

FAMILY KIT - FOR THE PARENT

How to explain the talking planes to a child

This page gives you the understanding, not just the script. Each chapter explains an idea properly, then shows the picture of it a child of 5 to 12 can hold, why that picture is honest, where it breaks, and the kitchen-table demonstration that makes it real. Read it once on your own; the child's page then does the telling.

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Why this subject works so well with children

Children between five and twelve are natural detectives of the invisible. They already accept that a phone "talks" to a tower they cannot see, that a remote control "sends" something to the television, that the moon pulls the sea. What they lack is not the willingness to believe in invisible things but a picture of how those things work, and they can tell the difference between a real explanation and "it's just magic" with surprising accuracy. ADS-B gives you a chain of five ideas, each of which has a concrete, honest picture a child can hold, and each of which can be demonstrated at home with a rope, a torch and a phone.

The guiding principle on this page is that a simplification must be a true thing said simply, not a false thing said comfortingly. "Radio is a light your eyes cannot see" is simplified but true, and a physicist would nod. "Radio is a special kind of sound" is simple and false, and will have to be unlearned at fourteen. Every analogy below is marked with where it holds and where it breaks, so that you can say "it's a bit like..." with confidence and "but not exactly, because..." when your child pushes.

Depth by age

With a 5- to 7-year-old, chapters 1, 3, 4 and 6 are plenty, told as a story, and the demonstrations are the point. With an 8- to 12-year-old, go through all six; they will want the numbers (twice a second, 300 000 km per second, 400 km) and the "why", and you can let them run the live map themselves. If you want the full adult explanation behind any chapter, the reference course covers it at length.

CHAPTER 1

The busy sky, and why someone has to keep track

The idea. On a normal day around 30 000 flights cross Europe. Over a Belgian town, there is nearly always at least one airliner in the sky, usually several, and almost all of them are far too high to see clearly: ten kilometres up, where the air is thin and cold and the aircraft show only as a glint or a white line. They fly at about 900 km/h, which is 250 metres every second, and they cannot see each other any better than we can see them. So somebody on the ground has to know where every one of them is, all the time, to keep them apart. That job is called air traffic control, and the whole question of the course is: how do they know?

The child's picture. The sky is a motorway with no road painted on it and no lines between the lanes, and the cars on it are going faster than anything on the ground and cannot see each other. Someone has to be the lollipop lady for the whole sky. Children find this genuinely exciting once they realise how many aircraft are up there; the surprise is the hook for everything after.

Where it holds and where it breaks. The motorway picture is good for "fast, many, must be kept apart". It is misleading if the child concludes aircraft follow painted routes close together; in fact they are kept at least 300 metres apart vertically and several kilometres horizontally, which is why collisions are so rare. Say "the rule is they must never be closer than three football pitches stacked on top of each other".

At home: the five-minute count

Stand at a window or in the garden for five minutes, looking and listening. Mark each aircraft you see or hear. Then open the live map on your phone, zoom to your town, and compare: nearly always there are several more than you noticed. The gap between what the eye catches and what the map shows is the lesson: the sky is far busier than it looks, and somebody can see all of it. Keep the count; you will use it again in chapter 6.

CHAPTER 2

How the plane knows where it is: thunder, lightning and satellites

The idea. The clever twist of ADS-B is that the ground does not have to find the plane: the plane already knows where it is and simply says so. It knows because of navigation satellites, about thirty of them circling the Earth 20 000 km up, each with a very accurate clock, each endlessly calling out "I am satellite number 12, and the time is exactly...". Radio takes a little while to come down from that height, about seven hundredths of a second, so the plane hears each satellite's time slightly late. How late tells it how far away that satellite is. From four satellites, four distances, and there is only one spot in the world that is the right distance from all four: that is where the plane is, to within a few metres.

The child's picture. Thunder and lightning. You see the flash at once, you hear the thunder later, and the longer the gap, the further away the storm: count the seconds and divide by three to get kilometres. The satellite is the lightning, the plane is you counting. Now imagine four storms at once in four directions; if you knew how far each one was, you could work out exactly where you were standing. Children who have counted thunder already own half of this idea.

Where it holds and where it breaks. It holds beautifully for "delay tells distance". It breaks in one place: with thunder, the slow thing (sound) arrives after the fast thing (light), and you compare the two. With satellites there is only one signal, and the plane knows when it was sent because the satellite writes the sending time inside the message, like a letter with the posting time written on it. If your child asks "but how does the plane know when the satellite shouted?", that is the right answer, and a sign they have understood.

At home: the echo game

Stand at opposite ends of a long room or garden. One of you claps; the other raises a hand the instant they hear it. Move closer, move further. Now try with a torch flash instead of a clap: no delay you can notice. That is the difference between sound (slow, 340 m every second) and light or radio (so fast the delay is invisible at home, but satellites are so far away that even light takes a measurable moment). For an older child, add the number: light goes 300 000 km in a second, and the satellite is 20 000 km up, so the delay is about one fifteenth of a second.

CHAPTER 3

The message: what a plane says, and how often

The idea. About twice every second, a small radio on the aircraft, the transponder, sends out a short message without anybody asking it to. The message has four parts: a name (a permanent code every aircraft is given when it is registered, a bit like a number plate, plus the flight's call sign such as "Brussels Airlines 1234"), a position (the satellite position from chapter 2), a height (measured from the air pressure outside, which falls as you climb), and a speed and direction. The message is tiny, 112 yes-or-no answers long, and lasts about one ten-thousandth of a second. At the end of it are 24 extra yes-or-no answers that work like the check digit on a bar code: the listener does a sum on the message, and if the sum does not match the check, something got garbled on the way and the message is thrown away.

The child's picture. A plane is a child walking around a room saying, every half second, "I'm Zoom, I'm by the sofa, I'm up high, I'm going fast". It does not wait to be asked, it does not care who is listening, and it never stops. This is the one picture in the course a child can act out with their whole body, and it is worth doing, because afterwards "the plane sends its message" is not an abstraction but something they have been.

Where it holds and where it breaks. It holds for "automatic, repeated, broadcast to everyone", which are exactly the three properties engineers care about. It breaks on the word "says": the message is not words or sound but a pattern of radio pulses, which is chapter 4. If the child is older, explain the 112 yes-or-no answers: "the plane can't send letters, it can only send yes or no, so it sends 112 of them in a row, and everyone has agreed what each one means. The first twenty-four, together, spell its name." A 10-year-old can be shown that 24 yes-or-no answers give nearly 17 million different names, enough for every aircraft ever built.

A common confusion to head off. Many children (and adults) think the plane is "seen by radar" or "watched by satellites". The satellite does not watch the plane; the plane listens to the satellite, works out where it is, and then tells the ground itself. Radar does exist and is still used, but it works the

opposite way, by bouncing a signal off the plane. The difference is worth stating clearly because it is the whole point of ADS-B: nobody finds the plane, the plane announces itself.

At home: be a plane, then be the tower

The child is the aircraft: arms out, walking around the room, saying the four-part message every few steps. You are the control tower with a sheet of paper, drawing where they are each time they speak. Then swap. Then try it with the child saying the message only once a minute: notice how far they get between messages, and how badly your drawing lags behind. That is why twice a second matters.

CHAPTER 4**Invisible light: what a radio wave actually is**

The idea. The message leaves the aircraft as a radio wave, and a radio wave is light. Not "like" light: the same thing. Light is a ripple of electricity and magnetism travelling through space at 300 000 km every second, and what makes one ripple red, another blue, another a radio wave or an X-ray is only how fast it wiggles. Our eyes happen to be built to notice a narrow band of wiggle-speeds, the colours of the rainbow. Radio wiggles far more slowly than anything our eyes can catch: the aircraft's wave wiggles 1 090 million times a second, which sounds fast until you learn that green light wiggles half a million times faster still. The slow wiggle also means the wave is "long": the distance from one ripple to the next is 27.5 cm, about a school ruler, whereas for green light it is less than a thousandth of a millimetre.

The child's picture. A colour your eyes cannot see. Children accept at once that dogs hear whistles we cannot, and that bees see patterns on flowers we cannot; "radio is a colour we cannot see, but the antenna can" lands in exactly the same place. Then the rope: shake a rope slowly and you get long, lazy waves; shake it fast and you get short, busy ones. Radio is the long lazy kind, light is the short busy kind, and both travel the same speed along the rope.

Where it holds and where it breaks. The rope holds for "wave", "wavelength" and "faster shaking makes shorter waves", which is real physics (the rope's speed is fixed, so frequency times wavelength is constant, exactly as for light). It breaks in that a rope needs the rope: light and radio need nothing, and cross empty space, which is how the satellite's signal reaches the plane. The confusion to avoid above all is radio with sound. Sound is air molecules bumping each other, slow (340 m per second), needing air. Radio is light, nearly a million times faster, needing nothing. The box in the kitchen called "a radio" is really a radio-light catcher that turns the catch into sound, and it is worth saying so.

At home: the rope and the torch

Tie a skipping rope to a door handle. Slow shakes, fast shakes; measure one wave of each with a ruler. Then the torch: switch it on and ask where the light is. Everywhere in the room, instantly. Ask: "if the torch was a radio, could the plane's antenna see it?" Yes, because it is the same stuff. Finally hold up a ruler: "the plane's wave is this long, from one ripple to the next, and it is passing through this room right now, thousands of ripples a second, and we can't see a single one."

CHAPTER 5

Metal ears: antennas, and why the Earth being round matters

The idea. A radio wave passing a piece of metal makes the electricity inside the metal slosh back and forth in time with it. That tiny sloshing is the "hearing". The metal hears best when it is the right size for the wave, a quarter of the ripple-to-ripple distance, which for the aircraft's wave is about 7 cm. That is why the antenna for this is a small stub, and why a wire of the wrong length hears badly: an antenna is a tuned ear, like a swing that only goes high when you push it at its own rhythm. Because radio is light, it goes in straight lines, and because the Earth is round, a straight line from a low antenna soon hits the ground. The higher the antenna, the further the line reaches before the Earth gets in the way: from a roof, an aircraft ten kilometres up can be heard from over 400 km away, further than Brussels to Paris and back. Beyond that, it is below the horizon and silent, however strong the signal.

The child's picture. Two pictures. The antenna is a metal ear, and like a real ear it has a size that suits certain sounds (a child knows a dog's big ears and a mouse's small ones hear different things). And the horizon is standing on a chair to see over a crowd: the Earth is a very big ball, and the higher you are, the further over its curve you can see. A ship's mast, a lighthouse, a lookout up a tree are all the same idea, and children have usually met one of them in a story.

Where it holds and where it breaks. The ear picture holds for "catches the wave, tuned to a size". It breaks in that an ear is also where hearing happens, whereas an antenna only catches: the actual decoding happens in a receiver and a computer, which is chapter 6's business. The chair picture is close to exact; the only refinement, for an older child, is that the air bends radio very slightly downward, so the radio horizon is a little further than the one you see.

At home: the antenna hunt and the horizon walk

Find the antennas: the Wi-Fi box (its stubs, or hidden inside), the car's fin, the phone (hidden inside its edge), a radio, the roof. Notice how many are up high, and ask why. Then go somewhere with a view: a child crouching, then standing, then on your shoulders sees a little further each time. Explain that the plane's antenna on the roof of a house is doing the same thing, and that a plane far away is "hiding behind the round Earth" until it climbs high enough to peep over.

CHAPTER 6

The map: many ears make one picture

The idea. One antenna hears a circle of sky a few hundred kilometres across. Nobody can hear all of Europe from one roof, so the map is built from hundreds of antennas, on houses, airports and schools, each sending what it hears over the internet to one place, where a computer joins the pieces: the same aircraft is usually heard by ten or twenty antennas at once, and the computer notices it is the same one. The result is the live map: every aircraft that is talking, where it is, how high, how fast, updated every second. The ground never measured any of it; the aircraft said it, the antennas listened, and the computer put the pieces together. Air traffic controllers see much the same picture, with radar added on top as a second opinion.

The child's picture. A jigsaw. Each antenna holds one piece, a circle of sky; put all the circles together and you have the whole picture, with the pieces overlapping at the edges. Or a game of Chinese whispers in reverse: instead of one message being passed along and garbled, hundreds of listeners each report what they heard, and the ones who heard the same thing confirm each other.

Where it holds and where it breaks. The jigsaw is close to exact for coverage. Where the picture needs a caution is "every plane": only aircraft that are talking appear. Airliners nearly all do; small private planes, gliders and many military aircraft may not, and an aircraft whose satellite receiver is jammed talks nonsense. So the map is honest but not complete, and that is a good thing for a child to know about any map.

At home: find your plane

Open the live map, zoom to your house, and wait for an aircraft to pass overhead. Find it on the map and tap it: the name, the height, the speed, where it came from and where it is going. Then look up at the glint and say: "that one is saying its message right now, twice a second, and someone's antenna caught it, and that is why we can see it on the map." Compare with the count from chapter 1. Finish with the question that tests the whole chain: "what would happen if that plane stopped talking?" (It would vanish from the map, though the controllers would still have radar.)

Questions children ask, and honest answers

These are the questions that come up most often, and each deserves a real answer rather than a reassuring one, because each is a sign the child is testing the model you have given them.

"Can the plane hear me if I shout?" No, and the reason is the whole of chapter 4: a shout is sound, a ripple in the air that dies out within a few hundred metres, while the plane's radio listens only for the invisible light of satellites and of other planes. It is worth adding that nothing in your house talks to the plane either. The map works entirely by listening.

"Does the pilot press a button to send the message?" No. The transponder sends it by itself, twice every second, from the moment the aircraft starts moving until it is parked, and the pilot could not stop it without switching the transponder off, which is forbidden in flight. This is the "automatic" in the system's name, and the reason the map never has gaps while an aircraft is in range.

"Can the plane see us on the map too?" It cannot see houses or people. But it can hear the messages of the other planes around it, and in a modern airliner those appear on a screen in the cockpit, so the pilots see the same picture the controllers see and can keep away from each other even if the ground were silent. The planes, in other words, are listening to each other as well as talking.

"Why can't I see the wave?" Because eyes are only built for light that wiggles extremely fast, the colours of the rainbow, and radio wiggles far too slowly for them, though still over a thousand million times a second. The antenna is a different kind of eye, built for exactly that slow wiggle. A good follow-up is to point out that the child cannot see the Wi-Fi in the house either, and that the same answer applies.

"What if two planes talk at the same time?" Their messages can overlap at the antenna and get garbled, and over a busy airport this happens constantly. That is exactly why every message ends with the 24-answer check from chapter 3: a garbled message fails the check and is thrown away, and since each plane repeats itself half a second later, nothing is lost for long. For an older child this is a nice example of why the message is built the way it is.

"Is it allowed to listen?" Yes. The plane is announcing itself to everyone on purpose, so that other planes and the people on the ground can hear it, and listening to a broadcast harms no one. Sending anything on the planes' frequency is a different matter, and strictly forbidden, which is why nothing in this course transmits.

NEXT

The last chapter is a real receiver

The story ends best with the real thing on the window ledge. The hands-on workshop lists exactly what to buy (about 100 to 150 euros), shows how to put it together with a child, how to prepare the small computer and install the Dataero feeder, and how, an hour later, the planes your own antenna hears appear on the live map with your family's station named as the source. A child who has watched the dot that is 'our plane' appear on the map does not forget how it got there.

Open the hands-on workshop <https://radar.dataero.eu/learning/workshop>