

Welcome the MV3500 Assignment 3 (Python Version)

This example simulates the replay of ADSB data collected by FlightAware on 1 Sept, 2021 for N569DS. This aircraft was flying under IFR rules from KMSN to KEFT and back to KMSN.

First, lets look at the data

```
In [1]: import pandas as pd
data_frame = pd.read_csv('N569DS_Track_1_Sept_1.csv')
```

```
In [2]: data_frame.head()
```

```
Out[2]:
```

		Time (EDT)	Latitude	Longitude	Course	kts	mph	feet	Rate	Reporting Facility
0		Wed 08:35:24 PM	43.1452	-89.3382	← 315°	86.0	99.0	950	NaN	FlightAware ADS-B (KMSN)
1	Wed 08:35:24 PM Departure (KMSN) @ Wednesday ...		NaN	NaN	NaN	NaN	NaN	NaN	NaN	FlightAware ADS-B (KMSN)
2		Wed 08:35:40 PM	43.1489	-89.3442	← 301°	81.0	93.0	1,225	938.0	FlightAware ADS-B (KMSN)
3		Wed 08:35:56 PM	43.1499	-89.3525	← 260°	92.0	106.0	1,450	984.0	FlightAware ADS-B (KMSN)
4		Wed 08:36:12 PM	43.1460	-89.3611	↙ 216°	92.0	106.0	1,750	844.0	FlightAware ADS-B (KMSN)

```
In [3]: # drop the rows that don't have position data
data_frame = data_frame.dropna()
data_frame = data_frame.reset_index()
```

```
In [4]: data_frame.head()
```

```
Out[4]:
```

	index	Time (EDT)	Latitude	Longitude	Course	kts	mph	feet	Rate	Reporting Facility
0	2	Wed 08:35:40 PM	43.1489	-89.3442	← 301°	81.0	93.0	1,225	938.0	FlightAware ADS-B (KMSN)
1	3	Wed 08:35:56 PM	43.1499	-89.3525	← 260°	92.0	106.0	1,450	984.0	FlightAware ADS-B (KMSN)
2	4	Wed 08:36:12 PM	43.1460	-89.3611	↙ 216°	92.0	106.0	1,750	844.0	FlightAware ADS-B (KMSN)
3	5	Wed 08:36:28 PM	43.1401	-89.3644	↓ 195°	98.0	113.0	1,900	750.0	FlightAware ADS-B (KMSN)
4	6	Wed 08:36:44 PM	43.1323	-89.3676	↓ 199°	99.0	114.0	2,150	984.0	FlightAware ADS-B (KMSN)

```
In [5]: # how many position reports do we have?
len(data_frame)
```

Out[5]: 156

```
In [6]: data_frame.tail()
```

Out[6]:

	index	Time (EDT)	Latitude	Longitude	Course	kts	mph	feet	Rate	Reporting Facility
151	186	Wed 11:09:44 PM	43.0898	-89.2665	↖ 316°	137.0	158.0	2,336	-726.0	Surface and Near-Surface
152	187	Wed 11:10:57 PM	43.1182	-89.3031	↖ 319°	91.0	105.0	1,400	-783.0	FlightAware ADS-B (KMSN)
153	188	Wed 11:11:13 PM	43.1232	-89.3095	← 315°	93.0	107.0	1,175	-703.0	FlightAware ADS-B (KMSN)
154	189	Wed 11:11:29 PM	43.1279	-89.3156	↖ 316°	89.0	102.0	1,025	-563.0	FlightAware ADS-B (KEFT)
155	190	Wed 11:11:45 PM	43.1330	-89.3222	↖ 318°	88.0	101.0	875	-563.0	FlightAware ADS-B (KMSN)

```
In [7]: # we see that the ADSB network first started collecting position data at 2035 and the last
```

```
In [8]: # since the data is not that big, lets just display it
for index, row in data_frame.iterrows():
    print(index, row['Time (EDT)'], row['Latitude'], row['Longitude'], row['Course'], row['
```

0	Wed 08:35:40 PM	43.1489	-89.3442	← 301°	81.0	1,225	938.0
1	Wed 08:35:56 PM	43.1499	-89.3525	← 260°	92.0	1,450	984.0
2	Wed 08:36:12 PM	43.146	-89.3611	↙ 216°	92.0	1,750	844.0
3	Wed 08:36:28 PM	43.1401	-89.3644	↓ 195°	98.0	1,900	750.0
4	Wed 08:36:44 PM	43.1323	-89.3676	↓ 199°	99.0	2,150	984.0
5	Wed 08:37:00 PM	43.1257	-89.3712	↙ 203°	96.0	2,425	938.0
6	Wed 08:37:16 PM	43.1197	-89.375	↙ 208°	93.0	2,650	844.0
7	Wed 08:37:32 PM	43.114	-89.3792	↙ 208°	93.0	2,875	891.0
8	Wed 08:37:48 PM	43.1072	-89.3839	↙ 208°	92.0	3,125	844.0
9	Wed 08:38:04 PM	43.1018	-89.3877	↙ 204°	93.0	3,325	797.0
10	Wed 08:38:20 PM	43.0952	-89.3907	↓ 197°	92.0	3,550	844.0
11	Wed 08:38:36 PM	43.0886	-89.3935	↓ 198°	92.0	3,775	844.0
12	Wed 08:38:52 PM	43.0819	-89.3965	↓ 198°	91.0	4,000	300.0
13	Wed 08:39:40 PM	43.0571	-89.4019	↓ 192°	126.0	4,000	-37.0
14	Wed 08:40:02 PM	43.0436	-89.4057	↓ 190°	130.0	3,975	-28.0
15	Wed 08:43:34 PM	42.9108	-89.4271	↓ 187°	137.0	3,975	-25.0
16	Wed 08:44:05 PM	42.8913	-89.4304	↓ 187°	138.0	3,950	-25.0
17	Wed 08:46:10 PM	42.8133	-89.4315	↘ 150°	132.0	3,950	43.0
18	Wed 08:46:27 PM	42.8048	-89.425	↘ 153°	132.0	3,975	38.0
19	Wed 08:46:49 PM	42.7918	-89.4168	↓ 157°	133.0	3,975	-29.0
20	Wed 08:47:19 PM	42.7749	-89.4074	↓ 158°	134.0	3,950	-33.0
21	Wed 08:49:06 PM	42.7132	-89.3747	↓ 159°	136.0	3,950	-49.0
22	Wed 08:49:36 PM	42.6955	-89.3654	↓ 158°	139.0	3,900	-75.0
23	Wed 08:50:06 PM	42.6773	-89.3558	↓ 159°	137.0	3,875	-96.0
24	Wed 08:50:23 PM	42.6668	-89.3504	↓ 159°	141.0	3,825	-191.0
25	Wed 08:50:53 PM	42.648	-89.3406	↓ 159°	144.0	3,725	-228.0
26	Wed 08:51:09 PM	42.6382	-89.3355	↓ 159°	145.0	3,650	-261.0
27	Wed 08:51:39 PM	42.6195	-89.3258	↓ 159°	147.0	3,525	-275.0
28	Wed 08:52:09 PM	42.6007	-89.3159	↓ 159°	149.0	3,375	-306.0
29	Wed 08:52:28 PM	42.5873	-89.3096	↓ 167°	153.0	3,275	-243.0
30	Wed 08:52:46 PM	42.5754	-89.3087	↓ 188°	158.0	3,225	-265.0
31	Wed 08:53:02 PM	42.5641	-89.3117	↓ 196°	159.0	3,125	-261.0
32	Wed 08:53:32 PM	42.5457	-89.3291	↙ 222°	160.0	3,025	-250.0
33	Wed 08:54:02 PM	42.5298	-89.3486	↙ 222°	159.0	2,875	-184.0
34	Wed 08:54:37 PM	42.512	-89.3708	↙ 223°	139.0	2,875	42.0
35	Wed 08:54:57 PM	42.5036	-89.3835	↙ 243°	133.0	2,900	75.0
36	Wed 08:55:34 PM	42.5054	-89.4129	← 304°	126.0	2,900	-105.0
37	Wed 08:56:00 PM	42.5154	-89.4274	↖ 317°	123.0	2,850	-26.0

38	Wed	08:56:31	PM	42.5282	-89.4432	↖	318°	123.0	2,875	25.0
39	Wed	08:57:17	PM	42.5477	-89.4672	↖	319°	125.0	2,875	-160.0
40	Wed	08:57:48	PM	42.5617	-89.4833	↖	320°	133.0	2,750	-295.0
41	Wed	08:58:13	PM	42.5722	-89.4959	↖	316°	110.0	2,600	-522.0
42	Wed	08:58:34	PM	42.5783	-89.5089	←	299°	119.0	2,350	-824.0
43	Wed	08:59:04	PM	42.5868	-89.5276	←	300°	108.0	1,900	-702.0
44	Wed	08:59:36	PM	42.5937	-89.5437	←	301°	84.0	1,625	-469.0
45	Wed	08:59:52	PM	42.5966	-89.5512	←	300°	83.0	1,525	-321.0
46	Wed	09:00:18	PM	42.6022	-89.5624	←	305°	87.0	1,400	-359.0
47	Wed	09:00:38	PM	42.6072	-89.572	←	304°	89.0	1,250	-281.0
48	Wed	09:01:06	PM	42.6134	-89.585	←	302°	98.0	1,175	142.0
49	Wed	09:01:31	PM	42.6199	-89.5996	←	298°	97.0	1,375	607.0
50	Wed	09:01:48	PM	42.6232	-89.6085	←	295°	98.0	1,600	926.0
51	Wed	09:02:05	PM	42.6233	-89.6187	↙	239°	101.0	1,900	882.0
52	Wed	09:02:22	PM	42.6174	-89.6261	↙	214°	108.0	2,100	568.0
53	Wed	09:02:42	PM	42.608	-89.6273	↘	155°	105.0	2,250	500.0
54	Wed	09:03:27	PM	42.5931	-89.6058	↘	125°	110.0	2,250	-327.0
55	Wed	09:03:53	PM	42.5853	-89.5915	↘	123°	102.0	2,100	-321.0
56	Wed	09:04:09	PM	42.5846	-89.5835	→	76°	85.0	2,025	-542.0
57	Wed	09:04:29	PM	42.5893	-89.5752	↗	39°	77.0	1,775	-716.0
58	Wed	09:04:53	PM	42.5962	-89.5697	↑	20°	69.0	1,500	-563.0
59	Wed	09:05:09	PM	42.6015	-89.5694	↑	345°	75.0	1,400	-557.0
60	Wed	09:05:28	PM	42.6073	-89.5734	↖	320°	77.0	1,175	-711.0
61	Wed	10:24:59	PM	42.6111	-89.5676	↗	40°	62.0	1,825	857.0
62	Wed	10:25:15	PM	42.6158	-89.5657	↑	5°	72.0	2,025	797.0
63	Wed	10:25:31	PM	42.6212	-89.5657	↑	355°	75.0	2,250	846.0
64	Wed	10:25:54	PM	42.6291	-89.566	↑	6°	74.0	2,575	802.0
65	Wed	10:26:14	PM	42.6358	-89.5645	↑	9°	78.0	2,825	770.0
66	Wed	10:26:31	PM	42.6424	-89.5635	↑	4°	82.0	3,050	818.0
67	Wed	10:26:58	PM	42.6529	-89.5634	↑	358°	82.0	3,425	784.0
68	Wed	10:27:15	PM	42.6592	-89.5637	↑	1°	85.0	3,625	750.0
69	Wed	10:27:40	PM	42.669	-89.5625	↑	9°	87.0	3,950	733.0
70	Wed	10:27:58	PM	42.6766	-89.5602	↑	14°	89.0	4,150	717.0
71	Wed	10:28:26	PM	42.6878	-89.5568	↑	11°	90.0	4,500	734.0
72	Wed	10:28:45	PM	42.6959	-89.5545	↑	13°	90.0	4,725	649.0
73	Wed	10:29:03	PM	42.7028	-89.5521	↗	22°	93.0	4,900	618.0
74	Wed	10:29:19	PM	42.7095	-89.5479	↗	24°	97.0	5,075	71.0
75	Wed	10:29:45	PM	42.7234	-89.5416	↑	20°	128.0	4,950	-54.0
76	Wed	10:30:15	PM	42.7394	-89.5333	↑	20°	131.0	5,025	-55.0
77	Wed	10:30:40	PM	42.7541	-89.5264	↑	17°	142.0	4,900	-196.0
78	Wed	10:31:01	PM	42.7681	-89.5203	↑	20°	136.0	4,875	-98.0
79	Wed	10:31:26	PM	42.7825	-89.5129	↑	19°	131.0	4,825	100.0
80	Wed	10:31:46	PM	42.7933	-89.5091	↑	16°	117.0	4,950	341.0
81	Wed	10:32:26	PM	42.8126	-89.5006	↑	4°	122.0	4,950	-686.0
82	Wed	10:32:45	PM	42.8236	-89.4983	↑	7°	121.0	4,675	-900.0
83	Wed	10:33:01	PM	42.8328	-89.4979	↑	5°	124.0	4,425	-932.0
84	Wed	10:33:22	PM	42.8444	-89.496	↑	7°	122.0	4,100	-825.0
85	Wed	10:33:41	PM	42.8543	-89.4939	↑	9°	115.0	3,875	-673.0
86	Wed	10:34:11	PM	42.8704	-89.4919	↑	4°	114.0	3,550	-375.0
87	Wed	10:34:41	PM	42.8864	-89.4905	↑	3°	110.0	3,500	-98.0
88	Wed	10:36:23	PM	42.9377	-89.4882	↑	4°	106.0	3,500	33.0
89	Wed	10:36:41	PM	42.946	-89.4856	↗	24°	104.0	3,500	-122.0
90	Wed	10:37:00	PM	42.9535	-89.4783	↗	38°	108.0	3,425	-136.0
91	Wed	10:37:25	PM	42.9638	-89.4693	↗	30°	109.0	3,400	-233.0
92	Wed	10:37:45	PM	42.9722	-89.4619	↗	34°	115.0	3,250	-450.0
93	Wed	10:38:15	PM	42.9863	-89.4488	↗	34°	118.0	3,025	-518.0
94	Wed	10:38:40	PM	42.9986	-89.4405	↗	24°	125.0	2,775	-574.0
95	Wed	10:39:02	PM	43.0106	-89.4334	↗	25°	125.0	2,575	-540.0
96	Wed	10:39:30	PM	43.0248	-89.4235	↗	27°	128.0	2,325	-540.0
97	Wed	10:39:52	PM	43.037	-89.4147	↗	26°	131.0	2,125	-513.0
98	Wed	10:40:08	PM	43.045	-89.4094	↗	27°	128.0	2,000	-375.0
99	Wed	10:40:24	PM	43.0534	-89.4026	↗	32°	124.0	1,925	-464.0
100	Wed	10:40:50	PM	43.0658	-89.3924	↗	29°	126.0	1,675	-389.0
101	Wed	10:40:57	PM	43.0696	-89.3896	↗	27°	127.0	1,711	-220.0
102	Wed	10:42:12	PM	43.1045	-89.3636	↗	30°	88.0	1,375	-287.0
103	Wed	10:42:28	PM	43.1101	-89.3594	↗	28°	89.0	1,275	-375.0
104	Wed	10:42:44	PM	43.1157	-89.355	↗	30°	87.0	1,175	-375.0
105	Wed	10:43:00	PM	43.1211	-89.351	↗	29°	77.0	1,075	-422.0
106	Wed	10:43:16	PM	43.1261	-89.3472	↗	28°	72.0	950	-3.0
107	Wed	10:51:21	PM	43.1478	-89.3416	↖	328°	84.0	1,050	33.0

```

108 Wed 10:51:37 PM 43.1531 -89.3443 ↑ 352° 85.0 1,225 750.0
109 Wed 10:51:53 PM 43.1585 -89.3417 ↗ 50° 77.0 1,450 891.0
110 Wed 10:52:09 PM 43.1601 -89.3348 → 86° 73.0 1,700 984.0
111 Wed 10:52:25 PM 43.1607 -89.3269 → 81° 71.0 1,975 891.0
112 Wed 10:52:41 PM 43.1611 -89.3194 → 89° 78.0 2,175 797.0
113 Wed 10:52:57 PM 43.1612 -89.312 → 86° 76.0 2,400 844.0
114 Wed 10:53:13 PM 43.1616 -89.3045 → 87° 77.0 2,625 750.0
115 Wed 10:53:29 PM 43.1616 -89.2964 → 91° 85.0 2,800 469.0
116 Wed 10:53:45 PM 43.1616 -89.2863 → 90° 102.0 2,875 188.0
117 Wed 10:54:01 PM 43.1618 -89.2756 → 88° 113.0 2,900 188.0
118 Wed 10:54:17 PM 43.162 -89.2639 → 90° 116.0 2,975 234.0
119 Wed 10:54:49 PM 43.1615 -89.2396 → 89° 129.0 2,975 -118.0
120 Wed 10:55:49 PM 43.1616 -89.1909 → 90° 133.0 2,875 -33.0
121 Wed 10:56:19 PM 43.1615 -89.1652 → 89° 127.0 2,925 96.0
122 Wed 10:56:36 PM 43.1608 -89.1526 ↘ 117° 127.0 2,950 44.0
123 Wed 10:57:16 PM 43.1358 -89.1463 ↓ 186° 144.0 2,950 31.0
124 Wed 10:57:42 PM 43.1202 -89.1481 ↓ 185° 145.0 2,975 87.0
125 Wed 10:58:08 PM 43.1025 -89.1498 ↓ 182° 144.0 3,025 34.0
126 Wed 10:58:26 PM 43.0908 -89.1497 ↓ 169° 139.0 3,000 -263.0
127 Wed 10:58:48 PM 43.0783 -89.139 ↘ 140° 147.0 2,850 -202.0
128 Wed 10:59:18 PM 43.0633 -89.1222 ↘ 141° 139.0 2,825 50.0
129 Wed 10:59:48 PM 43.0489 -89.1056 ↘ 139° 135.0 2,900 48.0
130 Wed 11:00:41 PM 43.0244 -89.0748 ↘ 135° 137.0 2,900 -29.0
131 Wed 11:01:11 PM 43.0096 -89.0574 ↘ 140° 138.0 2,850 -28.0
132 Wed 11:01:51 PM 42.9898 -89.0365 ↘ 145° 142.0 2,850 -33.0
133 Wed 11:02:21 PM 42.974 -89.0204 ↘ 144° 140.0 2,850 96.0
134 Wed 11:02:38 PM 42.9639 -89.0145 ↓ 169° 141.0 2,925 162.0
135 Wed 11:02:58 PM 42.9499 -89.0129 ↓ 178° 144.0 2,950 324.0
136 Wed 11:03:15 PM 42.9398 -89.0163 ↙ 209° 137.0 3,125 273.0
137 Wed 11:04:07 PM 42.933 -89.0563 ← 309° 141.0 3,100 -79.0
138 Wed 11:04:47 PM 42.9522 -89.0814 ↖ 318° 140.0 3,100 61.0
139 Wed 11:05:17 PM 42.966 -89.0994 ← 314° 139.0 3,125 -153.0
140 Wed 11:05:46 PM 42.9788 -89.1208 ← 307° 152.0 2,950 -351.0
141 Wed 11:06:04 PM 42.9867 -89.1346 ← 312° 151.0 2,850 -293.0
142 Wed 11:06:27 PM 42.9964 -89.1492 ← 314° 149.0 2,750 -308.0
143 Wed 11:06:43 PM 43.0047 -89.1604 ↖ 317° 146.0 2,650 -326.0
144 Wed 11:07:13 PM 43.019 -89.1783 ↖ 317° 144.0 2,500 -50.0
145 Wed 11:07:43 PM 43.0329 -89.1963 ↖ 317° 132.0 2,600 125.0
146 Wed 11:08:13 PM 43.0464 -89.2132 ↖ 320° 130.0 2,625 63.0
147 Wed 11:08:31 PM 43.0554 -89.2237 ↖ 318° 130.0 2,650 -35.0
148 Wed 11:08:56 PM 43.0663 -89.2366 ↖ 319° 137.0 2,600 62.0
149 Wed 11:09:06 PM 43.0713 -89.2427 ↖ 317° 139.0 2,686 -94.0
150 Wed 11:09:21 PM 43.0789 -89.2522 ↖ 318° 145.0 2,561 -553.0
151 Wed 11:09:44 PM 43.0898 -89.2665 ↖ 316° 137.0 2,336 -726.0
152 Wed 11:10:57 PM 43.1182 -89.3031 ↖ 319° 91.0 1,400 -783.0
153 Wed 11:11:13 PM 43.1232 -89.3095 ← 315° 93.0 1,175 -703.0
154 Wed 11:11:29 PM 43.1279 -89.3156 ↖ 316° 89.0 1,025 -563.0
155 Wed 11:11:45 PM 43.133 -89.3222 ↖ 318° 88.0 875 -563.0

```

```
In [9]: # we need to clean up the data a bit if we are going to send it as an Entity State PDU (m
```

```
In [10]: # you can skip this set if you already have opendis7 installed, else...
# unzip the main source into the local directory and install opendis using:
#!pip install open-dis-python-master/.
```

```
In [11]: # we import the things needed to package and send the Entity State PDU at a given time st
import socket
import time

from io import BytesIO

from opendis.DataOutputStream import DataOutputStream
from opendis.dis7 import EntityStatePdu
from opendis.RangeCoordinates import GPS
```

```

UDP_PORT = 3001
DESTINATION_ADDRESS = "127.0.0.1"

udpSocket = socket.socket(socket.AF_INET, socket.SOCK_DGRAM)
udpSocket.setsockopt(socket.SOL_SOCKET, socket.SO_BROADCAST, 1)

gps = GPS() # conversion helper

```

In [12]:

```

# next we
def send(lat, lon, alt):
    pdu = EntityStatePdu()
    pdu.entityID.entityID = 42
    pdu.entityID.siteID = 17
    pdu.entityID.applicationID = 23

    location = gps.lla2ecef((float(lat), float(lon), float(alt)) )
    pdu.entityLocation.x = location[0]
    pdu.entityLocation.y = location[1]
    pdu.entityLocation.z = location[2]

    memoryStream = BytesIO()
    outputStream = DataOutputStream(memoryStream)
    pdu.serialize(outputStream)
    data = memoryStream.getvalue()

    udpSocket.sendto(data, (DESTINATION_ADDRESS, UDP_PORT))
    print("Sent {}. {} bytes".format(pdu.__class__.__name__, len(data)))

```

In [13]:

```

# next get and install wireshark from https://www.wireshark.org/download.html
# then start a local loopback capture and apply a capture filter UDP destination port 3001

```

In [14]:

```

for index, row in data_frame.iterrows():
    send(row['Latitude'], row['Longitude'], row['feet'].replace(',', ''))
    print(index, row['Time (EDT)'], row['Latitude'], row['Longitude'], row['Course'], row['feet'])

```

```

Sent EntityStatePdu. 144 bytes
0 Wed 08:35:40 PM 43.1489 -89.3442 ← 301° 81.0 1,225 938.0
Sent EntityStatePdu. 144 bytes
1 Wed 08:35:56 PM 43.1499 -89.3525 ← 260° 92.0 1,450 984.0
Sent EntityStatePdu. 144 bytes
2 Wed 08:36:12 PM 43.146 -89.3611 ✓ 216° 92.0 1,750 844.0
Sent EntityStatePdu. 144 bytes
3 Wed 08:36:28 PM 43.1401 -89.3644 ↓ 195° 98.0 1,900 750.0
Sent EntityStatePdu. 144 bytes
4 Wed 08:36:44 PM 43.1323 -89.3676 ↓ 199° 99.0 2,150 984.0
Sent EntityStatePdu. 144 bytes
5 Wed 08:37:00 PM 43.1257 -89.3712 ✓ 203° 96.0 2,425 938.0
Sent EntityStatePdu. 144 bytes
6 Wed 08:37:16 PM 43.1197 -89.375 ✓ 208° 93.0 2,650 844.0
Sent EntityStatePdu. 144 bytes
7 Wed 08:37:32 PM 43.114 -89.3792 ✓ 208° 93.0 2,875 891.0
Sent EntityStatePdu. 144 bytes
8 Wed 08:37:48 PM 43.1072 -89.3839 ✓ 208° 92.0 3,125 844.0
Sent EntityStatePdu. 144 bytes
9 Wed 08:38:04 PM 43.1018 -89.3877 ✓ 204° 93.0 3,325 797.0
Sent EntityStatePdu. 144 bytes
10 Wed 08:38:20 PM 43.0952 -89.3907 ↓ 197° 92.0 3,550 844.0
Sent EntityStatePdu. 144 bytes
11 Wed 08:38:36 PM 43.0886 -89.3935 ↓ 198° 92.0 3,775 844.0
Sent EntityStatePdu. 144 bytes
12 Wed 08:38:52 PM 43.0819 -89.3965 ↓ 198° 91.0 4,000 300.0
Sent EntityStatePdu. 144 bytes
13 Wed 08:39:40 PM 43.0571 -89.4019 ↓ 192° 126.0 4,000 -37.0

```

Sent EntityStatePdu. 144 bytes
14 Wed 08:40:02 PM 43.0436 -89.4057 ↓ 190° 130.0 3,975 -28.0
Sent EntityStatePdu. 144 bytes
15 Wed 08:43:34 PM 42.9108 -89.4271 ↓ 187° 137.0 3,975 -25.0
Sent EntityStatePdu. 144 bytes
16 Wed 08:44:05 PM 42.8913 -89.4304 ↓ 187° 138.0 3,950 -25.0
Sent EntityStatePdu. 144 bytes
17 Wed 08:46:10 PM 42.8133 -89.4315 ↘ 150° 132.0 3,950 43.0
Sent EntityStatePdu. 144 bytes
18 Wed 08:46:27 PM 42.8048 -89.425 ↘ 153° 132.0 3,975 38.0
Sent EntityStatePdu. 144 bytes
19 Wed 08:46:49 PM 42.7918 -89.4168 ↓ 157° 133.0 3,975 -29.0
Sent EntityStatePdu. 144 bytes
20 Wed 08:47:19 PM 42.7749 -89.4074 ↓ 158° 134.0 3,950 -33.0
Sent EntityStatePdu. 144 bytes
21 Wed 08:49:06 PM 42.7132 -89.3747 ↓ 159° 136.0 3,950 -49.0
Sent EntityStatePdu. 144 bytes
22 Wed 08:49:36 PM 42.6955 -89.3654 ↓ 158° 139.0 3,900 -75.0
Sent EntityStatePdu. 144 bytes
23 Wed 08:50:06 PM 42.6773 -89.3558 ↓ 159° 137.0 3,875 -96.0
Sent EntityStatePdu. 144 bytes
24 Wed 08:50:23 PM 42.6668 -89.3504 ↓ 159° 141.0 3,825 -191.0
Sent EntityStatePdu. 144 bytes
25 Wed 08:50:53 PM 42.648 -89.3406 ↓ 159° 144.0 3,725 -228.0
Sent EntityStatePdu. 144 bytes
26 Wed 08:51:09 PM 42.6382 -89.3355 ↓ 159° 145.0 3,650 -261.0
Sent EntityStatePdu. 144 bytes
27 Wed 08:51:39 PM 42.6195 -89.3258 ↓ 159° 147.0 3,525 -275.0
Sent EntityStatePdu. 144 bytes
28 Wed 08:52:09 PM 42.6007 -89.3159 ↓ 159° 149.0 3,375 -306.0
Sent EntityStatePdu. 144 bytes
29 Wed 08:52:28 PM 42.5873 -89.3096 ↓ 167° 153.0 3,275 -243.0
Sent EntityStatePdu. 144 bytes
30 Wed 08:52:46 PM 42.5754 -89.3087 ↓ 188° 158.0 3,225 -265.0
Sent EntityStatePdu. 144 bytes
31 Wed 08:53:02 PM 42.5641 -89.3117 ↓ 196° 159.0 3,125 -261.0
Sent EntityStatePdu. 144 bytes
32 Wed 08:53:32 PM 42.5457 -89.3291 ↙ 222° 160.0 3,025 -250.0
Sent EntityStatePdu. 144 bytes
33 Wed 08:54:02 PM 42.5298 -89.3486 ↙ 222° 159.0 2,875 -184.0
Sent EntityStatePdu. 144 bytes
34 Wed 08:54:37 PM 42.512 -89.3708 ↙ 223° 139.0 2,875 42.0
Sent EntityStatePdu. 144 bytes
35 Wed 08:54:57 PM 42.5036 -89.3835 ↙ 243° 133.0 2,900 75.0
Sent EntityStatePdu. 144 bytes
36 Wed 08:55:34 PM 42.5054 -89.4129 ← 304° 126.0 2,900 -105.0
Sent EntityStatePdu. 144 bytes
37 Wed 08:56:00 PM 42.5154 -89.4274 ↖ 317° 123.0 2,850 -26.0
Sent EntityStatePdu. 144 bytes
38 Wed 08:56:31 PM 42.5282 -89.4432 ↖ 318° 123.0 2,875 25.0
Sent EntityStatePdu. 144 bytes
39 Wed 08:57:17 PM 42.5477 -89.4672 ↖ 319° 125.0 2,875 -160.0
Sent EntityStatePdu. 144 bytes
40 Wed 08:57:48 PM 42.5617 -89.4833 ↖ 320° 133.0 2,750 -295.0
Sent EntityStatePdu. 144 bytes
41 Wed 08:58:13 PM 42.5722 -89.4959 ↖ 316° 110.0 2,600 -522.0
Sent EntityStatePdu. 144 bytes
42 Wed 08:58:34 PM 42.5783 -89.5089 ← 299° 119.0 2,350 -824.0
Sent EntityStatePdu. 144 bytes
43 Wed 08:59:04 PM 42.5868 -89.5276 ← 300° 108.0 1,900 -702.0
Sent EntityStatePdu. 144 bytes
44 Wed 08:59:36 PM 42.5937 -89.5437 ← 301° 84.0 1,625 -469.0
Sent EntityStatePdu. 144 bytes
45 Wed 08:59:52 PM 42.5966 -89.5512 ← 300° 83.0 1,525 -321.0
Sent EntityStatePdu. 144 bytes
46 Wed 09:00:18 PM 42.6022 -89.5624 ← 305° 87.0 1,400 -359.0
Sent EntityStatePdu. 144 bytes
47 Wed 09:00:38 PM 42.6072 -89.572 ← 304° 89.0 1,250 -281.0
Sent EntityStatePdu. 144 bytes
48 Wed 09:01:06 PM 42.6134 -89.585 ← 302° 98.0 1,175 142.0

Sent EntityStatePdu. 144 bytes
49 Wed 09:01:31 PM 42.6199 -89.5996 ← 298° 97.0 1,375 607.0
Sent EntityStatePdu. 144 bytes
50 Wed 09:01:48 PM 42.6232 -89.6085 ← 295° 98.0 1,600 926.0
Sent EntityStatePdu. 144 bytes
51 Wed 09:02:05 PM 42.6233 -89.6187 ↙ 239° 101.0 1,900 882.0
Sent EntityStatePdu. 144 bytes
52 Wed 09:02:22 PM 42.6174 -89.6261 ↙ 214° 108.0 2,100 568.0
Sent EntityStatePdu. 144 bytes
53 Wed 09:02:42 PM 42.608 -89.6273 ↘ 155° 105.0 2,250 500.0
Sent EntityStatePdu. 144 bytes
54 Wed 09:03:27 PM 42.5931 -89.6058 ↘ 125° 110.0 2,250 -327.0
Sent EntityStatePdu. 144 bytes
55 Wed 09:03:53 PM 42.5853 -89.5915 ↘ 123° 102.0 2,100 -321.0
Sent EntityStatePdu. 144 bytes
56 Wed 09:04:09 PM 42.5846 -89.5835 → 76° 85.0 2,025 -542.0
Sent EntityStatePdu. 144 bytes
57 Wed 09:04:29 PM 42.5893 -89.5752 ↗ 39° 77.0 1,775 -716.0
Sent EntityStatePdu. 144 bytes
58 Wed 09:04:53 PM 42.5962 -89.5697 ↑ 20° 69.0 1,500 -563.0
Sent EntityStatePdu. 144 bytes
59 Wed 09:05:09 PM 42.6015 -89.5694 ↑ 345° 75.0 1,400 -557.0
Sent EntityStatePdu. 144 bytes
60 Wed 09:05:28 PM 42.6073 -89.5734 ↖ 320° 77.0 1,175 -711.0
Sent EntityStatePdu. 144 bytes
61 Wed 10:24:59 PM 42.6111 -89.5676 ↗ 40° 62.0 1,825 857.0
Sent EntityStatePdu. 144 bytes
62 Wed 10:25:15 PM 42.6158 -89.5657 ↑ 5° 72.0 2,025 797.0
Sent EntityStatePdu. 144 bytes
63 Wed 10:25:31 PM 42.6212 -89.5657 ↑ 355° 75.0 2,250 846.0
Sent EntityStatePdu. 144 bytes
64 Wed 10:25:54 PM 42.6291 -89.566 ↑ 6° 74.0 2,575 802.0
Sent EntityStatePdu. 144 bytes
65 Wed 10:26:14 PM 42.6358 -89.5645 ↑ 9° 78.0 2,825 770.0
Sent EntityStatePdu. 144 bytes
66 Wed 10:26:31 PM 42.6424 -89.5635 ↑ 4° 82.0 3,050 818.0
Sent EntityStatePdu. 144 bytes
67 Wed 10:26:58 PM 42.6529 -89.5634 ↑ 358° 82.0 3,425 784.0
Sent EntityStatePdu. 144 bytes
68 Wed 10:27:15 PM 42.6592 -89.5637 ↑ 1° 85.0 3,625 750.0
Sent EntityStatePdu. 144 bytes
69 Wed 10:27:40 PM 42.669 -89.5625 ↑ 9° 87.0 3,950 733.0
Sent EntityStatePdu. 144 bytes
70 Wed 10:27:58 PM 42.6766 -89.5602 ↑ 14° 89.0 4,150 717.0
Sent EntityStatePdu. 144 bytes
71 Wed 10:28:26 PM 42.6878 -89.5568 ↑ 11° 90.0 4,500 734.0
Sent EntityStatePdu. 144 bytes
72 Wed 10:28:45 PM 42.6959 -89.5545 ↑ 13° 90.0 4,725 649.0
Sent EntityStatePdu. 144 bytes
73 Wed 10:29:03 PM 42.7028 -89.5521 ↗ 22° 93.0 4,900 618.0
Sent EntityStatePdu. 144 bytes
74 Wed 10:29:19 PM 42.7095 -89.5479 ↗ 24° 97.0 5,075 71.0
Sent EntityStatePdu. 144 bytes
75 Wed 10:29:45 PM 42.7234 -89.5416 ↑ 20° 128.0 4,950 -54.0
Sent EntityStatePdu. 144 bytes
76 Wed 10:30:15 PM 42.7394 -89.5333 ↑ 20° 131.0 5,025 -55.0
Sent EntityStatePdu. 144 bytes
77 Wed 10:30:40 PM 42.7541 -89.5264 ↑ 17° 142.0 4,900 -196.0
Sent EntityStatePdu. 144 bytes
78 Wed 10:31:01 PM 42.7681 -89.5203 ↑ 20° 136.0 4,875 -98.0
Sent EntityStatePdu. 144 bytes
79 Wed 10:31:26 PM 42.7825 -89.5129 ↑ 19° 131.0 4,825 100.0
Sent EntityStatePdu. 144 bytes
80 Wed 10:31:46 PM 42.7933 -89.5091 ↑ 16° 117.0 4,950 341.0
Sent EntityStatePdu. 144 bytes
81 Wed 10:32:26 PM 42.8126 -89.5006 ↑ 4° 122.0 4,950 -686.0
Sent EntityStatePdu. 144 bytes
82 Wed 10:32:45 PM 42.8236 -89.4983 ↑ 7° 121.0 4,675 -900.0
Sent EntityStatePdu. 144 bytes
83 Wed 10:33:01 PM 42.8328 -89.4979 ↑ 5° 124.0 4,425 -932.0

Sent EntityStatePdu. 144 bytes
84 Wed 10:33:22 PM 42.8444 -89.496 ↑ 7° 122.0 4,100 -825.0
Sent EntityStatePdu. 144 bytes
85 Wed 10:33:41 PM 42.8543 -89.4939 ↑ 9° 115.0 3,875 -673.0
Sent EntityStatePdu. 144 bytes
86 Wed 10:34:11 PM 42.8704 -89.4919 ↑ 4° 114.0 3,550 -375.0
Sent EntityStatePdu. 144 bytes
87 Wed 10:34:41 PM 42.8864 -89.4905 ↑ 3° 110.0 3,500 -98.0
Sent EntityStatePdu. 144 bytes
88 Wed 10:36:23 PM 42.9377 -89.4882 ↑ 4° 106.0 3,500 33.0
Sent EntityStatePdu. 144 bytes
89 Wed 10:36:41 PM 42.946 -89.4856 ↗ 24° 104.0 3,500 -122.0
Sent EntityStatePdu. 144 bytes
90 Wed 10:37:00 PM 42.9535 -89.4783 ↗ 38° 108.0 3,425 -136.0
Sent EntityStatePdu. 144 bytes
91 Wed 10:37:25 PM 42.9638 -89.4693 ↗ 30° 109.0 3,400 -233.0
Sent EntityStatePdu. 144 bytes
92 Wed 10:37:45 PM 42.9722 -89.4619 ↗ 34° 115.0 3,250 -450.0
Sent EntityStatePdu. 144 bytes
93 Wed 10:38:15 PM 42.9863 -89.4488 ↗ 34° 118.0 3,025 -518.0
Sent EntityStatePdu. 144 bytes
94 Wed 10:38:40 PM 42.9986 -89.4405 ↗ 24° 125.0 2,775 -574.0
Sent EntityStatePdu. 144 bytes
95 Wed 10:39:02 PM 43.0106 -89.4334 ↗ 25° 125.0 2,575 -540.0
Sent EntityStatePdu. 144 bytes
96 Wed 10:39:30 PM 43.0248 -89.4235 ↗ 27° 128.0 2,325 -540.0
Sent EntityStatePdu. 144 bytes
97 Wed 10:39:52 PM 43.037 -89.4147 ↗ 26° 131.0 2,125 -513.0
Sent EntityStatePdu. 144 bytes
98 Wed 10:40:08 PM 43.045 -89.4094 ↗ 27° 128.0 2,000 -375.0
Sent EntityStatePdu. 144 bytes
99 Wed 10:40:24 PM 43.0534 -89.4026 ↗ 32° 124.0 1,925 -464.0
Sent EntityStatePdu. 144 bytes
100 Wed 10:40:50 PM 43.0658 -89.3924 ↗ 29° 126.0 1,675 -389.0
Sent EntityStatePdu. 144 bytes
101 Wed 10:40:57 PM 43.0696 -89.3896 ↗ 27° 127.0 1,711 -220.0
Sent EntityStatePdu. 144 bytes
102 Wed 10:42:12 PM 43.1045 -89.3636 ↗ 30° 88.0 1,375 -287.0
Sent EntityStatePdu. 144 bytes
103 Wed 10:42:28 PM 43.1101 -89.3594 ↗ 28° 89.0 1,275 -375.0
Sent EntityStatePdu. 144 bytes
104 Wed 10:42:44 PM 43.1157 -89.355 ↗ 30° 87.0 1,175 -375.0
Sent EntityStatePdu. 144 bytes
105 Wed 10:43:00 PM 43.1211 -89.351 ↗ 29° 77.0 1,075 -422.0
Sent EntityStatePdu. 144 bytes
106 Wed 10:43:16 PM 43.1261 -89.3472 ↗ 28° 72.0 950 -3.0
Sent EntityStatePdu. 144 bytes
107 Wed 10:51:21 PM 43.1478 -89.3416 ↖ 328° 84.0 1,050 33.0
Sent EntityStatePdu. 144 bytes
108 Wed 10:51:37 PM 43.1531 -89.3443 ↑ 352° 85.0 1,225 750.0
Sent EntityStatePdu. 144 bytes
109 Wed 10:51:53 PM 43.1585 -89.3417 ↗ 50° 77.0 1,450 891.0
Sent EntityStatePdu. 144 bytes
110 Wed 10:52:09 PM 43.1601 -89.3348 → 86° 73.0 1,700 984.0
Sent EntityStatePdu. 144 bytes
111 Wed 10:52:25 PM 43.1607 -89.3269 → 81° 71.0 1,975 891.0
Sent EntityStatePdu. 144 bytes
112 Wed 10:52:41 PM 43.1611 -89.3194 → 89° 78.0 2,175 797.0
Sent EntityStatePdu. 144 bytes
113 Wed 10:52:57 PM 43.1612 -89.312 → 86° 76.0 2,400 844.0
Sent EntityStatePdu. 144 bytes
114 Wed 10:53:13 PM 43.1616 -89.3045 → 87° 77.0 2,625 750.0
Sent EntityStatePdu. 144 bytes
115 Wed 10:53:29 PM 43.1616 -89.2964 → 91° 85.0 2,800 469.0
Sent EntityStatePdu. 144 bytes
116 Wed 10:53:45 PM 43.1616 -89.2863 → 90° 102.0 2,875 188.0
Sent EntityStatePdu. 144 bytes
117 Wed 10:54:01 PM 43.1618 -89.2756 → 88° 113.0 2,900 188.0
Sent EntityStatePdu. 144 bytes
118 Wed 10:54:17 PM 43.162 -89.2639 → 90° 116.0 2,975 234.0

Sent EntityStatePdu. 144 bytes
119 Wed 10:54:49 PM 43.1615 -89.2396 → 89° 129.0 2,975 -118.0
Sent EntityStatePdu. 144 bytes
120 Wed 10:55:49 PM 43.1616 -89.1909 → 90° 133.0 2,875 -33.0
Sent EntityStatePdu. 144 bytes
121 Wed 10:56:19 PM 43.1615 -89.1652 → 89° 127.0 2,925 96.0
Sent EntityStatePdu. 144 bytes
122 Wed 10:56:36 PM 43.1608 -89.1526 ↘ 117° 127.0 2,950 44.0
Sent EntityStatePdu. 144 bytes
123 Wed 10:57:16 PM 43.1358 -89.1463 ↓ 186° 144.0 2,950 31.0
Sent EntityStatePdu. 144 bytes
124 Wed 10:57:42 PM 43.1202 -89.1481 ↓ 185° 145.0 2,975 87.0
Sent EntityStatePdu. 144 bytes
125 Wed 10:58:08 PM 43.1025 -89.1498 ↓ 182° 144.0 3,025 34.0
Sent EntityStatePdu. 144 bytes
126 Wed 10:58:26 PM 43.0908 -89.1497 ↓ 169° 139.0 3,000 -263.0
Sent EntityStatePdu. 144 bytes
127 Wed 10:58:48 PM 43.0783 -89.139 ↘ 140° 147.0 2,850 -202.0
Sent EntityStatePdu. 144 bytes
128 Wed 10:59:18 PM 43.0633 -89.1222 ↘ 141° 139.0 2,825 50.0
Sent EntityStatePdu. 144 bytes
129 Wed 10:59:48 PM 43.0489 -89.1056 ↘ 139° 135.0 2,900 48.0
Sent EntityStatePdu. 144 bytes
130 Wed 11:00:41 PM 43.0244 -89.0748 ↘ 135° 137.0 2,900 -29.0
Sent EntityStatePdu. 144 bytes
131 Wed 11:01:11 PM 43.0096 -89.0574 ↘ 140° 138.0 2,850 -28.0
Sent EntityStatePdu. 144 bytes
132 Wed 11:01:51 PM 42.9898 -89.0365 ↘ 145° 142.0 2,850 -33.0
Sent EntityStatePdu. 144 bytes
133 Wed 11:02:21 PM 42.974 -89.0204 ↘ 144° 140.0 2,850 96.0
Sent EntityStatePdu. 144 bytes
134 Wed 11:02:38 PM 42.9639 -89.0145 ↓ 169° 141.0 2,925 162.0
Sent EntityStatePdu. 144 bytes
135 Wed 11:02:58 PM 42.9499 -89.0129 ↓ 178° 144.0 2,950 324.0
Sent EntityStatePdu. 144 bytes
136 Wed 11:03:15 PM 42.9398 -89.0163 ↙ 209° 137.0 3,125 273.0
Sent EntityStatePdu. 144 bytes
137 Wed 11:04:07 PM 42.933 -89.0563 ← 309° 141.0 3,100 -79.0
Sent EntityStatePdu. 144 bytes
138 Wed 11:04:47 PM 42.9522 -89.0814 ↖ 318° 140.0 3,100 61.0
Sent EntityStatePdu. 144 bytes
139 Wed 11:05:17 PM 42.966 -89.0994 ← 314° 139.0 3,125 -153.0
Sent EntityStatePdu. 144 bytes
140 Wed 11:05:46 PM 42.9788 -89.1208 ← 307° 152.0 2,950 -351.0
Sent EntityStatePdu. 144 bytes
141 Wed 11:06:04 PM 42.9867 -89.1346 ← 312° 151.0 2,850 -293.0
Sent EntityStatePdu. 144 bytes
142 Wed 11:06:27 PM 42.9964 -89.1492 ← 314° 149.0 2,750 -308.0
Sent EntityStatePdu. 144 bytes
143 Wed 11:06:43 PM 43.0047 -89.1604 ↖ 317° 146.0 2,650 -326.0
Sent EntityStatePdu. 144 bytes
144 Wed 11:07:13 PM 43.019 -89.1783 ↖ 317° 144.0 2,500 -50.0
Sent EntityStatePdu. 144 bytes
145 Wed 11:07:43 PM 43.0329 -89.1963 ↖ 317° 132.0 2,600 125.0
Sent EntityStatePdu. 144 bytes
146 Wed 11:08:13 PM 43.0464 -89.2132 ↖ 320° 130.0 2,625 63.0
Sent EntityStatePdu. 144 bytes
147 Wed 11:08:31 PM 43.0554 -89.2237 ↖ 318° 130.0 2,650 -35.0
Sent EntityStatePdu. 144 bytes
148 Wed 11:08:56 PM 43.0663 -89.2366 ↖ 319° 137.0 2,600 62.0
Sent EntityStatePdu. 144 bytes
149 Wed 11:09:06 PM 43.0713 -89.2427 ↖ 317° 139.0 2,686 -94.0
Sent EntityStatePdu. 144 bytes
150 Wed 11:09:21 PM 43.0789 -89.2522 ↖ 318° 145.0 2,561 -553.0
Sent EntityStatePdu. 144 bytes
151 Wed 11:09:44 PM 43.0898 -89.2665 ↖ 316° 137.0 2,336 -726.0
Sent EntityStatePdu. 144 bytes
152 Wed 11:10:57 PM 43.1182 -89.3031 ↖ 319° 91.0 1,400 -783.0
Sent EntityStatePdu. 144 bytes
153 Wed 11:11:13 PM 43.1232 -89.3095 ← 315° 93.0 1,175 -703.0

Sent EntityStatePdu. 144 bytes
154 Wed 11:11:29 PM 43.1279 -89.3156 ↖ 316° 89.0 1,025 -563.0
Sent EntityStatePdu. 144 bytes
155 Wed 11:11:45 PM 43.133 -89.3222 ↖ 318° 88.0 875 -563.0

```
In [15]: # We see that all 156 PDU Entity State simulated position replay packets were collected!  
from IPython.display import Image  
Image(filename='Wireshark.png')
```

Out[15]:

No.	Time	Source	Destination	Protocol	Length	Info
143	0.102622	127.0.0.1	127.0.0.1	UDP	176	52312 → 3001 Len=144
144	0.183135	127.0.0.1	127.0.0.1	UDP	176	52312 → 3001 Len=144
145	0.183474	127.0.0.1	127.0.0.1	UDP	176	52312 → 3001 Len=144
146	0.183759	127.0.0.1	127.0.0.1	UDP	176	52312 → 3001 Len=144
147	0.184038	127.0.0.1	127.0.0.1	UDP	176	52312 → 3001 Len=144
148	0.184514	127.0.0.1	127.0.0.1	UDP	176	52312 → 3001 Len=144
149	0.184960	127.0.0.1	127.0.0.1	UDP	176	52312 → 3001 Len=144
150	0.185633	127.0.0.1	127.0.0.1	UDP	176	52312 → 3001 Len=144
151	0.186034	127.0.0.1	127.0.0.1	UDP	176	52312 → 3001 Len=144
152	0.186463	127.0.0.1	127.0.0.1	UDP	176	52312 → 3001 Len=144
153	0.186961	127.0.0.1	127.0.0.1	UDP	176	52312 → 3001 Len=144
154	0.187340	127.0.0.1	127.0.0.1	UDP	176	52312 → 3001 Len=144
155	0.187728	127.0.0.1	127.0.0.1	UDP	176	52312 → 3001 Len=144
156	0.188200	127.0.0.1	127.0.0.1	UDP	176	52312 → 3001 Len=144

>

Frame 1: 176 bytes on wire (1408 bits), 176 bytes captured (1408 bits) on interface lo0, id 0

>

Null/Loopback

>

Internet Protocol Version 4, Src: 127.0.0.1, Dst: 127.0.0.1

>

User Datagram Protocol, Src Port: 52312, Dst Port: 3001

>

Data (144 bytes)