Ground Surveillance Radar Specs Need to be Known

Ground Surveillance Radars (GSR) are high technology sensor systems that monitor activity surrounding or on critical infrastructure areas such as airports, military installations, borders, refineries and other critical industries. These radars are characterized by their ability to detect movement at ground level of targets such as an individual walking or crawling or different size of vehicles.

GSR serve as the primary sensor for security operations and eliminate the need for continuous scanning by security personnel using cameras or binoculars, as field observation radars are capable of integrating with camera systems and other sensors.

Figure 1: Examples of critical infrastructure

It is important to use **GSR** at border areas or critical facilities as they are also very effective for bad weather conditions such as **foggy and cloudy weathers**. **Thermal camera systems** lose their effectiveness on this kind of bad weather conditions, but Ground Surveillance Radars are **still effective** as usual **during fog**.

GSR manufacturers list several parameters which can be overwhelming when a military or civilian officer trying to find the right radar system to cover his requirements. All these parameters and specifications give important information, but you should know most important specs and their meanings while you are making comparison between different ground surveillance radars.

Range

Range is the maximum visible distance at which a radar can detect a specified object. Radar range depends on radar **range equation formula** (REF). Therefore, range not just depends on the distance of the target from the radar but it also depends on parameters of this formula.

In the REF;

- transmitted signal power,
- gain of transmitting antenna,
- radar cross section (RCS) of the target,
- effective aperture of the receiving antenna,
- distance of the target from antennas of the radar,

are parameters which determines the **maximum visible range of the target**. That is why radar detection range also depends on the target size which is described as RCS in the radar literature.

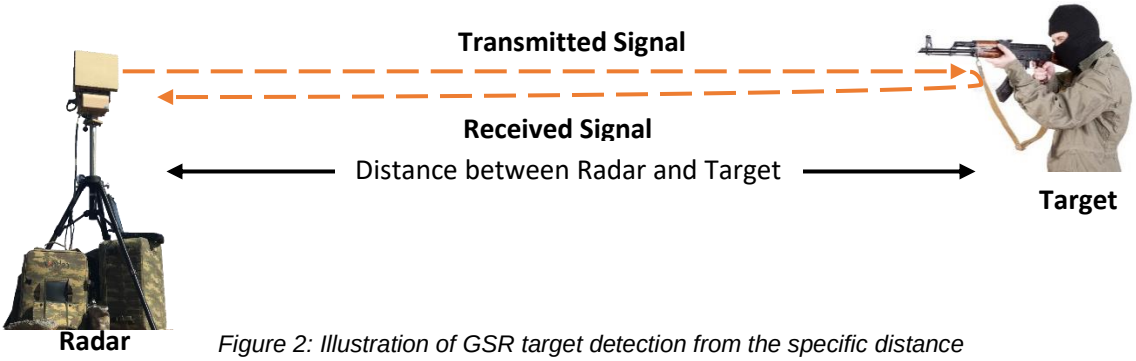

Figure 2: Illustration of GSR target detection from the specific distance

Range is also very important specification according to line of sight (LOS) between the radar and the target. If there **is no visual LOS** between the radar and the target, **radar can not detect the target**. Depending on your available LOS for your operational zone with the radar, you should choose small range, medium range or high range radars according to your applicable LOS. If you **buy high range radar** for an **operational zone with small or medium LOS,** it will be **not be cost effective**.

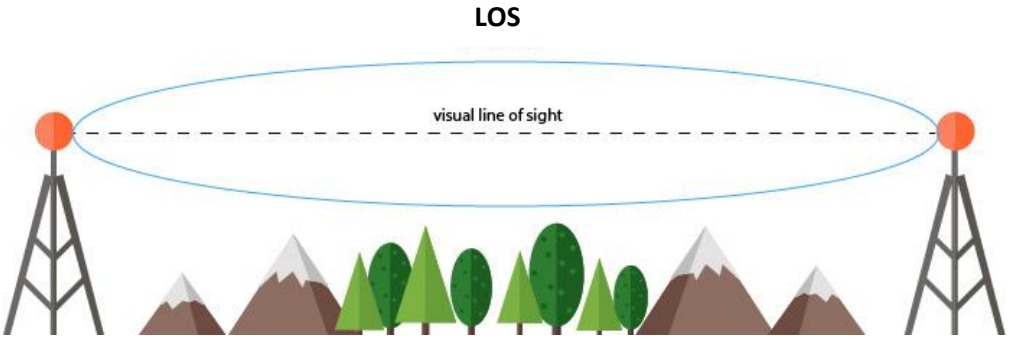

Figure 3: Demonstration of the visual LOS between two different antennas

Weight and Size

Weight and size of the radar is very important spec if your application for the radar is mainly mobile operations. Although there are many types of GSR with various weight and size, there are few portable types. Light weight and small size is very important if mobility and quick deployment and re-deployment are required by the radar operations.

Portability and mobility is very important especially for the military applications. U.S. Army Objective Force Warrior program aimed average **22 kg maximum load** for soldiers [1]. So, a portable radar load should not exceed **20 kg backpack limitations** for a soldier to fit in **maximum load** if we consider other essential loads of the soldier. Therefore, if mobility is a consideration of the GSR application, it is important to have light weight and small size radar.

Figure 4: Demonstration of soldiers carrying mobile light weight radar with backpacks

Carrier Frequency

A radar system uses a radio-frequency (RF signal) electromagnetic signal to detect a target and to determine information about that target. One of the main important specs of the GSR is this RF signal's frequency band of radar's emission. Signal frequencies are demonstrated in Figure 5 regarding to Wavelength and Frequency parameters. Especially, new generation GSR picks high frequency bands such as mm wave (milimetric waves from Figure 5) as carrier frequency because **high frequency radar parts** are advantageous with **benefits** like **low cost and small size**.

Also it is known that modulation of higher frequency carrier signals can be done with less percentage of carrier frequency. Therefore it is possible to have **high band width if you have high carrier frequency**. High band width is advantageous especially to provide effective resolution for GSR.

Effects of radar's radiation are also depending on carrier frequency. Skin Depth Effect (SDE) is one of the most important criteria regarding to radiation got from GSR. It is proven that **skin depth is decreasing** while the **frequency value is increasing** according to different inner tissues for human. Therefore high frequency radars provide with benefit of low SDE [2].

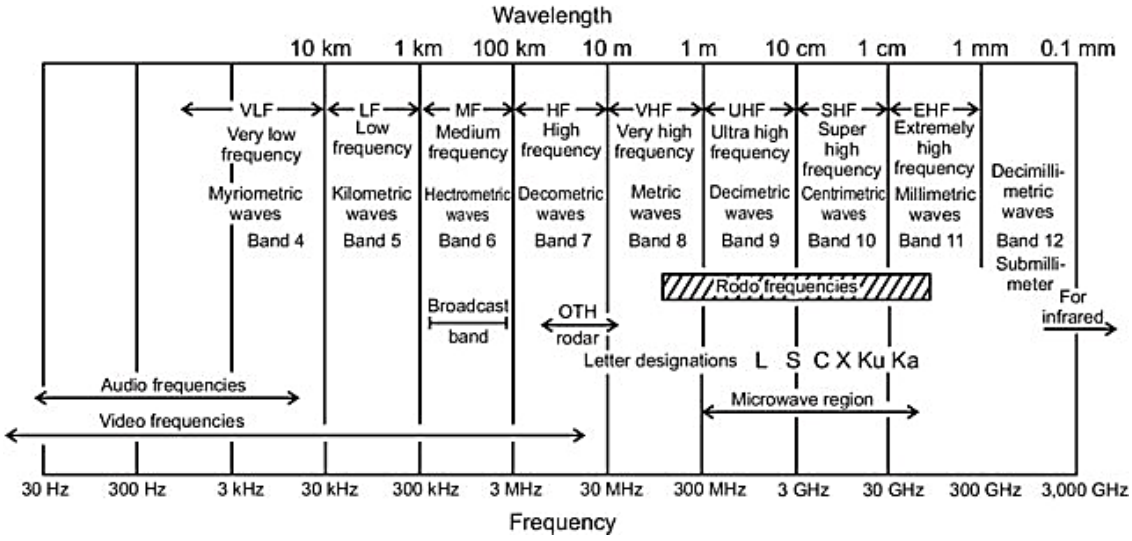

Figure 5: Spectrum of Radar RF frequencies [3]

There are advantages of lower carrier frequency as well. For example, if a radar operator needs to observe **higher ranges** it is beneficial to use **lower frequencies** because REF of range rely on the carrying frequency of the radar. If you have enough LOS without any obstacles such as trees, forests, buildings, it is good to pick **low carrying frequency** radar. But there is a **trade-off** regarding to determination of the carrying frequency if you need high bandwidth for **good resolution**, **mobility** and **less SDE** for a GSR you need to pick a radar with a **high carrying frequency**. These requirements are generally applicable for mobile operations and critical infrastructures with crowded environment.

Range Resolution (Lower is Better)

Range resolution is one of the essential specification of GSR systems. A GSR with **good range resolution** can provide more detailed border security **with small amount of error rates** for ammunition and artillery systems.

Range resolution depends on bandwidth of the radar. Therefore if your radar has **high bandwidth**, you can have a radar with **good resolution**. As it is mentioned in above Frequency section if a radar has **high carrier frequency** it may **have high bandwidth** so which means a good range resolution.

Below Figure 6 represents two different targets approach scenarios to a GSR with 3 meter range resolution. Left scenario of Figure 6 demonstrates that 2 close targets which have 2 meters with each other. In this case a radar with 3 meter range resolution will see them as one whole target because targets are in the same range cell. On the other hand, there are targets which have 3 meters between each other on the right side of Figure 6. In this scenario GSR can see them as two separate targets which have 3 meters between each other.

Therefore, **numerically low range resolution** spec provides with **very good resolution** to **distinguish between very close targets**. For example, if you have a GSR with very good range resolution you can understand exact number of targets while large group of targets are approaching towards to you.

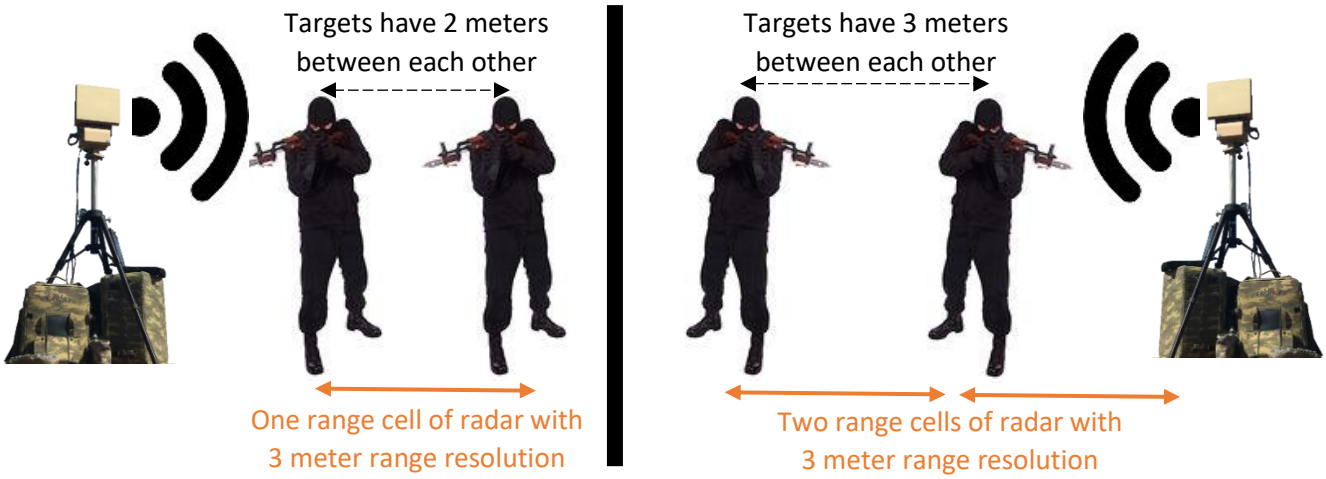

Figure 6: Demonstration of 2 Different Target Approaching Scenarios with different distances to the GSR system

Target Classification

Old GSRs were able to detect and track the targets. However, new GSRs are capable to classify between targets by the effects of developing **new radar technology**. It is important to distinguish between detected radar targets for perimeter surveillance operations such as military base protection, airport surveillance and power plants. Especially **classification of human, animal and vehicle** is key requirement to **avoid from undesired security resource and cost allocation** if there are non-threatening targets.

In the literature there are various types of classification methods for radar targets regarding to radar targets data types such as **micro-Doppler classification**, **high resolution range profile** (HRRP) classification, **RCS classification**, etc. While determining classification methods, the important things are that what kind of radar type you have and what kind of targets you want to distinguish. If you have a radar such as SAR with very high bandwidth it is good have HRRP using classification. You can classify targets which are same with different behaviors by the help of HRRP. However, GSRs usually have **middle amount of bandwidth** because they do not require detailed classification like SARs and **classification between human, animal and vehicle** is adequate. So, if you want to distinguish between targets with a **GSR**, it is **more applicable to use micro-Doppler** classification for perimeter protection [3].

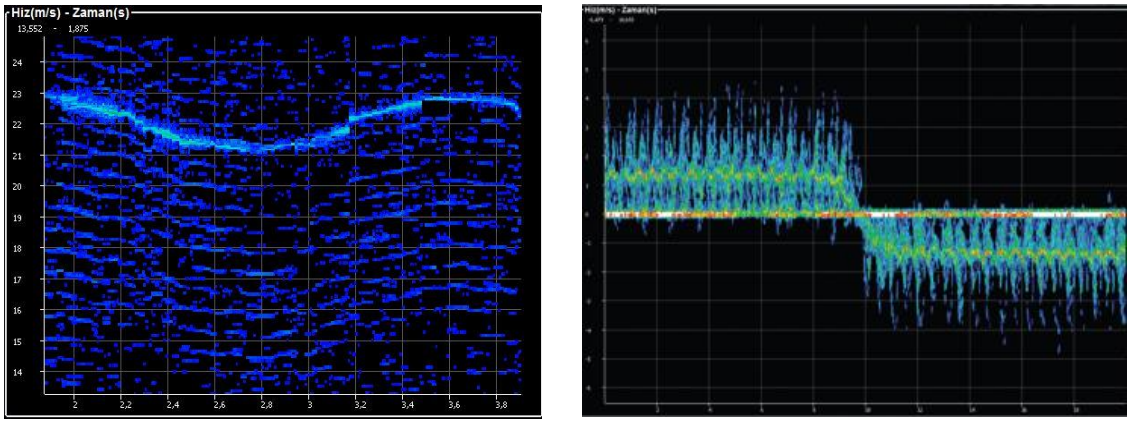

Figure 7: Typical micro-Doppler signatures of a vehicle (on right side, moving 20m/s speed) and a human (on left side, moving 1,5m/s speed)

By observing the above mentioned micro-Doppler signatures of targets, it is applicable to distinguish between targets if it is human or vehicle or animal. However, it is not easy as **micro-Doppler** analysis if you use **RCS of targets for classification**. For example, if a radar observes air targets, it might be **confusing** to understand that the target is a drone or is a bird because they **have similar RCS**. Additionally, **HRRP** may be an option if **bandwidth** of the radar is **very high** for precise and quick classification. As a result of these statements, it is up to the radar specifications to determine about what kind of classification method is the best.

Conclusion

You need to understand all these above mentioned specs which are **range, weight and size, carrying frequency, range resolution, and target classification** while comparing different GSRs and select the most suitable one for your requirements. Regarding to your indispensable operational needs, you should pick right specs. So, it is important to know that only one specification cannot tell the best choice, but you need to understand advantages and disadvantages of specs to make best combination when you are purchasing the right radar system for your application.

If you would like to have a medium range, high level detection and classification capability with small size, light weight, low power consumption, mobility and rapid deployment for your border and critical infrastructure security, you can check Meteksan Defence Retinar Perimeter Surveillance Radar Family; https://meteksan.com/en/products/perimeter-surveillance-systems

Retinar PTR video;
https://www.youtube.com/watch?v=a2LYMd3gW1Q

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References

[1] L. C. Brady, «A Review of the Soldier's Equipment Burden,» Defence Science and Technology Organisation of Australian Government Department of Defence, Edinburgh South Australia, 2011.

[2] S. R. Haque, «Numerical Evaluation of Specific Absorption Rate and Skin Depth on Human Body Tissue Due To Electromagnetic Field Emitted From Mobile Phone Antenna,» %1 içinde *ICECTE*, Rajshahi.

[3] S. Björklund, T. Johansson ve H. Petersson, «Target classification in perimeter protection with a micro-Doppler radar,» %1 içinde *2016 17th International Radar Symposium (IRS)*, Krakow, Poland, 2016.

[4] N. P. Bhatta ve M. Priya, «RADAR and its Applications,» %1 içinde *International Conference on Novel Issues and Challenges in Science & Engineering*, Tamilnadu, India, 2016.