Northern Video Graphics, Inc.

Weather Image Display Specialists

To: Satellite Receiver Users
From: Russ Green, Northern Video Graphics, nvg@nvgweather.com
Re: Reception for satellites with higher inclined orbits (MET 5, for example)

Most satellite dish antennas have an **axis** of symmetry defined by the center of the dish and the center of the feed assembly which is located at the dish focal point. This axis needs to be pointed at a satellite in order for proper reception to occur. The receiving system also has a property known as **beamwidth**. This refers to the maximum angle off axis that a signal source (satellite) can be and still give usable signal strength (inside of beamwidth gives good data, outside gives bad data). The **beamwidth is actually twice that max off-axis angle** and depends on the geometry of the dish, quality of the receiver electronics and strength of the transmitted signal.

Ideally, for geostationary satellites, once an antenna is pointed at a satellite, it stays that way. That is the beauty of geostationary orbits, the satellite appears to stay at the same position as it orbits around the earth. However the world is not ideal. As satellites age, they run low on fuel to keep them in a purely stationary orbit (even in space there are some small frictional forces that degrade orbits over time.) To save fuel at the end of a satellite's life, usually an orbit is allowed to become "inclined", which means that the plane of the orbit is no longer parallel to the plane of the equator. The result is that the satellite seems to drift north-south with a nearly 24 hour period. If looking at the satellite from below it appears to move north then south then north, etc. Its subsatellite point moves equally north and south of the equator. It crosses the equator twice a day. The number of degrees of maximum travel (also know as the **degree of inclination**) increases over the months and years.

The trick for good satellite reception is to keep angle between the antenna axis and the line to the satellite less to be than half the beamwidth even as the satellite moves north-south. If the degree of inclination is less than half the beamwidth then judicious pointing of the antenna should allow for continuous good reception without need to repoint the antenna.

Scenario 1 (low degree of inclination) antenna pointing procedure: Simple - **aim the antenna at a time when satellite subpoint is crossing the equator**. To "aim" the antenna, change the pointing direction (azimuth and elevation) until the signal strength meter is at a maximum. Since the satellite "spends time" equally north and south of its position at this point in time, this aiming position will have the best chance to capture a signal at both the north end and the south end of the satellite travel. If that is true then the antenna can be left in this position until the degree of inclination becomes too great (hopefully months or years).

As the degree of inclination increases it may be necessary to physicically re-point the antenna at certain times during the day. The question is when to do this and where to point each time.

Scenario 2 (higher degree of inclination -- twice-a-day repointing). This will work if the degree of inclination is between 0.5 and 1.0 times the beamwidth. That means that the antenna can at least cover the north half of the satellite travels with one pointing direction and it can cover the south half of the satellite travels with another pointing direction. Here is how to implement that:

1: Find the **half-north pointing direction** -- save settings for antenna azimuth (compass direction) and elevation (angle up from horizon) - refer to these as **North Settings**. You find these settings by adjusting the antenna to peak up the antenna signal strength meter at a time **2 hours after a North Equator Crossing or 2 hours before a South Equator Crossing**. (This is the time when the satellite subpoint has moved half way from the equator to its northern most point, or vice versa). You may read elevation from antenna elevation angle guage and you can make a mark with magic marker

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and/or masking tape to denote the azimuth setting. (Label it with an "N" if you like.)

2. Find the **half-south pointing direction**-- save settings for antenna azimuth (compass direction) and elevation (angle up from horizon) - refer to these as **South Settings**. You find these settings by adjusting the antenna to peak up the antenna signal strength meter at a time **2 hours after a South Equator Crossing or 2 hours before a North Equator Crossing**. (This is the time when the satellite subpoint has moved half way from the equator to its southern most point or vice versa). You may read elevation from antenna elevation angle guage and you can make a mark with magic marker and/or masking tape to denote the asimuth setting. (Label it with an "S" if you like.)

You only have to do steps 1 & 2 once (although you may want to repeat to get averages for the North Settings and South Settings.

Then each day do the following steps 3 & 4:

3. **At the time of the North Equator Crossing**, physically **re-point the antenna to the North Settings**. This will insure that the north part of the satellite travels are covered by the antenna. (Pay no attention to the signal strength meter at this time, just the settings for azimuth and elevation.)

4. **At the time of the South Equator Crossing**, roughly 12 hours later, physically **re-point the antenna to the South Settings**. This will insure that the south part of the satellite travels are covered by the antenna. (Pay no attention to the signal strength meter at this time, just the settings for azimuth and elevation.)

There will be an overlap in coverage between the north pointing direction and south pointing direction depending on the size of the angle of inclination in relation to the antenna beamwidth, so there will be a range of times around the equator crossing during which the re-pointing can occur, but as inclination increases, that window of time will get less, so it may be best to schedule a repoint to occur as close to equator crossings as personnel schedules will allow.

Possible time saving trick: If the difference in azimuth setting between the north settings and south settings is small enough, then simply **leaving the azimuth set at half way between the north setting and south setting** may be good enough to allow coverage of both north and south half by changing only the elevation. (For some antennas, this is a much easier procedure - changing elevation requires just winding a crank, but changing azimuth requires loosening and retightening of bolts). Trial and error may be necessary to insure that this "trick" will work. This has a better chance of working the closer the antenna location longitude is to the longitude of the satellite subpoint (i.e. antenna points more south or north rather than more east or west).

For even higher inclined orbit satellites, a four-time-per-day repointing is necessary (details if needed).

Now for some details relating to METEOSAT 5 satellite.
Angle of inclination (currently, 8/8/05, about 7.5 degrees, or about 15 degrees of travel north-south).
Inclination is increasing at about 0.5 degrees per year
Mod III (DSIG-5000) beamwidth is 6-12 degrees so Scenario 2 is probably necessary.
Note: MET 5 may not transmit continuously (some outages) so make sure tenna pointing occurs when good signal is present. Make initial antenna setup and pointing (including feed polarization) according to instructions that came with system. Then use the above as required.

NVG can supply a program which predicts equator crossings for weather satellites (an offshoot of our polar orbit ingest / tracking software). This will generate equator crossing lists for a up to 30 days at a time. This will require periodic (say monthly) downloading of parameters (Kepler element sets) for predicting satellite orbits. This is free and easy with internet connection.