USAF ACADEMY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
LESSONS 18–19 LAB - ADS-B AND AIS
Lab Packet
Spring 2027

Name: _____ **Section:** _____ **Date:** _____

Learning Objective 6.7: I can receive and decode ADS-B messages from aircraft transponders.
Learning Objective 6.8: I can receive and decode AIS messages from marine vessels.

This packet is the L18–L19 Lab, in three parts, and you turn it in once, complete, before Lesson 20. Do **Part 1** on your own before the lab period: fly an aircraft of your own through the ADS-B generator and work out the settings for the lab's AIS recording. **Part 2** is your own measurements, recorded in class: Questions 3 to 5 with a PlutoSDR, gr-adsb, and live aircraft, and Questions 6 to 8 on the lab's AIS recording. Do **Part 3** on your own after the lab: explain what you saw.

Grading. You submit the packet once, we grade it against Objectives 6.7 and 6.8 on the course's 1 / 0 scale, and you may revise it under course policy. Paste screenshots where a question asks for one.

Never on 1090 MHz. The Pluto only receives on 1090 MHz, and the AIS recording is simulated, written by a GNU Radio flowgraph rather than captured from an antenna. Never transmit the ADS-B or AIS generators on 1090 MHz or on the AIS channels: they carry safety-of-life traffic. The one transmission in this lab is optional, in Question 4: your own aircraft from `L18-adsb-tx-pluto.grc`, sent at 915 MHz into a cable from the Pluto's TX port through a 30 dB attenuator, or, if your instructor says so, over the air at 915 MHz at low power. Never set TX attenuation below 30 dB.

The flowgraphs are on the L18 and L19 lesson pages: `L18-adsb-tx.grc`, `L18-adsb-tx-pluto.grc`, `L18-adsb-rx.grc`, and `L19-ais-rx.grc`. `L18-adsb-rx.grc` needs gr-adsb, which radioconda includes as `gnuradio-adsb`. The lab's AIS recording, `L18-L19-lab-ais.sigmf-data` and its `.sigmf-meta`, is on the lab page. Its meta file gives the datatype `cf32_le`, a sample rate of 192000, and a center frequency of 162025000.

Part 1: Pre-Lab (individual, before the lab period)

1. **Your own aircraft.** Put `L18-adsb-tx.grc` and `L18-adsb-rx.grc` in one folder. Double-click the generator's ADS-B Out block, choose Open in Editor, and add a fifth line to `AIRCRAFT`: an ICAO address from `0xA00000` to `0xAFFFFF` that you choose, a callsign of up to 8 capital letters and digits made from your initials, a position within 50 km of USAFA, and an altitude, speed, track, and climb rate of your choice, and an amplitude between 0.45 and 0.8 that is not 0.6, so that no aircraft in the list has it. Save, run the generator once, then run the receiver.

    (a) Write the line you added, and the row the receiver's table shows for your aircraft. Do they agree?

    (b) Raise the Added noise slider a step at a time until your aircraft leaves the table, and record that noise level. Paste a screenshot of the receiver just before it leaves.

2. AIS settings for the lab recording. Your AIS receiver in Question 6 plays `L18-L19-lab-ais.sigmf-data`, whose meta file is described above.

(a) Find the center frequency of each channel's Frequency Xlating FIR Filter.

A: _____

B: _____

(b) Choose `decim` for 48 kS/s after the filter, and find the samples per bit and the Quadrature Demod gain.

decim: _____

sps: _____

gain: _____

Part 2: Measurements (in class)

3. **Build an ADS-B front end.** Start GRC with an empty canvas and build the front end the lab page lists: a PlutoSDR Source at 1090 MHz and 2 MS/s, an AGC3, Complex to Mag^2, and a triggered QT GUI Time Sink.

   (a) Paste a screenshot of your flowgraph on the GRC canvas. Every connection must be black, not red.

   (b) Paste a screenshot of the time sink frozen on a live preamble. Record the trigger level you chose, the noise floor, and the pulse heights of the strongest and weakest messages you saw, all in power, as the plot shows them.

4. **Live aircraft.** Add gr-adsb's ADS-B Framer, Demod, and Decoder after Complex to Mag^2, copy the Aircraft Table and its two Function Probes and QT GUI Labels from `L18-adsb-rx.grc`, and run it for 10 minutes with the Pluto at a window, as the lab page lists. If no aircraft decode, decode your own Question 1 aircraft sent from `L18-adsb-tx-pluto.grc` at 915 MHz into a cable through the 30 dB attenuator (see the box above), or the lesson's recording, and say which.

   (a) Record up to five aircraft, and find each one on a public flight tracker such as ADS-B Exchange or FlightAware. Mark whether the tracker agrees. For your own aircraft or the recording, compare with the `AIRCRAFT` list instead.

ICAO	Callsign	Altitude (ft)	Speed (kt)	Latitude, longitude	Tracker agrees?

   (b) Paste a screenshot of the running window with the Messages label and the table.

5. Gain. With the decoder running live, set the Pluto RX gain to each value in turn, wait 60 s, and record the number decoded on the Messages label (messages the Decoder turned into an identity, a position, or a velocity) and the number of aircraft in the table.

Pluto RX gain (dB)	70	60	50	40	30
Decoded in 60 s					
Aircraft					

(a) Describe which aircraft dropped out first as the gain fell, and how their altitude or position compared with the ones that stayed.

6. Build an AIS receiver. Start GRC with an empty canvas and build the two-channel receiver the lab page lists for `L18-L19-lab-ais.sigmf-data`, with your Question 2 settings and the Squelch slider at -30 dB.

(a) Paste a screenshot of your flowgraph on the GRC canvas. Every connection must be black, not red.

(b) Run it for one pass through the 5 s recording and record the Frames label. How many ships are in the table?

ships: [ ]

7. The ships. Read the decoder's printout in the GRC console and the table.

(a) Record every ship. The flag country comes from the first three digits of the MMSI, its Maritime Identification Digits; look them up in the ITU's MID table.

MMSI	Name	Flag	Destination	Latitude, longitude	Speed, course

(b) Copy one complete `!AIVDM` sentence from the console, paste it into `pyais` or an online AIVDM decoder, and record whether its fields match your table.

8. The squelch. Set the Squelch slider to each value in turn, wait for two passes through the recording, and mark which ships are in the table.

Squelch (dB)	-40	-30	-20	-15	-10	-5	0
Ships decoded							

(a) Record the Frames label after one pass at -40 dB and at -30 dB, and describe the time plot at each.

Part 3: Writeup (individual, after the lab)

9. Analysis.

(a) Compare your two receivers, using what your own time sinks showed. Explain why the ADS-B receiver needs only the power of each sample, while the AIS receiver needs an FM demodulator and timing recovery.

(b) Use your squelch table to rank the ships you decoded by received strength, and explain what each step of the table tells you. Then explain how you would choose the squelch for a real recording.

(c) Compare your live aircraft with the flight tracker, row by row: for each, give the difference in altitude and in position you saw, and explain it. If you decoded your own aircraft or the recording, compare with the `AIRCRAFT` list instead.

Documentation: _____