Understanding Standard Off-set Satellite Dishes

vs. Inverted Satellite Dishes

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When in different locations of the world, one will often see off-set satellite dishes in two planes; standard or inverted. Understanding the difference between the two can solve many problems when it comes to seeing satellites in high orbits or low orbits.

The following paper will show the difference between the two and explain why standard vs. inverted is used.

Standard Off-set

Figure 1 depicts a standard off-set antenna. These are found more prominently than inverted off-set antennas. We will use an off-set of 22.3^o for our discussion. We will also use 0^0 as the horizontal plane and 90^o as the vertical plane.

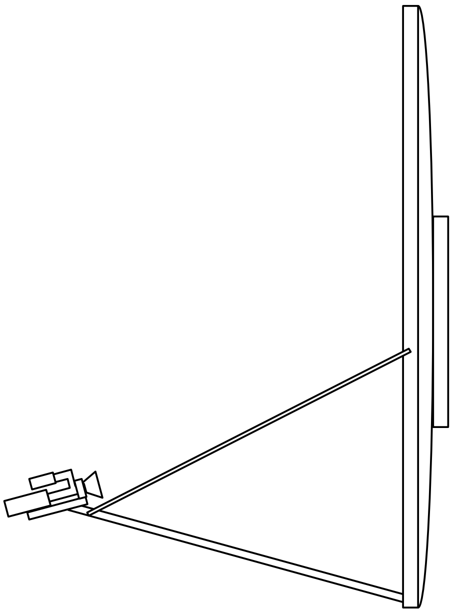

Figure 1: Standard Off-Set Satellite Dish

Prime Focus is defined as having the feed assembly place in the center of a parabolic dish. These dishs are more commonly found in larger antenna diameters and seldom seen with smaller dishes. However, all elevation angles are calculated using the prime focus parabolic antenna as the model.

When discussing “take off” angles, one is merely talking about how the signal leaves the antenna. With a standard off-set antenna and the off-set angle of 22.3^o, the feed assembly is not creating a shadow or blind spot while transmitting or receiving. The angle is measured from the base of the reflector and goes right over the feed horn. Some have even said that the boom of the antenna is pointing at the satellite. This is not entirely true. If the boom were pointing at the satellite then the feed assembly would cast a shadow thus blocking part of the signal. Figure 2 shows the “take off” angle of a standard off-set antenna.

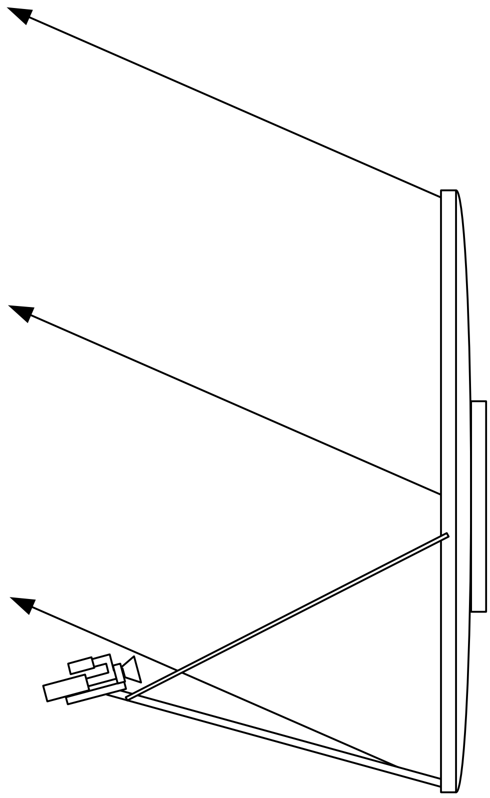

Figure 2: Take off angle on Standard Off-set Antenna

As mentioned before, when the dish is set as shown, the vertical plane of the reflector is 0^o. However, because of the off-set of 22.3^o we need to subtract 22.3 to get prime focus. So with the dish set in this configuration, the actual angle of 22.3^o prime focus would result in a 0^o reflector angle. In order to get a prime focus elevation angle of 0^o degrees, one would have to tilt the dish forward so the back plane of the reflector is set to 22.3^o as seen in Figure 3. When making measurements, it should be done on a flat surface on the back of the antenna.

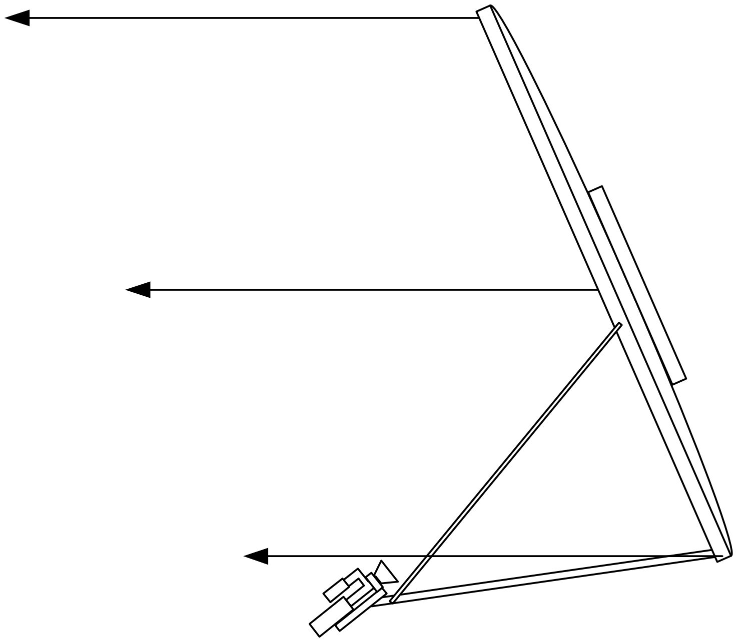

Figure 3: Zero degree take off angle on Standard Off-set antenna

Not always is it possible to get 0^o elevation from a Standard Off-set as the king post may be in the way. As a matter of fact, why would one what to tilt the dish that far forward when there are no satellites to be seen at that angle? This illustration is just an example of how the off-set affects the angle of the reflector.

When doing calculations to obtain the correct take off angle with a standard off-set antenna, one only needs to subtract 22.3 from the calculated prime focus angle.

An example would be for a satellite located at 64^o east as viewed from Bagram, Afghanistan.

The calculated elevation would be 49.8^o for prime focus. Therefore, 49.8 - 22.3 = 27.5. The antenna would then be moved to an angle of 27.5^o based on reading an inclinometer place on the back of the dish. Figure 4 shows the antenna set at 27.5^o elevation. Because we are using 90^o in the vertical plane, we have to do something different. We have to subtract our results from 90. Therefore, 90 – 27.5 = 62.5. What if we want to use 0^o in the vertical plane? Then you do not need to subtract the results from 90.

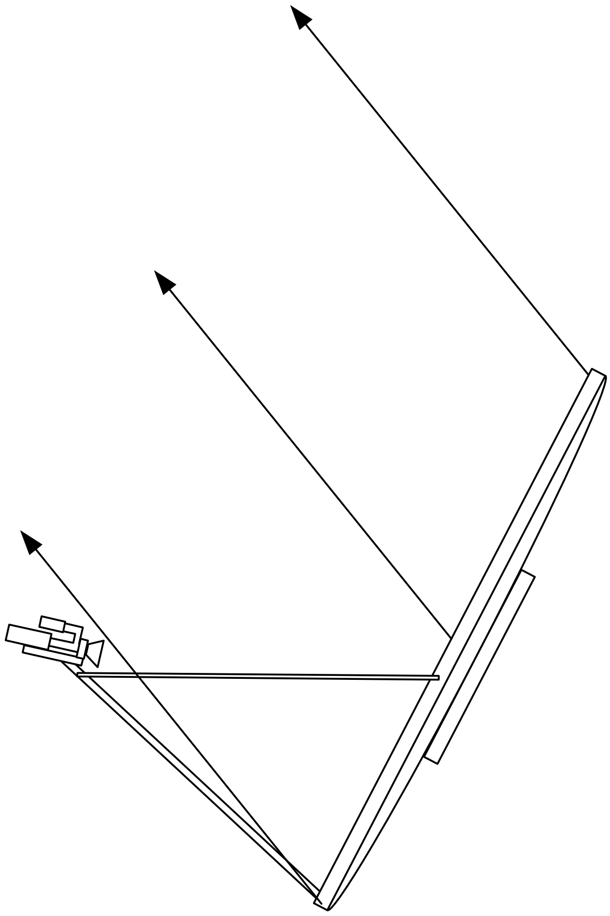

Figure 4: Antenna pointed at 64E satellite

Inverted Off-set

Let’s look to see what would happen if we invert the dish. Figure 5 shows the same antenna but inverted, meaning the feed assembly is at the top of the dish, not at the bottom as in a standard off-set dish.

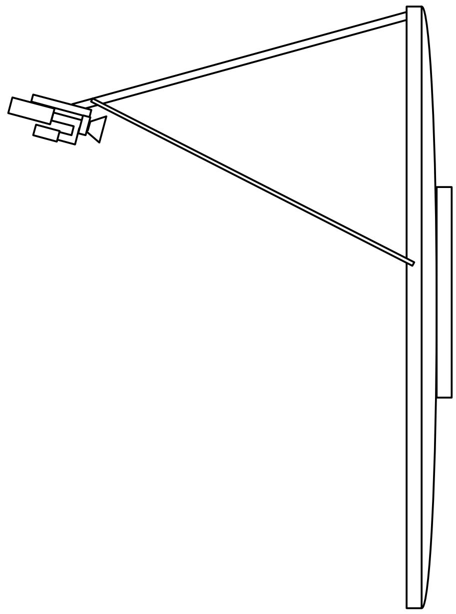

Figure 5: Inverted Off-set antenna

Unlike the standard off-set, the take off angle is very different. It is easy to see that when we talked about the signal passing just over the feed assembly on a standard off-set, in an inverted condition the signal passes just under the feed assembly. This would put the take off angle lower than the plane of the reflector. Figure 6 shows the take off angle and Figure 7 shows if we want to have the prime focus take off angle of o^{o}.

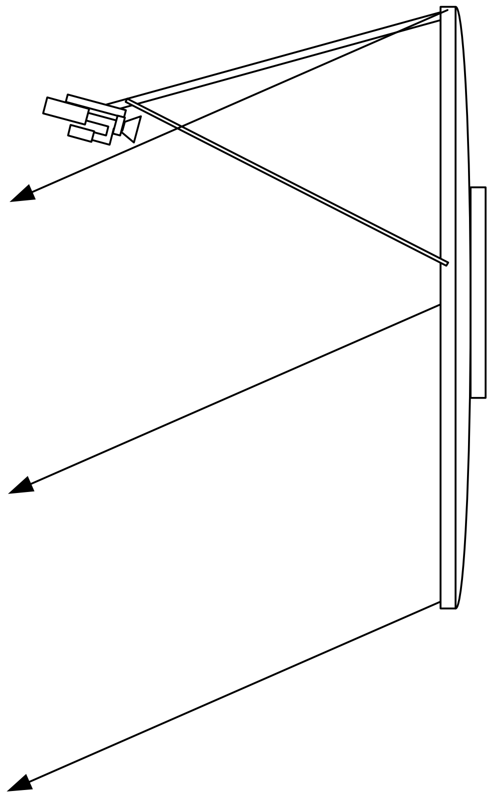

Figure 6: Take off angle of inverted off-set antenna

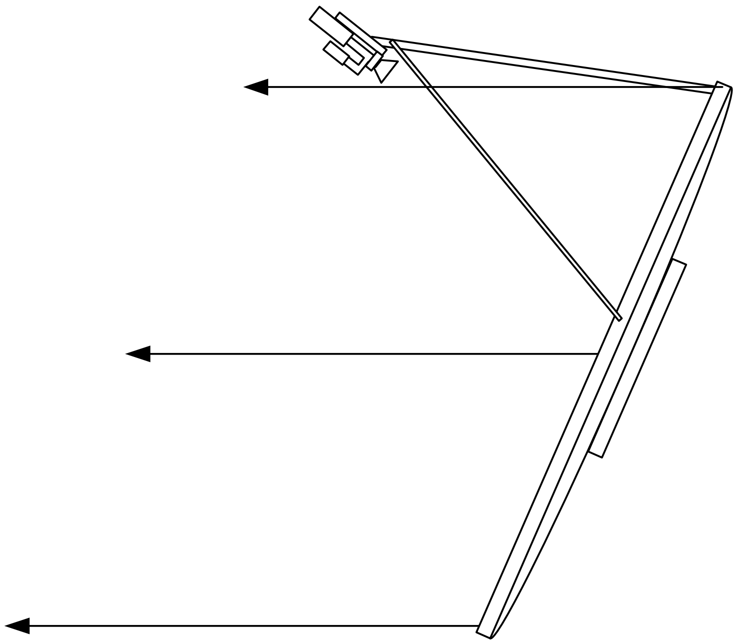

Figure 7: Zero degree take off angle on inverted off-set antenna

The first thing one should notice is the take off angle in Figure 6 is pointing down. I don't think there would be a time that we would access a satellite that is below the horizon. However, when one looks at the take off angle of 0^o, one will notice that the antenna is tilted backwards, not forwards as in a standard off-set. With the whole dish inverted, we gain several advantages that were missing with the standard off-set. Meaning, we cannot access lower angle satellites without the reflector hitting the king post.

Already we can see a major difference that may not have been apparent before. Simply inverting the entire antenna gives us completely different results. However, there is something to be gained by inverting the antenna as I have already stated; seeing satellites in lower orbits.

In order to get the 0^o prime focus angle, we needed to add 22.3. This is different than before when we subtracted 22.3. The face of the reflector is now facing the sky as opposed to facing the ground in the standard off-set. This also has the advantage of less thermal noise, but that is beyond the scope of this paper.

So let's go back to our example of our location is Bagram with the primary satellite being 64^o east. With a prime focus angle of 49.8^o we now need to calculate the new angle. 49.8 + 22.3 = 71.1. Because the plane of the back of the reflector is 90°, we need do that silly math again. So, 90 – 71.1 = 18.9. With the inclinometer placed on the back of the reflector, move the dish to 18.9°. Figure 8 shows what the dish will look like at that angle. Looks like the dish wants to lie down on its back.

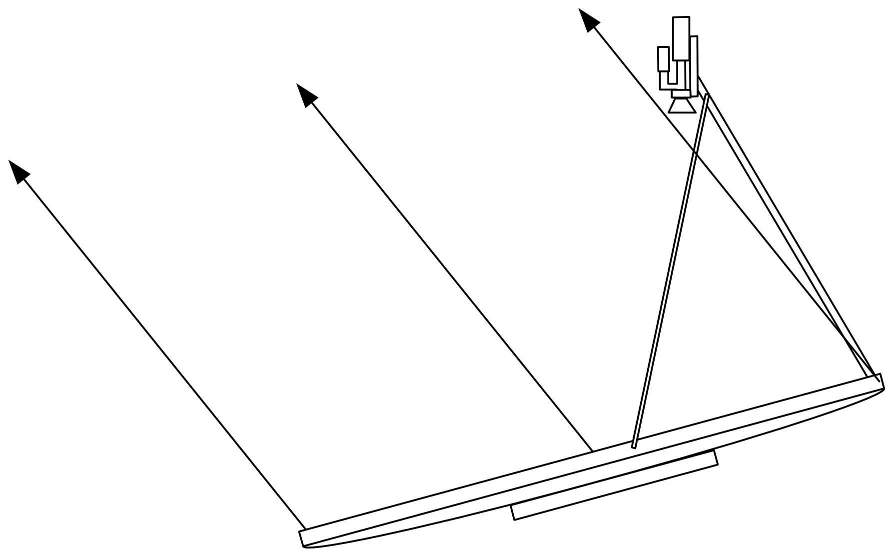

Figure 8Inverted dish on 64E satellite.

So how can we prove without actually putting two dishes on the satellite that the two antennas are matching? Well, with the magic of Visio, we can super impose both images one on top of the other. Figure 9 is the result of this magic. We have also included the Prime Focus so one can see how the standard leans forward while the inverted leans back.

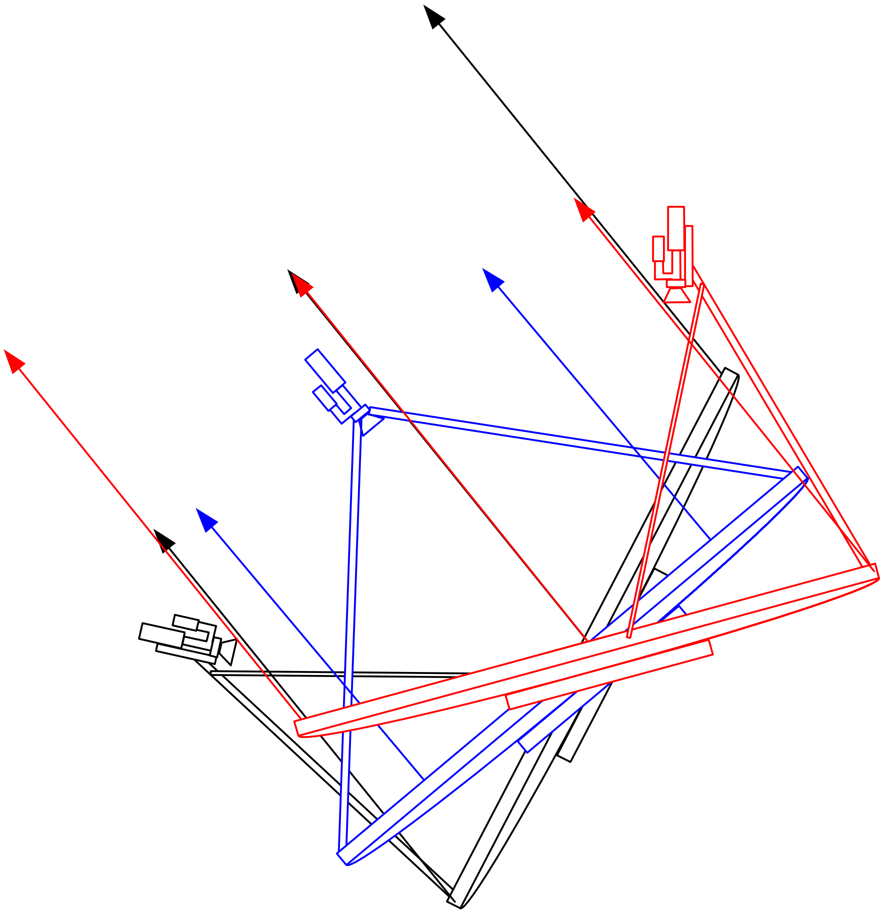

Figure 9: Standard, Inverted, and prime focus super imposed.

One will see right away that the plane of the reflectors are way off and do not line up. But the take off angles do indeed match. One can take it from me that this is really what happens, or one can actually test the theory. However, the math actually tells the story.

The Math

No paper on satellite communications or dish theory would be complete without math. So in order to appease the geekness in all of us, here are the equations for the standard vs

Standard Off-set

Take off Angle = 90 – (prime focus – offset)

> Where 90 = vertical plane of reflector
> Prime focus = calculated elevation based off of lat and lon of earth station and station
> Offset = manufactures off-set of the boom/feed assembly to reflector surface

Inverted Off-Set

Take off Angle = 90 – (prime focus + offset)

Where 90 = vertical plane of reflector
Prime focus = calculated elevation based off of lat and lon of earth station and station
Offset = manufactures off-set of the boom/feed assembly to reflector surface

Conclusion

When setting up a dish, one may not have a choice or standard off-set or inverted off-set. However, one may need to invert their dish in order to get a lower take off angle. Either way, with this paper in hand one should have no problem finding the satellite if one knows the difference between a standard off-set and an inverted off-set.

Brian Donaldson is a freelance photojournalist and writer. He has lived in many countries and travels to find interesting stories and pictures. Brian writes for the International Press Association.

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