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**Radars. Operating Principles and Applications**

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Imagine trying to land a jumbo jet the size of a large building on a short strip of tarmac, in the middle of a city, in the depth of the night, in thick fog. If you can't see where you're going, how can you hope to land safely? Airplane pilots get around this difficulty using radar, a way of "seeing" that uses high-frequency radio waves. Radar was originally developed to detect enemy aircraft during World War II, but it is now widely used in everything from police speed-detector guns to weather forecasting [1].

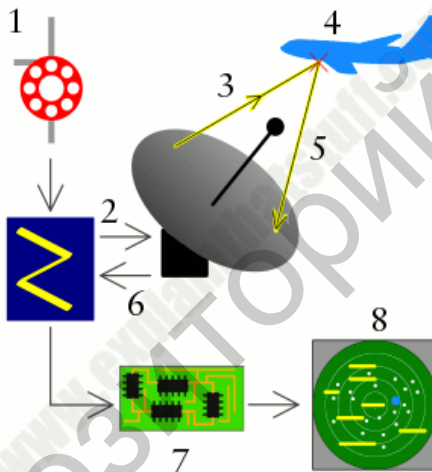
We can see objects in the world around us because light (usually from the Sun) reflects off them into our eyes. If you want to walk at night, you can shine a torch in front to see where you're going. The light beam travels out from the torch, reflects off objects in front of you, and bounces back into your eyes. Your brain instantly computes what this means: it tells you how far away objects are and makes your body move so you don't trip over things. Radar works in much the same way. The word "radar" stands for radio detection and ranging [2] – and that gives a pretty big clue as to what it does and how it works.

An airplane's radar is a bit like a torch that uses radio waves instead of light. The plane transmits an intermittent radar beam (so it sends a signal only part of the time) and, for the rest of the time, "listens" out for any reflections of that beam from nearby objects. If reflections are detected, the plane knows something is nearby – and it can use the time taken for

the reflections to arrive to figure out how far away it is. In other words, radar is a bit like the echolocation system that "blind" bats use to see and fly in the dark.

Whether it's mounted on a plane, a ship, or anything else, a radar set needs the same basic set of components: something to generate radio waves, something to send them out into space, something to receive them, and some means of displaying information so the radar operator can quickly understand it.

Here's a summary of how radar works [1]:



Magnetron generates high-frequency radio waves.

Duplexer switches magnetron through to antenna.

Antenna acts as transmitter, sending narrow beam of radio waves through the air.

Radio waves hit enemy airplane and reflect back.

Antenna picks up reflected waves during a break between transmissions. Note that the same antenna acts as both transmitter and receiver, alternately sending out radio waves and receiving them.

Duplexer switches antenna through to receiver unit.

Computer in receiver unit processes reflected waves and draws them on a TV screen.

Enemy plane shows up on TV radar display with any other nearby targets.

Radar is still most familiar as a military technology. Radar antennas mounted at airports or other ground stations can be used to detect approaching enemy airplanes or missiles, for example. The United States has a very elaborate Ballistic Missile Early Warning System (BMEWS) to detect incoming missiles, with three major radar detector stations in Clear in Alaska, Thule in Greenland, and Fylingdales Moor in England. It's not just the military who use radar, however. Most civilian airplanes and larger boats and ships now have radar too as a general aid to navigation. Every major airport has a huge radar scanning dish to help air traffic controllers guide planes in and out, whatever the weather. Next time you head for an airport, look out for the rotating radar dish mounted on or near the control tower [3].

You may have seen police officers using radar guns by the roadside to detect people who are driving too fast. These are based on a slightly different technology called Doppler radar. You've probably noticed that a fire engine's siren seems to drop in pitch as it screams past. As the engine drives toward you, the sound waves from its siren arrive more often because the speed of the vehicle makes them travel a bit faster. When the engine drives away from you, the vehicle's speed works the opposite way – making the sound waves travel slower and arrive less often. So you hear quite a noticeable drop in the siren's pitch at the exact moment when it passes by. This is called the Doppler effect.

The same science is at work in a radar speed gun. When a police officer fires a radar beam at your car, the metal bodywork reflects the beam straight back. But the faster your

car is traveling, the more it will change the frequency of the radio waves in the beam. Sensitive electronic equipment in the radar gun uses this information to calculate how fast your car is going.

Radar has many scientific uses. Doppler radar is also used in weather forecasting to figure out how fast storms are moving and when they are likely to arrive in particular towns and cities. Effectively, the weather forecasters fire out radar beams into clouds and use the reflected beams to measure how quickly the rain is traveling and how fast it's falling. Scientists use a form of visible radar called lidar (light detection and ranging) to measure air pollution with lasers. Archeologists and geologists point radar down into the ground to study the composition of the Earth and find buried deposits of historical interest. One place radar isn't used is on board submarines. Electromagnetic waves don't travel readily through dense seawater (that's why it's dark in the deep ocean). Instead, submarines use a very similar system called SONAR (Sound Navigation And Ranging), which uses sound to "see" objects instead of radio waves [1].

#### References:

1. Mode of access:

<http://www.explainthatstuff.com/radar.html>. – Date of access: 26.02.2017

2. Mode of access:

<https://www.reference.com/science/radar-used-0d8c28fc9e7bf>.  
– Date of access: 01.01.2017

3. Mode of access:

<http://searchmobilecomputing.techtarget.com/definition/radar>.  
– Date of access: 26.02.2017