INDOOR POSITIONING SYSTEM (IPS) WITH BLUETOOTH

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BY: ADRIAN PEREZ, ALBERT WOLLISTON,

DHARMIN MISTRY, SARA MAKBOUL

KENNESAW STATE UNIVERSITY

OBJECTIVE

- Research indoor positioning system to track an object inside of building.
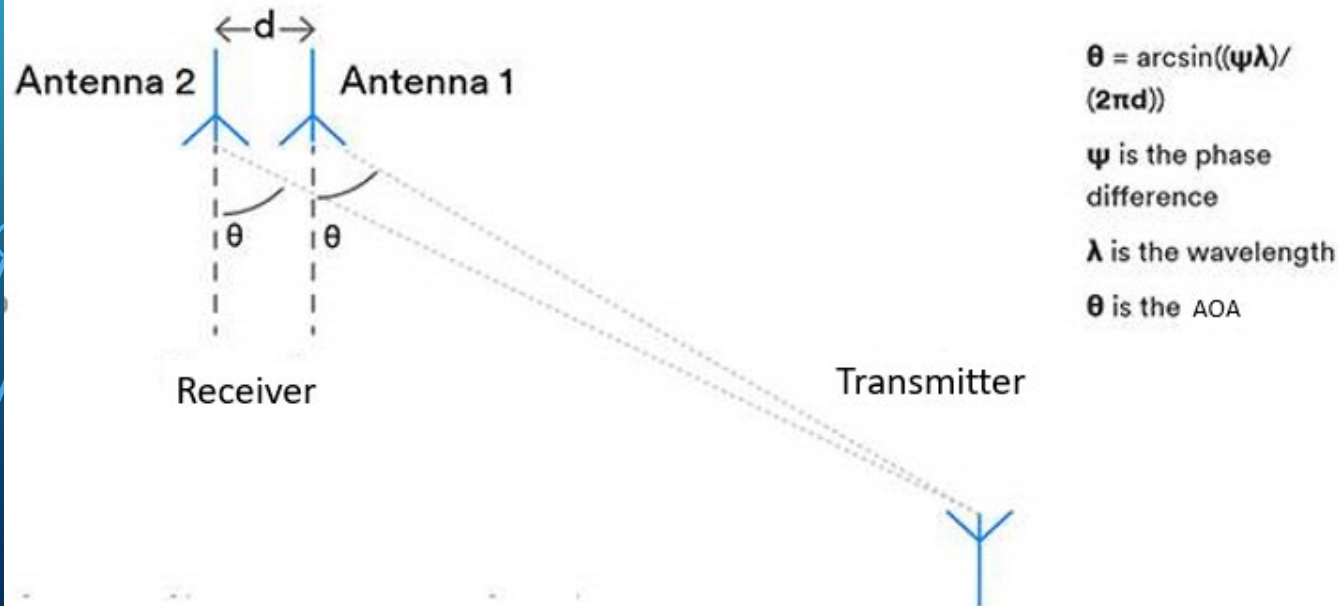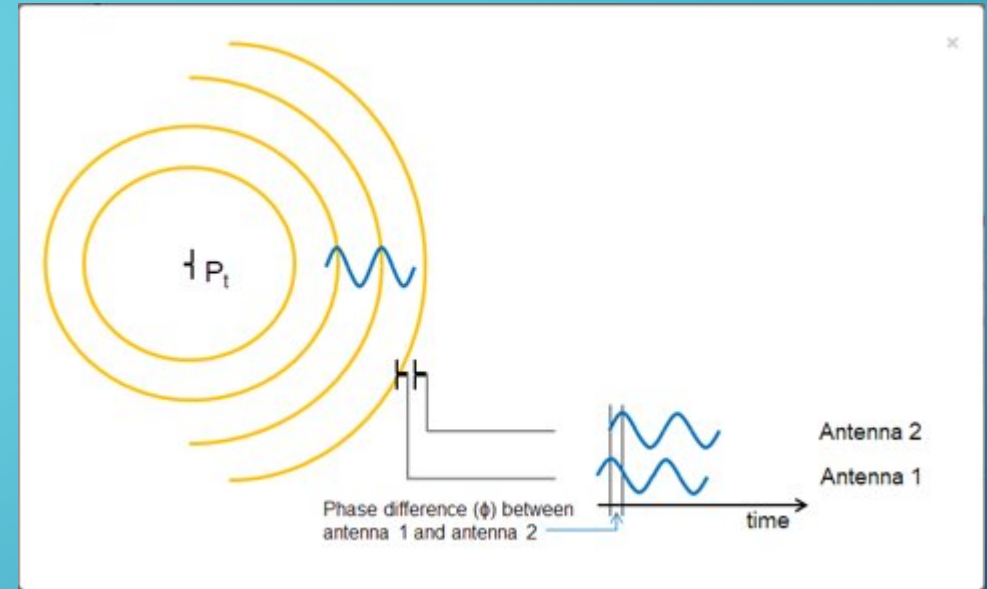
POSSIBLE SOLUTIONS

- RSSI
  - Received Signal Strength Indicator
  - Inaccurate
  - Need multiple testing to collect data

- TOF
  - Time of Flight
  - Accurate in ideal environment (no interference with signals)

- AOA/AOD
  - Angle of Arrival/Departure
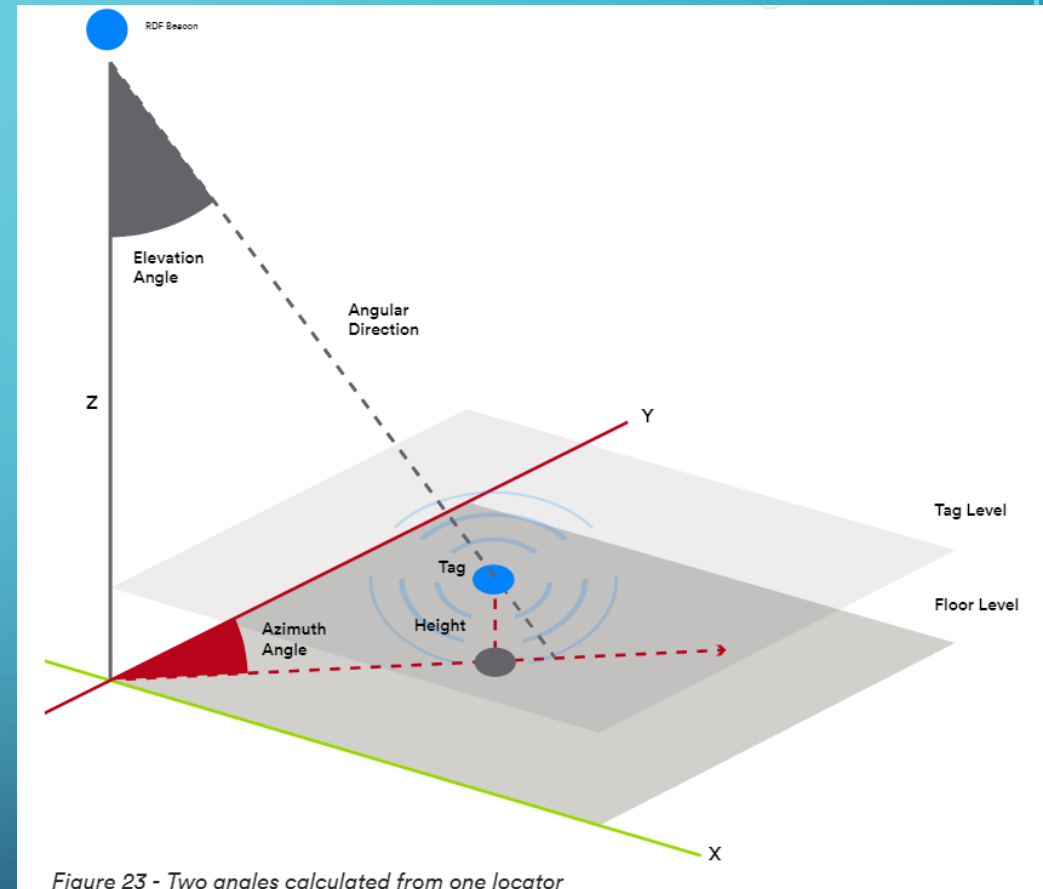 - Accurate
  - New Technology!
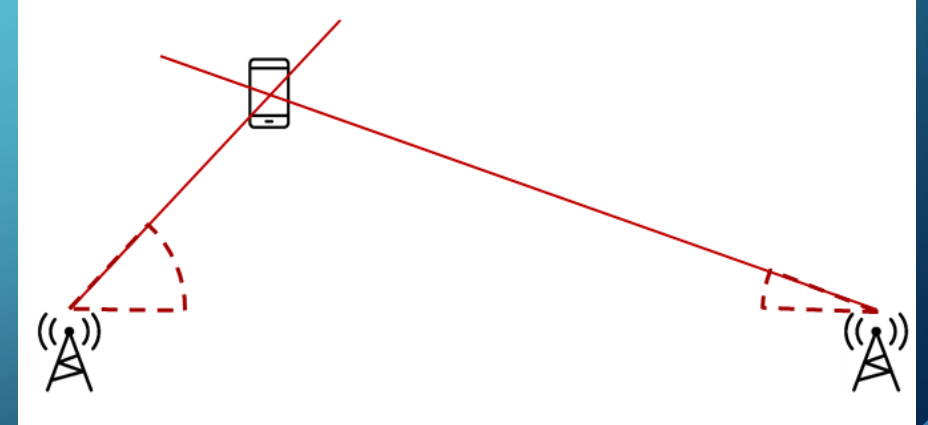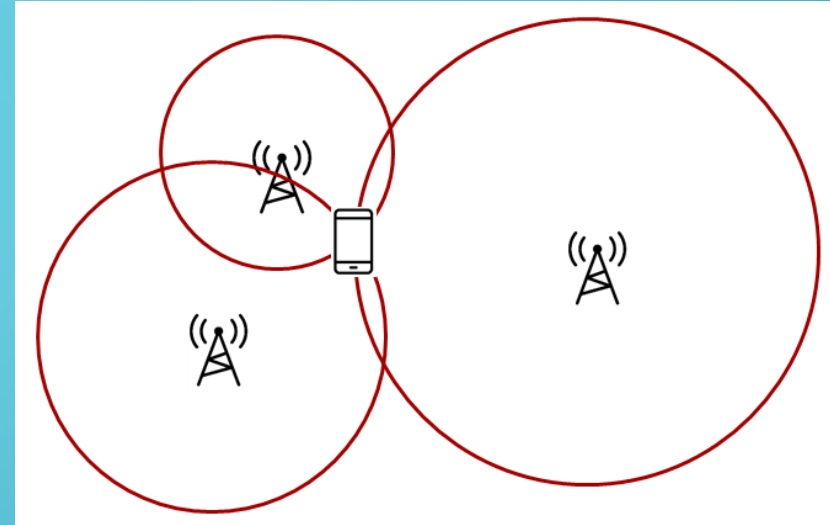
ANGLE OF ARRIVAL (AOA)

- Use two or more antenna in array to calculate phase difference of signal.

- From 1 sets of antenna array, one angle can receive, which can give direction, but not location

$\theta = arcsin((\psi\lambda)/(2\pi d))$

ψ is the phase difference

λ is the wavelength

θ is the AOA

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DOES IT WORK 3D?

- YES!

  - If one elevation angle is given

  - Since X and Y is known:

    - An antenna to measure elevation angle can be place either XZ plane or YZ plane.

  - Let assume that antenna measure elevation angle in XZ plane

    - $\tan(\phi) = \left(\dfrac{x}{z}\right) \Rightarrow z = x\left(\dfrac{1}{\tan(\phi)}\right)$

    - $Z = x(\tan(90 - \phi)) = \cot(\phi)x$

Figure 23 - Two angles calculated from one locator

IDEAS

- 2 module & 1 antenna array
  - 1 device act as sender and 1 device with antenna array act as receiver
  - Assumption
    - 1 antenna array gives both azimuth and elevation angle
  - Problem
    - It only gives 2 angles!
    - There is antenna array in market, but it only available to select customers!
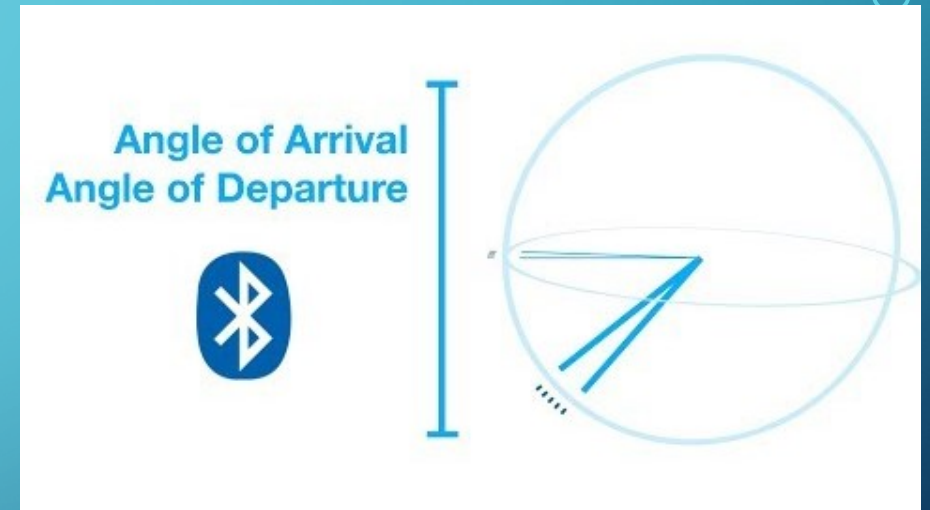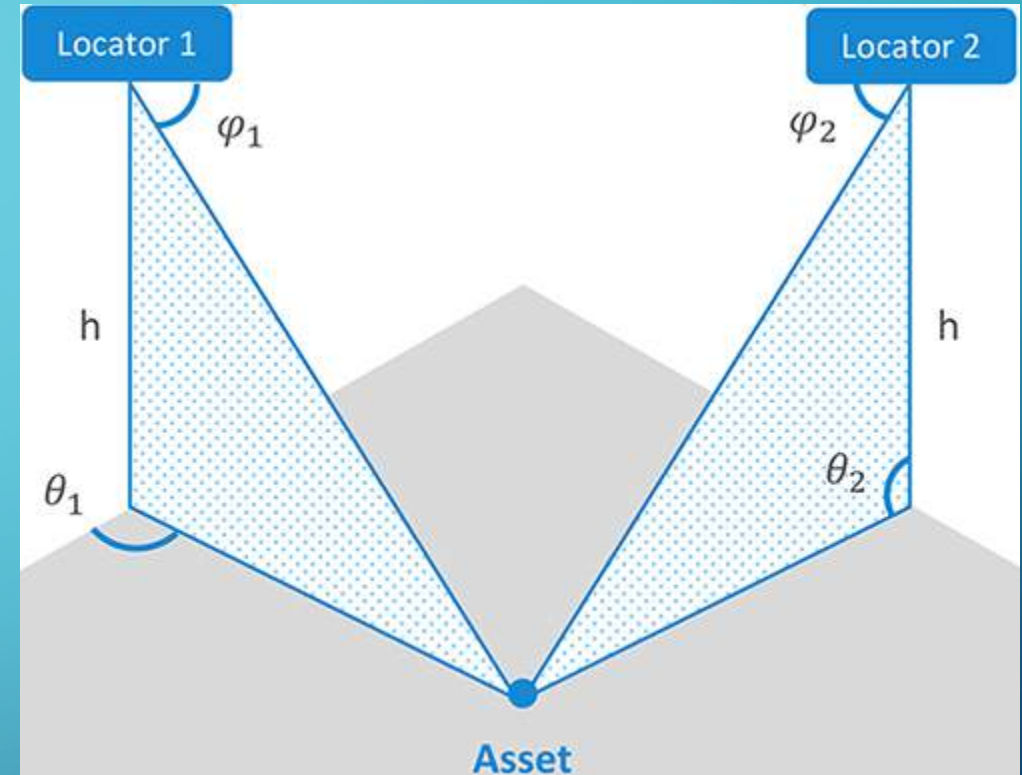
IDEAS

- 3 module & 2 antenna array

  - 1 device act as sender and 2 devices with antenna array act as receiver

  - Assumption

    - antenna array gives both azimuth and elevation angle

  - Problem

    - There is antenna array in market, but it only available to select customers!
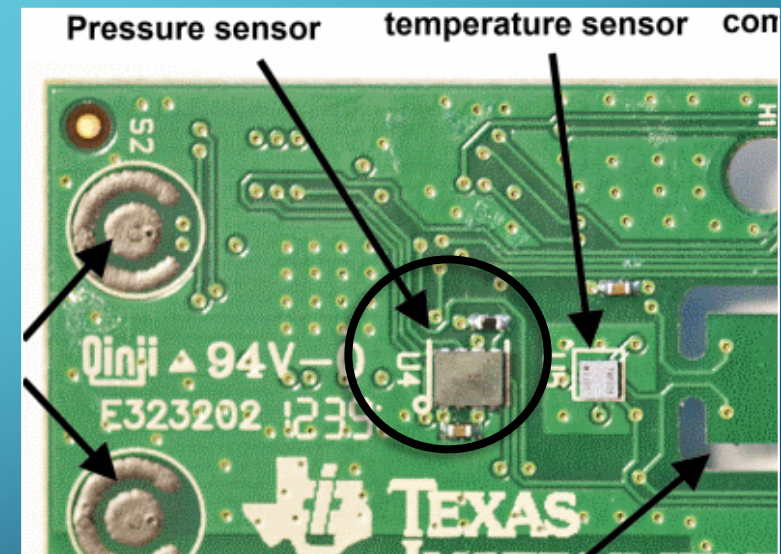
IDEAS

- 3 module, 2 antenna arrays and Beacons
  - 1 device act as sender and 2 devices with antenna array act as receiver
  - Assumption
    - antenna array gives azimuth angle.
    - Beacons give floor numbers
  - Problems
    - Less accurate on Z direction
    - More components

IDEAS

- Barometer Pressure **sensor** on **Tx Tags** for **elevation**

  - **Transmitted before/after/or within CTE to Rx's**

  - Applications:

    - **Inventory Tracking**

- **Rx Arrays → known Floor**

- **Tx → Elevation**

  - Convert Pressure --> Altitude (ex. meters)

  - Pro: **Inexpensive and Small**

 - Con: **+/- 1 m accuracy for low-cost sensors**

IDEAS

- 4 module & 3 antenna arrays
  - 1 device act as sender and 3 device with antenna array act as receiver
    - 2 receiver devices should be on XY plane
    - 1 receiver devices can be XZ or YZ plane
  - Assumption
    - 2 antenna arrays gives azimuth angles; position can be calculated by method 2.
    - 1 antenna array give elevation angle to calculate Z using X and Y position.
  - Problem
    - Cost of antenna arrays is higher!

IDEAS

- 3 module & 2 antenna array
  - 1 device act as sender and 2 devices with antenna array act as receiver
  - Assumption
    - 1 receiver devices should be on XY plane
      - Use combination of 2 antennas from antenna arrays.
    - 1 receiver devices can be XZ or YZ plane
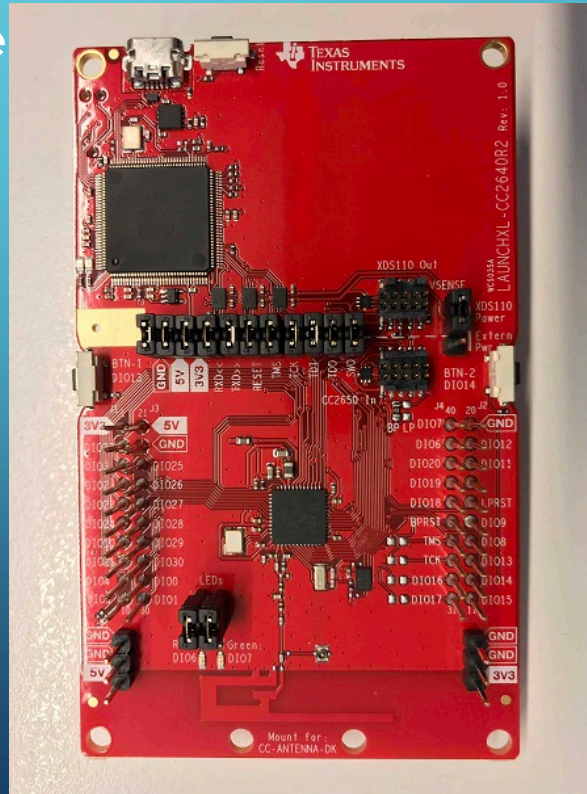 - Problems
   - Less accurate angles
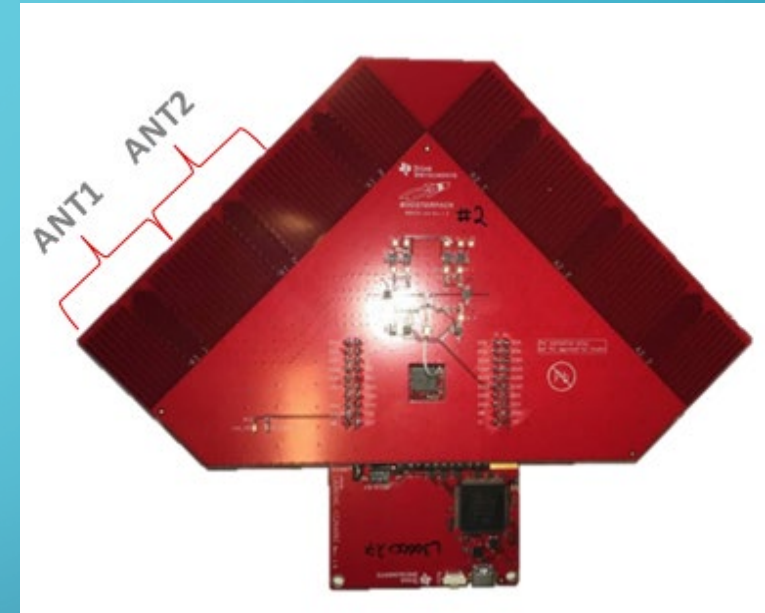
IDEAS

- 3 module & 2 antenna array
  - 1 device act as sender and 2 devices with antenna array act as receiver
  - Assumption
    - Create own 2D antenna arrays which gives both azimuth and elevation angle
  - Problems
    - Takes more time to build and test antenna arrays

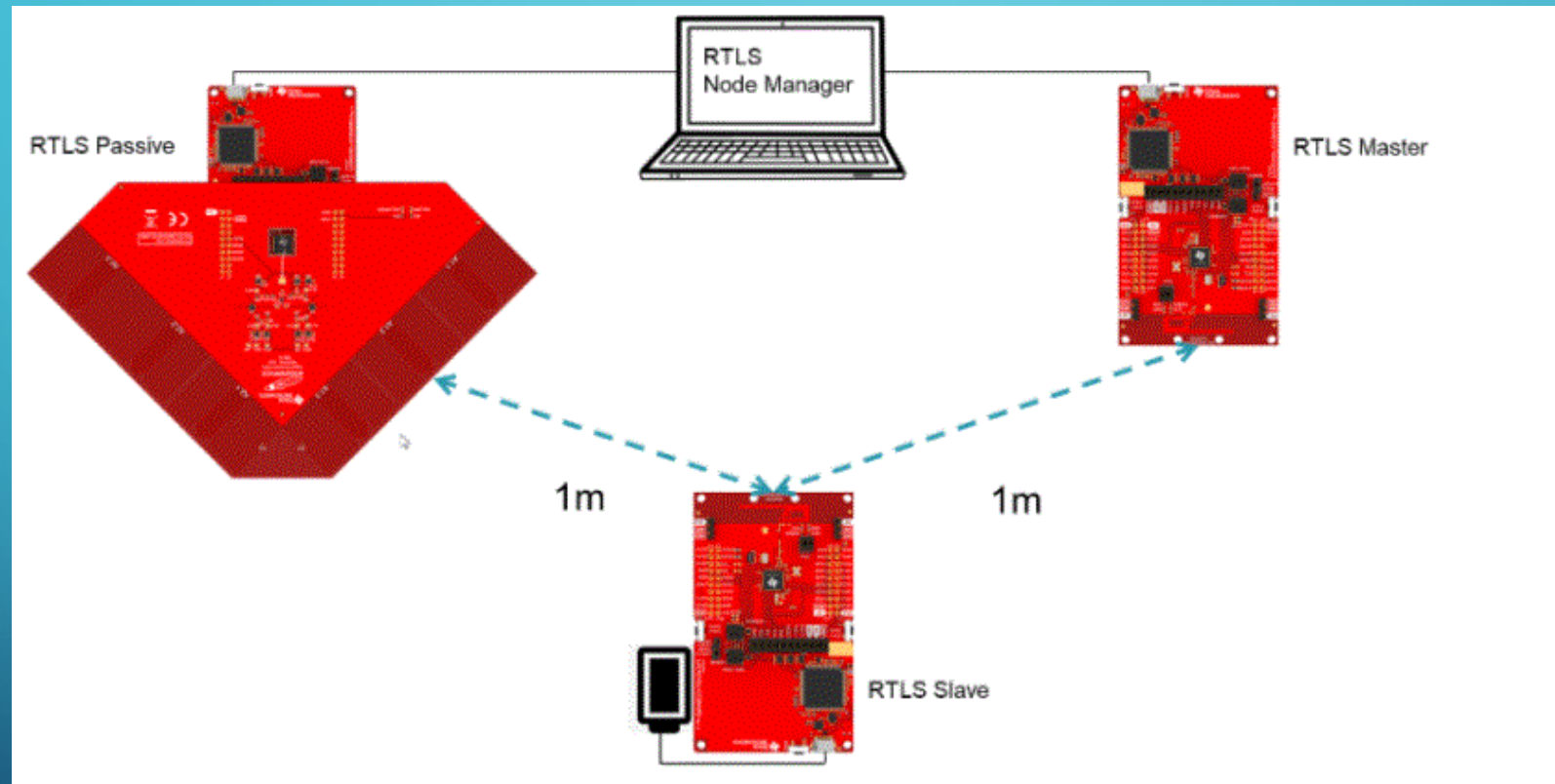# PREVIOUS ACCOMPLISHMENT

• Found and buy devices from Texas Instruments.

• Follow instruction from TI to prepare   external antenna

arrays

  • Rotate capacitor on Launchpad
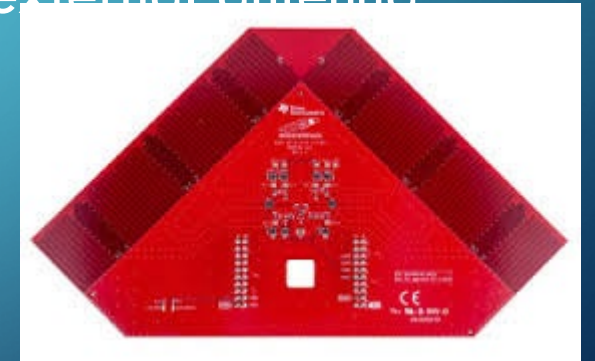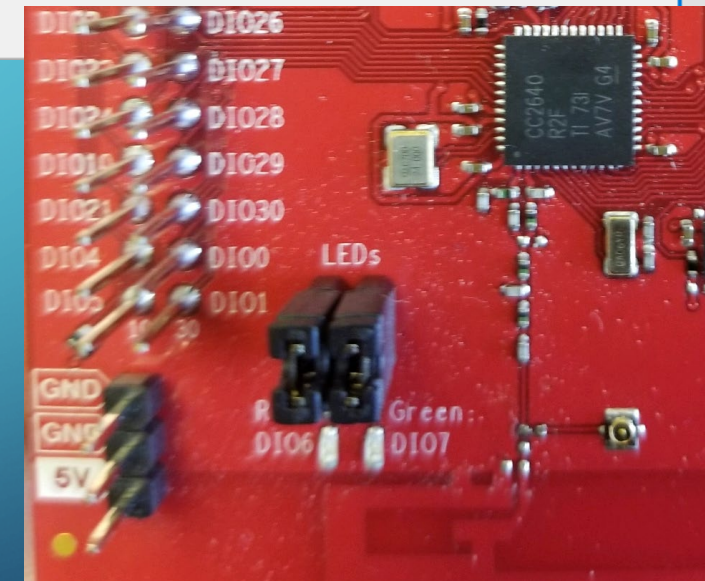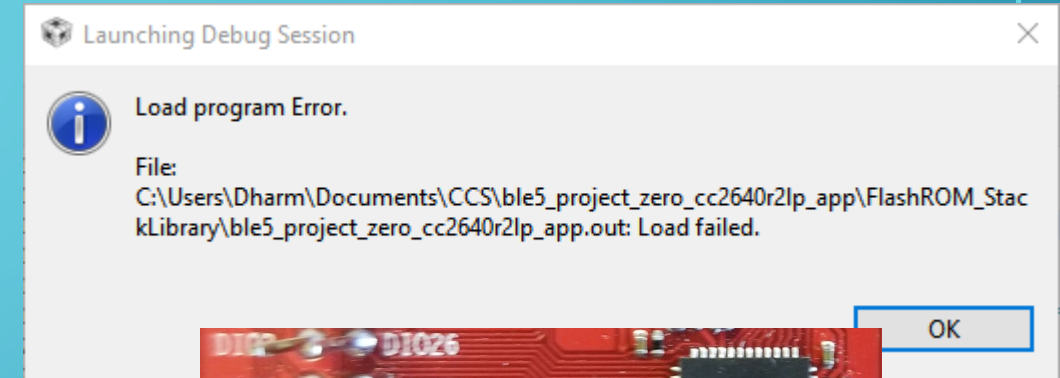
IDEAL TEST SET UP

PREVIOUS WORK AND PROBLEMS

- Running example AOA from TI
  - Problems:
  - Giving error of flashing program into board
    - Tempary Solution: Need to erase flash if error occurs
  - Need three working Launchpads
    - Solution: Capacitor is missing, so waiting for it to arrive to move forward
  - Agent connection was not connecting with Master and passive

SOLUTION

- We change the download of each microcontroller 8.5 MHz 2.5 MHz

- Soldered the capacitor to lauchpad for internal antenna

- Updated both the master, slave, passive, and Agent_RTLS to the last SDK
  - Preivousely the passive, master, and Agent was running on diffent SDK

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CURRENT PROBLEMS

Accuracy of the anntena for far distances

Accuracy of angles

Connecting the master lauchpad through bluetooth to the App
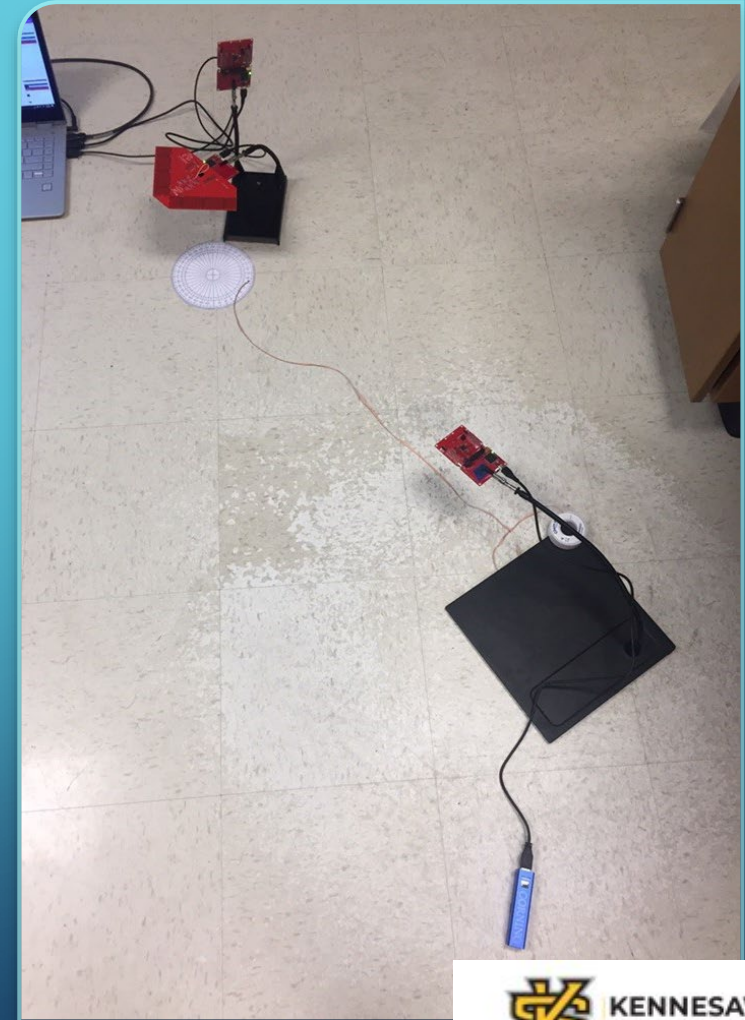
Proccessing the mass amount of data being recived by anntena

Error in the angle when pathway is obstructed

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HORIZONTAL SETUPS (TESTING ACCURACY OF ANGLE MEASUREMENTS

ANTENNA 1 ONLY HORIZONTAL

Angle	Min measured angle	Max measured angle	Avg	Difference	Error	Dip
0	-1	0	-0.5	-0.5	0%	
10	9	10	9.5	-0.5	5%	
20	26	27	26.5	6.5	33%	20
30	34	35	34.5	4.5	15%	30
45	44	45	44.5	-0.5	1%	40
60	57	60	58.5	-1.5	3%	
70	73	75	74	4	6%	60
80	25	75	50	-30	38%	
90	82	85	83.5	-6.5	7%	60

Figure: angles using only antenna 1

● antenna 1 only horizontal setup
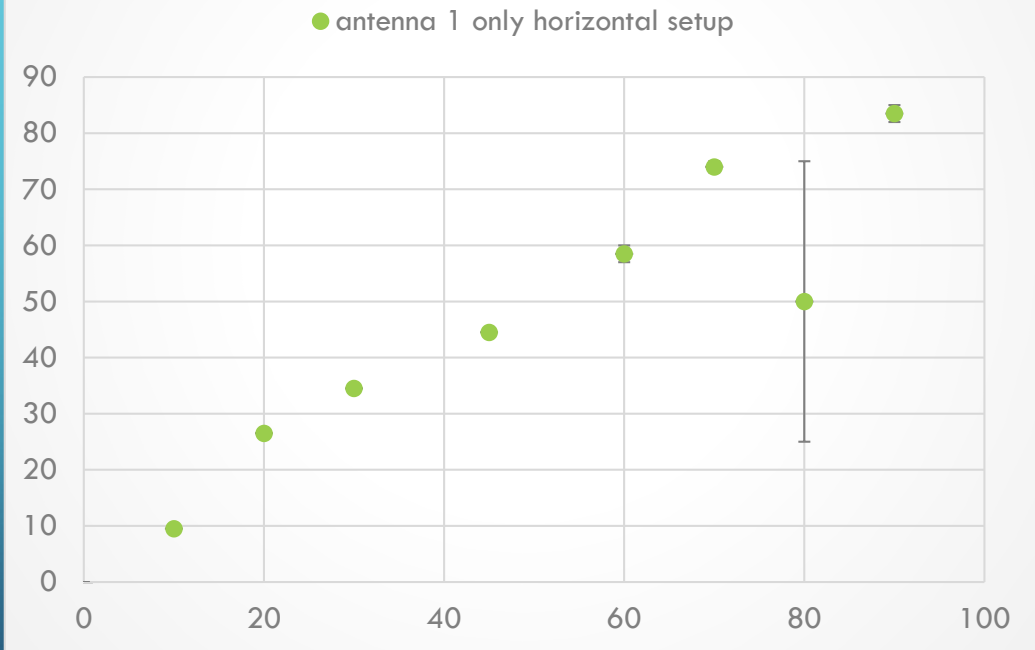
ANTENNA 1 AND 2 HORIZONTAL SETUP

Angle	Min measured angle	Max measured angle	Avg	Difference	Error
0	-1	4	1.5	1.5	
10	2	7	4.5	-5.5	55%
20	16	19	17.5	-2.5	13%
30	27	28	27.5	-2.5	8%
45	43	45	44	-1	2%
60	55	56	55.5	-4.5	8%
70	64	65	64.5	-5.5	8%
80	75	76	75.5	-4.5	6%
90	89	91	90	0	0%

Figure: angles using only antenna 1
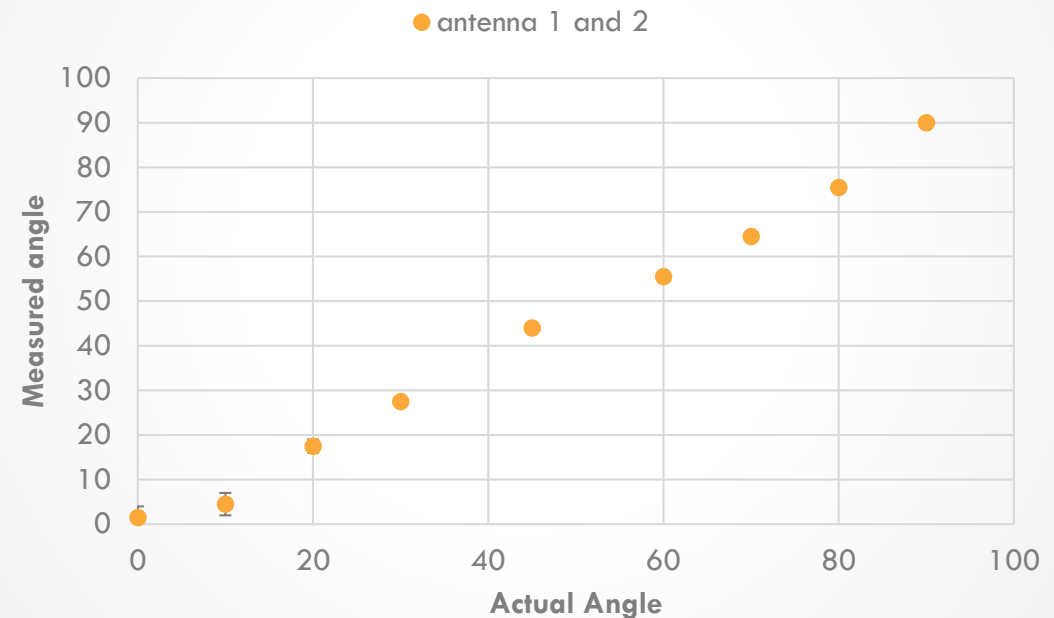
COMPARE?

Figure: angle comparation between antenna 1 and andtenna 1 +2

● antenna 1 only horizontal setup ● antenna 1 and 2
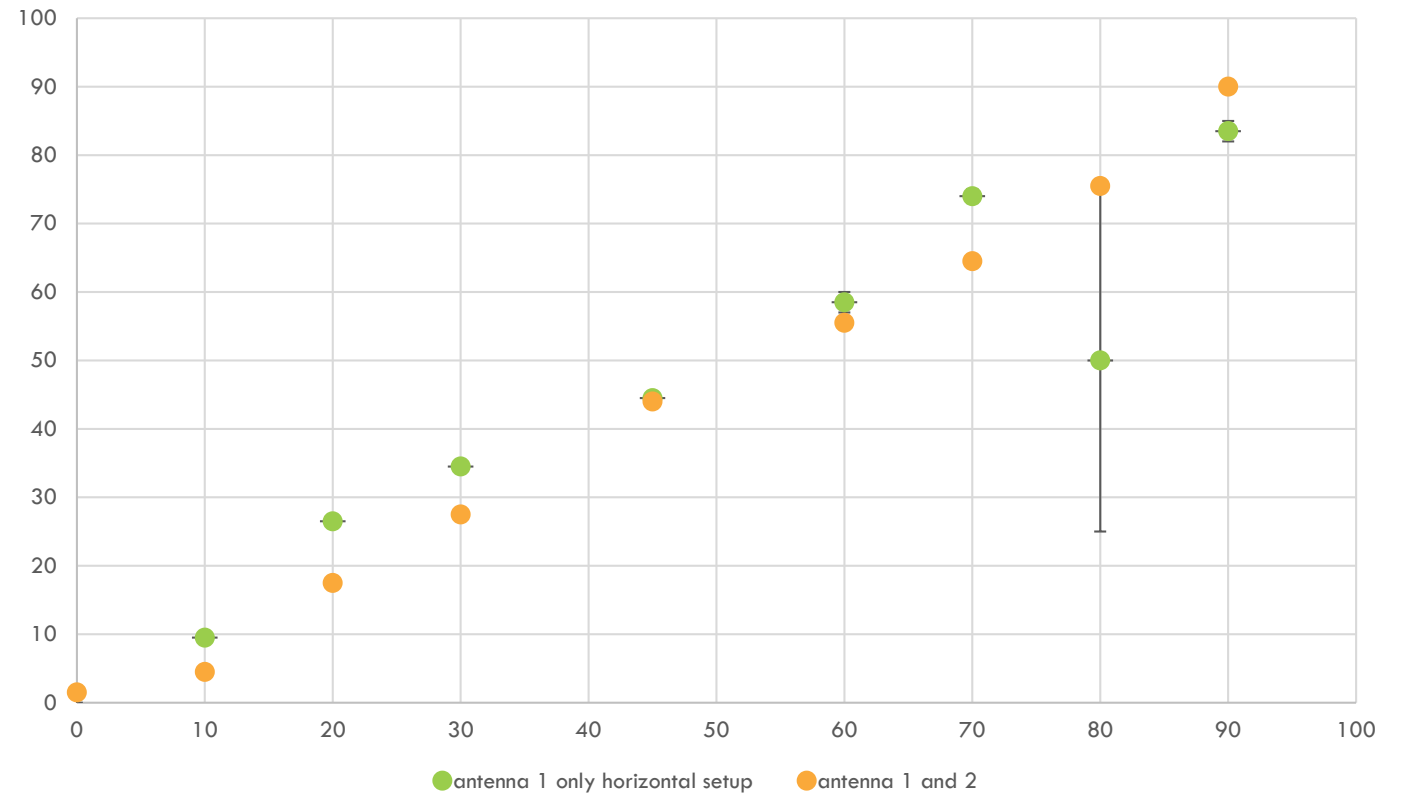
VERTICAL SETUPS
(TESTING ACCURACY OF
ANGLE MEASUREMENTS)
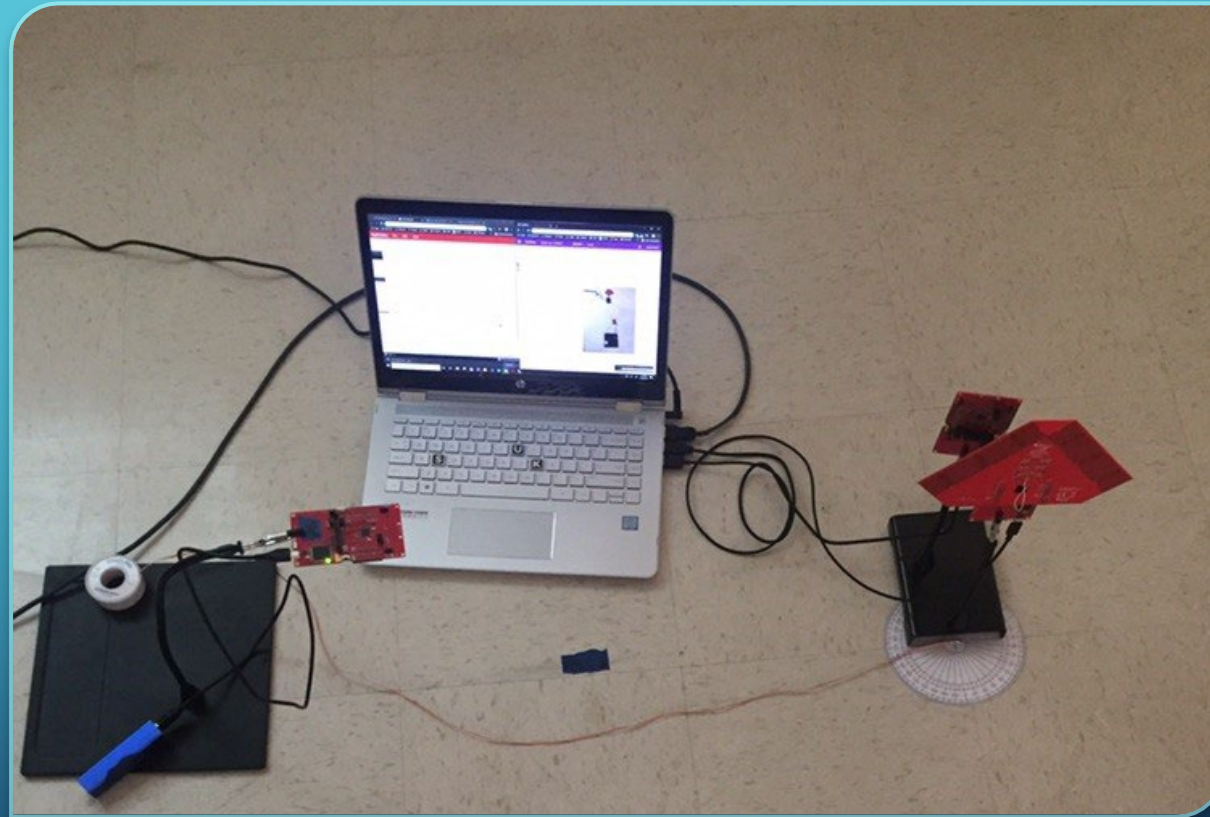
ANTENNA 1 AND 2 VERTICAL SETUP

| Angle	Min measured angle	Max measured angle	Avg	Difference	Error
0	50	56	53	53	
10	56	57	56.5	46.5	465%
20	62	65	63.5	43.5	218%
30	15	74	44.5	14.5	48%
45	0	40	20	-25	56%
60	45	104	74.5	14.5	24%
70	0	75	37.5	-32.5	46%
80	0	50	25	-55	69%
90	82	122	102	12	13%

Figure: antenna 1 and 2 vertical setup
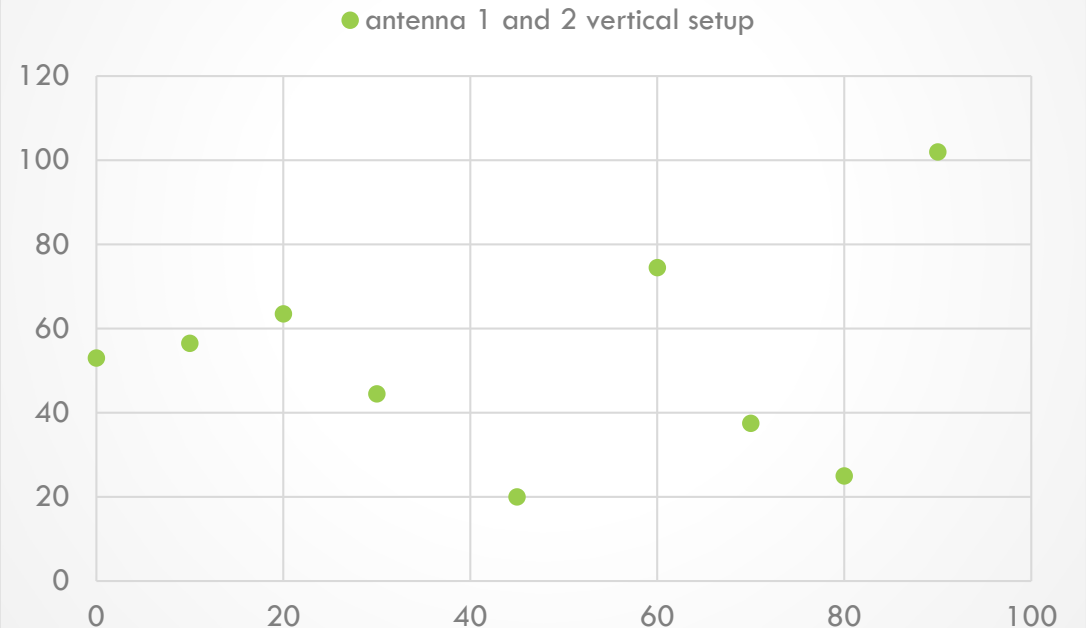
ANTENNA 1 AND 2 ANGLE VS DISTANCE (90°)

Distance (Tiles) (1 tile ~ 1ft)	Min angle	Max angle	Avg angle
1	89	92	90.5
2	94	95	94.5
3	80	92	86
4	77	90	83.5
5	60	87	73.5
10	55	95	75
15	-75	20	-27.5
20	-25	60	17.5

Figure Average Angle vs Distance
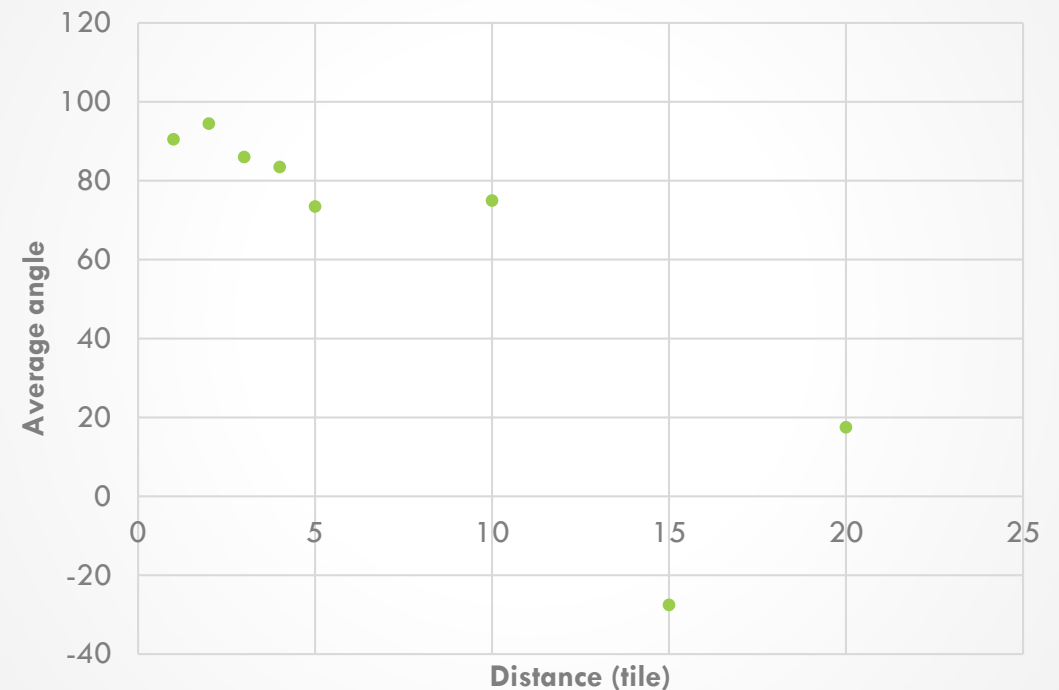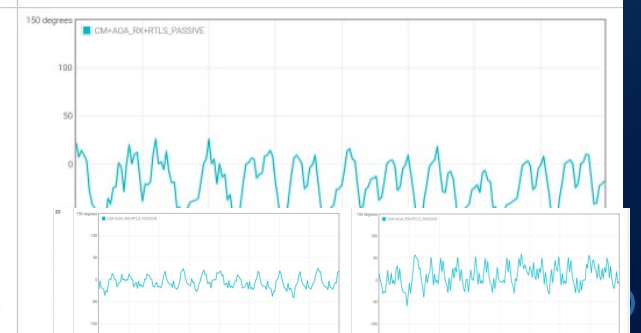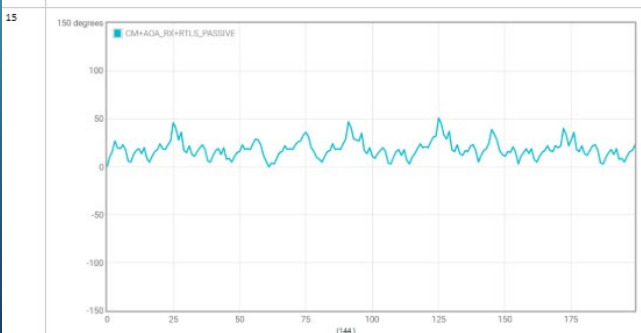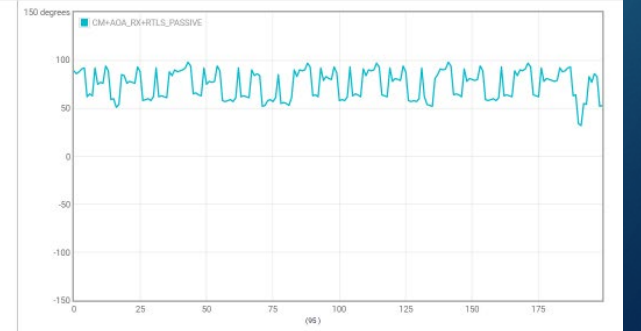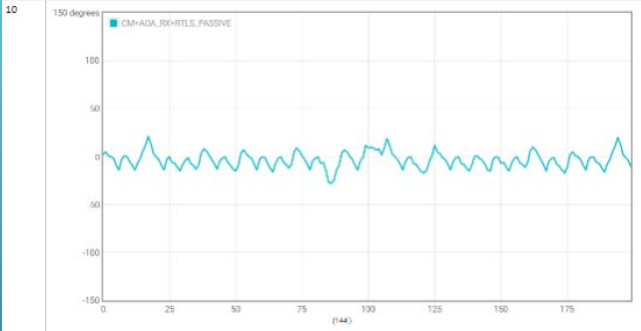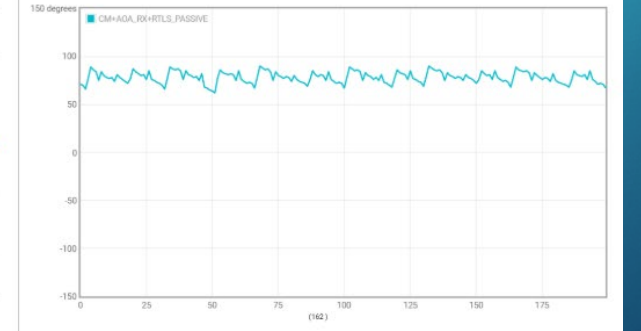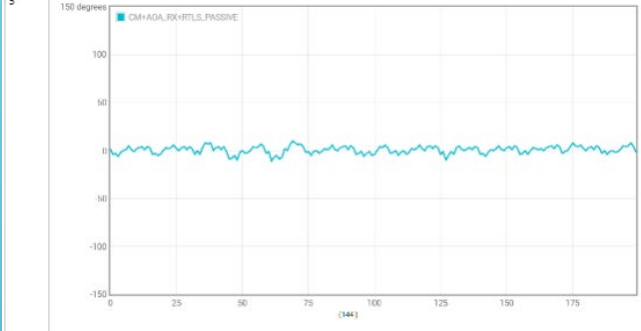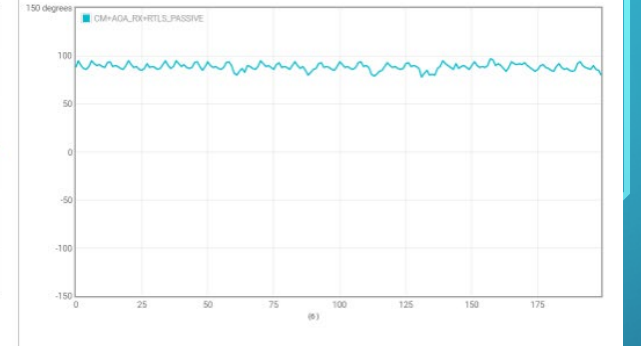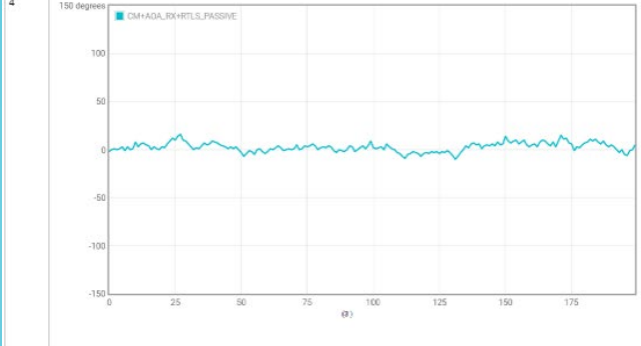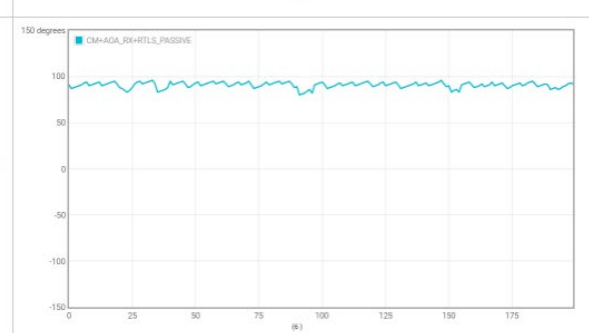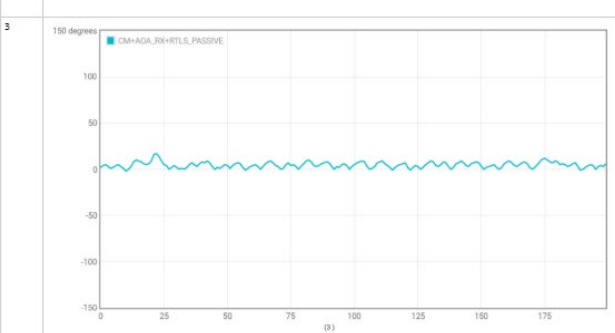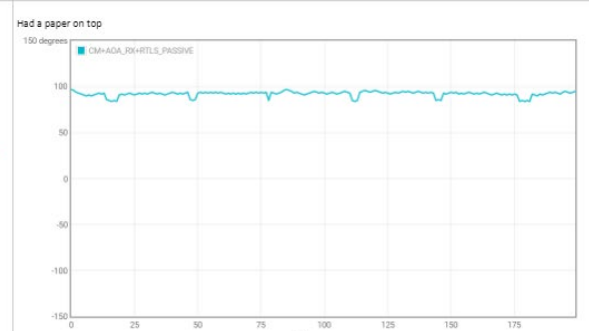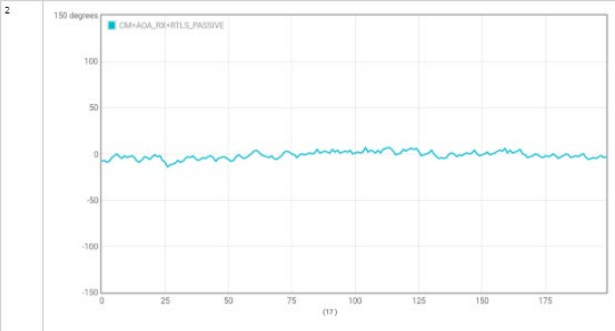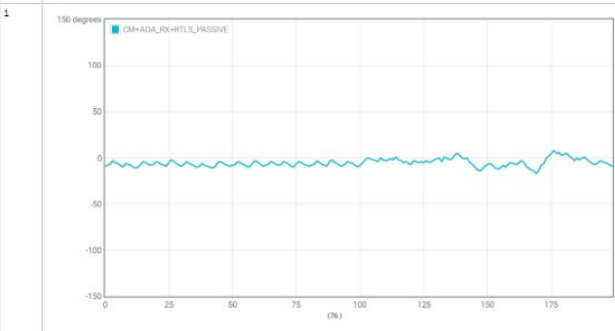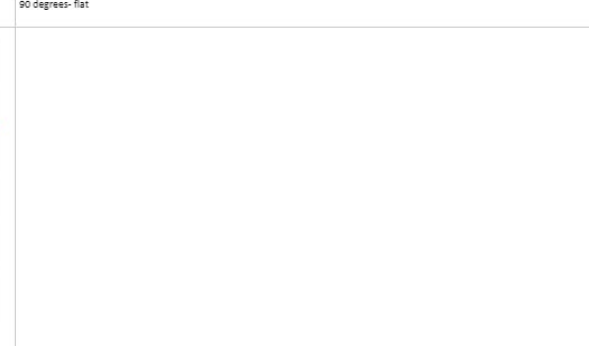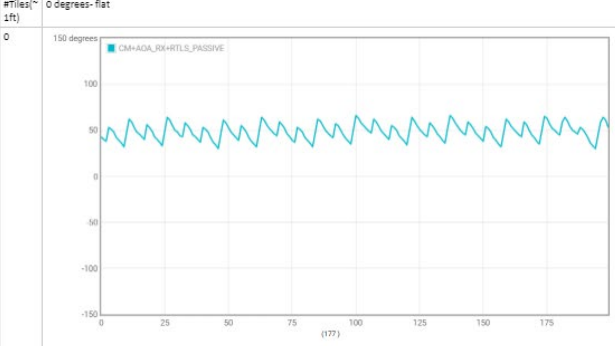
CONNECTIVITY WITH THE APP

TOO MUCH DATA (HOW TO FILTER)

- Python code giving angles

11_13_2019_14_43_59_rtls_example_with_rtls_util.log

37   [2019-11-13 14:44:24,784] rtls_util.py   ln 115 Thread-1   Level 60 - MASTER: 54:6C:0E:A0:42:EE --> {"originator": "Nwp", "type": "SyncRsp", "subsystem": "RTLS", "command": "RTLS_CMD_AOA_SET_PARAMS", "payload": {"status": "RTLS_SUCCESS"}}
38   [2019-11-13 14:44:24,862] rtls_util.py   ln 514 MainThread Level 51 - AOA Started
39   [2019-11-13 14:44:24,941] rtls_util.py   ln 113 Thread-1   Level 60 - PASSIVE: 54:6C:0E:83:2B:F3 --> {"originator": "Nwp", "type": "SyncRsp", "subsystem": "RTLS", "command": "RTLS_CMD_AOA_ENABLE", "payload": {"status": "RTLS_SUCCESS"}}
40   [2019-11-13 14:44:24,972] rtls_util.py   ln 115 Thread-1   Level 60 - MASTER: 54:6C:0E:A0:42:EE --> {"originator": "Nwp", "type": "SyncRsp", "subsystem": "RTLS", "command": "RTLS_CMD_AOA_ENABLE", "payload": {"status": "RTLS_SUCCESS"}}
41   [2019-11-13 14:44:26,448] rtls_util.py   ln 113 Thread-1   Level 60 - PASSIVE: 54:6C:0E:83:2B:F3 --> {"originator": "Nwp", "type": "AsyncReq", "subsystem": "RTLS", "command": "RTLS_CMD_AOA_RESULT_ANGLE", "payload": {"angle": 6, "rssi": -54, "antenna": 1, "channel": 17}}
42   [2019-11-13 14:44:26,448] rtls_util.py   ln 150 Thread-1   Level 53 - {"angle": 6, "rssi": -54, "antenna": 1, "channel": 17}
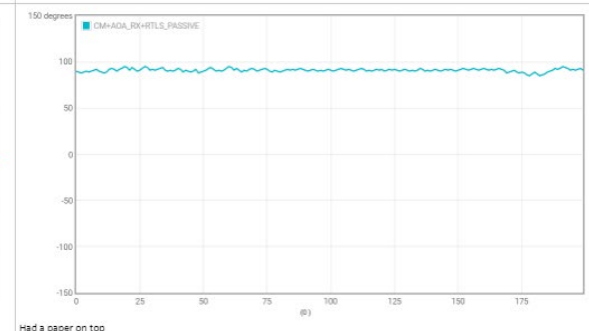43   [2019-11-13 14:44:27,437] rtls_util.py   ln 113 Thread-1   Level 60 - PASSIVE: 54:6C:0E:83:2B:F3 --> {"originator": "Nwp", "type": "AsyncReq", "subsystem": "RTLS", "command": "RTLS_CMD_AOA_RESULT_ANGLE", "payload": {"angle": 18, "rssi": -59, "antenna": 1, "channel": 2}}
44   [2019-11-13 14:44:27,438] rtls_util.py   ln 150 Thread-1   Level 53 - {"angle": 18, "rssi": -59, "antenna": 1, "channel": 2}
45   [2019-11-13 14:44:28,410] rtls_util.py   ln 113 Thread-1   Level 60 - PASSIVE: 54:6C:0E:83:2B:F3 --> {"originator": "Nwp", "type": "AsyncReq", "subsystem": "RTLS", "command": "RTLS_CMD_AOA_RESULT_ANGLE", "payload": {"angle": 10, "rssi": -60, "antenna": 2, "channel": 35}}
46   [2019-11-13 14:44:28,410] rtls_util.py   ln 150 Thread-1   Level 53 - {"angle": 10, "rssi": -60, "antenna": 2, "channel": 35}
47   [2019-11-13 14:44:29,400] rtls_util.py   ln 113 Thread-1   Level 60 - PASSIVE: 54:6C:0E:83:2B:F3 --> {"originator": "Nwp", "type": "AsyncReq", "subsystem": "RTLS", "command": "RTLS_CMD_AOA_RESULT_ANGLE", "payload": {"angle": 3, "rssi": -58, "antenna": 2, "channel": 20}}
48   [2019-11-13 14:44:29,400] rtls_util.py   ln 150 Thread-1   Level 53 - {"angle": 3, "rssi": -58, "antenna": 2, "channel": 20}
49   [2019-11-13 14:44:30,410] rtls_util.py   ln 113 Thread-1   Level 60 - PASSIVE: 54:6C:0E:83:2B:F3 --> {"originator": "Nwp", "type": "AsyncReq", "subsystem": "RTLS", "command": "RTLS_CMD_AOA_RESULT_ANGLE", "payload": {"angle": -3, "rssi": -59, "antenna": 2, "channel": 5}}
50   [2019-11-13 14:44:30,410] rtls_util.py   ln 150 Thread-1   Level 53 - {"angle": -3, "rssi": -59, "antenna": 2, "channel": 5}
51   [2019-11-13 14:44:31,410] rtls_util.py   ln 113 Thread-1   Level 60 - PASSIVE: 54:6C:0E:83:2B:F3 --> {"originator": "Nwp", "type": "AsyncReq", "subsystem": "RTLS", "command": "RTLS_CMD_AOA_RESULT_ANGLE", "payload": {"angle": 7, "rssi": -62, "antenna": 1, "channel": 16}}
52   [2019-11-13 14:44:31,410] rtls_util.py   ln 150 Thread-1   Level 53 - {"angle": 7, "rssi": -62, "antenna": 1, "channel": 16}
53   [2019-11-13 14:44:32,399] rtls_util.py   ln 113 Thread-1   Level 60 - PASSIVE: 54:6C:0E:83:2B:F3 --> {"originator": "Nwp", "type": "AsyncReq", "subsystem": "RTLS", "command": "RTLS_CMD_AOA_RESULT_ANGLE", "payload": {"angle": 12, "rssi": -58, "antenna": 1, "channel": 1}}
54   [2019-11-13 14:44:32,400] rtls_util.py   ln 150 Thread-1   Level 53 - {"angle": 12, "rssi": -58, "antenna": 1, "channel": 1}
55   [2019-11-13 14:44:33,410] rtls_util.py   ln 113 Thread-1   Level 60 - PASSIVE: 54:6C:0E:83:2B:F3 --> {"originator": "Nwp", "type": "AsyncReq", "subsystem": "RTLS", "command": "RTLS_CMD_AOA_RESULT_ANGLE", "payload": {"angle": -7, "rssi": -60, "antenna": 2, "channel": 34}}
56   [2019-11-13 14:44:33,426] rtls_util.py   ln 150 Thread-1   Level 53 - {"angle": -7, "rssi": -60, "antenna": 2, "channel": 34}
57   [2019-11-13 14:44:34,444] rtls_util.py   ln 113 Thread-1   Level 60 - PASSIVE: 54:6C:0E:83:2B:F3 --> {"originator": "Nwp", "type": "AsyncReq", "subsystem": "RTLS", "command": "RTLS_CMD_AOA_RESULT_ANGLE", "payload": {"angle": -5, "rssi": -59, "antenna": 2, "channel": 19}}
58   [2019-11-13 14:44:34,444] rtls_util.py   ln 150 Thread-1   Level 53 - {"angle": -5, "rssi": -59, "antenna": 2, "channel": 19}
59   [2019-11-13 14:44:35,054] rtls_util.py   ln 115 Thread-1   Level 60 - MASTER: 54:6C:0E:A0:42:EE --> {"originator": "Nwp", "type": "SyncRsp", "subsystem": "RTLS", "command": "RTLS_CMD_IDENTIFY", "payload": {"capabilities": {"CM": false, "AOA_TX": false, "AOA_RX": true, "TOF_SLAVE": false, "TOF_PASSIVE": false, "TOF_MASTER": false, "RTLS_SLAVE": false, "RTLS_MASTER": true, "RTLS_PASSIVE": false}, "revNum": 1, "devId": "DeviceFamily_ID_CC26X0R2", "identifier": "54:6C:0E:A0:42:EE"}}
60   [2019-11-13 14:44:35,069] rtls_util.py   ln 113 Thread-1   Level 60 - PASSIVE: 54:6C:0E:83:2B:F3 --> {"originator": "Nwp", "type": "SyncRsp", "subsystem": "RTLS", "command": "RTLS_CMD_IDENTIFY", "payload": {"capabilities": {"CM": true, "AOA_TX": false, "AOA_RX": true, "TOF_SLAVE": false, "TOF_PASSIVE": false, "TOF_MASTER": false, "RTLS_SLAVE": false, "RTLS_MASTER": false, "RTLS_PASSIVE": true}, "revNum": 1, "devId": "DeviceFamily_ID_CC26X0R2", "identifier": "54:6C:0E:83:2B:F3"}}
61   [2019-11-13 14:44:35,132] rtls_util.py   ln 518 MainThread Level 51 - AOA Stopped
62   [2019-11-13 14:44:35,241] rtls_util.py   ln 115 Thread-1   Level 60 - MASTER: 54:6C:0E:A0:42:EE --> {"originator": "Nwp", "type": "SyncRsp", "subsystem": "RTLS", "command": "RTLS_CMD_AO {"status": "RTLS_SUCCESS"}}
63   [2019-11-13 14:44:35,257] rtls_util.py   ln 113 Thread-1   Level 60 - PASSIVE: 54:6C:0E:83:2B:F3 --> {"originator": "Nwp", "type": "SyncRsp", "subsystem": "RTLS", "command": "RTLS_CMD_A
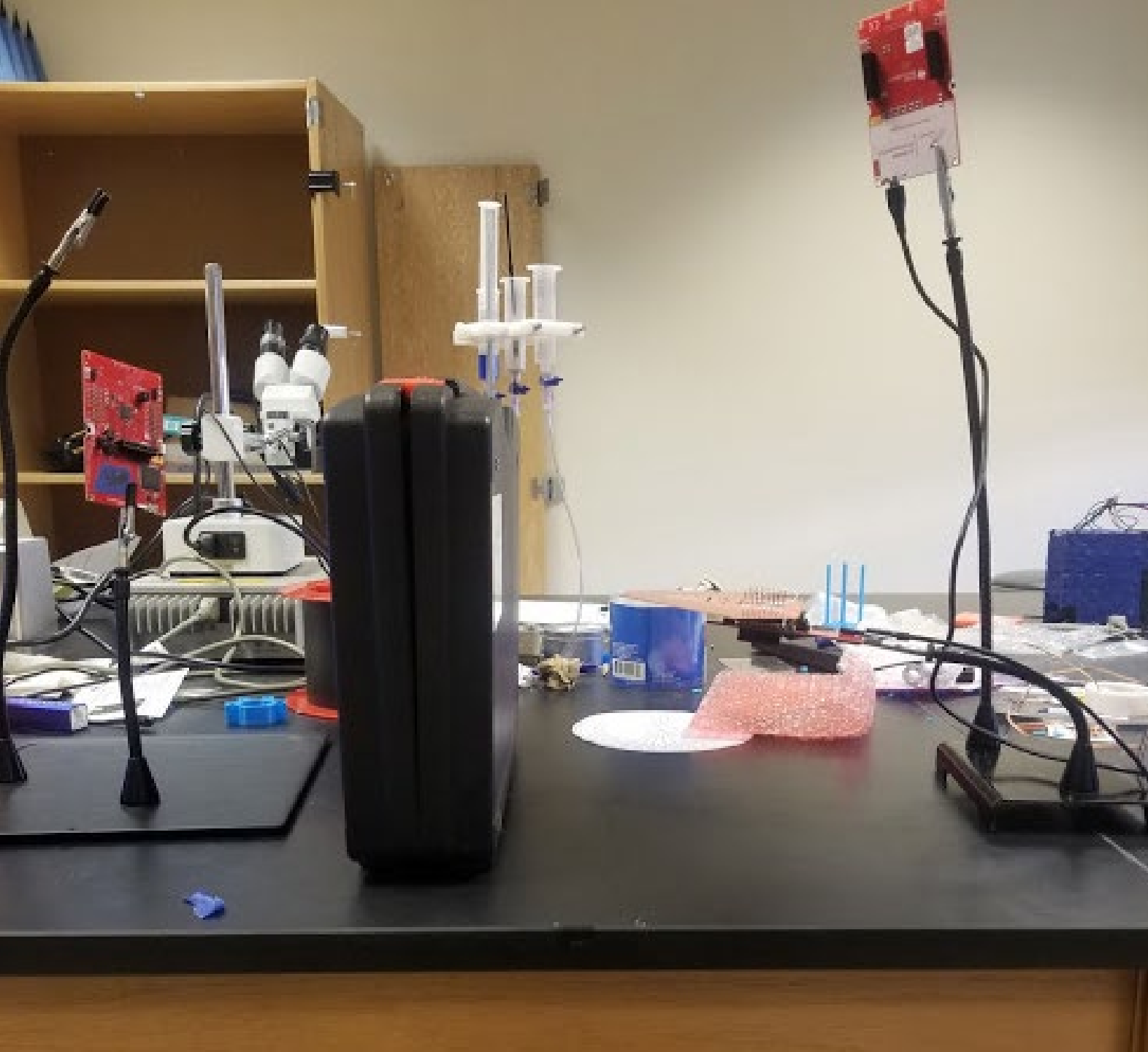
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TOO MUCH DATA (HOW TO FILTER)
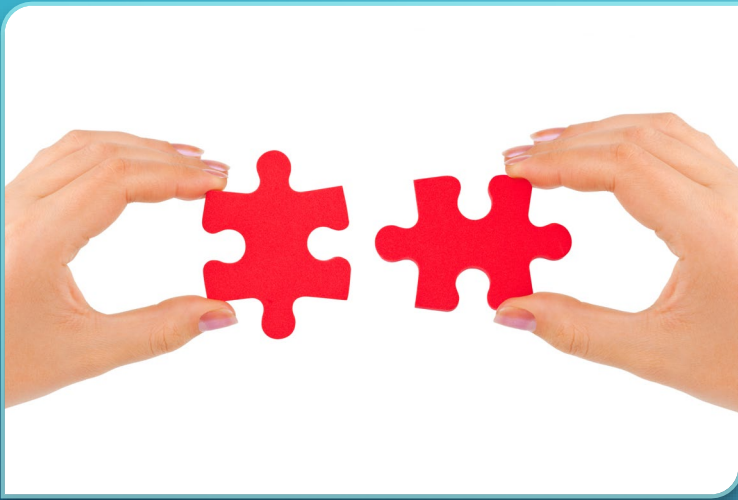
- Python code giving IQ Data (RAW DATA)

11_14_2019_18_05_47_rtls_aoa_iq_with_rtls_util_export_into_csv.log

185   [2019-11-14 18:06:01,874] serialnode.py   ln 106 CC2640r2 TOF Passive   DEBUG - <<< UNPIMessage(originator=Nwp type=AsyncReq, subsystem=RTLS, command=RTLS_CMD_AOA_RESULT_RAW,
      data=C4:01:17:C0:00:FF:01:DC:FF:52:00:FD:FF:5A:00:18:00:55:00:32:00:48:00:48:00:30:00:55:00:16:00:57:00:F6:FF:4E:00:D9:FF:3A:00:C0:FF:1A:00:AF:FF:FB:FF:AB:FF:E0:FF:B2:FF:C8:FF:C4:FF:B7:FF:D9:FF:AB:FF:F4:FF:A8:FF:0E:00
      :AF:FF:28:00:C3:FF:3F:00:DE:FF:4C:00:00:00:53:00:1E:00:4E:00:36:00:42:00:49:00:2A:00:52:00:0F:00:52:00:EE:FF:48:00:D1:FF:35:00:BB:FF:1B:00:AE:FF:01:00:AB:FF:E4:FF:B2:FF:CE:FF:BF:FF:BC:FF:D1:FF)

186   [2019-11-14 18:06:01,875] rtls_util.py   ln 150 Thread-1   Level 53 - {"rssi": -60, "antenna": 1, "channel": 23, "offset": 0, "samplesLength": 511, "samples": [{"q": -82, "i": 26}, {"q": -70, "i": 51}, {"q": -46,
      "i": 73}, {"q": -18, "i": 82}, {"q": 13, "i": 51}, {"q": 46, "i": 70}, {"q": 69, "i": 51}, {"q": 83, "i": 22}, {"q": 84, "i": 11}, {"q": 76, "i": -34}, {"q": 57, "i": -60}, {"q": 34, "i": -76}, {"q": 4, "i": -84},
      {"q": -24, "i": -82}, {"q": -51, "i": -71}, {"q": -74, "i": -48}, {"q": -85, "i": -20}, {"q": -83, "i": 17}, {"q": -69, "i": 47}, {"q": -48, "i": 69}, {"q": -20, "i": 82}, {"q": 6, "i": 83}, {"q": 32, "i": 77}, {"q":
      58, "i": 59}, {"q": 76, "i": 36}, {"q": 86, "i": 4}, {"q": 83, "i": -26}, {"q": 72, "i": -54}, {"q": 48, "i": -76}, {"q": 21, "i": -86}, {"q": -12, "i": -86}, {"q": -40, "i": -77}]}

187   [2019-11-14 18:06:01,879] rtlsnode.py   ln 206 CC2640r2 TOF Passive   DEBUG - Have 0 subscribers for UNPIMessage(originator=Nwp type=AsyncReq, subsystem=RTLS, command=RTLS_CMD_AOA_RESULT_RAW,
      data=C4:01:17:60:00:FF:01:3C:00:CA:FF:25:00:B8:FF:09:00:AF:FF:E9:FF:B0:FF:D0:FF:BB:FF:BB:FF:CE:FF:AD:FF:EB:FF:AB:FF:08:00:B5:FF:26:00:C8:FF:3D:00:E0:FF:4C:00:FE:FF:52:00:1A:00:4E:00:38:00:40:00:4C:00:2C:00:56:00:13:00
      :55:00:F4:FF:4B:00:D9:FF:37:00:BE:FF:1F:00:AE:FF:01:00:A8:FF:E0:FF:B1:FF:C6:FF:C3:FF:B2:FF:E1:FF:AB:FF:FE:FF:AE:FF:19:00:BB:FF:34:00:CF:FF:47:00:EA:FF:53:00:0A:00:56:00:25:00:4E:00:3D:00:3A:00)

188   [2019-11-14 18:06:01,881] serialnode.py   ln 103 CC2640r2 TOF Passive   DEBUG - <<<
      FE:87:00:59:24:C4:01:17:00:01:FF:01:C8:FF:BE:FF:B2:FF:DA:FF:A9:FF:F8:FF:AD:FF:17:00:BE:FF:35:00:D4:FF:48:00:F2:FF:53:00:0E:00:53:00:2A:00:4B:00:45:00:35:00:53:00:19:00:55:00:F4:FF:49:00:D5:FF:35:00:BD:FF:16:00:AD:FF:F
      A:FF:AB:FF:DB:FF:B4:FF:C3:FF:C6:FF:B1:FF:DF:FF:A9:FF:00:00:AE:FF:1B:00:BD:FF:34:00:D0:FF:44:00:E8:FF:4F:00:05:00:53:00:20:00:4F:00:38:00:41:00:4B:00:28:00:53:00:0C:00:50:00:EA:FF:44:00:CE:FF:2F:00:B8:FF:B4:FE:87:00:59
      :24:C4:01:17:20:01:FF:01:0F:00:A9:FF:EF:FF:A9:FF:CF:FF:B5:FF:BA:FF:CA:FF:AF:FF:E5:FF:AD:FF:04:00:B3:FF:1F:00:C4:FF:39:00:D8:FF:4A:00:F3:FF:53:00:13:00:52:00:2F:00:47:00:46:00:31:00:53:00:1A:00:55:00:FF:FF:4C:00:DF:FF:
      3B:00:C6:FF:21:00:B2:FF:04:00:AA:FF:E7:FF:AC:FF:C9:FF:BA:FF:B7:FF:D1:FF:AE:FF:ED:FF:AF:FF:0F:00:BA:FF:2B:00:CF:FF:43:00:E9:FF:4E:00:07:00:51:00:28:00:49:00:40:00:38:00:51:00:1C:00:54:00:00:00:DD:FE:87:00:59:24:C4:01:1
      7:40:01:FF:01:50:00:E4:FF:42:00:C8:FF:2D:00:B6:FF:11:00:AC:FF:F5:FF:AC:FF:DA:FF:B6:FF:C1:FF:CA:FF:B2:FF:E2:FF:AA:FF:02:00:AE:FF:1F:00:BD:FF:39:00:DA:FF:4E:00:F9:FF:56:00:19:00:53:00:37:00:43:00:4A:00:2D:00:53:00:0E:00
      :52:00:F2:FF:48:00:D6:FF:32:00:BC:FF:16:00:AC:FF:F3:FF:A9:FF:D7:FF:B3:FF:C0:FF:C7:FF:AF:FF:E6:FF:AB:FF:03:00:B2:FF:24:00:C2:FF:3C:00:D9:FF:4D:00:F8:FF:54:00:14:00:50:00:30:00:42:00:F7:FE:87:00:59:24:C4:01:17:60:01:FF:
      01:43:00:2E:00:4F:00:15:00:52:00:F5:FF:49:00:D9:FF:33:00:BF:FF:16:00:B0:FF:F8:FF:AD:FF:D9:FF:B3:FF:C4:FF:C2:FF:B5:FF:D8:FF:AE:FF:F7:FF:B0:FF:14:00:BF:FF:32:00:D5:FF:44:00:F0:FF:4E:00:10:00:4E:00:2A:00:44:00:43:00:2D:0
      0:50:00:10:00:53:00:F0:FF:48:00:CE:FF:32:00:B8:FF:12:00:A9:FF:F2:FF:A8:FF:D5:FF:B2:FF:BC:FF:C6:FF:AE:FF:DE:FF:AA:FF:FD:FF:AF:FF:1A:00:BC:FF:35:00:D3:FF:4B:00:EE:FF:54:00:E2:FE:87:00:59:24:C4:01:17:80:01:FF:01:0E:00:53
      :00:29:00:48:00:40:00:35:00:50:00:19:00:54:00:FF:FF:4E:00:E4:FF:3C:00:C9:FF:26:00:B8:FF:07:00:AC:FF:EB:FF:AD:FF:CE:FF:B9:FF:B4:FF:D4:FF:A8:FF:F3:FF:AC:FF:18:00:BB:FF:33:00:D3:FF:47:00:F3:FF:52:00:10:00:51:00:2E:00:46:
      00:42:00:34:00:4F:00:1C:00:53:00:FD:FF:4F:00:E1:FF:40:00:C5:FF:2A:00:B2:FF:0E:00:A7:FF:EC:FF:A7:FF:D0:FF:B3:FF:BA:FF:C8:FF:AC:FF:E6:FF:AA:FF:03:00:B2:FF:24:00:02:FE:87:00:59:24:C4:01:17:A0:01:FF:01:C2:FF:3C:00:D9:FF:4
      D:00:F7:FF:57:00:12:00:56:00:30:00:4B:00:44:00:37:00:51:00:1D:00:54:00:FC:FF:4C:00:E1:FF:39:00:C7:FF:20:00:B7:FF:01:00:B0:FF:DD:FF:B5:FF:C2:FF:C5:FF:AE:FF:E0:FF:A7:FF:FD:FF:AB:FF:1A:00:B9:FF:35:00:CE:FF:47:00:EB:FF:53
      :00:08:00:54:00:26:00:4B:00:42:00:36:00:52:00:1B:00:56:00:FC:FF:4D:00:DA:FF:3B:00:C1:FF:20:00:B0:FF:02:00:AA:FF:E5:FF:AF:FF:C7:FF:BF:FF

189   [2019-11-14 18:06:01,882] rtls_util.py   ln 113 Thread-1   Level 60 - PASSIVE: 54:6C:0E:83:2B:F3 --> {"originator": "Nwp", "type": "AsyncReq", "subsystem": "RTLS", "command": "RTLS_CMD_AOA_RESULT_RAW", "payload":
      {"rssi": -60, "antenna": 1, "channel": 23, "offset": 64, "samplesLength": 511, "samples": [{"q": 7, "i": -82}, {"q": -23, "i": -82}, {"q": -54, "i": -70}, {"q": -74, "i": -49}, {"q": -86, "i": -18}, {"q": -85, "i":
      12}, {"q": -76, "i": 40}, {"q": -56, "i": 65}, {"q": -32, "i": 80}, {"q": -3, "i": 85}, {"q": 32, "i": 77}, {"q": 60, "i": 60}, {"q": 82, "i": 32}, {"q": 89, "i": 2}, {"q": 84, "i": -27}, {"q": 65, "i": -56}, {"q":
      41, "i": -75}, {"q": 8, "i": -85}, {"q": -23, "i": -83}, {"q": -50, "i": -70}, {"q": -74, "i": -45}, {"q": -84, "i": -14}, {"q": -83, "i": 22}, {"q": -69, "i": 51}, {"q": -47, "i": 72}, {"q": -16, "i": 85}, {"q": 13,
      "i": 84}, {"q": 43, "i": 71}, {"q": 63, "i": 52}, {"q": 76, "i": 29}, {"q": 81, "i": -1}, {"q": 76, "i": -27}]]}}

190   [2019-11-14 18:06:01,884] rtlsnode.py   ln 206 CC2640r2 TOF Passive   DEBUG - Have 0 subscribers for UNPIMessage(originator=Nwp type=AsyncReq, subsystem=RTLS, command=RTLS_CMD_AOA_RESULT_RAW,
      data=C4:01:17:20:00:FF:01:C1:FF:C5:FF:B1:FF:E4:FF:AD:FF:03:00:B5:FF:25:00:C5:FF:3D:00:DA:FF:4D:00:F7:FF:54:00:12:00:52:00:30:00:46:00:45:00:33:00:52:00:1A:00:54:00:F9:FF:4C:00:DD:FF:3C:00:C5:FF:23:00:B3:FF:07:00:AD:FF
      :E6:FF:AF:FF:CB:FF:BB:FF:B5:FF:CE:FF:A9:FF:EC:FF:A8:FF:0B:00:B5:FF:2D:00:CA:FF:47:00:E6:FF:56:00:09:00:59:00:26:00:50:00:40:00:3B:00:4F:00:21:00:54:00:04:00:4E:00:E5:FF:3F:00:CC:FF:23:00:B7:FF)

191   [2019-11-14 18:06:01,885] serialnode.py   ln 106 CC2640r2 TOF Passive   DEBUG - <<< UNPIMessage(originator=Nwp type=AsyncReq, subsystem=RTLS, command=RTLS_CMD_AOA_RESULT_RAW,
      data=C4:01:17:E0:00:FF:01:AF:FF:EB:FF:AD:FF:07:00:B6:FF:26:00:C9:FF:3D:00:E3:FF:4E:00:04:00:55:00:21:00:50:00:3C:00:3D:00:50:00:1F:00:57:00:FD:FF:4F:00:DA:FF:3C:00:C2:FF:22:00:B2:FF:01:00:AC:FF:E3:FF:B1:FF:C6:FF:C2:FF
      :B4:FF:DA:FF:AC:FF:F7:FF:B0:FF:19:00:BF:FF:34:00:D8:FF:48:00:F3:FF:51:00:0F:00:52:00:2D:00:49:00:44:00:38:00:54:00:1B:00:57:00:FE:FF:4E:00:E0:FF:39:00:C4:FF:1F:00:B3:FF:03:00:AB:FF:E2:FF:B0:FF)

192   [2019-11-14 18:06:01,885] rtls_util.py   ln 150 Thread-1   Level 53 - {"rssi": -60, "antenna": 1, "channel": 23, "offset": 64, "samplesLength": 511, "samples": [{"q": 7, "i": -82}, {"q": -23, "i": -82}, {"q": -54,
      "i": -70}, {"q": -74, "i": -49}, {"q": -86, "i": -18}, {"q": -85, "i": 12}, {"q": -76, "i": 40}, {"q": -56, "i": 65}, {"q": -32, "i": 80}, {"q": -3, "i": 85}, {"q": 32, "i": 77}, {"q": 60, "i": 60}, {"q": 82, "i": 32}
      , {"q": 89, "i": 2}, {"q": 84, "i": -27}, {"q": 65, "i": -56}, {"q": 41, "i": -75}, {"q": 8, "i": -85}, {"q": -23, "i": -83}, {"q": -50, "i": -70}, {"q": -74, "i": -45}, {"q": -84, "i": -14}, {"q": -83, "i": 22},
      {"q": -69, "i": 51}, {"q": -47, "i": 72}, {"q": -16, "i": 85}, {"q": 13, "i": 84}, {"q": 43, "i": 71}, {"q": 63, "i": 52}, {"q": 76, "i": 29}, {"q": 81, "i": -1}, {"q": 76, "i": -27}]}

193   [2019-11-14 18:06:01,887] rtlsnode.py   ln 206 CC2640r2 TOF Passive   DEBUG - Have 0 subscribers for UNPIMessage(originator=Nwp type=AsyncReq, subsystem=RTLS, command=RTLS_CMD_AOA_RESULT_RAW,
      data=C4:01:17:A0:00:FF:01:22:00:4D:00:3C:00:3C:00:4E:00:24:00:56:00:04:00:53:00:E9:FF:43:00:CD:FF:2E:00:BB:FF:13:00:B0:FF:F2:FF:AF:FF:D5:FF:B7:FF:BC:FF:CC:FF:AE:FF:E7:FF:AC:FF:06:00:B7:
      :08:00:56:00:25:00:4E:00:40:00:39:00:4F:00:20:00:55:00:03:00:4E:FF:44:FF:41:00:CC:FF:29:00:B8:FF:10:00:AE:FF:F4:FF:AC:FF:D5:FF:B6:FF:BE:FF:C9:FF:AE:FF:E6:FF:A9:FF:05:00:B0:FF:22:00:C3:F

194   [2019-11-14 18:06:01,888] serialnode.py   ln 103 CC2640r2 TOF Passive   DEBUG - <<<
      FE:87:00:59:24:C4:01:17:20:01:FF:01:0F:00:A9:FF:EF:FF:A9:FF:CF:FF:B5:FF:BA:FF:CA:FF:AF:FF:E5:FF:AD:FF:04:00:B3:FF:1F:00:C4:FF:39:00:D8:FF:4A:00:F3:FF:53:00:13:00:52:00:2F:00:47:00:46:00

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ERROR IN THE ANGLE WHEN PATHWAY IS OBSTRUCTED

CONCLUSION

- Antenna works best when slave and antenna are on same horizontal setups

- Only displays angles for a 2D plane

- Using one antenna only helps if we measuring angle from -20 to 20

- Accurate angles when no obstructions and less than 10 ft away

- Connectivity with the current board software and firmware is difficult and unattainable
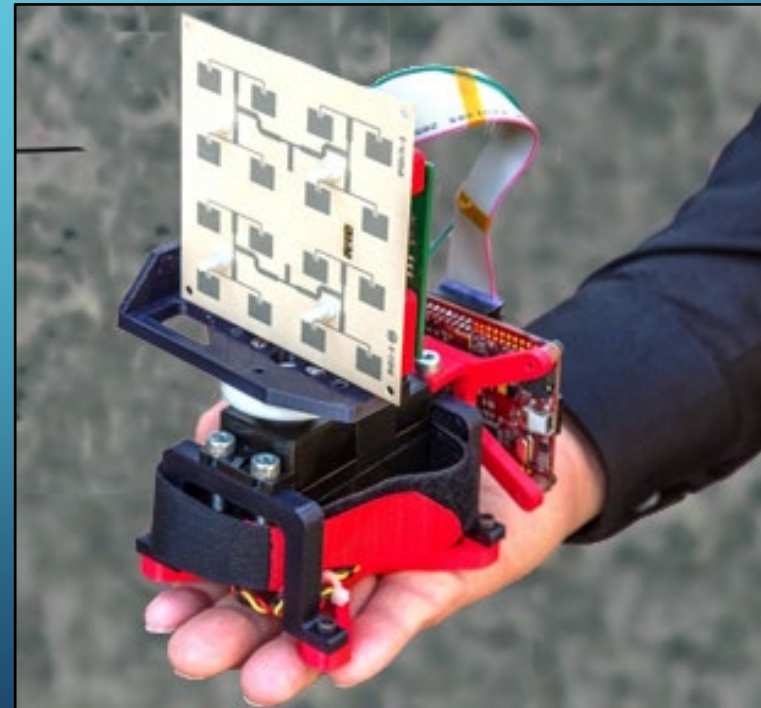
FUTURE WORK OR END GOAL?

- Mobile/Web UI to forward Rx data to and **display coordinates on Floor plan/Map**
  - User inputs:
    - Max X and Y lengths per floor
    - Distance between the 2, linearly-spaced receivers
  - Smoothly tracking displacement

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LESS-COSTLY PROTOTYPES?

- Develop "Homemade" **Rx** / Phased Antenna Arrays (**2-in-1**):
  - Try/Test accuracy of:
    - Less antenna's?
    - Directional/Rotating array?
    - Smaller Device?
    - Circular antenna array?

Thank You!
Any Questions?