LRF Performance

Ranging Limitations

Laser rangefinders use advanced technology developed for the military to accurately measure the distance to a target. LRFs work by pulsing a SWIR laser towards a target, and a receiver then detects the reflection of that light and accurately calculates the distance based on the time it took for the light to bounce back.

Infiniti uses weapons-grade LRFs that are produced for a variety of applications such as weapons targeting, advanced tracking, autonomous cars and surveillance. Our EDPSS erbium-glass diode-pumped solid-state SWIR micro lasers provide short, high-pulse-energy pulses, with diffraction-limited beam quality and low divergence, resulting in superior range and performance. However, despite the high quality of the LRFs, they still suffer from problems and limitations common to the technology.

Real-World Results vs “Extended Range”

In excellent conditions our standard LRF model can obtain up to 17km on a NATO-sized vehicle target. Longer ranges could theoretically be achieved with a perfect atmosphere, perfect target, perfect reflection, target larger than the beam, and no stray light. Referred to as “extended range”, this metric is a common rating among LRFs but is a theoretical laboratory calculation for comparison and benchmarking, not a value to be obtained in the real world.

How an LRF Functions

Let’s consider the procedure of ranging a 5km target. First, the photons from the laser beam must travel 5km to the target. Even in ideal conditions, the air through which the laser light travels is not pure, even though it may appear so to the human eye. Air will always contain foreign particles such as dust, pollen, smoke, fog, and humidity. Along the way, any photons that hit particulates or moisture in the atmosphere get absorbed or deflected and won’t reach the target. The ones that do reach the target are spread across a relatively large area, and the majority of those photons are absorbed by the target or reflected in other directions.

This means that only a small amount of photons from that initial beam are reflected back towards the LRF. This diminished beam then travels another 5km back through the atmosphere (again losing photons to particulates and moisture) before hitting the LRF receiver, which has an aperture diameter of 50mm. The receiver will read all of the reflected photons it collects through that aperture, including not just those reflected off the target but also those which may have reflected back from targets at other distances, and will be able to return a reading if it detects a spike of photons at a specific distance, based on the time it took for them to be reflected back to the LRF.

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Other Environmental Limitations

Long-range eye safe LRFs operate on the SWIR spectrum of light, typically 1500–1575nm. The sun emits a wide spectrum of light including SWIR, so in daytime the receiver is also reading millions of photons coming either directly or indirectly from the sun. If the reflection of the sun is stronger than the LRF beam, it will provide a false or no reading because this extra, intense light overwhelms and confuses the LRF's InGaAs sensor. This component is highly sensitive, and InGaAs sensitivity increases with longer-range LRF models. This means that sunny days can result in reduced performance, reduced accuracy, as well as increased occurrences of false or no readings. This effect is especially prevalent in urban environments that have many reflective surfaces.

Cloud cover can help performance, as can ranging from a shadow into a shadow, but only marginally. The very longest ranging can be achieved in overcast weather, at dusk, or at night. These conditions allow the LRF to get within 20% of its rated performance for targets like vehicles (not extended ranges).

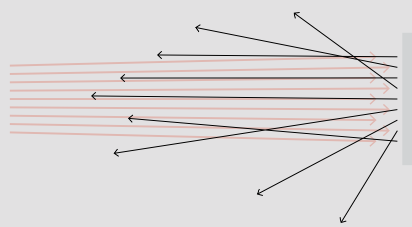
Another factor to consider when ranging in coastal regions is that bodies of water can reflect, absorb, and diffuse both the sun and the LRF's laser. Relative humidity levels over 55% (which are common in coastal environments) can greatly affect performance with long-range distances, as ranging through a high humidity atmosphere is essentially like trying to range through water.

In summary, there are many impediments that the LRF beam faces, and if those impediments are serious enough, they can render the LRF either completely useless or dramatically reduce its range and accuracy.

LRF Performance

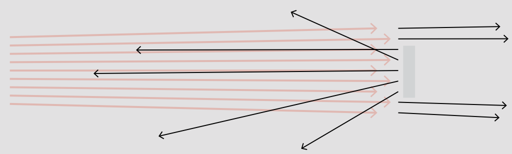
Ranging Limitations

Target Reflectivity



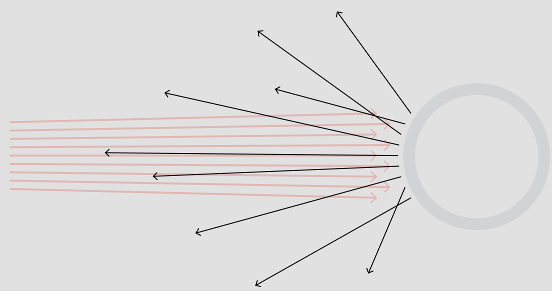
In addition to atmospheric conditions, the reflective properties of a target will also affect the performance of an LRF. Obviously, a shiny surface reflects laser light better than a dull surface, but other aspects such as type of material, size, shape and even color will result in different amounts of reflectivity for the SWIR laser. A better reflection will produce more reliable and accurate results. Some of the best materials are license plates or corrugated aluminum.

SIZE



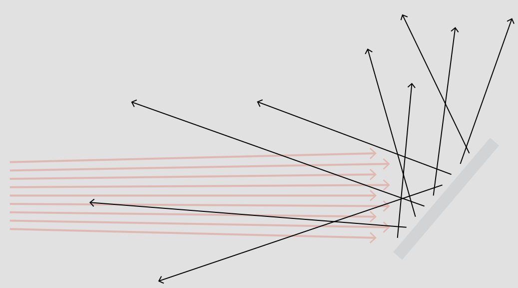
A target that is larger than the projected beam has the potential to reflect far more light than a target that is smaller than the beam, which is only being lit by a fraction of the photons. Note that the beam size expands as it gets further from the LRF.

SHAPE



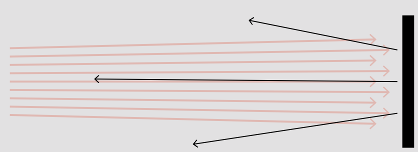
Ranging onto a flat surface generates better reflections than a concave or convex surface (when the flat surface is facing the LRF). For example, a flat rock the same width as a tree trunk should reflect more readable light because light hitting the curved trunk will be deflected left or right while a flat surface bounces most light straight back.

ANGLE



Related to a target's shape is the angle and elevation of the laser beam. For the most effective reflected light, the beam should impact at 90 degrees, or perpendicular, to the object's surface. The further the angle is from 90°, the weaker the signal and higher susceptibility to loss of transmission through the air. Ranging from a high elevation and at a steep angle can greatly reduce the range as less light is reflected to the sensor.

COLOR & FINISH



Brightly colored or glossy objects tend to reflect better than dark colored or matte finish objects. Black is typically the worst color to a laser because it absorbs a high percentage of light, and different types of finishes and textures reflect different amounts of light.