Application Note – SONAbeam™ Performance in Sandstorms

fSONA has deployed SONAbeam™ systems around the world in every type of environment. In most places the discussion revolves around the effects of fog or extreme rain. But a significant part of the FSO market lies in dry desert-like areas where the main concern is sandstorms and dust storms. What effect do these have on FSO, and what kind of performance can we expect to see in these parts of the world?

Looking Through a Sandstorm

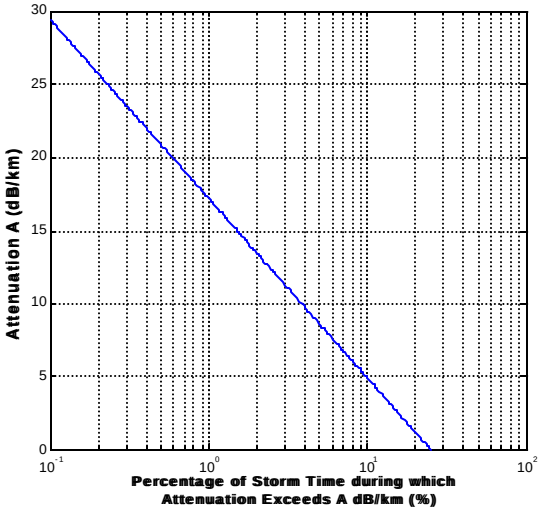
In general, the range and availability of an FSO link are a function of the visibility between the terminals. The further you can see through the atmosphere, the further an FSO beam can "see" through it as well. But we should be careful not to be too simplistic. The detailed characteristics of fog or rain, especially the particulate size of the medium, create certain scattering and absorption effects on the light itself, affecting in turn the attenuation of the signal. In the case of RF transmission, rain droplets and moisture in the air are the worst culprits. The finer particulate size of fog, by contrast, is less forgiving on FSO transmission. Sandstorms and dust storms appear to have characteristics of both rain and fog; particle sizes ranging from very small to very large mixed with moisture and heavy winds. How this all translates into performance of an FSO link is not at all obvious. But there does exist a set of equations, validated with real-world measurements, that provides users with the answers they need to set up a reliable FSO link.

Predicting Availability in Sandstorms

According to a detailed study[1] done in Riyadh, Saudi Arabia, the effect of sandstorms and dust storms on an FSO link can be predicted using a fairly straightforward probability model. While the study focused on mm-wave RF and 880nm FSO, the attenuation characteristics of 880nm and 1550nm transmission are nearly identical. Measurements were taken over the course of four years and this data was compared to theoretical calculations. In the end, a formula was derived to calculate the probability that a certain attenuation level (in dB/km) will be seen during any given sandstorm or dust storm. This formula is the following…

$$P(A) = 0.25 \times e^{(-.25A)}$$

where A is the attenuation of the optical signal in dB/km.



Probability of Attenuation

[1] Adel A. Ali and Mohammed A. Alhaider, "Millimeter Wave Propogation in Arid Land – A Field Study in Riyadh," *IEEE Transactions on Antennas and Propogation*, vol. 40, no. 5, May 1992

From the equation above, and using fSONA's proven techniques for calculating link margin and range, we can determine the maximum range of a SONAbeam™ link in desert-like conditions for different availability requirements. These are shown in the table below.

SONAbeam™	Maximum Range for Different Availabilities		
	90% Availability	99% Availability	99.9% Availability
SONAbeam 52-M	4200 m	1700 m	1100 m
SONAbeam 155-S	1800 m	900 m	630 m
SONAbeam 155-M	3000 m	1300 m	900 m
SONAbeam 1250-S	1600 m	850 m	600 m
SONAbeam 1250-M	2750 m	1250 m	850 m

It is important to understand that the "availability" numbers given above do not refer to the annual availability that is typically quoted for FSO links. These numbers correspond to the percentage of time *during a sandstorm or dust storm only*. The total annual availability will depend on the number of storms per year. For example, "99% availability" in the table above means that the link will be down 1% of the time that the storm exists in the line of sight of the link. If the storm lasts for 200 minutes, the total down-time will be 2 minutes. If there are 30 such storms in a year, then the total annual availability will be 30x2 = 60 minutes, or 99.99%…

99% storm availability ⇨ 99.99% total annual availability (example only)

Rules of Thumb

Along with the technical and mathematical characteristics of sandstorms and dust storms there are some practical matters to consider when mounting an FSO link in desert-like areas. In general, the worst visibility in a dust or sandstorm is concentrated in the lowest part of the storm, below approximately 20 feet. It is therefore recommended to mount the link at least 20 feet above the ground in order to avoid this low-visibility region.

Dust and sandstorms also often include a certain amount of moisture or precipitation. This can cause the dust particles to stick to the optical windows of the SONAbeam™ transceivers and accumulate over time. It is good general practice to wipe these windows clean on a regular basis to avoid excessive signal loss.

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