VOR line of sight reception distance calculations come up often on the exams, and often people struggle with this. There are three possible scenarios that can be presented to you. Let's have a look at all three scenarios so that you know how to deal with them.

Firstly, you need to know that the VOR transmits signals using VHF frequencies. VHF signals travel in straight lines. That means that if you can draw a straight line from the transmitter (ground station) to the receiver (aircraft) then you should be able to receive the signal.

Secondly, you need to know that the Earth is NOT flat, it is generally spherical (this shouldn't be a surprise!) with all sorts of topographical features that can interrupt or block a radio signal that can only travel in a straight line.

Even without topographic features, as you travel away from the VOR you eventually get to a point where the curvature of the Earth will block the signal. This is the maximum line of sight distance, and defines the maximum range at which you can receive VHF signals. You can calculate this distance using the formula below:

$$\textbf{Aircraft line-of-sight [nm]} = \mathbf{1.25} \times \sqrt{\textbf{aircraft\_height [ft]}}$$

Note:
The formula presented here uses a multiplier of 1.25 and gives a result in nautical miles. This formula is used by Transport Canada in its exams.

In reality, the actual reception distance is a bit less, with the correct formula using a multiplier of 1.23 and the result in statute miles. In addition, weak VOR station signal, receiver sensitivity and obstructions may further reduce the reception distance.

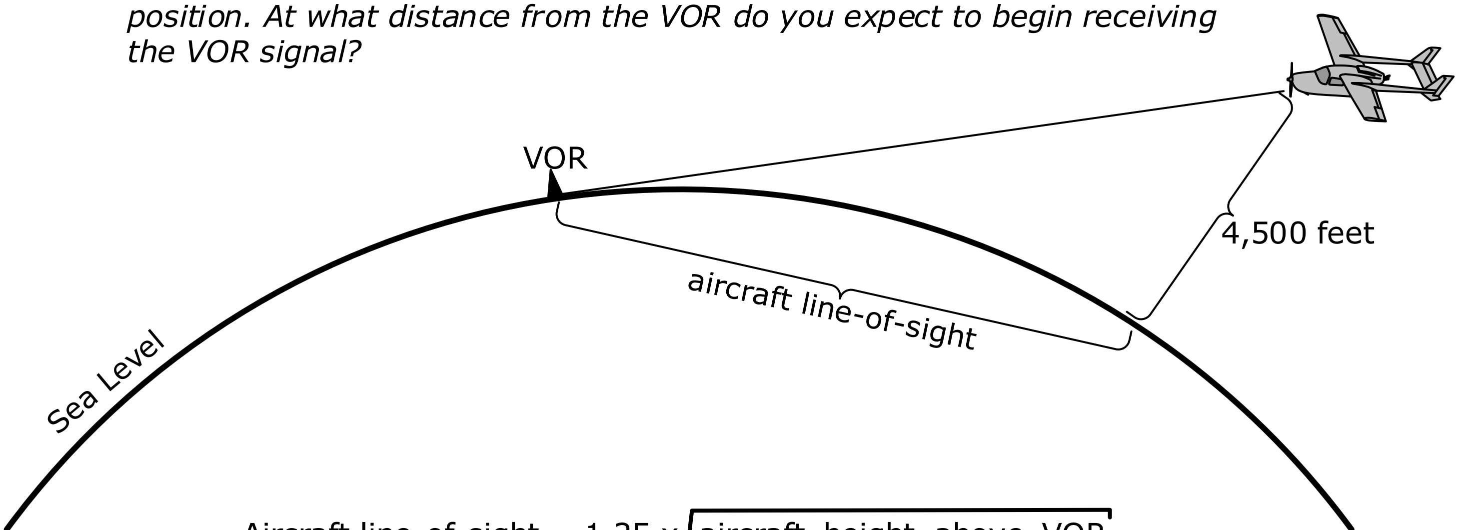
Scenario 1: VOR at Sea Level

In this scenario, the VOR is installed at sea level with flat terrain between your position and the VOR.

The difference in height between your aircraft and the VOR is what you enter into the formula to determine reception range.

The question is often worded something like this:

You are flying at 4,500 ft and try to tune into the ABC VOR to check your position. At what distance from the VOR do you expect to begin receiving the VOR signal?



$$\text{Aircraft line-of-sight} = 1.25 \times \sqrt{\text{aircraft\_height\_above\_VOR}}$$

$$= 1.25 \times \sqrt{4{,}500 \text{ ft}}$$

$$= 83.9 \text{ nm}$$

The maximum reception distance is **83.9 nm**

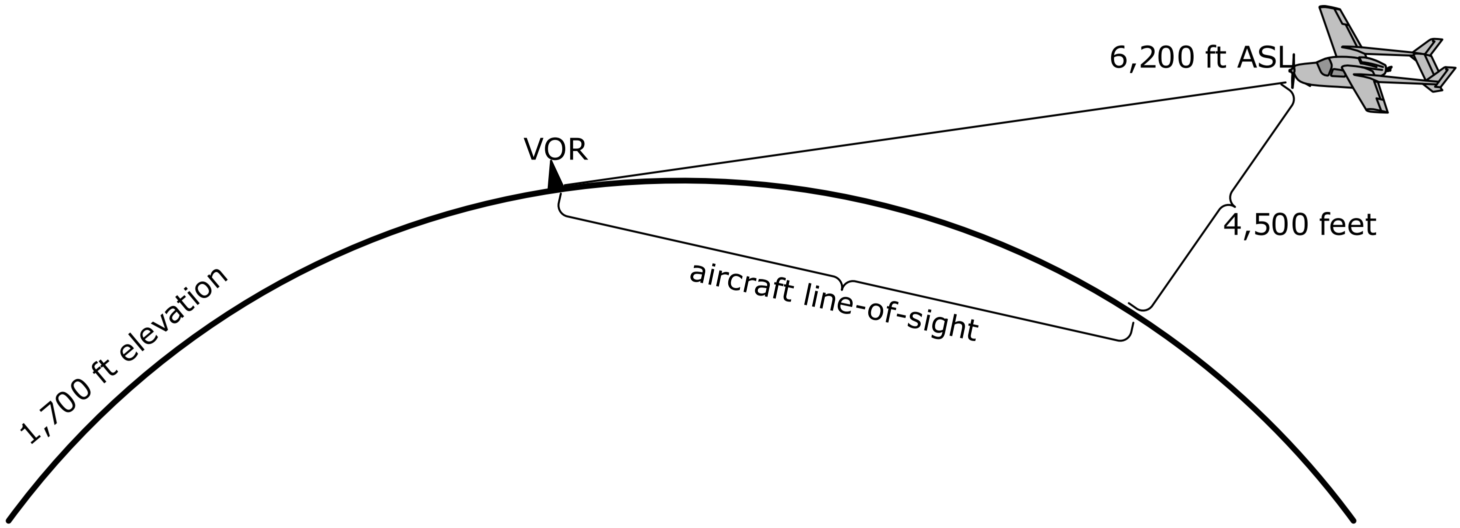
Scenario 2: VOR in high elevation, flat terrain

In this scenario, the VOR is installed at an elevation with flat terrain between your position and the VOR.

The difference in height between your aircraft and the VOR, which is actually just your height above the ground, is what you enter into the formula to determine reception range.

The question is often worded something like this:

You are flying at 6,200 ft ASL and try to tune into the ABC VOR (elevation 1,700 ft) to check your position. At what distance from the VOR do you expect to begin receiving the VOR signal?



$$\text{Aircraft\_height\_above\_VOR} = \text{aircraft\_altitude\_ASL} - \text{VOR\_elevation}$$
$$= 6{,}200 \text{ ft} - 1{,}700 \text{ ft}$$
$$= 4{,}500 \text{ ft}$$

$$\text{Aircraft line-of-sight} = 1.25 \times \sqrt{\text{aircraft\_height\_above\_VOR}}$$
$$= 1.25 \times \sqrt{4500 \text{ ft}}$$
$$= 83.9 \text{ nm}$$

The maximum reception distance is **83.9 nm**

Notice that if the VOR station is NOT on a mountain (and there are no other obstructions), then the only part that impacts your maximum line of sight reception distance is the <u>difference</u> between your altitude and the VOR's elevation.

Very Important!
A common mistake is to just use the aircraft altitude and to not consider the VOR elevation. This would give you 98.4 nm if you used 6,200 ft in the equation, and this will probably appear as one of the multiple choice answers on the exam, but this answer is INCORRECT! Take your time, draw a sketch of the situation and don't get tricked into selecting an incorrect answer!

Scenario 3: VOR on top of a mountain

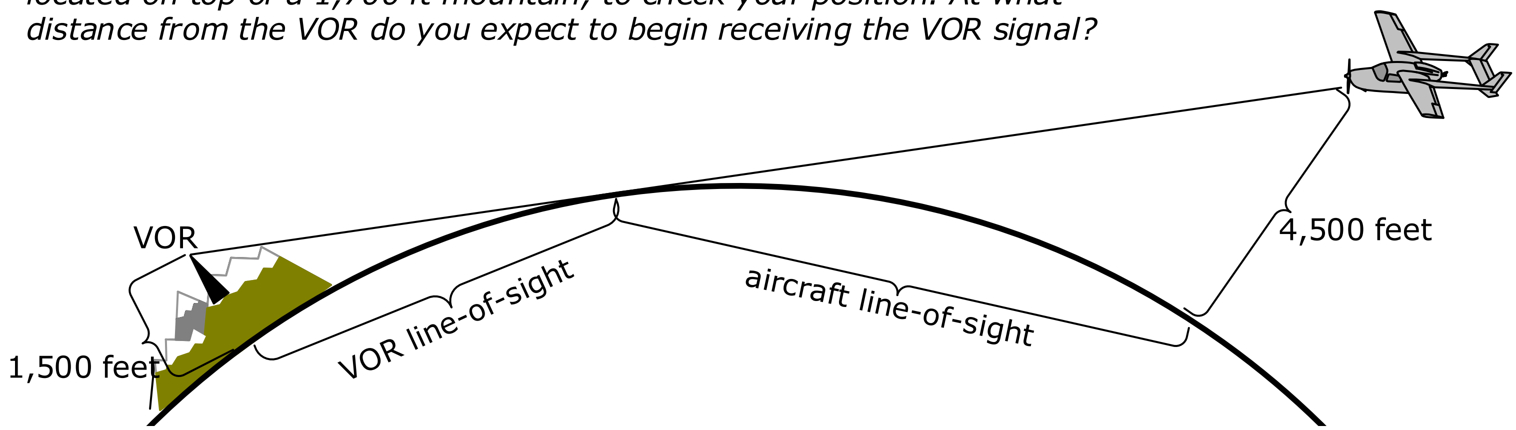
In this scenario, the VOR is installed at some height above the surrounding terrain, usually on a mountain top.

This is different to the previous example, because the higher the VOR is mounted, the greater the line of sight range. Take your time and sketch out the problem.

The question is often worded something like this:

Normally the elevation of the terrain between your aircraft and the VOR is not mentioned in the question. In this case just assume sea level terrain

You are flying at 4,500 ft and try to tune into the ABC VOR, which is located on top of a 1,700 ft mountain, to check your position. At what distance from the VOR do you expect to begin receiving the VOR signal?



The VOR operates on VHF frequencies, whose maximum reception range is line-of-sight. However, if the radio waves just skim over the surface of the earth then they continue to propagate as shown in the diagram above.

This means that you need to calculate the maximum line-of-sight distance from the VOR, and add to it the maximum line-of-sight distance from the aircraft (using the normal formula). This is shown below;

$$\text{VOR\_line\_of\_sight} = 1.25 \times \sqrt{\text{VOR\_height}}$$
$$= 1.25 \times \sqrt{1{,}500 \text{ ft}}$$
$$= 48.4 \text{ nm}$$

$$\text{Aircraft\_line-of-sight} = 1.25 \times \sqrt{\text{aircraft\_height\_above\_VOR}}$$
$$= 1.25 \times \sqrt{4{,}500 \text{ ft}}$$
$$= 83.9 \text{ nm}$$

$$\text{Maximum\_reception\_distance} = \text{VOR\_line\_of\_sight} + \text{Aircraft\_line\_of\_sight}$$
$$= 48.4 \text{ nm} + 83.9 \text{ nm}$$
$$= 132.3 \text{ nm}$$

The maximum reception distance is **132.3 nm**

Very Important!
A common mistake is to use the difference between the aircraft height and the VOR height, like you would do in flat terrain. In this example, you would get an incorrect answer of 68.5 nm!