - Always runs a full cycle. Equivalent to a stuck pedestrian button.
    - Side street never gets serviced.
  - Resolution: Can be detected using monitoring tools (Waze, Bluetoad, CCTV)
- Fiber optics:
  - Impact: Loss of communication.
  - Resolution: Easily detected.
- Connected Vehicles:
  - Miller et al (2015) showed that cars can been hacked.
  - Challenges:
    - Vehicles get a bigger say.
    - More devices to hack.
- Other issues:
  - Privacy issues.
  - Transmitting massive amount of data.

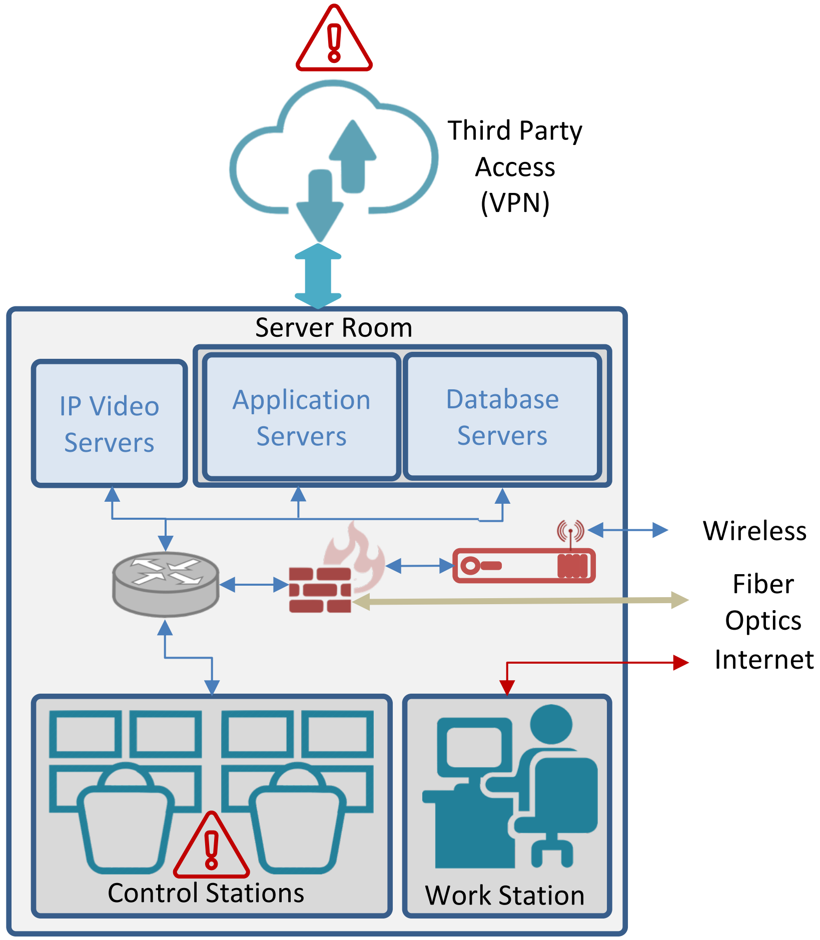
References:
1. Cerrudo, Cesar. "An emerging us (and world) threat: Cities wide open to cyber attacks." *Securing Smart Cities* (2015).
2. Ghena, Branden, William Beyer, Allen Hillaker, Jonathan Pevarnek, and J. Alex Halderman. "Green Lights Forever: Analyzing the Security of Traffic Infrastructure." *WOOT* 14 (2014): 7-7.
3. Miller, Charlie, and Chris Valasek. "Remote exploitation of an unaltered passenger vehicle." *Black Hat USA* 2015 (2015).

Risk Analysis: Signal Cabinet



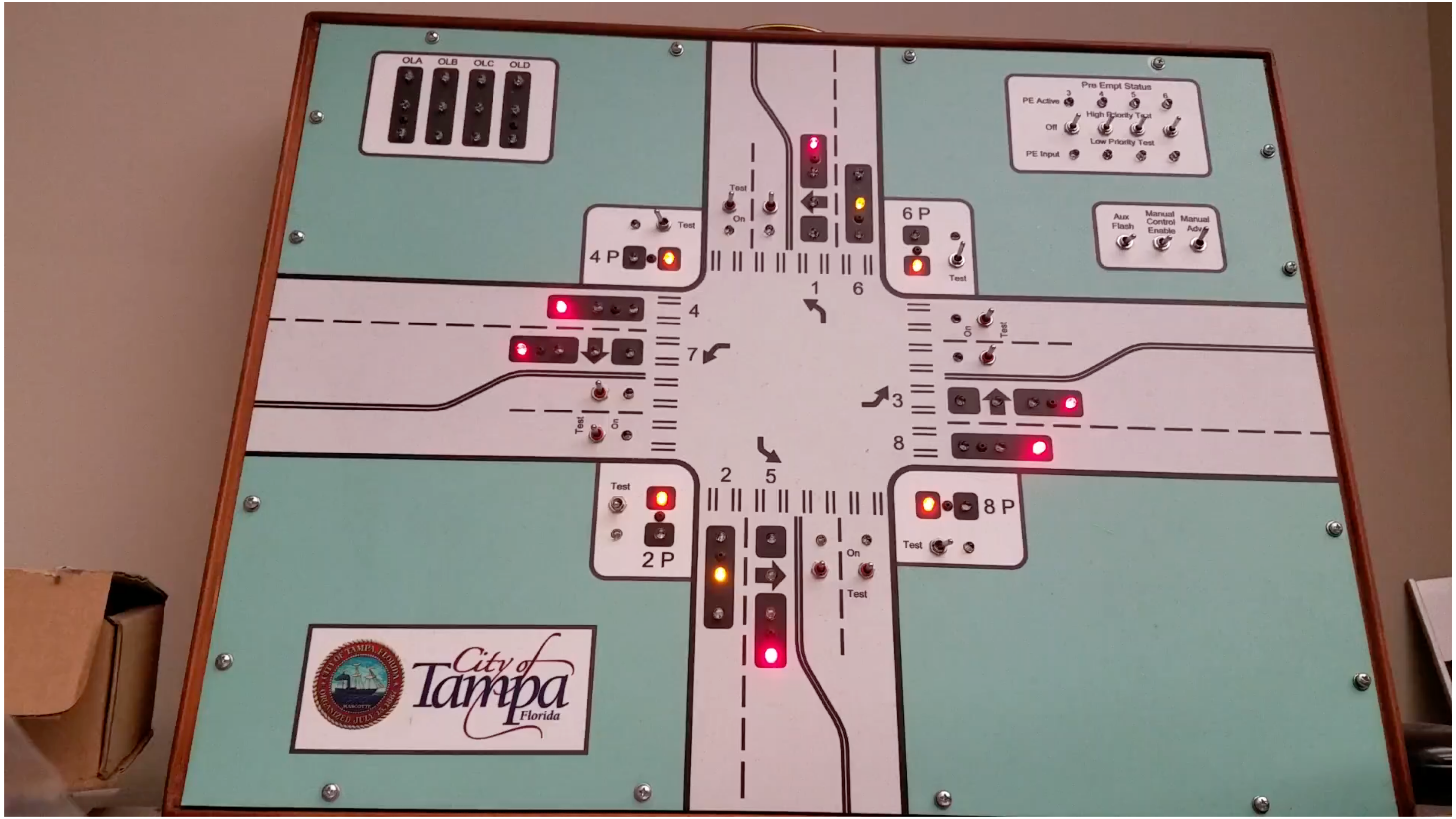
- Wireless Communication:
  - <u>Outcome</u>: Gain access to controller.
  - <u>Resolution</u>: Disable SSID broadcast, enable encryption, do not use default configuration/credential
- Controller:
  - Ghena et al (2014) have shown it can be compromised.
  - <u>Outcome</u>: Change signal timing, update firmware.
  - <u>Impacts</u>: Congestion, diminished safety
    - But MMU maintains safety.
  - <u>Resolution</u>: Disable debug port, enable password protection, enable access control
- Network:
  - <u>Outcome</u>: Gain access to all communication
  - <u>Impacts</u>: Denial of Service (DoS) attack
  - <u>Resolution</u>: Firewalls

Risk Analysis: TMC



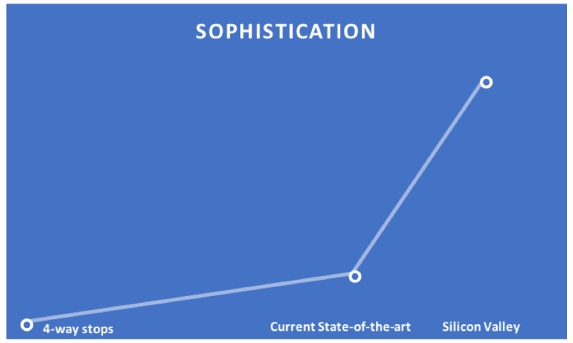
- Control stations:
  - Social engineering.
- Third party access:
  - Are they following security practices?
  - Outcome: Access to entire infrastructure.

Demo


OLA
OLB
OLC
OLD
Pre Empt Status
PE Active
Off
High Priority Test
Low Priority Test
PE Input
Aux Flash
Manual Control Enable
Manual Adv
4 P
6 P
2 P
8 P
Test
On
1
6
4
7
3
8
2
5
City of Tampa
Florida

Conclusion

- Cybersecurity is **currently** not a major concern for transportation systems.
  - reliance on the isolated network and physical protection of devices.
  - i.e. all the systems are within the trust boundary.
- However existing architecture poses serious cybersecurity threats for the **emerging** transportation technologies.
  - With connected and autonomous technologies, the isolation assumption is no longer valid.
  - Plus the gap between current and emerging technologies is vast.
  - The stakes are much higher in transportation than in traditional IT systems.

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Questions ?