Zoom Performance

How far can I see?

"How far can your cameras see?" is a request we receive daily. The problem with this question is that it requires more information in order to provide a useful answer.

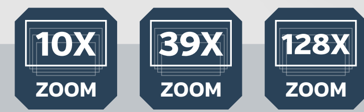
To help explain, here is the "technically correct" (but not very helpful) answer to how far our cameras can see: Over 150 million kilometers. This is because cameras are a passive detector of light, which means the ability to see an object depends on light from that object reaching the camera, not the camera reaching the light. If there is enough light hitting the camera's sensor, it can "see" it. So while a scene lit by candlelight may not be visible from 1 kilometre away (because not enough light is reaching the sensor), the sun is clearly visible from a much farther distance of 150 million kilometres away, because it puts out a lot more light.

Now, obviously our customers aren't asking for a camera that can see the sun. When someone requires a camera to "see" a certain distance, they will have a specific situation in mind. One inquirer may want to recognize a person's face from 5km away, while another needs to see an oil tanker at that distance. These two scenarios require very different levels of performance. The context is different for everyone, and a different camera is often required for each scenario.

More information is needed to determine the best solution

There are a number of aspects that play into this type of request. The information required to determine the ideal camera starts with what the customer needs to see. Is it a person, a vehicle, a license plate? How large is the object, and how much detail is needed? We also need to know the details of the environment. How far away is the object? What are the lighting conditions? What are the atmospheric conditions? How high is the camera going to be mounted? All of these factors will affect camera performance.

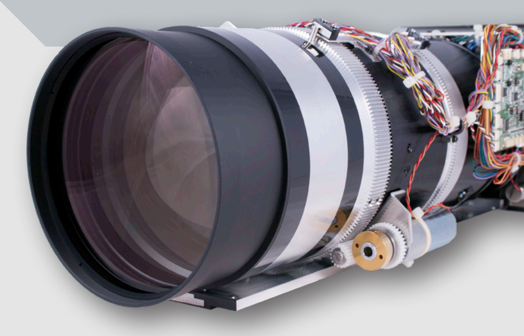
The two main specifications in a camera that affect "zoom" performance are field of view (determined by lens size and sensor size) and resolution. Other factors (such as lens brightness and sensor sensitivity) will affect image clarity and visibility, but for this paper we will focus on the factors specifically related to zoom performance.



The X number does not determine how far a camera can see

When a camera's zoom range is displayed as "10X" or "39X", this is communicating the wide to narrow ratio of a camera's zoom capabilities. These numbers do not tell us how small a field of view the camera will have. In other words, the "X" numbers are not measurements of how "far" it can see and can not be used to calculate this information.

For example, a lens with a zoom range of 5mm to 500mm would be a 100X lens, because it can zoom to 100 times its widest focal point. Yet a lens that measures 500mm to 1000mm would only be a 2X lens, even though it "sees" twice as far as the 5-500mm lens does.



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As mentioned on the previous page, the measurements that determine the “zoom” performance and detail of a camera are angle of view and resolution. These two measurements combine to form the pixels per metre (PPM). We’ve found that this is the simplest and most useful measurement to use when comparing how far cameras can see.

Field of View

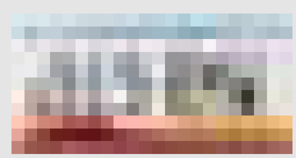
The field of view (FOV, also called angle of view) is the width of the image in relation to the location of the camera. It is determined by the focal length of the lens in relation to the sensor size. Longer lenses or smaller sensors produce narrower fields of view, while shorter lenses or larger sensors produce wider fields of view.

A smaller field of view means that a camera is more “zoomed in” (to use a term that most people are familiar with). For example, a camera with a 90° horizontal field of view (HFOV) will see a 1000m wide section of a wall that is 500m in front of it. If you then adjust that camera’s HFOV to only 1°, it will fill the screen with an 8.7m wide portion of that same wall. This second “zoomed in” field of view is what customers are looking for when they want a camera that can see a long distance. They want a narrow field of view.

Resolution and Pixels Per Metre

The other contributor to camera zoom performance which is sometimes overlooked is the sensor resolution. This determines the level of detail within a camera’s field of view. For example, using the 1° HFOV result from the previous paragraph, a newer HD sensor and an old analog CCTV sensor will both produce images that fill the screen with 8.7m of the wall. The analog sensor has a horizontal resolution of 640 pixels, which means it displays 640 segments of detail across that 8.7m scene. This works out to 73.5 pixels per meter. The HD sensor on the other hand, with a horizontal resolution of 1920 pixels, provides 3 times that level of detail with a value of 221 pixels per meter.

The images to the right show the importance of taking resolution into consideration. In the previous example, a North American license plate would take up 3.5% of the screen width on both cameras (it would be the same field of view), however the older analog sensor would render that plate with only 242 pixels (22×11), while the HD sensor would render it with over 2,200 pixels (67×33). This distinction is the difference between a blur of pixels and a clearly readable plate.



License Plate @ 73ppm (22×11 pixels)

License Plate @ 221ppm (67×33 pixels)

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PPM of Common Lenses

Here are some calculations for the pixels per metre (ppm) values of our most common cameras. We've also provided comparisons against two common standard definition (SD) analog sensor cameras from other manufacturers to highlight the difference that resolution can make.

These numbers are consistent in any conditions, meaning the pixels per meter value is always the same at these distances. However, whether you will clearly see your target is dependent on weather, camera stability, and scene brightness.

License Plate @ 450ppm (138×69 pixels)

	250m	500m	1000m	2000m	5000m	10km
2MP 1/2.8" w/315mm (Infiniti Phoenix)	444ppm	222m	111ppm	56ppm	22ppm	11ppm
SD 1/4" w/122mm (FLIR PT Series)	87ppm	43ppm	22ppm	11ppm	4ppm	2ppm
2MP 1/2.8" w/1000mm lens	1,412ppm	706ppm	353ppm	176ppm	71ppm	35ppm
SD 1/2" w/1000mm lens	400ppm	200ppm	100ppm	50ppm	20ppm	10ppm
2MP 1/2.8" w/2050mm lens	2,909ppm	1,446m	725ppm	362ppm	144ppm	72ppm

Size on Screen

If you don't want to spend time learning about pixels per meter, we find it's easier for the average end user to understand performance distances based on how much of the screen is filled by the target object. The following calculations are based on an average human height of 1.7m and vehicle width of 2.2m. All calculations are made assuming a 1080p 1/2.8" sensor and display resolution of 1920×1080.

License Plate @ 225ppm (69×35 pixels)

	315mm	1000mm	2050mm
Human 5% of screen height	3.5km	11.1km	22.7km
Human 10% of screen height	1.7km	5.5km	11.4km
Human 50% of screen height	350m	1.1km	2.2km
Vehicle 5% of screen width	2.5km	8.1km	16.5km
Vehicle 10% of screen width	1.2km	4.0km	8.3km
Vehicle 50% of screen width	255m	800m	1.6km

License Plate @ 150ppm (46×23 pixels)


License Plate @ 50ppm (16×8 pixels)

Keep in mind that we have many other lens options available, and we excel at designing customized systems to suit specific needs. Contact us today for expert advice on the ideal solution for you.

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