CFI Bootcamp

Flight Instructor Training

Equipment

ADS-B

How it works and what it shows



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CFI BOOTCAMP · GROUND LESSON

ADS-B FOR PILOTS

Understand what your box sends, what it receives, and what it never shows you

Out & In | 91.225 / 91.227 | TIS-B · ADS-R · FIS-B | Receivers & EFBs

For pilots and CFIs · About 45 minutes

CFI Bootcamp
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TODAY'S PLAN

OVERVIEW

1 How it works

Out and In, 1090ES and 978 UAT

2 The rule

91.225 airspace and 91.227 performance

3 Services

TIS-B, ADS-R and FIS-B

4 Blind spots

Old radar, missing traffic, coverage and setup errors

5 In the cockpit

Receivers, EFBs and discipline

6 Takeaways

A preflight ADS-B checklist

SECTION 01

HOW ADS-B WORKS

Out and In, and the two links: 1090ES and 978 UAT

WHAT THE LETTERS MEAN

A Automatic

Transmits about once per second with no radar interrogation and no pilot action.

D Dependent

Position comes from your own GPS. If the GPS source is degraded, so is your ADS-B.

S Surveillance

ATC and other aircraft use it to track you, including where radar is weak or absent.

B Broadcast

Anyone with a receiver hears it: ground stations, other aircraft and flight-tracking sites.

ADS-B OUT AND ADS-B IN

1 Out: what you send

Required in the rule airspace.

- GPS position and velocity
- Pressure and GPS altitude
- ICAO address and Flight ID
- Squawk, IDENT, emergency status
- Accuracy and integrity values

2 In: what you receive

Never required. Optional benefits.

- Direct air-to-air from same-link aircraft
- TIS-B: radar targets, rebroadcast
- ADS-R: other-link aircraft, relayed
- FIS-B: weather and NOTAMs (978 only)

Out keeps you legal and visible to ATC. In is what you see. The two are separate boxes or separate functions.

1090ES VS. 978 UAT

	1090ES	978 UAT
Frequency	1090 MHz, shared with transponders	978 MHz, dedicated
Typical box	Mode S transponder with extended squitter	Separate UAT unit beside a transponder
Class A (FL180+)	Required	Not allowed
Below FL180	Allowed	Allowed
FIS-B weather	No	Yes, 978 only
Anonymous mode	No	Yes, VFR without ATC services

HOW EACH TARGET REACHES YOU

1 Same link

Direct, air to air, about once per second. No ground station needed.

2 Other link

Only through ADS-R: a ground station hears one link and rebroadcasts on the other.

3 No ADS-B Out

Only through TIS-B: radar sees its transponder, then a ground station uplinks it.

CAUTION

Two of the three paths depend on a ground station. Lose the uplink and you see only same-link ADS-B Out traffic.

SECTION 02

THE ADS-B OUT RULE

14 CFR 91.225 says where. 91.227 says how well.

WHERE ADS-B OUT IS REQUIRED

Airspace	Vertical limits
Class A (1090ES only)	FL180 and above
Class B and Class C	Surface to the top of the airspace
Mode C veil: 30 NM of listed Class B airports	Surface to 10,000 MSL
Above Class B or C, within its lateral limits	Up to 10,000 MSL
Class E, 48 states and DC	10,000 MSL and above, but not at or below 2,500 AGL
Class E over the Gulf, within 12 NM of the coast	3,000 MSL and above

Not on the list: Class D, Class G, and Class E below 10,000 MSL outside the veil and away from Class B and C.

EQUIPMENT, EXCEPTIONS, ALWAYS ON

1 Which link

Class A: 1090ES (TSO-C166b or c). Elsewhere in the rule airspace: 1090ES or UAT (TSO-C154c or d).

2 No electrical system

Gliders, balloons and similar aircraft may fly in the veil outside and below Class B or C, and in Class E above 10,000 MSL, without Out.

3 Always transmit

If installed, it stays in transmit mode at all times, in the air and on the airport surface, unless ATC directs otherwise.

4 Deviations

Not equipped: ask ATC at least 1 hour before.
Equipment inoperative: ask at any time. See AC 90-114.

91.227: HOW GOOD IT MUST BE

< 0.05 NM	< 0.2 NM	1 per sec	≤ 2.0 s
NACp: position accuracy	**NIC:** integrity containment	Position and velocity while airborne	Total position latency

Also required: NACv under 10 m/s, SIL $\leq 1\times10^{-7}$ and SDA $\leq 1\times10^{-5}$. In practice that means an approved, integrity-monitored GPS position source, usually WAAS.

Why you care: TIS-B “client” status depends on these same quality values.

WHAT THE RULE DOES NOT DO

CAUTION

Compliance is not coverage.

The rule makes some aircraft transmit in some airspace. It never requires ADS-B In, and it does not reach Class D, Class G or most Class E below 10,000 MSL, where most training happens.

1 Expect unequipped traffic

Legally, outside the rule airspace, with no ADS-B Out at all.

2 Some have no transponder

Those will not appear even as TIS-B targets.

SECTION 03

BROADCAST SERVICES

TIS-B, ADS-R and FIS-B: what the ground stations send you

TIS-B: RADAR TRAFFIC, UPLINKED

Ground stations take radar and multilateration targets of aircraft that are not on ADS-B and broadcast them to nearby ADS-B users. Available at or below FL240.

To receive it, all three must be true:

1 Equipped

ADS-B transmitter and receiver, plus a traffic display.

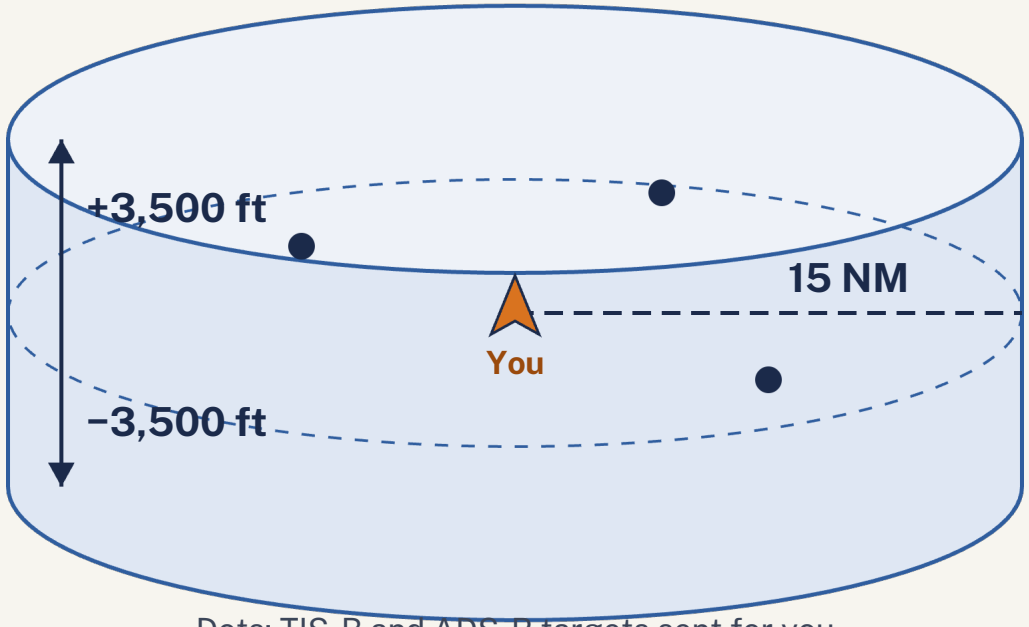
2 Ground station

Within range of one that sends TIS-B. Not all of them do.

3 Radar sees you

Detected by at least one ATC radar serving that station.

THE HOCKEY PUCK



Dots: TIS-B and ADS-R targets sent for you

1 15 NM radius

Centered on you, moving with you.

2 ±3,500 feet

Above and below your altitude.

3 Clients only

Your Out must meet minimum quality (NACp, NIC and others). Receiver-only aircraft see only other clients' pucks.

TIS-B LIMITATIONS

1 Slower updates

Every 3 to 13 seconds, depending on the radar, versus about 1 second for ADS-B. Targets jump.

2 Shadows and ghosts

Duplicate symbols when radar and ADS-B don’t correlate. A target of yourself when maneuvering.

3 Transponders only

No transponder, no TIS-B target. Radar siting can also limit coverage low, near some airports.

4 No warning

Nothing tells you when you leave the TIS-B service volume. An empty screen looks like an empty sky.

ADS-R: BRIDGING THE TWO LINKS

1 What it does

A ground station hears 1090ES and rebroadcasts it on 978, and the reverse, so a single-link receiver sees both.

2 When it works

In ADS-B coverage, at or below FL240, and only when a client on the other link is in the vicinity.

3 On the surface

At some airports, same-link rebroadcast fills gaps where buildings block air-to-air signals.

CAUTION

A 978-only receiver hears a 1090ES airliner only when a ground station relays it, and only inside your puck.

FIS-B: FREE WEATHER ON 978

1 978 UAT only

A 1090-only receiver gets no FIS-B. No ADS-B Out is needed to receive it.

2 Line of sight

Received only within range and line of sight of a transmitting ground station.

3 Ceiling FL240

Often receivable higher. Most products stop near FL240; winds and temperatures aloft go to FL390.

4 Advisory only

For long- and near-term planning. Not a replacement for a preflight briefing or for ATC and Flight Service.

FIS-B PRODUCTS AND THEIR TIMING

Update: how often the source makes a new product. **Transmission:** how long it can take to reach you, and how often it repeats.

Product	Update	Transmission
NEXRAD, regional	2 min	2.5 min
NEXRAD, CONUS	2 min	15 min
METAR / SPECI	1 min where available	5 min
TAF / amendments	6 h	10 min
Winds and temperatures aloft	12 h	10 min
PIREP	As available	10 min
AIRMET, SIGMET, convective SIGMET	As available	5 min
NOTAM-D/FDC and TFR	As available	10 min
Lightning	5 min	5 min
Icing forecast (FIP)	60 min	15 min

SECTION 04

BLIND SPOTS

What pilots overlook, misread or never set up

NEXRAD MOSAIC LATENCY

WARNING

The radar is older than it says.

The age on the display is when the mosaic image was built, not when the radar saw the storm. Plan on the picture being 5 to 15+ minutes older than its timestamp.

Always

older than the age label

15–20 min

extra age possible in extreme cases

15 min

CONUS mosaic transmission interval

STRATEGIC, NOT TACTICAL

1 Tactical: under 3 minutes

Picking a path through or between cells.

FIS-B NEXRAD: not appropriate.

2 Strategic: 20+ minutes

Choosing a route that avoids the whole area.

FIS-B NEXRAD: this is its job.

BEST PRACTICE

Use it to stay far away. Keep severe storms at least 20 miles off, and confirm with ATC, Flight Service and your own eyes.

TRAFFIC YOU WILL NOT SEE

1 No transponder

Gliders, balloons, ultralights, some antiques. Not on ADS-B or TIS-B.

2 No radar

Transponder only and outside radar coverage: no TIS-B target.

3 Outside the puck

Beyond 15 NM or ±3,500 ft of a client: not sent.

4 Not a client

Receiver only: you see what other clients' pucks happen to cover.

5 No ADS-R relay

Other-link traffic with no ground relay is invisible to a single-band box.

6 Above FL240

TIS-B and ADS-R service ends at FL240.

GROUND STATIONS NEED LINE OF SIGHT

1 Radio line of sight

FIS-B, TIS-B and ADS-R come from ground stations. Terrain, low altitude and the ramp can block them.

2 Radar, too

TIS-B also needs radar to see the target. Radar siting leaves low-altitude gaps near some airports.

CAUTION

No uplink looks like no traffic.

In valleys, in hilly terrain and in the pattern at low altitude, you may get no uplink at all. Check how many ground stations your receiver hears before you rely on it.

CONFIGURATION ERRORS

1 Flight ID

Up to 7 characters. Must match the aircraft ID on your flight plan, or ATC gets a call sign mismatch and services may be delayed.

2 ICAO address

The 24-bit code is set at installation. A wrong or duplicate address can lose your track where there is no radar.

3 Squawk and altitude

Mode A code and pressure altitude go out in ADS-B too. An encoder failure means loss of ATC altitude services.

BEST PRACTICE

After avionics work, a re-registration or a new aircraft, request the FAA's free Public ADS-B Performance Report (PAPR) to confirm what you transmit.

UAT ANONYMOUS MODE

CAUTION

Anonymous means no ATC services.

A UAT box can broadcast a random 24-bit address instead of yours. You stay compliant, but you give up flight following and may lose ADS-B search-and-rescue benefits.

1 Allowed only when

No IFR flight plan, no ATC services requested, squawking 1200.

2 Turn it off

Before you call ATC for any service, and before an IFR flight.

NOTAM AND TFR GAPS

1 30-day window

NOTAM-D and FDC are sent only if issued or effective in the past 30 days. Older ones, except TFRs, are not.

2 100 NM look-ahead

NOTAM products cover about 100 NM around you and repeat every 10 minutes.

3 Advisory only

For situational awareness, not navigation. Stay well clear of any TFR shown.

4 Not guaranteed complete

No TFR on the screen is not proof there is none. Verify with Flight Service or ATC.

EVERY PRODUCT HAS AN AGE

1 Read the time

Each product carries its own time. Radar, METARs and PIREPs age at different rates.

2 Know the cycle

TAFs update every 6 hours, winds aloft every 12. Received recently is not issued recently.

3 Watch for stale

Lose the uplink and old products can stay on screen. When they expire depends on your avionics or EFB.

BEST PRACTICE

Before you act on any product, ask two questions: how old is it, and when will it update next?

SECTION 05

IN THE COCKPIT

Receivers, EFB integration and the discipline to look outside

RECEIVERS: PORTABLE OR INSTALLED

1 Portable receiver

Units such as ForeFlight Sentry or Stratux connect to the EFB over Wi-Fi or Bluetooth. Many add GPS and attitude data.

Without your own qualifying Out, the traffic picture is partial.

2 Installed ADS-B In

Feeds a panel display, and often an EFB too. Paired with your own compliant Out, you are a client with a full puck.

CAUTION

Single band, half the picture. 978-only misses direct 1090ES traffic. 1090-only gets no FIS-B weather. Choose dual-band.

SETTING UP THE EFB

1 Confirm the link

Check the device status page (in ForeFlight, Devices) for connection, GPS and ADS-B reception.

2 Filter ownship

Enter your aircraft's ICAO or Mode S code where the app allows, so you don't show as traffic.

3 Know your filters

Altitude filters cut clutter. Know what band you are hiding.

4 Show data age

Keep weather age labels on, and read them every time.

5 Know the source

Internet data downloaded on the ground is not FIS-B. In flight, it stops updating.

6 Use audio alerts

Let traffic callouts bring your eyes outside instead of down.

HEADS UP, EYES OUT

WARNING

ADS-B traffic is not collision avoidance.

It only helps you spot traffic. It does not relieve you of see-and-avoid, and no avoidance maneuver is authorized from a displayed target alone, especially in IMC.

1 The heads-down trap

Zooming, panning and layering weather keep your eyes inside. Too much information adds workload.

2 Glance, then look

Note bearing, distance and altitude, then find the airplane outside. Report it in sight only when you see it.

PREFLIGHT ADS-B CHECK

BEST PRACTICE

- Official briefing, NOTAMs and TFRs first
- Flight ID matches the flight plan
- Anonymous mode off if using ATC
- Squawk set, altitude reporting on
- Receiver connected, GPS source correct
- Ownship filtered, filters known
- Ground stations heard, weather updating
- Weather age labels on
- Low-altitude gaps briefed for the route
- Plan to look outside, not down

KEY TAKEAWAYS

WRAP-UP

1 Old radar

Treat FIS-B NEXRAD as 5 to 15+ minutes old. Strategic use only.

2 Missing traffic

An empty screen is not an empty sky.

3 The puck

TIS-B and ADS-R: 15 NM, ±3,500 ft, clients only, FL240 and below.

4 Line of sight

Low and in terrain, uplinks can disappear without warning.

5 Setup

Correct Flight ID and ICAO address. Anonymous off for ATC.

6 Eyes outside

ADS-B helps you find traffic. You still see and avoid.

REFERENCES

QUESTIONS?

- **AIM 4-5-7 to 4-5-10:** ADS-B, TIS-B, FIS-B and ADS-R; Table 4-5-9, FIS-B intervals
- **AIM 7-1:** Flight Information Services, FIS-B, thunderstorm flying
- **14 CFR 91.225 and 91.227:** ADS-B Out airspace, equipment and performance
- **FAA ADS-B website:** ADS-B In pilot applications (TIS-B, ADS-R, FIS-B)
- **AC 00-63:** Use of Cockpit Displays of Digital Weather and Aeronautical Information
- **AC 90-114:** ADS-B Operations
- **NTSB Safety Alert SA-017:** In-cockpit NEXRAD mosaic imagery

Always check the current editions. Your avionics and EFB guides cover the exact displays.

Special Announcement

Initial CFI Airplane 7-Day Courses

AI Class – Nov 9 – 11am to 5pm EDT

Nov 9 – 15 (11am – 6pm EST – Remote via Zoom)

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Register Here

Sample - Course Syllabus – Hour by Hour Here



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Special Announcement

Using AI as a Teacher and a Learner

Recording and Summarizing Audio from Class and the Airplane

How to create quizzes, workbooks, flashcards

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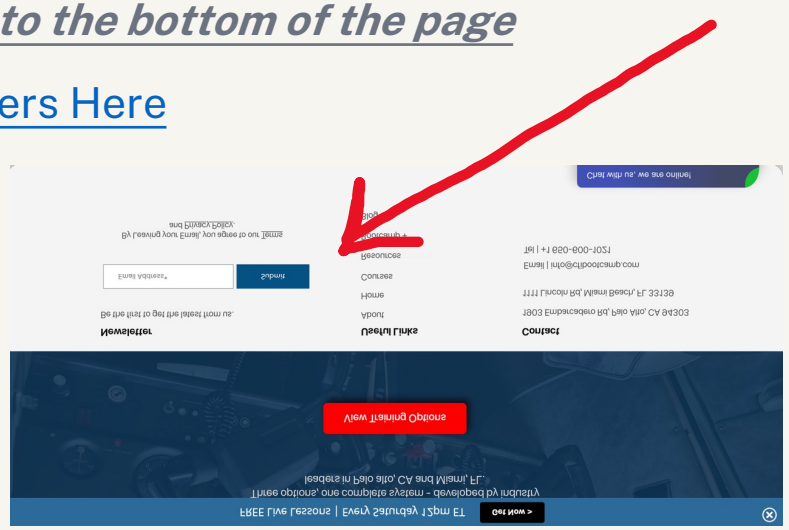
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