SensorFX

Users Guide

JRM Technologies
Real Physics • Real Sensors • Real-time

VT MÄK
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1. Using SensorFX

This chapter introduces SensorFX, explains how to install it, and explains how to use it.

1.1. Introduction to SensorFX

SensorFX is a plug-in to VR-Vantage. SensorFX was created by JRM Technologies. It provides physics-based sensor views for Long Wave Infrared (LWIR), Midwave Infrared (MWIR), and night vision goggles (NVG). In physics-based sensor views, the rendering of terrain and simulated objects takes into account the material of the object, air and material temperature, ambient light, and the characteristics of the sensor. Therefore, SensorFX provides much more realistic sensors than the CameraFX sensors included in VR-Vantage, which are more akin to putting a colored filter on a camera.

To take advantage of physics-based sensors, the terrain and simulated objects must be "materially classified". That is, their composition must be specified and included in the terrain and model definitions. The ability to classify materials is not part of SensorFX or VR-Vantage. You must use the GenesisMC™ software from JRM.

SensorFX can apply material classification on demand for terrains loaded using osgEarth earth files.

Material classifications have been provided for the *VR-Village-SensorFX.mtf* terrain database. Scenarios that use this terrain will probably reference entities and effects that have not been material classified, so they may not look correct. The material-classifications are notional only to provide some indication of capability, but not reflect actual vehicle signatures.

The terrains *VR-TheWorld Online - MAK Earth_mcod.mtf* and *VR-TheWorld Online - MAK Earth_mcod_lights.mtf* are configured for material classification on demand. VR-TheWorld Online - MAK Earth_mcod should also work with SensorFX.

i When you run a SensorFX version of VR-Vantage, the CameraFX sensors are not available.

1.2. Installing SensorFX

On Windows, SensorFX is provided as a standard Windows installer. To install it, run the installer. Be sure to install it into the version of VR-Vantage for which it was compiled, for example, VR-Vantage 2.0, VC 10.

On Linux, SensorFX is supplied as a compressed tar file. To install it, uncompress it and untar it in the VR-Vantage installation directory.

When you install SensorFX, it installs a version of the VR-Village terrain called *VR-Village-SensorFX.mtf*.

1.2.1. Installing the SensorFX License

SensorFX is licensed separately from VR-Vantage.

On Windows, the license is provided as a registration file that modifies the Windows registry.

➤ To install the SensorFX license on Windows, in the Windows Explorer, double-click the registration file.

On Linux, the license is a file that you must copy to the *./bin* directory.

1.3. Starting VR-Vantage with SensorFX

VR-Vantage with SensorFX has its own startup shortcut. This allows you to run VR-Vantage with SensorFX or the standard VR-Vantage applications without SensorFX.

➤ To start VR-Vantage with SensorFX, on the Start menu, choose **All Programs** → **MÄK Technologies** → **VR-Vantage 2.0** → **VR-Vantage with SensorFX**.

1.4. Using SensorFX

When SensorFX is installed, you choose the sensor to use by choosing an observer mode that has a sensor as part of its configuration, just as you do with the native CameraFX sensors. (For details, please see Section 14.2, "Enabling Sensors,", in *VR-Vantage Users Guide*.) SensorFX the following observer modes:

- Stealth. Uses the Visual mode sensor. It displays the scene using the visual spectrum that is viewable by the human eye.
- MWIR (Out-the-Window). This sensor uses mid-wave infrared. MWIR is also called intermediate infrared (IIR): 3-8 µm. In guided missile technology the 3-5 µm portion of this band is the atmospheric window in which the homing heads of passive IR heat seeking missiles are designed to work. They home in on the infrared signature of the target aircraft, typically the jet engine exhaust plume. The default MWIR mode is white hot. You can change it to black hot on the Display Settings dialog box, Sensor Settings page.
- LWIR (Out-the-Window). This sensor uses long wave Infrared: 8–15 µm. This is the thermal imaging region, in which sensors can obtain a completely passive picture of the outside world based on thermal emissions only and requiring no external light or thermal source such as the sun, moon or infrared illuminator.
- NVG (Out-the-Window). This sensor mimics night-vision goggles, which allow images to be produced in levels of light approaching total darkness.

SensorFX works with multiple observers. However secondary observers do not provide materially classified effects. They provide the equivalent of CameraFX effects. If you have multiple windows that use the same observer, they all use SensorFX. (For information about CameraFX, please see Chapter 14, *Using Sensors*, in *VR-Vantage Users Guide*.)

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- Clouds and precipitation are not supported when SensorFX is installed.
- When you switch observer modes, there may be a delay of several seconds before the new sensor takes effect.

1.4.1. Creating New Sensors

You can create new sensors with settings that vary from the installed IR and NVG sensors. The process for creating new sensors is generically the same as for creating new sensors with CameraFX. You add a new sensor on the Sensor Settings page and then you configure it. (For details, please see Section 14.3, "Configuring Sensors," in *VR-Vantage Users Guide*.) However, the process is not quite as simple as it sounds. SensorFX does not have an option to, for example, create a new default IR sensor. The IR-ness of a sensor is based on the specific settings of the sensor. Furthermore, if you add a new sensor, some sensor-specific options, such as blackhot and halo effects are not available among the generic sensor parameters. Therefore, it is not entirely practical to create new sensors. We recommend that you just use the sensors supplied with SensorFX.

1.5. Configuring SensorFX Sensors

The SensorFX sensors are configured on the Display Settings dialog box, Sensor Settings page. Configuration options are organized into tabs as follows:

- Effects.
  - Sensor Effects. Table 1-1 lists options for IR (MWIR and LWIR) and NVG.
  - Optics (Table 1-2)
  - Detector (Table 1-3)
  - Electronics (Table 1-4).
- Sensor (Table 1-5).
- Advanced Table 1-6).

Table 1-1: Effects tab, Sensor Effects

Option	Description
Enable Selected Sensor Effects	Enables or disables the selected options on this page.
Enable Filter Effects	Enables filtering.
Enable Noise Effects	Enables noise.
Enable Automatic Gain Control	SensorFX automatically adjusts the scene to provide the best contrast and brightness given time-of-day, weather, and other scene parameters. It overrides the Gain and Level settings.
Enable Gain/Level Effects	Enables the settings in the Scale Sensor Effect group box.
Enable Halo Effects	Show halos around bright points of light such as head lights and street lamps. (NVG Only)
Enable Blackhot	Changes IR from white hot to blackhot. (IR Only)
Motion Blur	Enables motion blur effects.
Blur	Affects the focus of the scene.
Noise	Affects the graininess of the scene.
Gain	Affects the contrast in the scene.
Level	Affects the brightness of the scene.

Table 1-2: Effects tab, Optics Effects

Option	Description
Aperture Shape	Choose elliptical or rectangular.
Aperture Aspect Ratio	Ratio between horizontal and vertical Instantaneous Field of View (IFOV). Changes are most noticeable when blur is high.
Aperture Diameter	Specified in millimeters. It is used in diffraction calculations. Lower values produce more diffraction spreading (blur).
Blur Spot Diameter	This quantity [mrad] is a measure of the amount of spherical aberration, and thus the focusing power of the lens. The more this number varies from the focal point the more blur in the scene.
F-Number	Non-editable field. It is calculated based on the FOV and aperture diameter.
Focal Length	Non-editable field. It is calculated based on the FOV and aperture Parameters. Units are cm.
Halo Threshold	The point at which halo effects are used. A halo is shown around bright points of light such as vehicle headlights or street lights.
Halo Radius	Determines the overall maximum size of the Halo.
Halo Intensity	Determines the maximum brightness of the Halo.

Table 1-3: Effects tab, Detector Effects (Sheet 1 of 2)

Option	Description
Dwell Time	Dwell time is the time [μsec] over which the post-detector electronics integrates the detector output voltage. A value of zero denotes no integration. Increasing dwell time results in higher signal-to-noise ratio.
Temporal NEdR	This is the “noise-equivalent delta-temperature”. Any real IR sensor will produce self-noise, which adds a constant to the effective apparent temperature of the scene, and may be generated from a variety of effects. Noise converted to a DeltaT. If 0 then no noise impacting the temperature.
% Fixed Pattern	Unwanted signal component that is usually constant or very slowly changing with time. May vary spatially and so could potentially be confused with true fringes. Examples of fixed pattern noise are the pixel to pixel gain variations cosmetic defects in CCD detectors parasitic interference caused by unwanted reflections from various air/glass surfaces.

Table 1-3: Effects tab, Detector Effects (Sheet 2 of 2)

Option	Description
% Poisson	The Percent Poisson Noise is the statistical fluctuations in charge carrier number. It is also known as “shot” noise. Percent Poisson Noise is more important for optical wavelengths than infrared because in the short wavelengths the energy per photon is higher and so there are fewer photons per unit power of illumination.
% 1/F	Also known as “flicker” or ‘pink noise”, this occurs in any biased detector and is a thermo-mechanical effect related to material inhomogeneity or transistor recombination.
Horizontal Detector Pitch	The horizontal distance between detector centers [mm], used in determining focal length.
Vertical Detector Pitch	The vertical distance between detector centers [mm], used in determining focal length.
Background Temperature	The effective temperature [degK] of the ambient background. Can usually be set to nominal air or ground temperature.
Detector Pixel Fill	Term of measurement of FPA performance, which measures how much of the total FPA is sensitive to IR energy. Because the FPA is made of numerous individual detector cells, the total amount of sensitivity is measured by the pathways used to separate the cells and transmit signals. The higher the fill factor, the higher the ratio of sensitivity.
FPA Operability	This indicates the effectiveness of the detector and 100% would be fully functional and as the operability percentage drops the image quality drops.
Noise Frequency Exponent	[Also known as “beta”, this is the exponent of the 1/f noise power spectrum.
Noise Frequency Knee	The frequency above which 1/f noise is overshadowed by thermal or statistical noise from other processes.

Table 1-4: Effects tab, Electronics Effects

Option	Description
Frame Rate	The frame rate parameter is used to determine the change in temporal noise per frame.
Pre-Amp Cuton Frequency	Frequency at which amplification of the signal occurs after conversion to a voltage. Good values to use for this parameter are 1-10.
Post-Amp Cutoff Frequency	Frequency at which amplification of the signal ceases. Good values to use for this parameter are 50 – 500.
Manual Gain	This is the manual gain value and also the maximum gain used by the automatic gain control. The Effects section will scale the gain from 0-100% of this value.
Manual Level	This is the manual level and is added to the value from the Effects section, so if you are using a slider for that, then this would be set to zero. This could probably be left out of a GUI if the slider was being used.
Max AGC Gain Min AGC Gain	Maximum and minimum values for automatic gain control.

Table 1-5: Sensor tab

Option	Description
Lower Band	Lowest wavelength of band in microns.
Upper Band	Highest wavelength of band in microns.
Min Temp	If Automatic Radiance Scaling is not set, then this determines the range used to encode the response textures generated from the mcm textures (for IR).
Max Temp	If Automatic Radiance Scaling is not set, then this determines the range used to encode the response textures generated from the mcm textures (for IR).
Max Light Level	Sets the maximum light level [uW/cm2] which the NVG sensor can detect without saturating. (Visual sensor and NVG only)
Light Pool Gain	(NVG only) Adjusts the brightness of light pools under street lights.
Intensity Modulation Gain	Together with the geometry-model-specific IMOD files, this governs the extent to which detail variance present in the RGB texture for the entity or terrain models is translated into additional variance in the NVG scene. Typical value: 0 - 1.00.

Table 1-6: SensorFX Advanced tab

Option	Description
Non-uniformity On	The non-uniformity feature applies a gain and/or an offset to each pixel at the end of the sensor effects processing.
Non-uniform Gain File	Specifies the gain to apply.
Non-uniform Offset File	Specifies the offset to apply.
Min Gain Max Gain Min Offset Max Offset	The Min/Max Gain and Min/Max Offset parameters can be adjusted to increase/decrease the amount of variation.
Scanning Direction	The direction of the Sensor scanning direction.
Scanline Spacing	The Scanline Spacing can be changed to make it more blocky.
Color Mapping On	A monochrome format with value interpolated from user-defined LUT scaling curve.
Color Mapping Type	1) User-Defined ColorMap: A monochrome format with value interpolated from user-defined LUT scaling curve. 2) LADAR ColorMap: A format designed to emphasize blue at low input values, green in mid-range values, and red at high values. 3) NVG ColorMap: A format characterized by low blue and red channels (until saturation, when they switch to high values), and a constantly-increasing scaled green channel. 4) LogScale ColorMap: A monochrome format based on a logarithmic scaling of the input.
User Defined File	A user-defined color mapping file.
Pre-Aperture	If selected, record the image before applying sensor effects.
Image(s) File Path	Location to store recorded images.

1.5.1. Using Active Sensor Regions (Dynamic Hot Spots)

SensorFX supports active sensor regions. An active sensor region changes its sensor effect as part of a model, such as an engine or gun barrel heats up or cools down. The following models have active sensor regions:

- SH-60 Sea Hawk helicopter (RotaryWingSH-60Seahawk model definition).
- USS Harry S. Truman (CVN 75) aircraft carrier (SurfaceCVN-75HarrySTruman model definition).
- T-72 main battle tank (TrackedT72B_DESERT model definition).

When using a DIS or HLA connection, these models activate a dynamic region when the power_plant_status appearance bit is set. Additionally, the T72's tracks grows hotter when the tank is moving and the gun barrel heats up as the result of firing its main gun.

> **i** Sensor effects that happen over time require the Ephemeris model (clock) to be active.

If you are using CIGI, you can activate dynamic sensor regions using a Component Control or Short Component Control message. Active sensor regions are named (the names can be found in *.ar* files in the data directories for the models included). CIGI Mappings are provided to map integer values to the names of sensor regions found in the example models. The Component Control message contains a Component class of Entity(0); the instance ID is the ID of the entity to change; the Component State is Sensor State(6), and the component data is a long value of '0' or '1'. '1' turns an active region on; '0' turns it off. The gun barrel on the T72 is an exception. It is impulsed-based. You should send a component data value of '1' each time the gun is fired. '0' is not used.

> **i** Multiple instances of the same model will not have independent dynamic hot spots when instancing is turned on. A work around is to set the instancing flag to off in the Model Definition for that model.

1.6. Configuring the Environment

Sensors are sensitive to environmental factors such as lighting and temperature. SensorFX adds configuration options to the Scene Settings dialog box, Environment Settings tab. Table 1-7 describes these options.

Table 1-7: SensorFX Environment tab

Option	Description
Night Sky Table File	Contains planetary and stellar irradiance info.
Atmospheric Model	An atmospheric model is a mathematical model constructed around the full set of primitive dynamical equations which govern atmospheric motions. It can supplement these equations with parameterizations for turbulent diffusion, radiation, moist processes (clouds and precipitation), heat exchange, soil, vegetation, surface water, the kinematic effects of terrain, and convection. Select Atmospheric model from drop down menu.Select model that best describes the simulated scene. User Specified Atmosphere End users can define custom Atmospheric models and Identify the model by name in the “User Specified Atmosphere” field.
Haze Model	The amount of haze in the atmosphere. Select an option from the list.
Wind Speed	This is used in the thermal temperature calculations and would likely be constant for a short scenario.
Visibility	This overrides the Modtran visibility when not using a user defined atmosphere file. The units are meters. A setting of 0.0 instructs Modtran to use the default visibility for the chosen atmosphere, and is a recommended setting.
Season	One of the four seasons.
Min Diurnal Temp Max Diurnal Temp	These specify the temperature range of the air through out a diurnal cycle and would not need to change during a short run scenario, but is important to set correctly even for such scenarios.
Rain Temp [degC]	The temperature of the precipitation falling in the scene.

Table 1-7: SensorFX Environment tab

Option	Description
Rain Rate [mm/hr]	Is the precipitation rate per hour
Relative Humidity	The amount of water vapor in a mixture of air and water vapor. It is defined as the partial pressure of water vapor in the air-water mixture, given as a percentage of the saturated vapor pressure under those conditions. The relative humidity of air thus changes not only with respect to the absolute humidity (moisture content) but also temperature and pressure, upon which the saturated vapor pressure depends. Relative humidity is often used instead of absolute humidity in situations where the rate of water evaporation is important, as it takes into account the variation in saturated vapor pressure.

1.7. Using SensorFX with Remote Display Engines

You can use SensorFX with remote display engines.

➤ To run a remote display engine that uses SensorFX, on the Start menu, choose **All Programs** → **MÄK Technologies** → **VR-Vantage 2.0** → **VR-Vantage Display Engine with SensorFX**.

1.7.1. Changing the Sensor on a Remote Display Engine

Ordinarily, to change the sensor being used, you change to an observer that has the sensor you want. However, you cannot change the observer on remote display engines. If you want to change the sensor on a remote display engine, you can do so by changing the sensor for the remote display engine's channel. (You can change the sensor for any channel this way, not just remote display engines.)

To change the sensor for a remote display engine:

1. Choose **View** → **Display Engine Configuration Editor Panel**. The Display Engine Configuration Editor opens.
2. Select the channel for the remote display engine. By default, the Sensor attribute has the value From Observer (Figure 1-1).

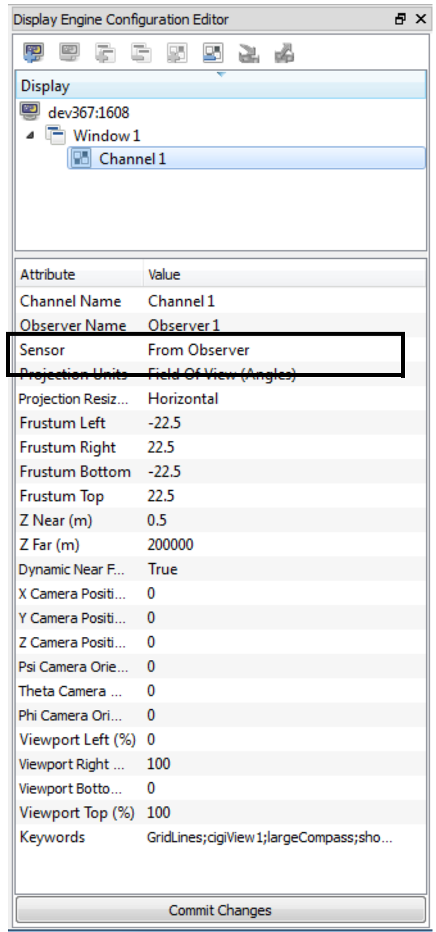

Figure 1-1. Display Engine Configuration Editor

3. Click the value to make it editable.
4. Select a sensor from the list (Figure 1-2).

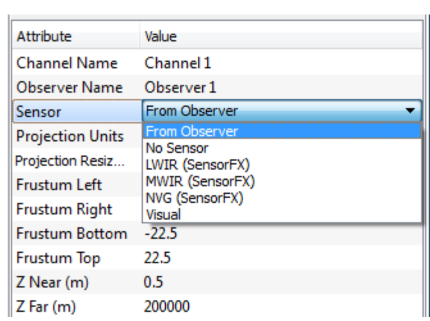

Figure 1-2. Sensor list

5. Click Commit Changes. The sensor in the remote display engine will change.

1.8. Material Classification on Demand

SensorFX material classification on demand (MCOD) provides automatic material classification using vector shape-files, and combines them with an intensity-modulated image to produce material encoded textures used in the real-time sensor rendering. The material encoded textures use JRM's Eigen material technique, which provides excellent rendering capabilities with the ability to mimic an unlimited number of material systems through the combination of multiple eigen materials.

Eigen materials can be thought of as a basic material group that can be combined to form specific material systems. These textures are in a continuous parameter space that is not dependent on time-of-day and other environmental conditions and can be Mipped/interpolated and compressed. The textures can be used to simulate all the different sensor bands (NVG, IR, and so on) without being regenerated.

The process is done automatically as the data is paged in from the server, and once the material textures have been generated, the texture array images are saved to the standard osgEarth file cache ready for fast loading on subsequent runs.

This section explains how to define generation of a material classified texture in an earth file.

The MCOD process:

- Processes any number of vector shape-files as raster images for each LOD. These shape-files represent material features (for example, roads, building footprints, water, and so on.)
- Combines the image textures to produce a per-pixel intensity modulation that maintains the spatial variation.
- Generates the material classified texture layers that are processed in real-time to calculate sensor wavelength-specific output using JRM's sensor suite.

MCOD:

- Supports an unlimited number of material types by the use of texture arrays. Individual Eigen materials are stored as distinct components in each of the texture array layers.
- Stores individual materials as distinct components in each of the texture array layers.
- Specifies material components using osgEarth earth files. A feature component's color is specified using the standard style symbol set. This section describes how to use the styles necessary to define features plus any custom styles particular to MCOD.
- Caches files using the standard osgEarth pipeline to accelerate run-time load performance.

The MCOD plug-in uses standard osgEarth terminology plus the following terms:

- texture layer. Corresponds to an index of an output texture array (0 to number of available layers-1).
- channel. An image color component (for example, R,G,B or A).
- default material. The material to use in the areas that are not defined by a shape-file.
- Intensity Modulation (IM). An optional channel to hold a gray scale representation of the visual imagery.
- feature level. Extends the osgEarth concept of level, but is particular to features, such as shapefiles.

The following code is a template for setting up an MCOD layer in an earth file:

```
<map name="Name of the Map" type="geocentric" version="2">
  <!-- [Optional] Visible Image layers go here -->

  <!-- [Optional] Elevation source can be specified here -->
  <image name="MaterialClassificationOnDemand" driver="mcod"
  visible="false" shared="true">
    <!-- optional file cache id -->
    <cacheid>mcod</cacheid>
    <!-- defines the depth of the texture array, must be 1 or more -->
    <num_texture_layers>2</num_texture_layers>

    <!-- for now texture compression MUST be set to none -->
    <texture_compression>none</texture_compression>
    <!-- assign default material channel (RGBA) and texture layer -->
    <default_material_channel>#0000ff00</default_material_channel>
    <default_material_texture_layer>0</default_material_texture_layer>

    <!-- assign intensity modulation color channel (RGBA) and
      texture layer -->

  <intensity_modulation_channel>#000000ff</intensity_modulation_channel

  <intensity_modulation_texture_layer>0</intensity_modulation_texture_la
  yer>

    <!-- specify minimum level where features (shapefiles) will begin
      to render -->
    <min_feature_level>10</min_feature_level>
    <!-- [Optional] image layers - to compute intensity modulation -->
    <image>
      ...
    </image>
    <image>
      ...
    </image>
    <!-- features layers - contain material shapefiles to render -->
     <features>
      ...
    </features>
    <features>
      ...
    </features>
    <!-- define rendering styles, by name, for the features -->
```

```
      <styles>
        <style type="text/css">
          ...
        </style>
      </styles>
    </image>
  </map>
```

Layer flags (osgEarth standard):

- driver="mcod". Specifies the MCOD plug-in.
- visible="false". Layer will not be rendered directly.
- shared="true". Textures are made available to shaders.

MCOD specific variables:

- num_texture_layers. The number of texture layers defining the creation of the output texture array.
- default_material_channel. Channel (color component, RGBA order) that will contain the default material. in the example above, default material channel is defined as #0000ff00 indicating that the 8-bit Blue channel will contain the default material.
- default_material_texture_layer. Texture array id [0 to num_texture_layers-1] for the default material.
- intensity_modulation_channel. Channel (color component, RGBA order) that will contain intensity modulation. In the example above, the intensity modulation channel is defined as #000000ff, indicating that the 8-bit Alpha channel will contain IM.
- intensity_modulation_texture_layer. Texture array id [0 to num_texture_layers-1] for intensity modulation.
- min_feature_level. Similar to the osgEarth variable min_level, but is specific to features (material shapefiles). Default: 0.

The following code shows the MCOD setup in *VR-theWorld Online - MAK Earth_mcod.earth*:

```
<image name="features"
        driver="mcod"
        opacity="1.0"
        visible="false"
        shared="true"
        min_filter     = "LINEAR_MIPMAP_LINEAR"
        mag_filter     = "LINEAR"
        max_range      = "100000000">
  <cacheid>mcod</cacheid>

  <!-- specify the minimum level that features (shapefiles) will begin to
  render -->
  <min_feature_level>10</min_feature_level>

  <num_texture_layers>1</num_texture_layers>

  <texture_compression>none</texture_compression>
  <!-- assign default material channel (RGBA) and texture layer -->
  <default_material_channel>#0000ff00</default_material_channel>
  <default_material_texture_layer>0</default_material_texture_layer>

  <!-- assign intensity modulation color channel (RGBA) and texture layer
  -->
  <intensity_modulation_channel>#000000ff</intensity_modulation_channel
  <intensity_modulation_texture_layer>0</intensity_modulation_texture_laye
  r>
```

1.8.1. Associating Styles and Features

Styles specify how features are rasterized into a layer. The feature rasterization is implemented using the osgEarth framework that wraps the AggLite renderer. Styles defined in the earth file control raster characteristics such as color and stroke width. The MCOD process associates a style with a given feature, such as a road, by the matching case-sensitive name string. The following code is from *VR-theWorld Online - MAK Earth_mcod.earth*:

```
<features name="buildings-1" driver="wfs">
  <url>http://vr-theworld.com/vr-theworld/features/wfs</url>
  <build_spatial_index>true</build_spatial_index>
  <typename>65</typename>
</features>

<features name="roads-1" driver="wfs">
  <url>http://vr-theworld.com/vr-theworld/features/wfs</url>
  <build_spatial_index>true</build_spatial_index>
  <typename>55</typename>
</features>

<styles>
  <style type="text/css">
    roads-1 {
      stroke:             #ff0000;
      stroke-width:       50m;
      stroke-min-pixels:  0;
      altitude-clamping:  terrain-drape;
      texture-layer:      0;
    }
    buildings-1 {
      fill:         #00ff00;
      stroke:   #00ff00;
      stroke-min-pixels:  0;
      stroke-width:  0px;
      texture-layer:      0;
    }
  </style>
</styles>
```

This example has the MCOD specific style variable texture-layer, a texture array id [0 to num_texture_layers-1] for the feature.

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