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Local ADS-B Receiver & SDR Utilities

CS7319 – Fall 2025

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# Problem Statement

## The Problem:

- SDR hardware is powerful but often requires complex, monolithic software setups.
- Limited modularity and scalability in existing solutions

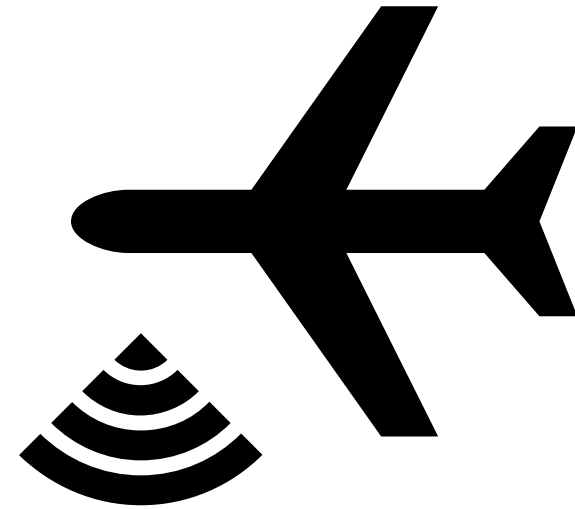


## Motivation:

- Make SDR usage more modular, maintainable, and expandable.
- Enable distributed deployment across devices.

# ADS-B Background

- Automatic Dependent Surveillance – Broadcast is an aviation air traffic communication protocol used to broadcast the location and basic information about aircraft.
- Services such as FlightAware and ADSB-Exchange use this protocol to track air traffic.



# Project Overview

## Main Functions

- Capture ADS-B signals from aircraft using SDR hardware.
- Decode and store received data.
- Present live and historical data to users.

## Scope

- Local ADS-B Receiver
- ATC Voice Comms Decoder
- Future expandability for other radio signals

# Expected Results



Distributed SDR platform with modular microservices.



Easy-to-use API for integration and expansion.



Simple Python Tkinter UI for control and data visualization.



Dockerized deployment for portability

# Architectural Style



## Microservices Architecture

Allows for modularity, scalability, and maintainability

Can design services with clear separation between use

Utilizing “**Pub-Sub**” pattern to allow all components to operate independently and asynchronously (implicit invocation)



## WaveTap Core Services

SDR Data Capture

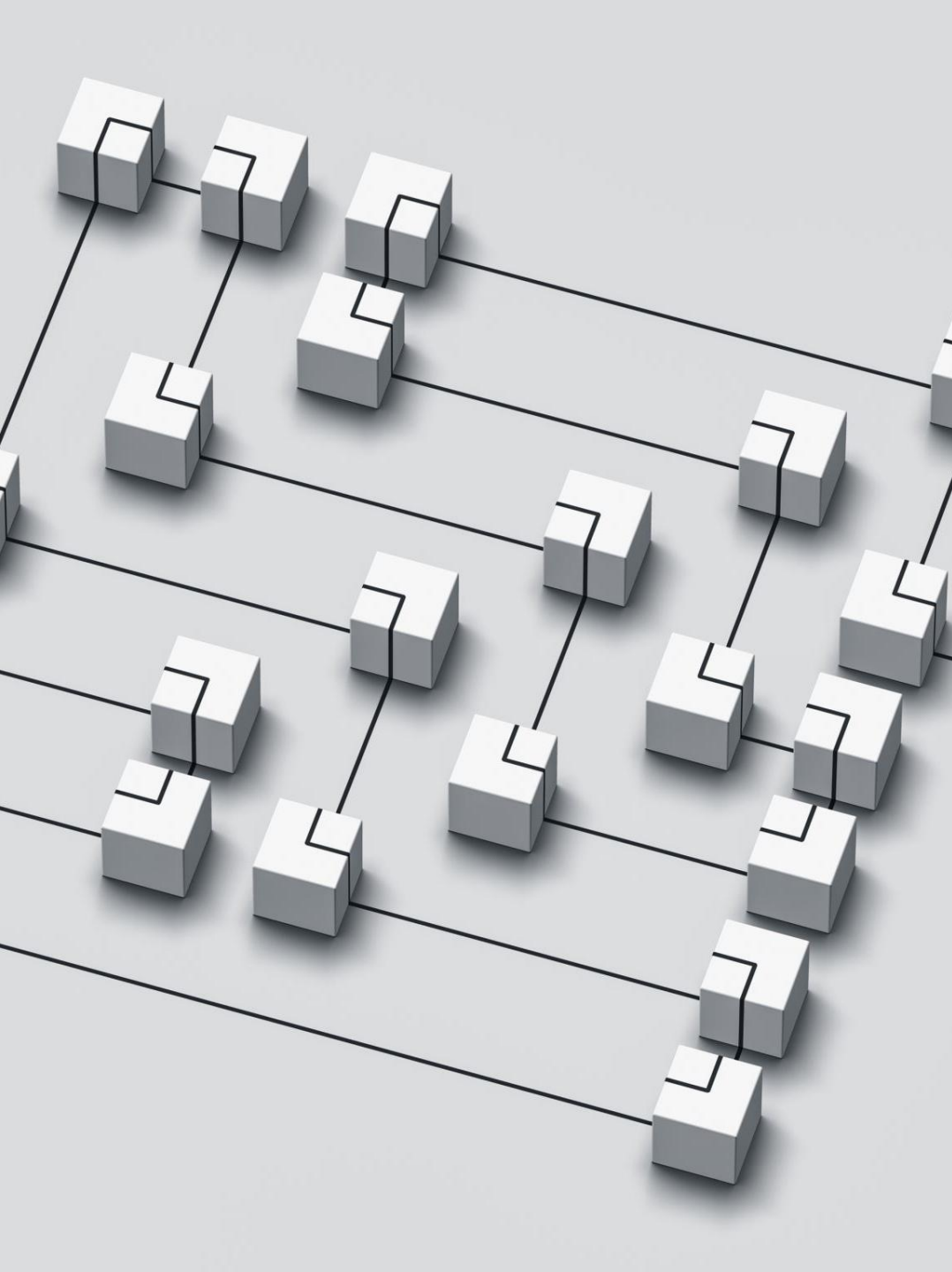
RF Signal Decoding

Event Storage

Resource Coordinator/Arbiter

API Gateway

Modular UI



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## Adjustments from Proposal

- Arbiter & tkinter based GUI were not fully implemented due to time constraints
  - Deployed early basic modules that will mature to this capability
- Difficulties in implementing raw IQ stream over network
  - Handled all conversion of IQ stream to bytes using dump1090 application then transmitted that over TCP

# Platform & Tools

- Language: Python
- Libraries:
  - Flask API
  - Tkinter
  - PyRTLSDR
  - pyModeS
  - dump1090-fa
- Hardware
  - USB RTL-SDR
  - Raspberry Pi (Optional)
- Deployment
  - Docker containers

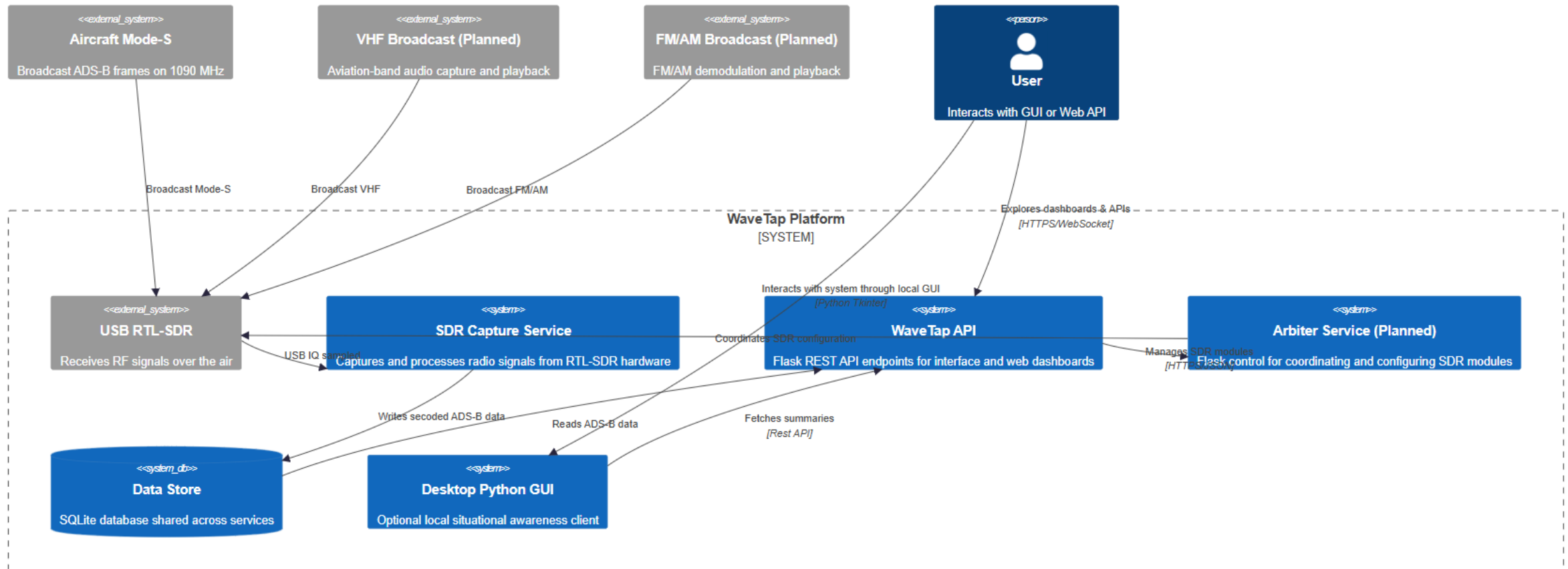




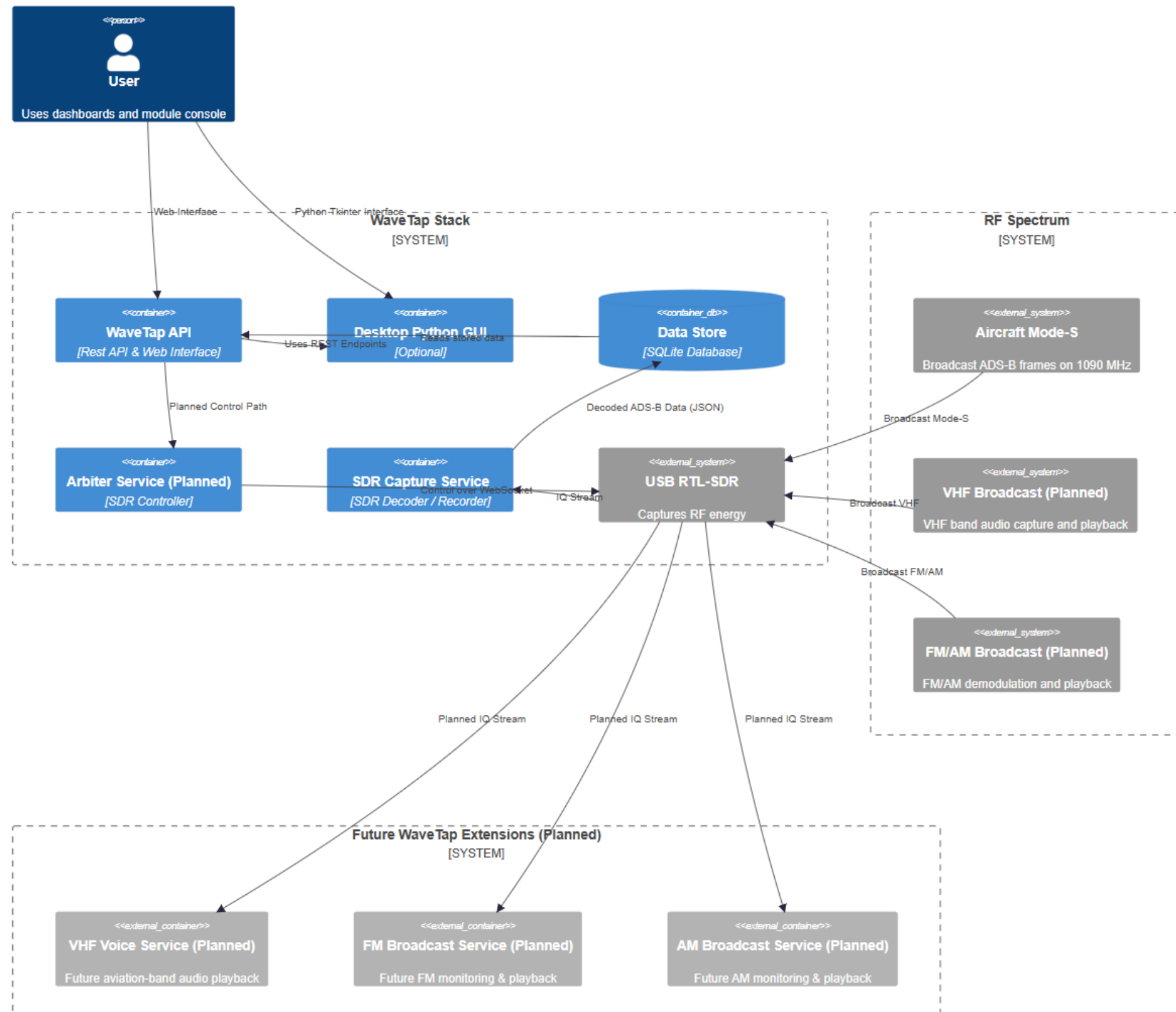
# Architectural Diagrams

C4 Diagrams

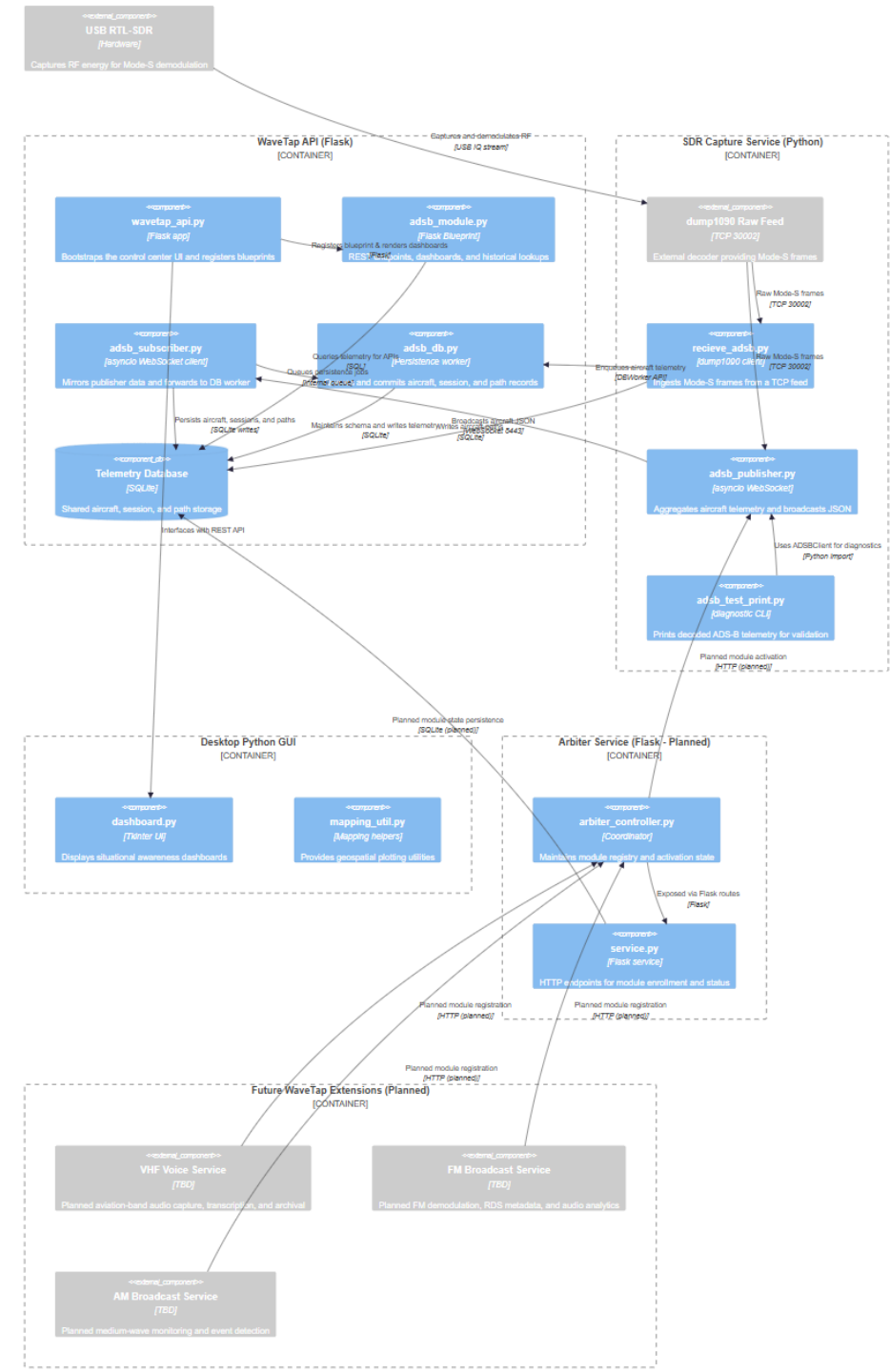
# System Context Diagram



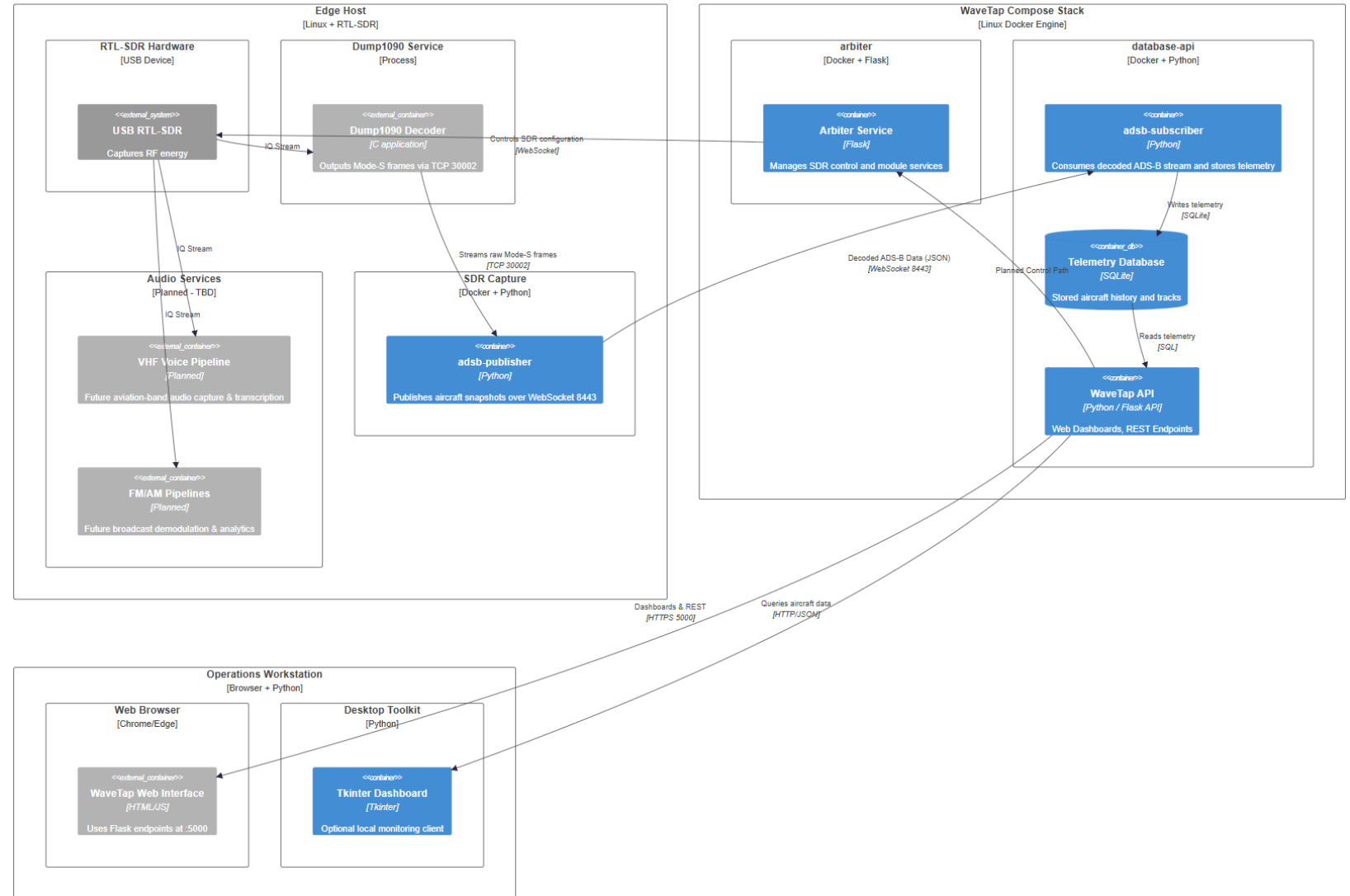
# Container Diagram



# Component Diagram

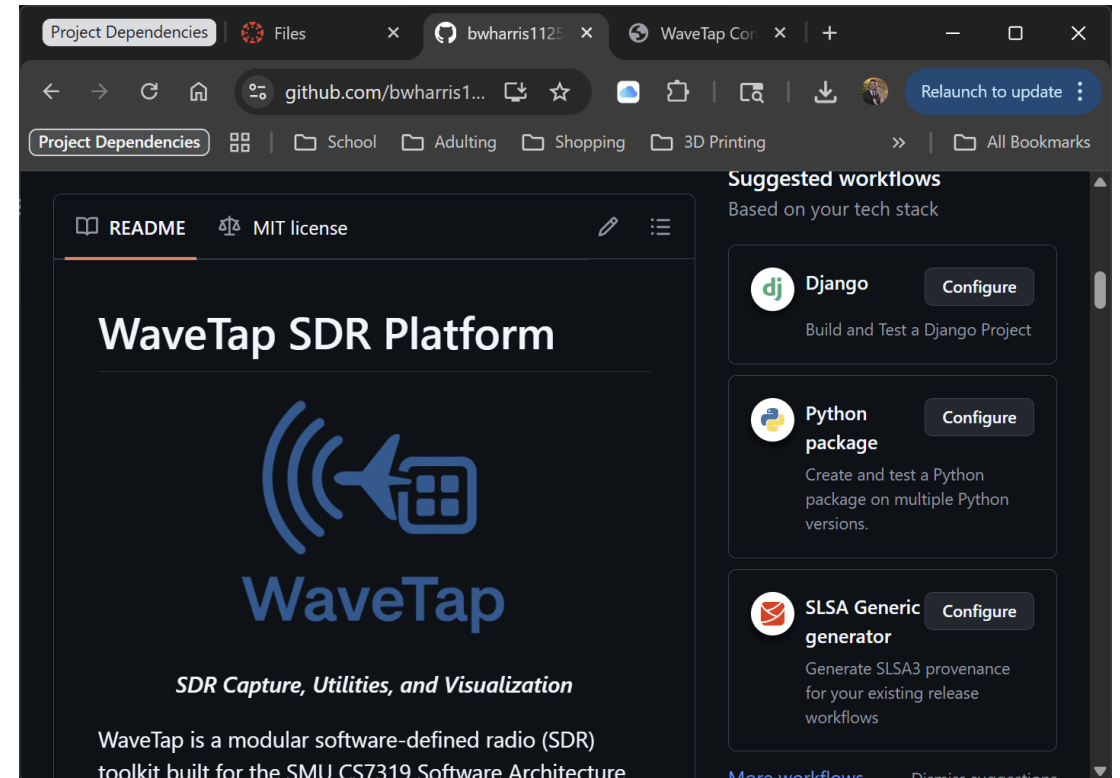


# Deployment Diagram



# GitHub Repository

- Future expandability for CI/CD pipelines
- Version control
- Pipelines to lint and review code, docker images, etc.
- Link to Repo:  
[https://github.com/bwharris1125/CS7319\\_Project\\_WaveTap](https://github.com/bwharris1125/CS7319_Project_WaveTap)



# Demonstration

# Concept of Operations



*\*this is an example hardware configuration, the containers are agnostic to device*



# Docker Containers Running

```
[+] Running 8/8
✓ project-database-api      Built
✓ project-adbs-publisher    Built
✓ project-adbs-subscriber   Built
✓ project-arbiter           Built
✓ Container project-adbs-publisher-1 Started
✓ Container project-arbiter-1 Started
✓ Container project-adbs-subscriber-1 Started
✓ Container project-database-api-1 Started
```

```
• (.venv) bwarris@Nighthawk:~/cs7319/project$ docker ps
CONTAINER ID   IMAGE                                COMMAND                  CREATED        STATUS        PORTS                                                                 NAMES
4f2758ed8973   project-database-api                "gunicorn --bind 0.0..." 58 minutes ago Up 19 minutes 0.0.0.0:5000->5000/tcp, [::]:5000->5000/tcp project-database-api-1
ff749307b10b   project-adbs-subscriber             "python -m adbs_subs..." 58 minutes ago Up 19 minutes 5000/tcp                                              project-adbs-subscriber-1
e4ee39511b62   project-adbs-publisher              "python -m sdr_cap.a..." 58 minutes ago Up 19 minutes 0.0.0.0:8443->8443/tcp, [::]:8443->8443/tcp project-adbs-publisher-1
1355ee983e0a   project-arbiter                     "gunicorn arbiter.se..." 58 minutes ago Up 19 minutes 0.0.0.0:8000->8000/tcp, [::]:8000->8000/tcp project-arbiter-1
• (.venv) bwarris@Nighthawk:~/cs7319/project$ docker compose down
[+] Running 5/5
✓ Container project-database-api-1      Removed
✓ Container project-arbiter-1           Removed
✓ Container project-adbs-subscriber-1   Removed
✓ Container project-adbs-publisher-1    Removed
✓ Network project_default                Removed
```

Example shows all containers deployed to a single device

# WaveTap Main Menu & ADS-B Menu

WaveTap Control


• [ADS-B](#)

• [VHF Radio](#)

• [FM Radio](#)

• [AM Radio](#)

• [Other Signals](#)



## WaveTap Control Center

Use the control panel below to navigate through the live monitoring tools, historical archives, and aircraft lookups. Future releases will add controls for the SDR arbiter and acquisition pipeline.

ADS-B Operations

Monitor ADS-B telemetry, history, and situational awareness tools.

[Explore ADS-B Data](#)

VHF Radio (Future)

Roadmap for aviation-band voice capture and analysis.

[Explore VHF Data](#)

FM Radio (Future)

Roadmap for FM broadcast reception and analytics.

[Explore FM Data](#)

AM Radio (Future)

Placeholder for AM broadcast demodulation initiatives.

[Explore AM Data](#)

Other Signals

Concepts and experiments for future SDR domains within WaveTap.

## ADS-B Operations

Access the full WaveTap ADS-B toolkit: live traffic monitoring, historical analysis, ICAO lookups, flight-path inspection, and map visualization.

### Live ADS-B Data

View aircraft detected in the last five minutes with key telemetry.

[Explore Live Data](#)

### Historical Records

Browse a catalog of all aircraft ever recorded by WaveTap.

[Review History](#)

### ICAO Lookup

Search for a specific aircraft by ICAO identifier.

[Lookup ICAO](#)

### Flight Paths

Inspect recent track points captured across all aircraft.

[Inspect Track](#)

### Live Map

Visualize active aircraft on an interactive global map.

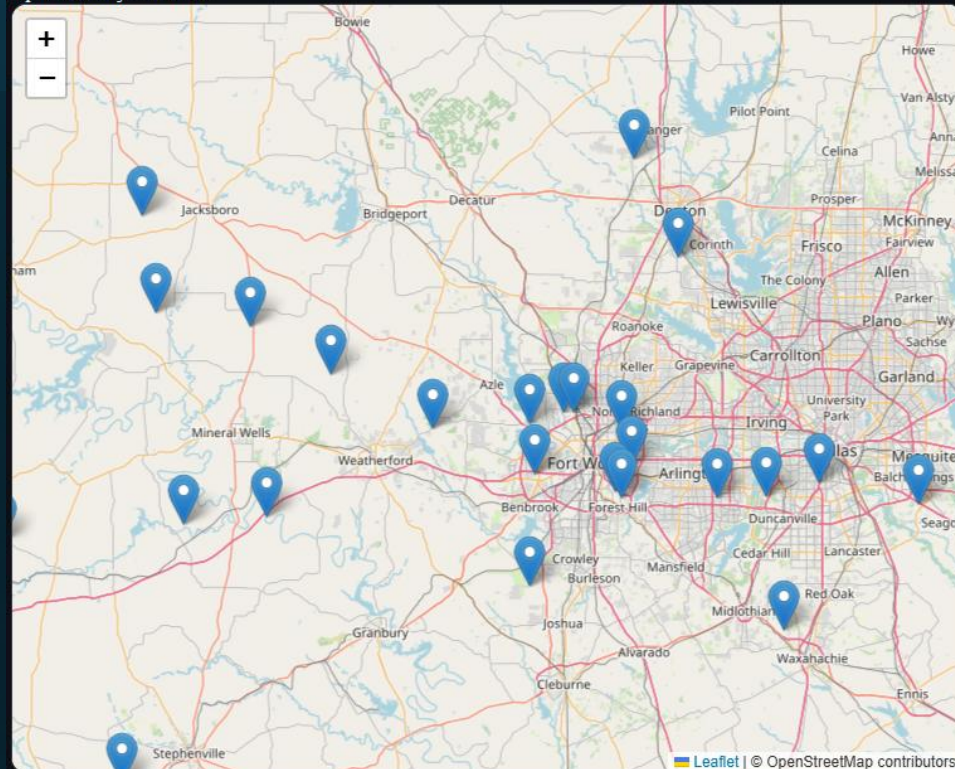
[Visualize Map](#)

# Live ADS-B Data & Live Map

## Live Aircraft Map

Displaying active aircraft detected by WaveTap in near real time.

Updates every 5 seconds



## WaveTap Control

- [ADS-B](#)
- [VHF Radio](#)
- [FM Radio](#)
- [AM Radio](#)
- [Other Signals](#)

## Live ADS-B Data

Showing aircraft observed in the last 5 minutes.

[Refresh](#)

ICAO	Callsign	First Seen	Latitude	Longitude	Altitude (ft)	Speed (kt)	Track (°)	Vertical Rate	Last Update
A6FB32	AAL1771	2025-10-02 07:56:22 PM	32.936127	-97.874843	16175	420.0	291.3210060000543	1600.0	2025-10-02 07:57:00 PM
AA8BFA	ENY3705	2025-10-02 07:56:22 PM	32.696228	-97.109363	8100	294.0	258.23171106797935	3072.0	2025-10-02 07:57:00 PM
A34199	ENY3378	2025-10-02 07:56:24 PM	32.701457	-97.273678	10950	350.0	280.18788663221926	1984.0	2025-10-02 07:57:00 PM
AD3D4E	AAL2597	2025-10-02 07:56:22 PM	32.670919	-97.824732	18275	433.0	264.57844526114934	2176.0	2025-10-02 07:57:00 PM
AD50A9	SWA369	2025-10-02 07:56:24 PM	33.240672	-98.478138	39000	474.0	141.67988606322257		2025-10-02 07:57:00 PM
ABE40A	SWA746	2025-10-02 07:56:22 PM	33.134720	-97.286737	39000	431.0	14.068414031369498		2025-10-02 07:57:00 PM
A9ABA0	N722GR	2025-10-02 07:56:22 PM	32.895813	-97.373969	1625	129.0	172.4346789315677	192.0	2025-10-02 07:57:00 PM
A34C57	AAL364	2025-10-02 07:56:22 PM	32.785670	-97.299182	10075	299.0	286.31385242626055	1728.0	2025-10-02 07:57:00 PM
A5EC61	ASA397	2025-10-02 07:56:22 PM	32.166572	-98.171082	34000	451.0	269.2377951271843		2025-10-02 07:57:00 PM
A53473	N43408	2025-10-02 07:56:48 PM	32.809226	-97.381411	1200	98.0	337.3354425653039	-64.0	2025-10-02 07:57:00 PM
AAC7B1	ENY3875	2025-10-02 07:56:29 PM	32.419281	-97.582764	17300	351.0	43.96256406268304	-2112.0	2025-10-02 07:57:00 PM
A4CE28		2025-10-02 07:56:24 PM	32.640564	-97.264325	3850	258.0	10.918989325354486	-64.0	2025-10-02 07:56:59 PM
A1C5E0	ENY3567	2025-10-02 07:56:23 PM	33.042938	-97.145563	14700	349.0	4.260582989500757	1280.0	2025-10-02 07:56:58 PM
A191A8	RAX270	2025-10-02 07:56:22 PM	32.795059	-97.909442	37000	466.0	84.46062106219513	64.0	2025-10-02 07:56:58 PM
A6452D	ATN3359	2025-10-02 07:56:22 PM	32.671198	-96.956251	15725	347.0	65.7196690856149	2880.0	2025-10-02 07:56:56 PM
A1E6B9	SWA2252	2025-10-02 07:56:43 PM	32.625577	-98.392097	36950	432.0	264.4213637446066	1216.0	2025-10-02 07:56:55 PM
AC2B61	SWA2004	2025-10-02 07:56:22 PM	32.763016	-96.843823	37000	477.0	114.25512288635655		2025-10-02 07:56:51 PM
AC96BE	AAL1847	2025-10-02 07:56:26 PM	32.689680	-96.944817	8075	281.0	102.10898498322899	2304.0	2025-10-02 07:56:50 PM
AB3982		2025-10-02 07:56:46 PM							2025-10-02 07:56:46 PM
AC20C4	SWA2182	2025-10-02 07:56:25 PM	33.204941	-98.309784	31600	437.0	293.9890640095524	1088.0	2025-10-02 07:56:42 PM
ADSFEA	AAL1207	2025-10-02 07:56:37 PM	32.639877	-98.217993	24150	448.0	264.49298861117484	1536.0	2025-10-02 07:56:39 PM
A5A106		2025-10-02 07:56:26 PM							2025-10-02 07:56:26 PM
A79AAE		2025-10-02 07:56:23 PM							2025-10-02 07:56:26 PM

WaveTap ADS-B Monitoring Console • Local Timezone: CDT

# Historical Data & ICAO Lookup

## ICAO Lookup

Search for a specific aircraft by ICAO identifier.

ICAO Address

**ICAO A191A8**

**Callsign**  
RAX270

**First Seen**  
2025-10-02 07:56:22 PM

**Last Seen**  
2025-10-02 07:57:39 PM

**Last Known Position**  
32.803711, -97.804138 at 37000 ft

## Historical Aircraft Records

Complete inventory of aircraft seen by WaveTap.

[Refresh](#)

ICAO	Callsign	First Seen	Last Seen	Last Latitude	Last Longitude	Last Altitude (ft)
A19CB0	GTX489	2025-09-30 12:24:07 AM	2025-09-30 12:28:06 AM	33.023645	-97.557585	4800
C82741	ANZ1	2025-09-30 12:23:07 AM	2025-09-30 12:28:06 AM	33.416639	-98.142383	32000
A693AA	SCX3000	2025-09-30 12:17:38 AM	2025-09-30 12:28:01 AM	33.141376	-98.505884	25450
AC57D2	SWA2466	2025-09-30 12:13:38 AM	2025-09-30 12:27:56 AM	31.963139	-97.333262	41000
A4F6D4	N419P	2025-09-29 11:42:36 PM	2025-09-30 12:26:59 AM	32.785538	-97.242517	1425
AC73F9	N901MC	2025-09-30 12:12:30 AM	2025-09-30 12:24:30 AM	32.718658	-97.160834	4800
A2C4B6	FDX1100	2025-09-30 12:15:07 AM	2025-09-30 12:20:43 AM	33.279190	-97.703998	7775
A028E5	ABX3116	2025-09-30 12:09:16 AM	2025-09-30 12:19:51 AM	33.132857	-98.479932	29350
A67F04	SCX3072	2025-09-30 12:11:47 AM	2025-09-30 12:19:10 AM	33.098362	-98.023158	19725
A0B8FB	AAL2904	2025-09-29 11:57:10 PM	2025-09-30 12:15:24 AM	32.990919	-97.149970	4500
A2F9B3	FDX1124	2025-09-30 12:02:24 AM	2025-09-30 12:08:26 AM	32.972122	-97.218622	4075
AD7DA2	AAL935	2025-09-30 12:01:32 AM	2025-09-30 12:08:04 AM	32.043549	-96.711823	30000
AD002B	FDX1125	2025-09-30 12:00:23 AM	2025-09-30 12:06:03 AM	32.937570	-97.238253	4125
AE0976	CNV4404	2025-09-29 11:42:03 PM	2025-09-30 12:04:08 AM	32.791303	-97.441275	675
AB9A5C	N847FE	2025-09-29 11:51:47 PM	2025-09-30 12:01:59 AM	32.904053	-97.340955	2850
A5D927	UAL1636	2025-09-29 11:44:26 PM	2025-09-30 12:01:14 AM	32.946183	-97.165833	4500
A987BF	FFT2136	2025-09-29 11:53:51 PM	2025-09-29 11:56:07 PM	32.767981	-96.851713	8475
A2B05B	UCA4241	2025-09-29 11:33:34 PM	2025-09-29 11:51:04 PM	32.010544	-97.109967	31000
AA147B	BVN7280	2025-09-29 11:40:56 PM	2025-09-29 11:49:40 PM	32.929284	-97.367678	2475
ADCC99	AMF7175	2025-09-29 10:19:05 PM	2025-09-29 11:42:20 PM	32.908035	-97.149298	6900



# Conclusion



**Summary:** WaveTap will deliver a modular, distributed SDR platform starting with ADS-B signal capture.



**Impact:** Easier SDR experimentation, scalable architecture, and extensibility to other radio applications.



**Next Steps:** Continue to implement other modules for additional SDR capabilities.

# Thank you

Questions?

