Hacking Traffic Control Systems (U.S, UK, Australia, France, etc.)

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Hardware | Software | Wetware

SECURITY SERVICES

About Me

- Hacker, vulnerability researcher, created novel exploitation techniques, dozens of vulnerabilities found (Microsoft® Windows®, SQL Server®, Oracle®, etc.).
- Developed, sold exploits, and 0day vulnerabilities (7-10 years ago)
- CEO of software company
- CTO at IOActive labs
- Live in small city in third world country, far away from everything

Thanks

- Barnaby Jack
- Ruben Santamarta
- Mike Davis
- Mike Milvich
- Susan Wheeler
- Ian Amit
- Robert Erbes

Southwest Waterfront
Capitol Riverfront
Near Southeast

1300+

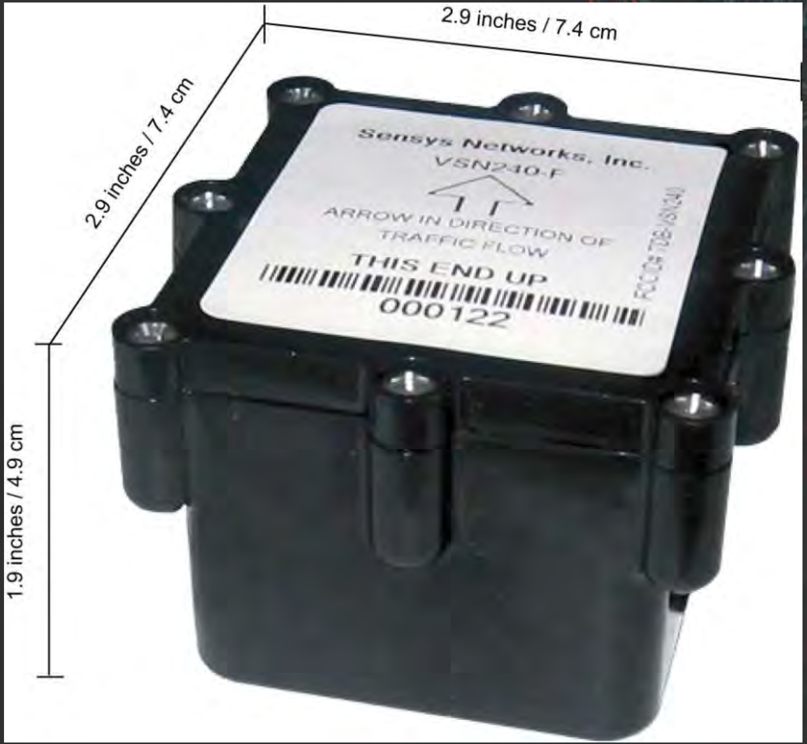
Wireless Sensors

How It All Started

- Getting the devices
  - Social engineered the vendor
  - Shipped them to Puerto Rico and traveled with them back and forth to the U.S. from Argentina several times with no problems

Devices: Wireless Sensors

- Magnetometer, installs in a small hole
- Rugged mechanical design, 10 year battery life
- TI CC2430 RF transceiver IEEE 802.15.4 system-on-chip 2.4-GHz
- TI MSP430 MCU (microcontroller) 16-bit RISC CPU , i386 Linux (probably TinyOS RTOS)



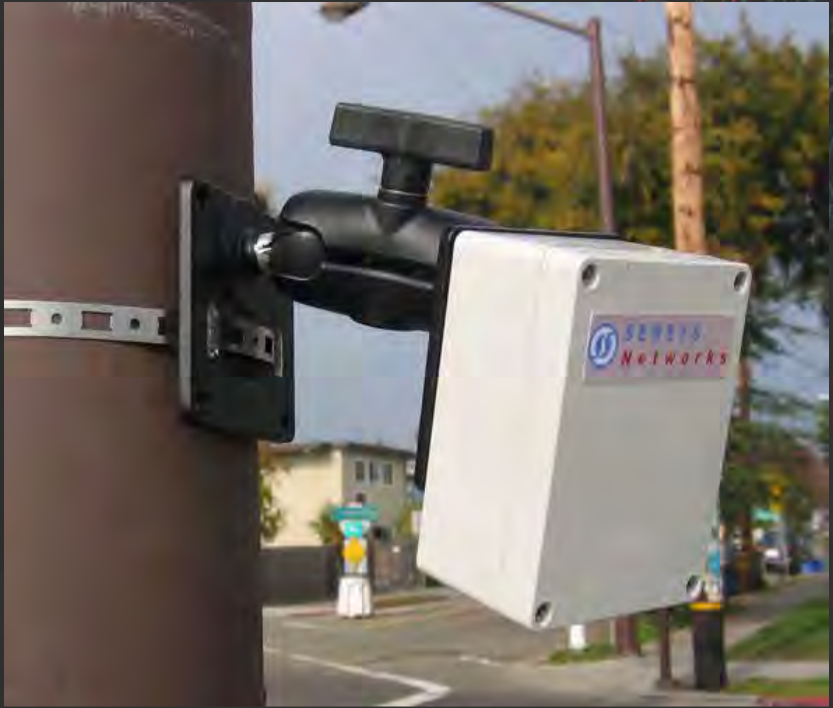
Devices: Wireless Sensors

Devices: Access Point

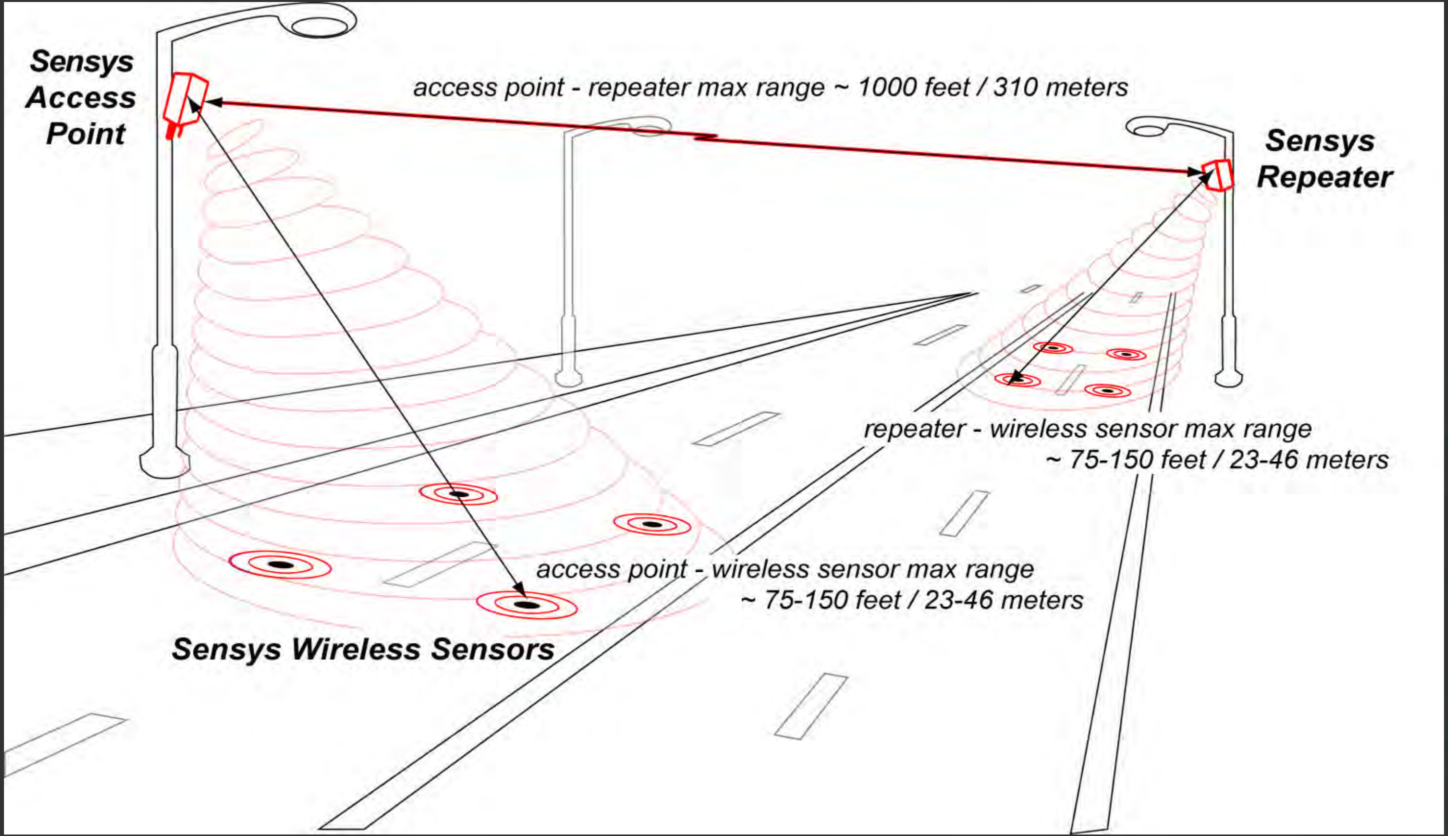
- Processes, stores, and/or relays sensor data (uCLinux)
- 66 MHz 5272 Coldfire processor, 4 MB flash memory, 16 MB DRAM
- Contact closure to traffic controller, IP (fiber or cellular) to central servers, PoE
- Supports as many sensors as necessary, Can serve as IP router for peripherals (video cams, etc.)

Devices: Repeaters

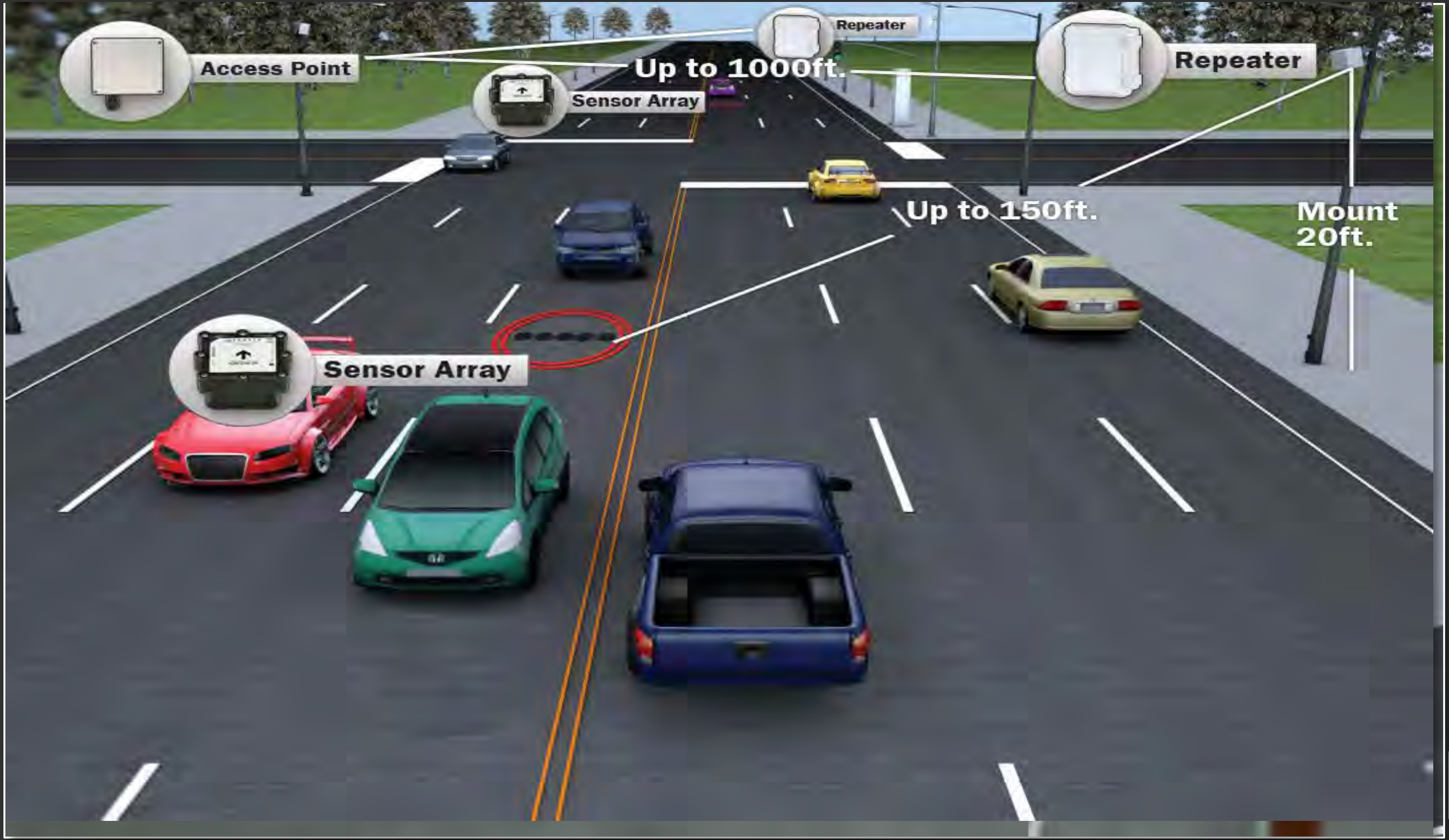
- Battery powered unit
- Supports up to 10 wireless sensors
- Relays detection data back to access point, extending range
  - One channel for getting data and another channel for sending data



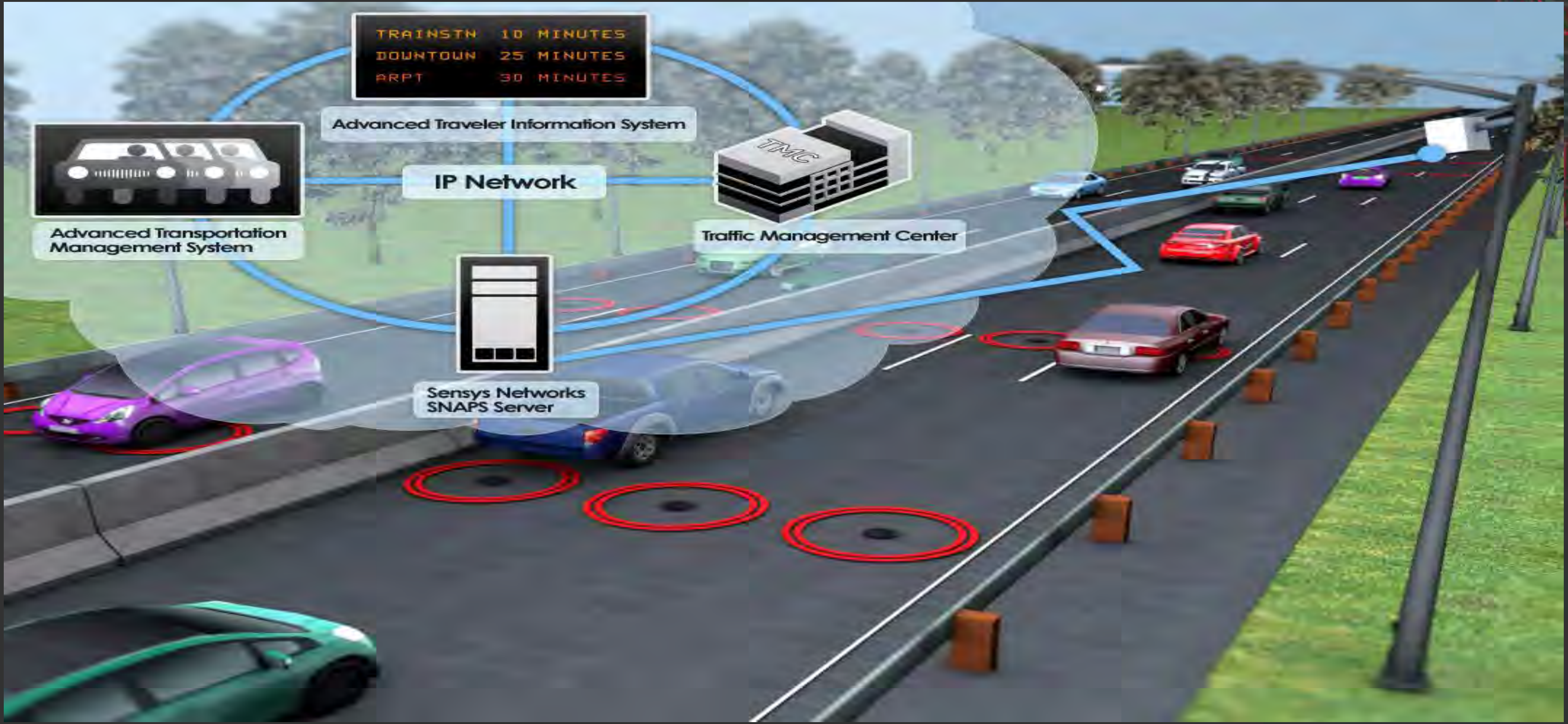
Devices: Radio ranges


Sensys Access Point
access point - repeater max range ~ 1000 feet / 310 meters
Sensys Repeater
repeater - wireless sensor max range ~ 75-150 feet / 23-46 meters
access point - wireless sensor max range ~ 75-150 feet / 23-46 meters
Sensys Wireless Sensors

How Devices Work



Software


TRAINSTN 10 MINUTES
DOWNTOWN 25 MINUTES
ARPT 30 MINUTES
Advanced Traveler Information System
Advanced Transportation Management System
IP Network
TMC
Traffic Management Center
Sensys Networks SNAPS Server

Vulnerabilities

- No encryption, all wireless communication in clear text
- Vendor claims:

“Security: ***SNP radio transmissions never carry commands***; only data is transmitted. Therefore, while RF communications may be subject to local interference, ***there is no opportunity to embed malicious instructions*** to a network device or upstream traffic system.”

“***The option for encrypting the over the air information was removed early in the product's life cycle based on customer feedback.*** There was nothing broken on the system as ***we did not intend the over the air information to be protected***.”

Vulnerabilities

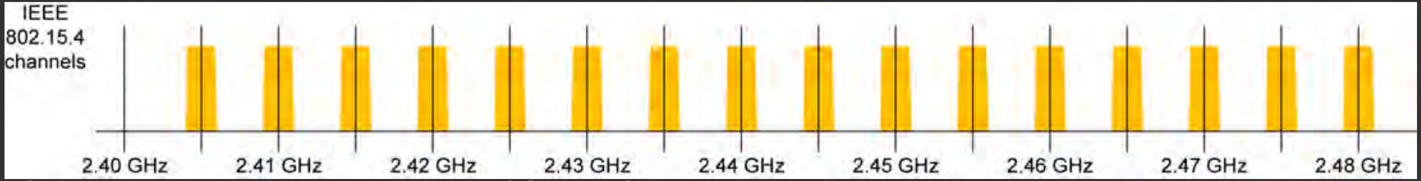
- No authentication
  - Sensors and repeaters can be accessed and manipulated over the air by anyone, including firmware updates
  - AP does not authenticate sensors, just blindly trusts wireless data
- Firmware updates are neither encrypted nor signed
  - Anyone can modify the firmware and update it on sensors and repeaters
- Vendor claims:

  “We are encrypting/signing firmware in new sensor version” (they just forgot a little and insignificant detail…)

  “Security: Proprietary protocol – hacker safe”

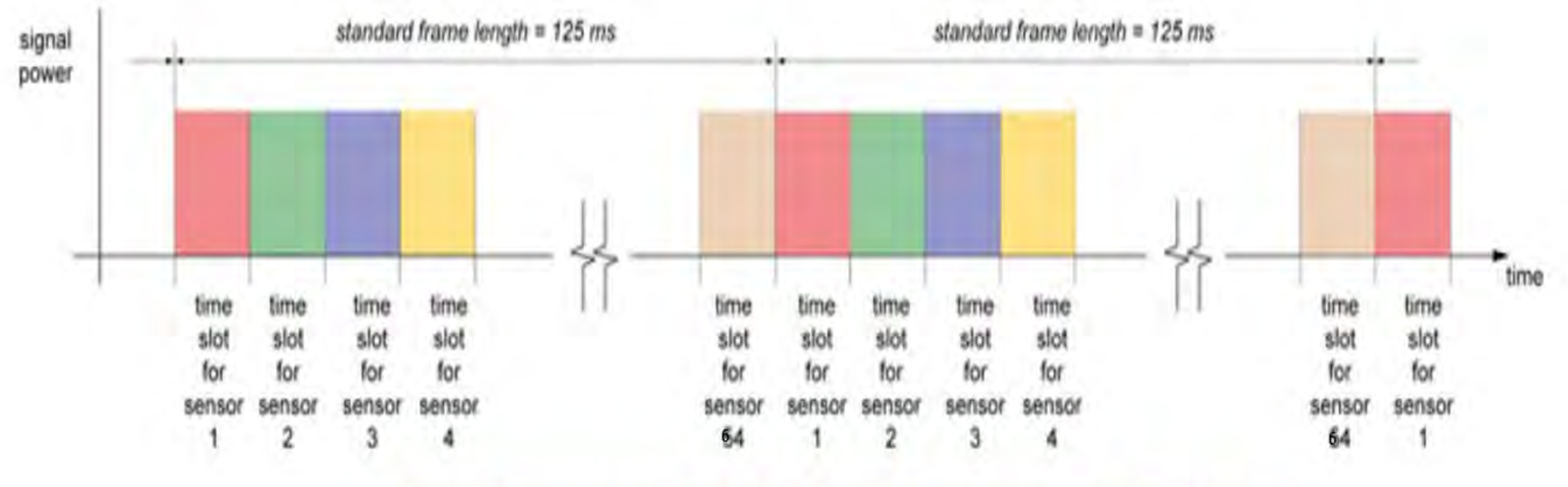
Protocol

- IEEE 802.15.4 PHY, used by ZigBee and other wireless systems
  - Data rate of 250 kbps, 16 frequency channels in the 2.4 GHz ISM band



- Sensys NanoPower (SNP) protocol
  - On top of 802.15.4 PHY as Media Access Protocol (MAC)
  - The MAC layer is TDMA based and uses headers similar to IEEE 802.15.4 MAC layer.

Protocol



Simplified representation of the Sensys NanoPower TDMA scheme

Protocol

- Packet structure: 80 80 55 AA BB 55 55 55 55 55 55
  [frame header (2 bytes)] + [sequence # (1 byte)] + [address (2 bytes)] + [data]
- Frame header is used to specify the type of packet
- Sequence # from sensor packets is used by AP to acknowledge them
- Address is used to identify sensors by the AP and second byte in address is ”color code” used by sensors to identify the AP

Protocol

- Data can be 4 to 50 bytes long, first two bytes is data type
  - Sensor data: mode, version, battery level, detection (presence or not of traffic), etc.
  - AP data: commands, synchronization, sensor and repeater firmware updates, etc.

Protocol

- Sample packets

  80 41 69 CA B6 65 00 FF 7F -> sensor to AP, no detection event, count mode

  80 41 67 CA B6 65 00 CE E7 -> sensor to AP, detection event, count mode

  80 41 C0 CA B6 02 00 4C 00 03 00 03 BA 00 00 00 00 65 00 00 00 00 02 CA B6 FF 00 -> sensor to AP, sensor info

  80 80 89 F0 FF 01 00 07 1E 40 07 C0 01 1A 00 00 00 00 00 00 40 40 20 01 00 ->AP to sensor

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Protocol

- Firmware file, Idrect proprietary format

I0012AF10DADA***AAE1E60C***5A00006A0200301330136C19021B3013A461D03030133013 42

I0088AF10DADA***AA6FC60D***5A00006A02003089308 96C8F02913089A4D7D0A630893089 37

I201230133013301330131C17001300120300 03004C00FFFFFFFFFFFFFFFFFFFFDF

I20883089308930893089 1C8D008900880300 03004C00FFFFFFFFFFFFFFFFFFFFB9…

- Firmware update packet

80 00 45 F0 F4 D2 00 ***00 12 AF 10 DA DA AA E1 E6 0C 5A 00 00 6A 02 00 30 13 30 13 6C 19 02 1B 30 13 A4 61 D0 30 30 13 30 13***

  – AP firmware broadcast, data part except first two bytes is a exact line from firmware file without the checksum byte

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Tools

Attack Impact

- +200,000 sensors and ? repeaters worldwide that could be compromised and maybe bricked
- Traffic jams at intersections, at ramps and freeways
  - Rest in green (exceeds max. green time), **Red** rest (all red until detection), flashing, wrong speed limit display, etc.
- Accidents, even deadly ones by cars crash or by traffic blocking ambulances, fire fighters, police cars, etc.
- US DOT Federal Highway Administration (Traffic Detector Handbook):

"…sensor malfunctions and associated signal failures increase motorists' time and delay, maintenance costs, accidents, and liability."

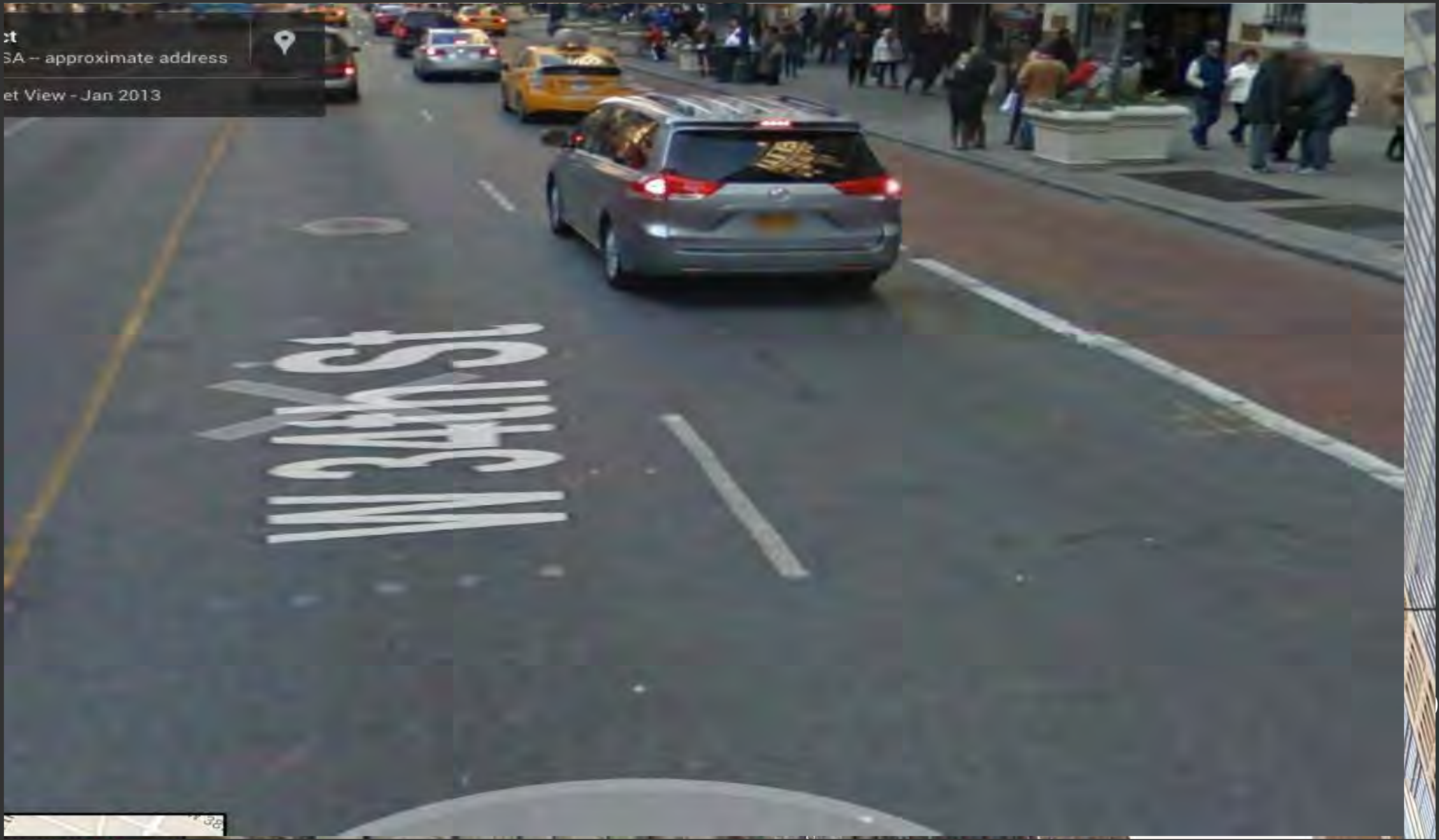
Onsite Passive Testing

- Made AP portable
  - USB powered instead of PoE with USB battery charger
  - WiFi portable router battery powered, connect notebook to AP by WiFi
- Put AP in my backpack and went to Seattle, NY, and Washington DC
  - Took out notebook and start sniffing around in the sidewalk while pointing my backpack in the right directions
  - Saw some spooks at DC but got no problems
  - Video

Attacks

- DoS
  - Disabling sensors/repeaters by changing configuration or firmware
  - Making sensors/repeaters temporarily (maybe permanently) unusable by changing firmware
  - Flooding AP with fake packets
- Fake traffic detection data
  - Send lots of car detections when there is no traffic
  - Send no detection on stop bar at exit ramps
  - Disable sensors/repeaters and send no detection data when there is a lot of traffic

Attacks



Attacks

- Sensor malicious firmware update worm
  - Compromise one sensor with malicious firmware and it can replicate later on other sensors
  - Impossible to know if there are already compromised sensors since firmware version is returned by firmware itself
- NSA/Gov/Special Forces/terrorist/etc. style attacks
  - Locate persons in real time, hack smartphone, launch attack
  - Use sensor car identification data to trigger bomb when car target is near, no need to track car, just sniff sensor wireless packet (Cadillac One fingerprint?)

Conclusions

- Any third world guy can easily get devices used by U.S. critical infrastructure, hack them, and then attack the U.S.
- Anyone can build a $100 device to cause traffic problems in most important cities in U.S. and other large cities around the world.
- Critical infrastructure related technologies should be properly audited to make certain that they are secure before use
- Smart cities are not so smart when the data that feeds them is blindly trusted and easily manipulated
- Cyberwar is cheap

BuildItSecure.ly

Our Goals for the "Internet of Things"

👁 FOCUS effort towards crowd-funded, small commercial and bootstrapped vendors

❤ BUILD partnerships and goodwill between IoT vendors and the security community

✓ COORDINATE efforts to incentivize security researchers for reporting vulnerabilities

✎ CURATE informational resources to help educate vendors on security best practices

👤 PRESENT research at relevant events and be a point of contact for press inquiries

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Fin

- “Battles can be won being smart not just with a great attack power. We need to focus more on ideas, on innovation, trying to do things in different ways as hackers usually do”

- Questions?

- Gracias.
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- twitter: @cesarcer

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