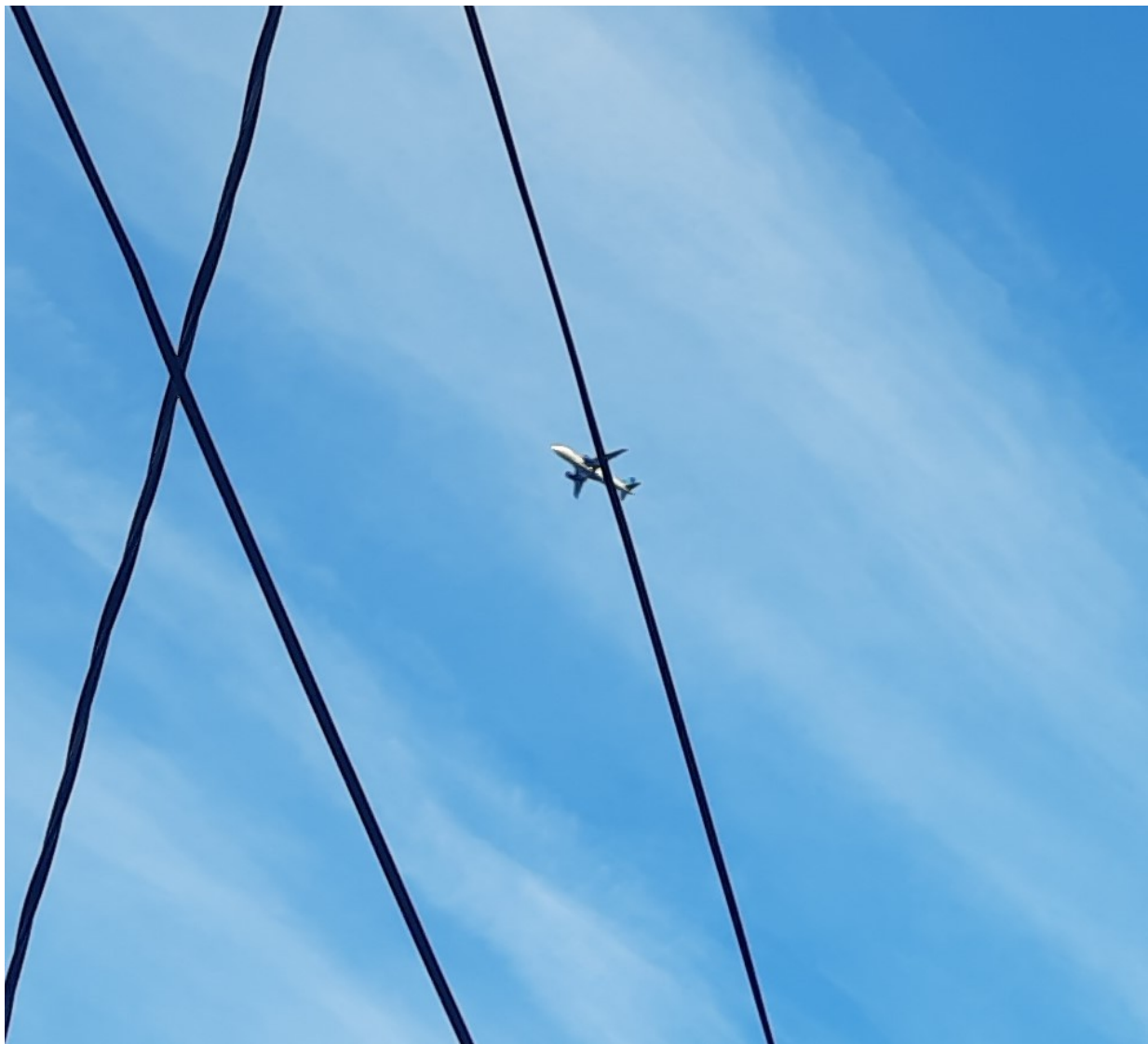# Aircraft Tracking Using SDR

Peter Morrison AC1KY
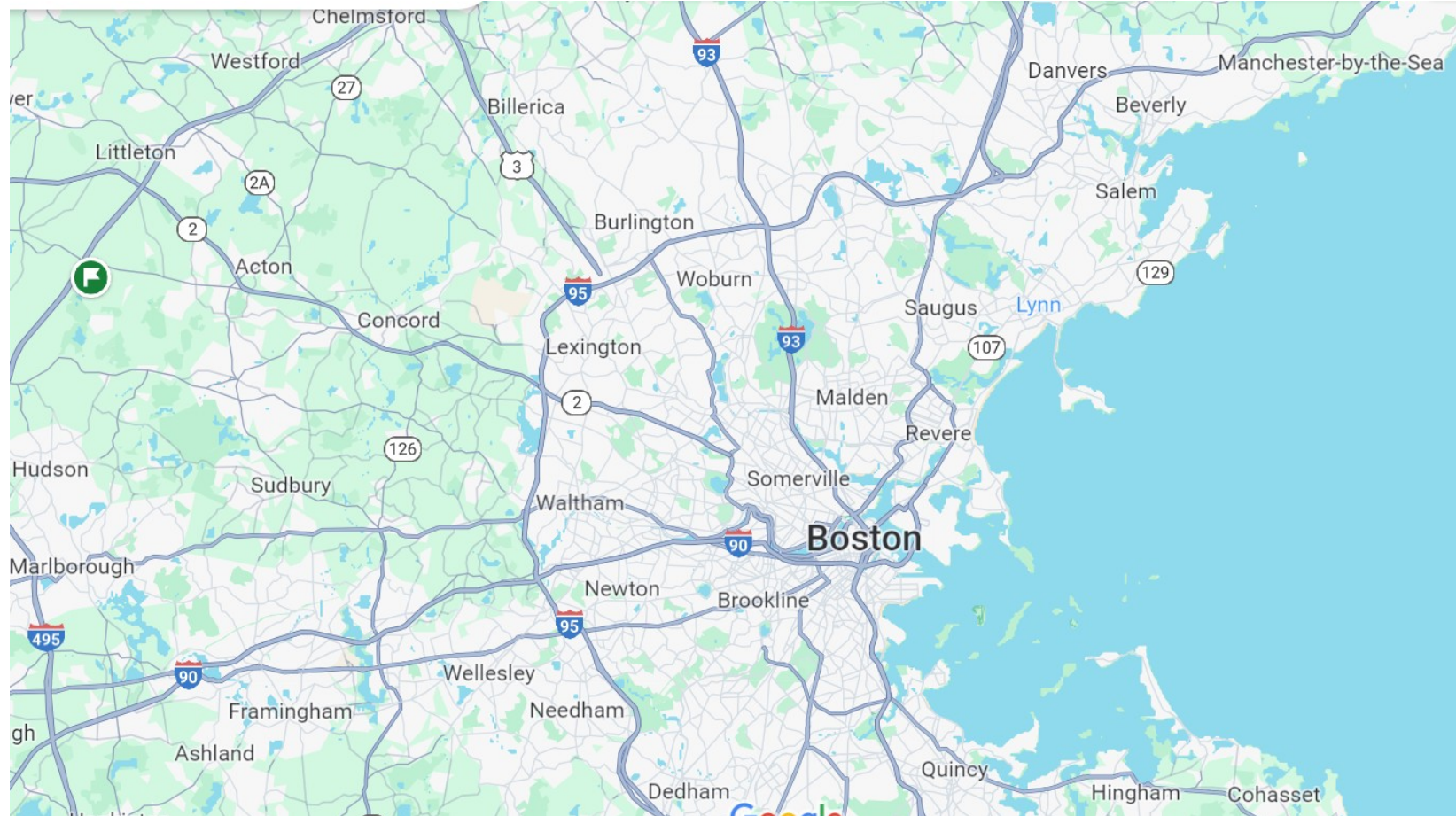
Framingham Amateur Radio Association
February 1, 2024

Why I am interested

- Moved from Framingham to Beverly in 2018

- Noticed many overflights

- Started using flight-tracking apps

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Framingham and Beverly

Real Time Flight Tracker Apps

- Flight Aware   http://www.flightaware.com/

- Flight Radar 24   http://www.flightradar24.com/

- ADS B Exchange
             http://globe.adsbexchange.com/

- PlaneSpotter   http://radar.planespotters.net/

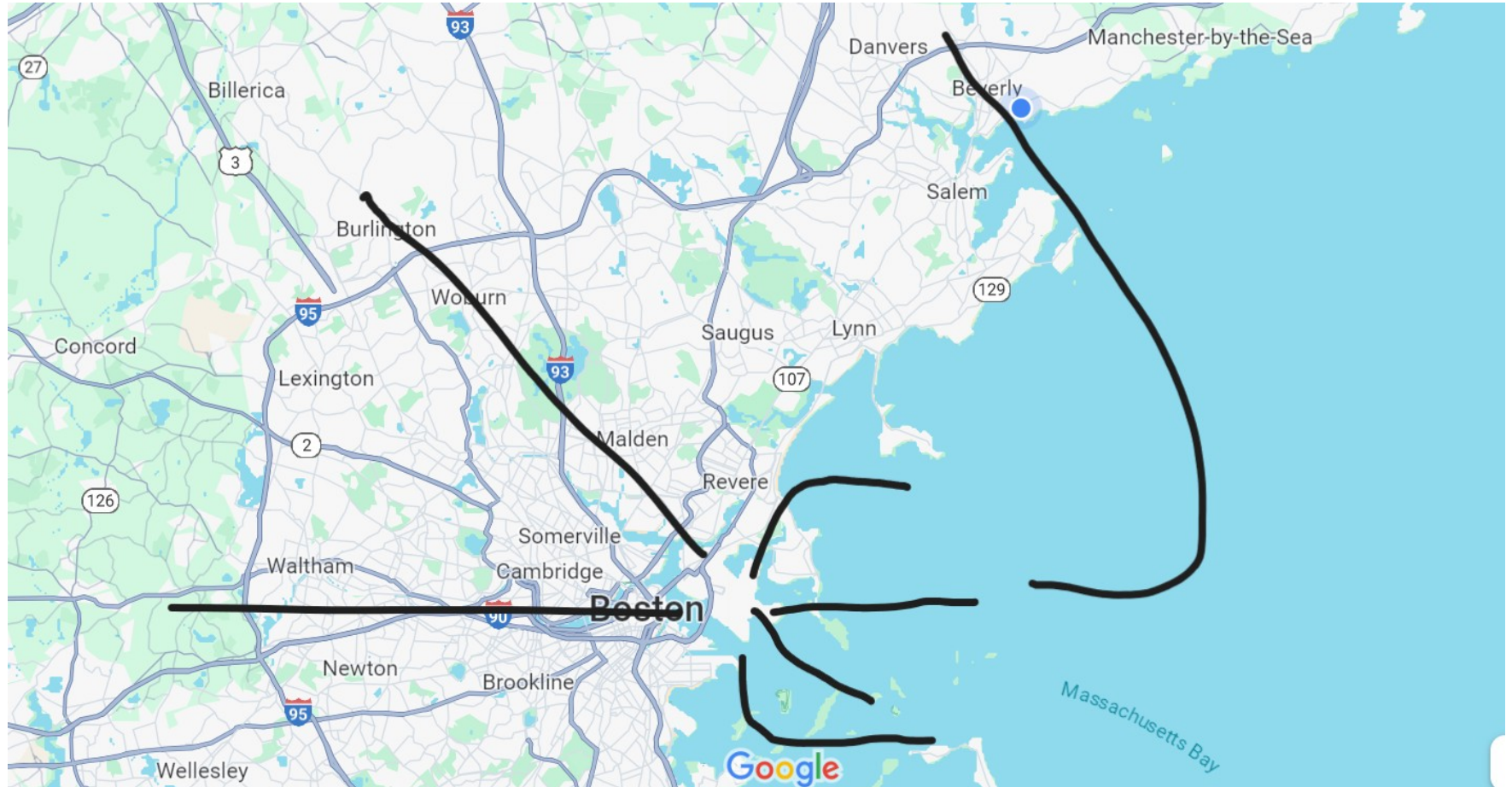 - All these trackers use ADS-B to track aircraft

What I Found

- Using the apps, discovered four types of traffic over Beverly

  – High altitude flights (to and from New York)

  – Local Beverly Airport traffic

  – Logan Rwy 22 arrivals

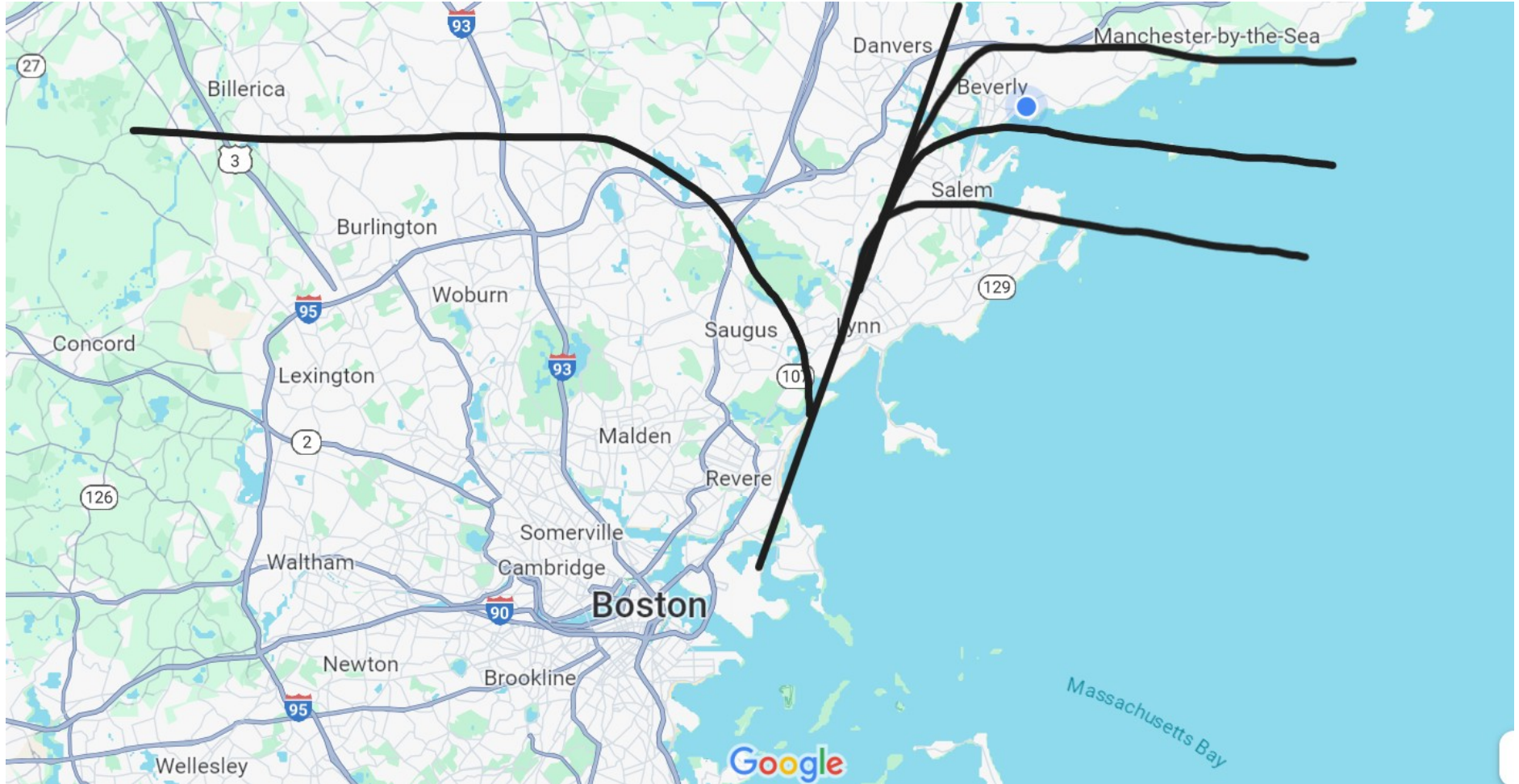 – Logan Rwy 4,9,15,22 departures to the West

Logan Airport

Departures Rwy 4,9,15,22

Arrivals Rwy 22

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ADS-B

- Automatic Dependent Surveillance Broadcast
  - Mandated in US since about 2020
  - Aircraft periodically broadcast position, altitude and other data
  - Based on GPS
  - Uses 1090 MHz aircraft transponder transmitter

Aircraft Transponder

- Airborne equipment first introduced in the 1970s to support secondary radar. (Mode A)

- Transponder interrogated by narrow beam of pulses aligned with primary radar beam at 1030 MHz.

- Replies with a series of pulses, a 12-bit "squawk" code and a 13th Ident bit at 1090 MHZ after a fixed delay to support ranging.

- Mode B transponder included barometric altitude.

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SSR Antenna

Mode A/B Transponder

Mode S Transponder

- New design compatible with Mode A/B

  - "S" for select mode

  - Introduces 24-bit unique aircraft addresses assigned by ICAO

  - New interrogation format

  - Defines up to 32 message formats (up-link and down-link)

  - Ground can interrogate multiple aircraft parameters

  - Same response technology – 1090 MHz OOK (CW)

- Supports airborne anti-collision

- Message formats support ground position but GPS was not available when Mode S was first introduced.

ADS-B

- Relies on GPS

- Uses Mode S DF17 (Downlink Format 17)

- Defines 32 sub-formats

- One format gives encoded altitude and position in one message

- When airborne, altitude/position is transmitted about twice per second.

ADS-B Transmission

- 1090ES Transmitter (Extended Squitter)

- 120 watt OOK limited to 5% duty cycle on 1090 MHz

- 112 Bit payload

  - Preamble   – S Mode response pulse sequence

  - DF   - 5 bits   (= 17)

  - Transponder Capability   - 3 bits

  - ICAO Address   - 24 bits

  - TC (sub format)   - 5 bits

  - Data Field   - 51 bits

  - CRC Check   - 24 bits

Altitude and Position Encoding

- Complete description at http://mode-s.org/

- Altitude 12 bits, 100 ft resolution

- Position 17 bits each, CPR encoding

    - CPR value is position within a grid

    - Two grids are used to provide absolute position

NooElec RTL-SDR

RTL-SDR

- This is the device that started the SDR craze.

- Tuner + Signal Processor

- Up to 1.5 GHz input

- Up to 2.8 Mega Samples per second

- 8-bit ADC

- Many receiver software packages

    - SDR#   http://airspy.com/download

    - HDSDR   http://www.hdsdr.de/

SDRPlay RSP 2

RSP2

- Tuner + Signal Processor

- Up to 2 GHz

- Up to 10 Mega Samples per second

- 12-bit ADC

- Switched-filter front end with preamp

- Proprietary receiver software: SDRUno

DUMP1090

- ADS-B decode software written in 2014

- Available on GitHub as source or windows install. Supports RTL-SDR. Many versions.

- Good version of dump1090 for RTL-SDR

  - https://github.com/MalcolmRobb/dump1090/raw/master/dump1090-win.1.10.3010.14.zip

  - Display with https://www.virtualradarserver.co.uk/

- SDRPlay has dump1090 version as a plug-in

DUMP1090

- Tracks and plots air traffic on webpage served on port 8080

- Provides data streams on TCP ports

  - Base Station format on port 30003

    - MSG,3,1,1,4CA4CC,1,2018/10/11,20:30:22.139,2018/10/11,20:30:22.155,32450,58.39029,15.67850,0,0,0

  - Raw format on port 3002

    - *8D451E8B99019699C00B0A81F36E; (112 bits)

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SDRPlay Dump1090

127.0.0.1:8080
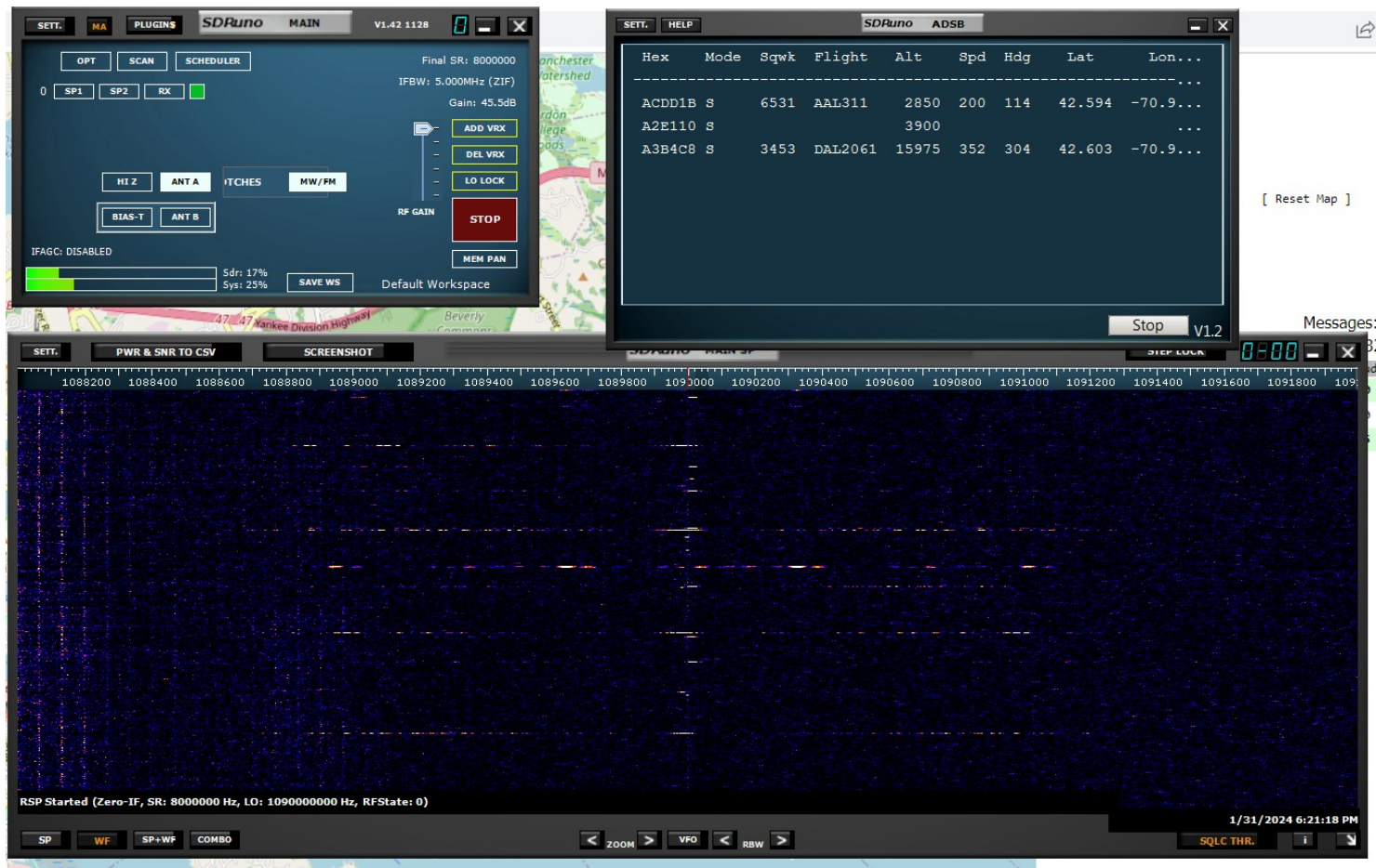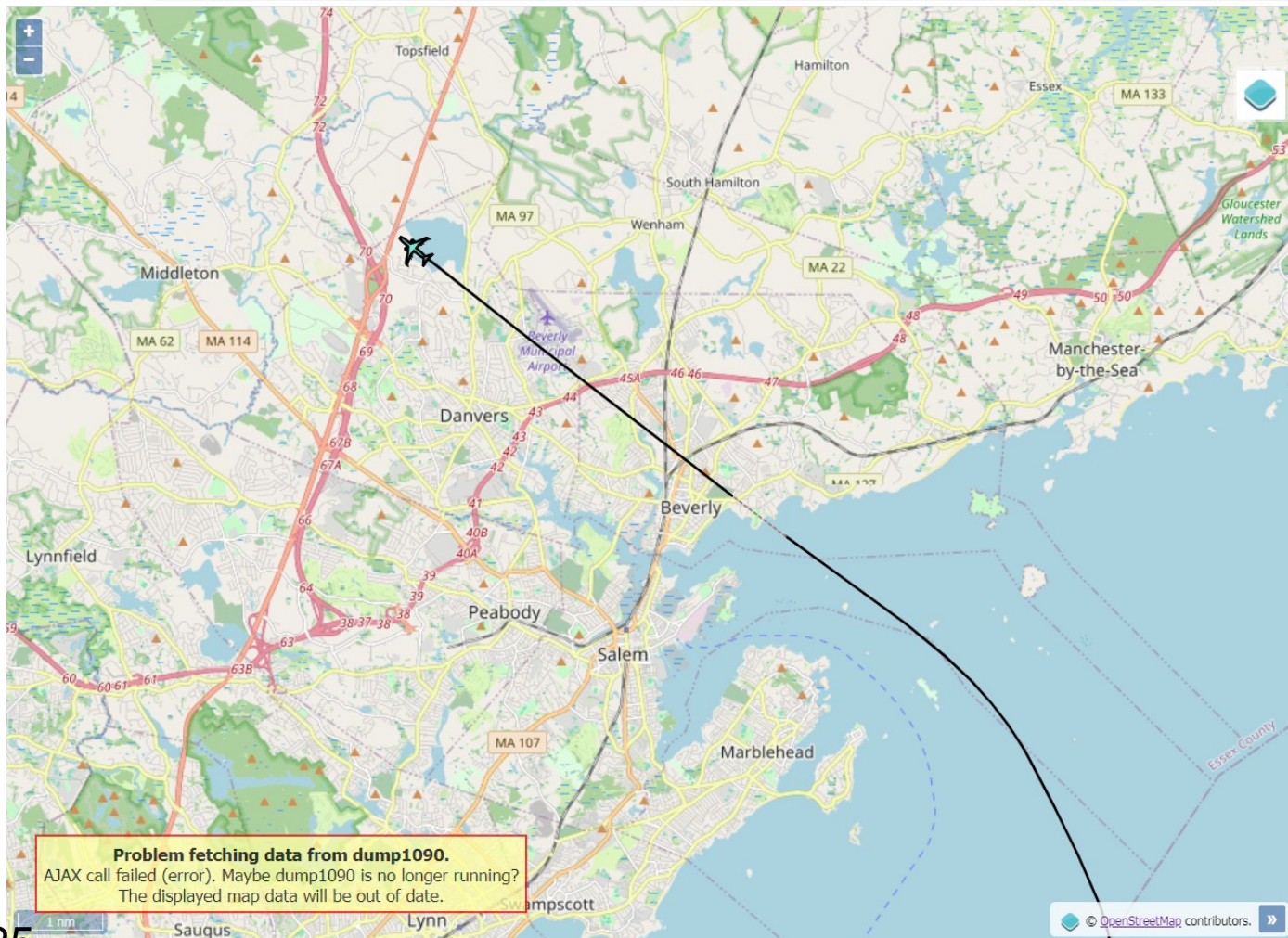
UTC   Last Update

[Reset Map]

UAL1783 ⇒ Flag AAA5D4 N78524 B738 [FlightAware] [FR24] [FlightStats]

[PlaneFinder]

Country of registration: United States
Altitude: ▲ 15425 ft | 4702 m   Squawk: 7353
Speed: 379 kt | 702 km/h   RSSI: -49.5 dBFS
Track: 309° (Northwest)   Last seen: now
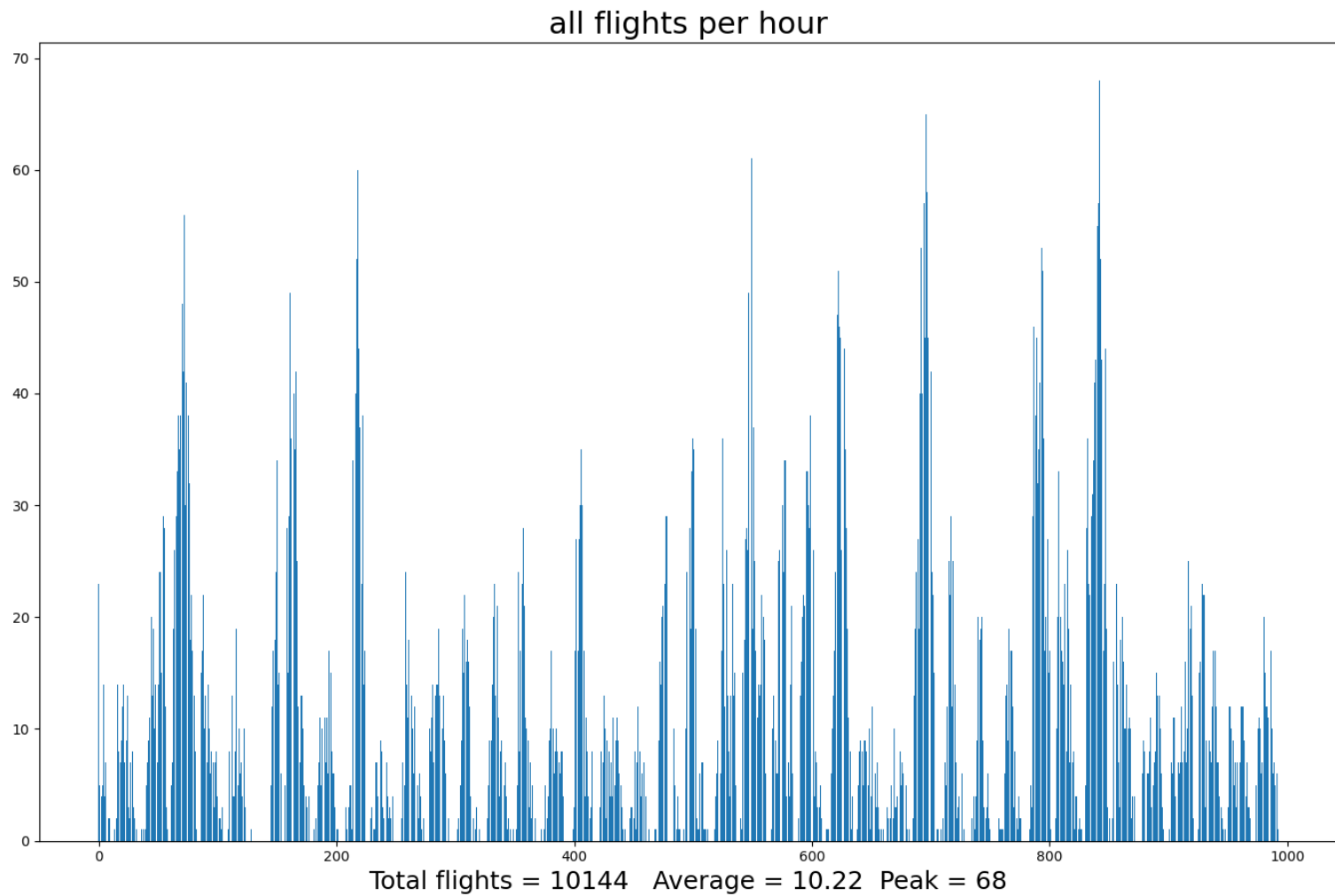Position: 42.600°, -70.953°
Distance from Site: n/a

ICAO	Flight	Squawk	Altitude	Speed	Track	Msgs	Age
aa763f	Flag		6247	6750 ▼	257	153	61	7
a04e00	Flag			10025	237	46	28	0
a35949	Flag JBU931		11825 ▲	342	252	32	3
aaa5d4	Flag UAL1783	7353	15425 ▲	379	309	1318	0
a59d5f	Flag AAL2783	7335	16850 ▲	364	300	1836	0
ac90a0	Flag PDT5824	3527	36000	432	206	250	2
407cf6	Flag JCO25FM	7121	39100 ▲	523	64	787	0
a5a553	Flag LXJ463	6040	41000	493	50	963	0

Problem fetching data from dump1090.
AJAX call failed (error). Maybe dump1090 is no longer running?
The displayed map data will be out of date.
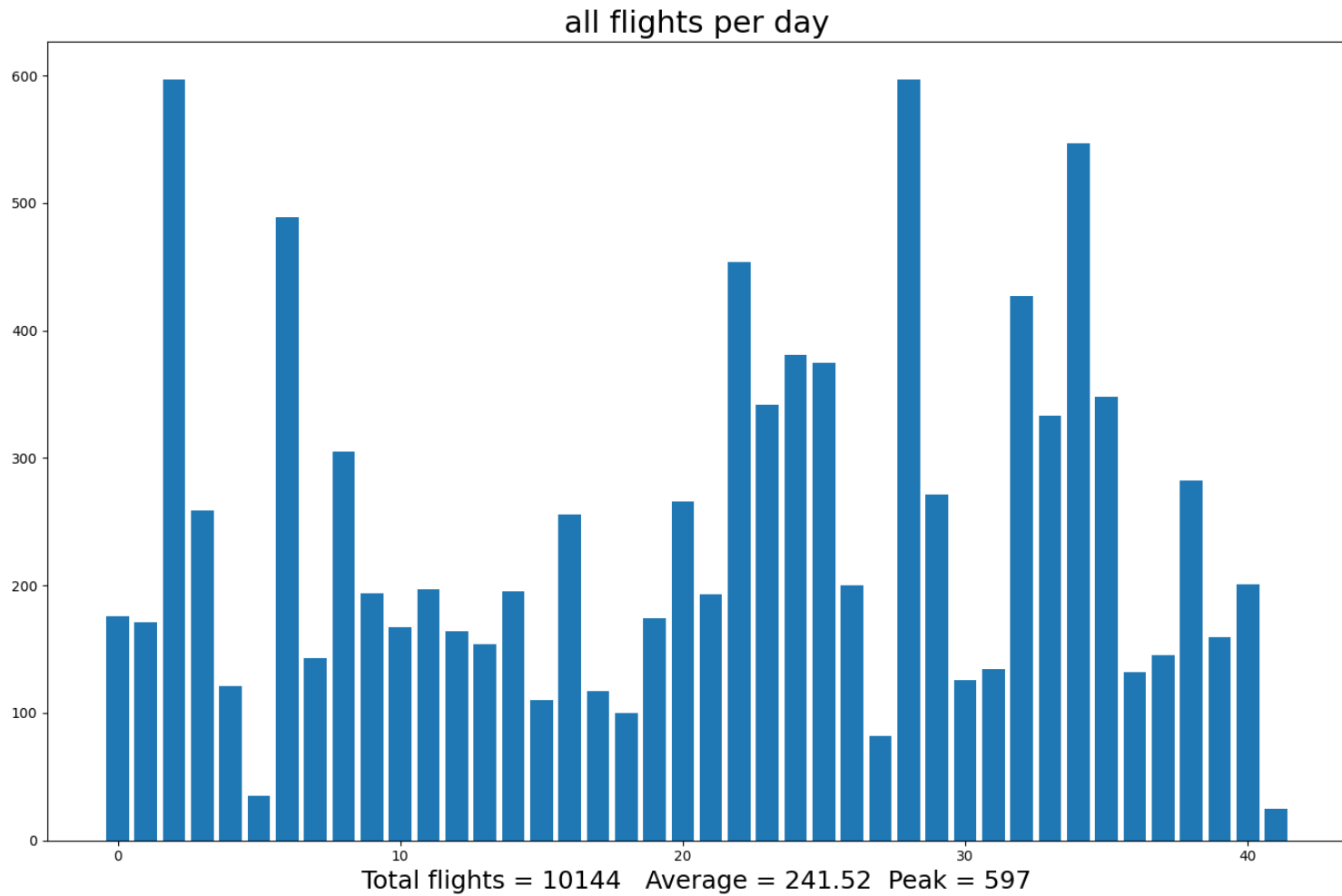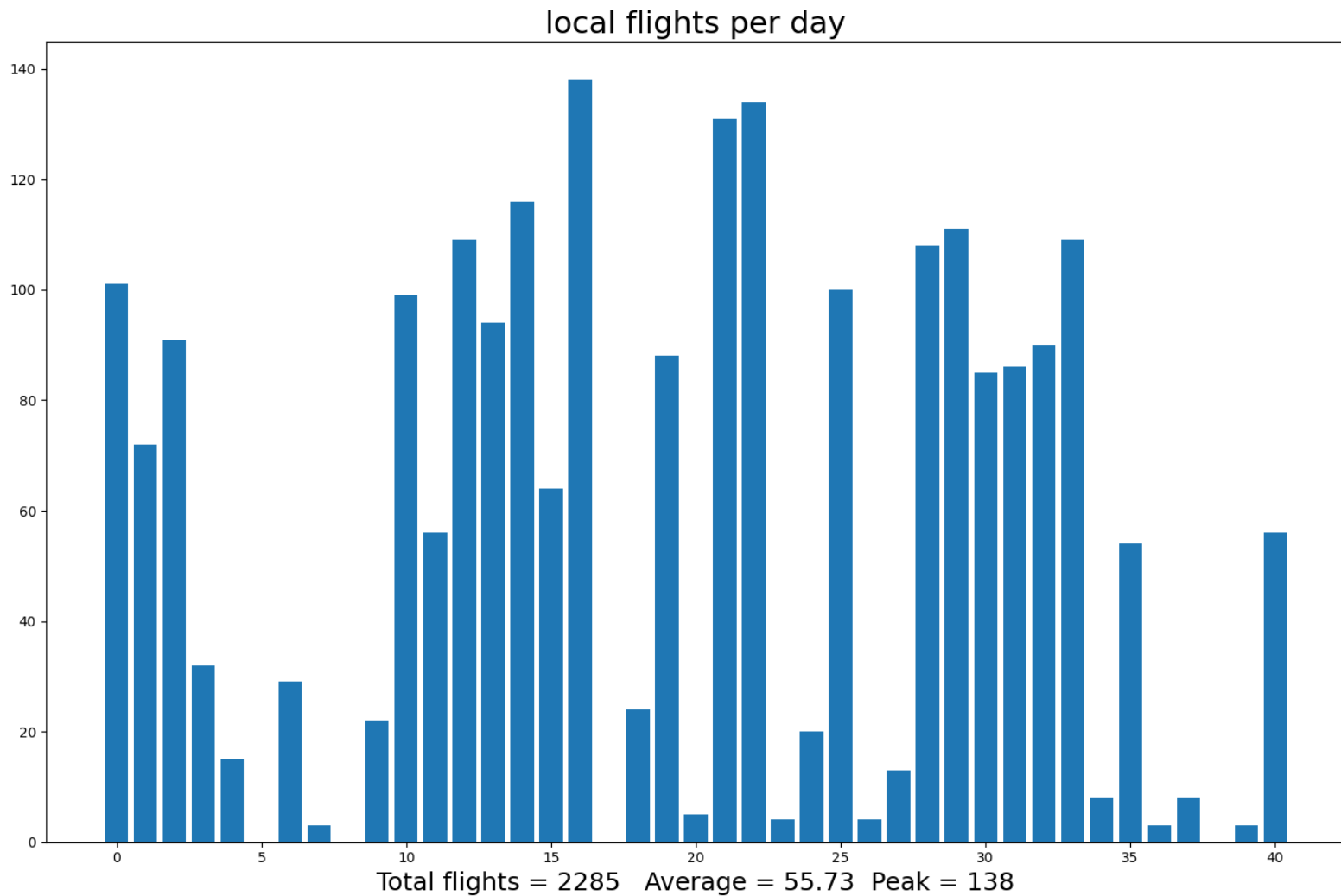
© OpenStreetMap contributors.

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Data Capture

- Standalone Python program that reads Base Station format data from dump1090 port 30003

- Tracks aircraft and logs aircraft on closest approach if less than 4 statute miles.

  - A4615C N3810C   2023/12/20 15:36:50.017 42.56424 -70.78666 3.944 8400 departure

  - ICAO   callsign   date   time   latitude   longitude dist   alt   type

- Type depends on altitude:

  - Local: less than 1,599 ft

  - Arrival: 1,600 ft to 7,999 ft

  - Departure: 8,000 ft to 19,999 ft

  - Enroute: greater than 20,000 ft

- Recorded 10,144 flights over 42 days
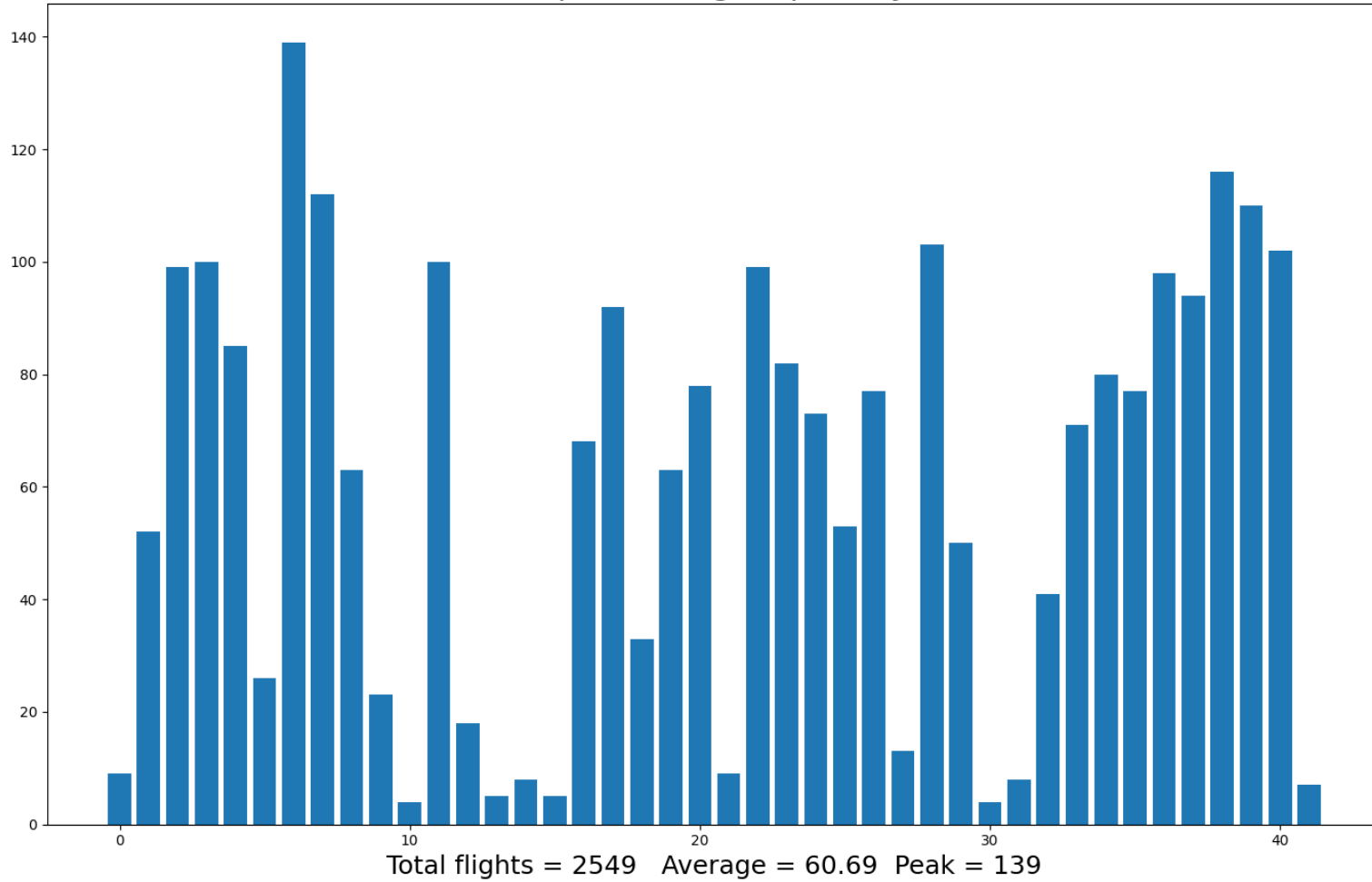
Data Analysis

- Stand alone Python program to read log and display bar graphs by hour or day and by category

    - All   (Local + Departures + Arrivals + Enroute)

    - Local

    - Logan   (Departures + Arrivals)

    - Departures

    - Arrivals

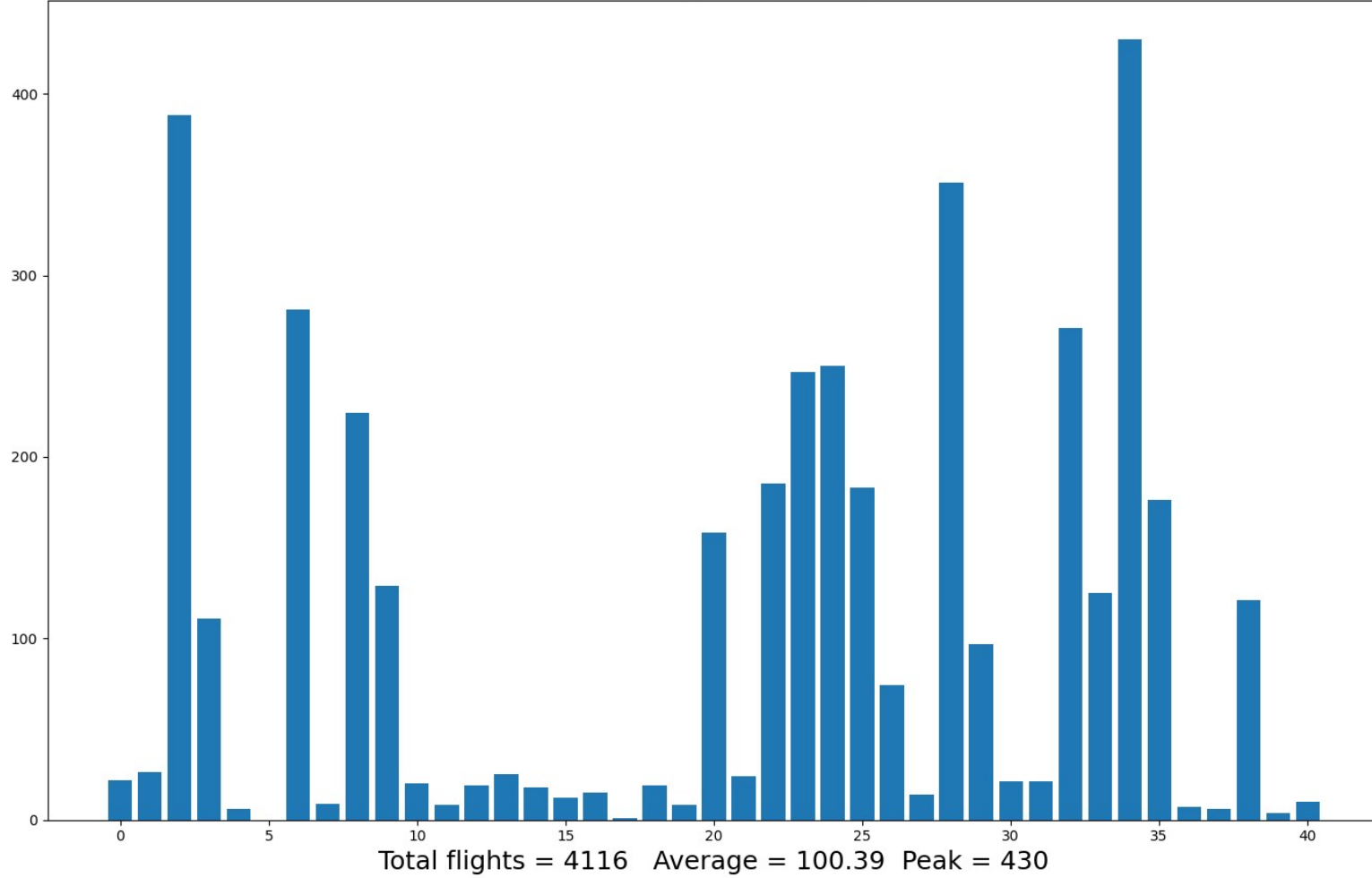   - Enroute

all flights per hour

Total flights = 10144   Average = 10.22   Peak = 68

28

all flights per day

Total flights = 10144   Average = 241.52   Peak = 597

29

local flights per day

Total flights = 2285   Average = 55.73   Peak = 138

30

departure flights per day

Total flights = 2549   Average = 60.69   Peak = 139

31

arrival flights per day

Total flights = 4116   Average = 100.39   Peak = 430

32

enroute flights per day

Total flights = 1194   Average = 28.43   Peak = 53

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