SensorFX

Users Guide

JRM Technologies
Real Physics • Real Sensors • Real-time

VT MÄK
A company of VT Systems

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Contents

Preface

Chapter 1. Using SensorFX

Preface

This manual is for persons who will install SensorFX and use it to view simulations. The manual assumes that you are familiar with basic administrative tasks and the graphical window environment for your operating system. SensorFX is a plug-in to VR-Vantage. This manual assumes you are familiar with use of VR-Vantage.

MÄK Products

The SensorFX is a member of the VT MÄK line of software products designed to streamline the process of developing and using networked simulated environments. The VT MÄK product line includes the following:

- VR-Link® Network Toolkit. VR-Link is an object-oriented library of C++ functions and definitions that implement the High Level Architecture (HLA) and the Distributed Interactive Simulation (DIS) protocol. VR-Link has built-in support for the RPR FOM and allows you to map to other FOMs. This library minimizes the time and effort required to build and maintain new HLA or DIS-compliant applications, and to integrate such compliance into existing applications.

  VR-Link includes a set of sample debugging applications and their source code. The source code serves as an example of how to use the VR-Link Toolkit to write applications. The executables provide valuable debugging services such as generating a predictable stream of HLA or DIS messages, and displaying the contents of messages transmitted on the network.

- MÄK RTI. An RTI (Run-Time Infrastructure) is required to run applications using the High Level Architecture (HLA). The MÄK RTI is optimized for high performance. It has an API, RTIspy®, that allows you to extend the RTI using plug-in modules. It also has a graphical user interface (the RTI Assistant) that helps users with configuration tasks and managing federates and federations.

- VR-Forces®. VR-Forces is a computer generated forces application and toolkit. It provides an application with a GUI, that gives you a 2D and 3D views of a simulated environment.

  You can create and view entities, aggregate them into hierarchical units, assign tasks, set state parameters, and create plans that have tasks, set statements, and conditional statements. You can simulate using entity-level modeling, which focuses on the actions of individual people and vehicles, and aggregate-level modeling, which focuses on the interaction of large hierarchical units.

  VR-Forces also functions as a plan view display for viewing remote simulation objects taking part in an exercise. Using the toolkit, you can extend the VR-Forces application or create your own application for use with another user interface.

- VR-Vantage™. VR-Vantage is a line of products designed to meet your simulation visualization needs. It includes three end-user applications (VR-Vantage Stealth, VR-Vantage PVD, and VR-Vantage IG) and the VR-Vantage Toolkit.
  - VR-Vantage Stealth displays a realistic, 3D view of your virtual world, a 2D plan view, and an exaggerated reality (XR) view. Together these views provide both situational awareness and the big picture of the simulated world. You can move your viewpoint to any location in the 3D world and can attach it to simulation objects so that it moves as they do.
  - VR-Vantage IG is a configurable desktop image generator (IG) for out the window (OTW) scenes and remote camera views. It has most of the features of the Stealth, but is optimized for its IG function.
  - VR-Vantage PVD provides a 2D plan view display. It gives you the big picture of the simulated world.
  - SensorFX. SensorFX is an enhanced version of VR-Vantage that uses physics based sensors to view terrain and simulation object models that have been materially classified. It is built in partnership with JRM Technologies.
  - The VR-Vantage Toolkit is a 3D visual application development toolkit. Use it to customize or extend MÄK's VR-Vantage applications, or to integrate VR-Vantage capabilities into your custom applications. VR-Vantage is built on top of OpenSceneGraph (OSG). The toolkit includes the OSG version used to build VR-Vantage.
- MÄK Data Logger. The Data Logger, also called the Logger, can record HLA and DIS exercises and play them back for after-action review. You can play a recorded file at speeds above or below normal and can quickly jump to areas of interest. The Logger has a GUI and a text interface. The Logger API allows you to extend the Logger using plug-in modules or embed the Logger into your own application. The Logger editing features let you merge, trim, and offset Logger recordings.
- VR-Exchange™. VR-Exchange allows simulations that use incompatible communications protocols to interoperate. For example, within the HLA world, using VR-Exchange, federations using the HLA RPR FOM 1.0 can interoperate with simulations using RPR FOM 2.0, or federations using different RTIs can interoperate. VR-Exchange supports HLA, TENA, and DIS translation.

- VR-TheWorld™ Server. VR-TheWorld Server is a simple, yet powerful, web-based streaming terrain server, developed in conjunction with Pelican Mapping. Delivered with a global base map, you can also easily populate it with your own custom source data through a web-based interface. The server can be deployed on private, classified networks to provide streaming terrain data to a variety of simulation and visualization applications behind your firewall.
- DI-Guy™. The DI-Guy product line is a set of software tools for real-time human visualization, simulation, and artificial intelligence. Every DI-Guy software offering comes with thousands of ready-to-use characters, appearances, and motions. DI-Guy enables the easy creation of crowds and individuals who are terrain aware, autonomous, and react intelligently to ongoing events. Save time, money and create outstanding simulations with DI-Guy. The DI-Guy product line includes the following products:
  - The DI-Guy SDK. Embed the DI-Guy library in your real-time application and populate your world with lifelike human characters.
  - DI-Guy Scenario™. Author and visualize human performances in a rich, user-friendly graphical environment. Use DI-Guy Scenario as an end visualization application or save scenarios and load them into your DI-Guy SDK enabled application.
  - ECOSim. Enhanced Company Operations Simulation (ECOSim) is a company-level training simulation that teaches leaders how best to deploy troops, UAVs, convoys, and other assets. ECOSim focuses on ease-of-use, rapid scenario generation, runtime operator control, and realistic and reactive human simulation.
  - DI-Guy AI. Generate crowds of autonomous characters to quickly populate your worlds with hundreds and thousands of terrain-aware, collision avoiding DI-Guys. Used as a module on top of DI-Guy Scenario and DI-Guy SDK.
  - Expressive Faces Module. Enable DI-Guy characters to have faces that display emotion, eyes that look in directions and blink, and lips that sync to sound files.
  - DI-Guy Motion Editor. Create or customize motions to your particular needs in an easy-to-use graphical application.
- RadarFX. RadarFX is a client-server application that can simulates synthetic-aperture radar (SAR). The server application, which is based on VR-Vantage and SensorFX, loads a terrain database and, optionally, connects to simulations. A client application requests SAR images from the server. SensorFX includes a sample client application.

How to Contact Us

For SensorFX technical support, information about upgrades, and information about other MÄK products, you can contact us in the following ways:

Telephone

Call or fax us at:	Voice:	617-876-8085 (extension 3 for support)
	Fax:	617-876-9208

E-mail

Sales and upgrade information:	info@mak.com
Technical support:	support@mak.com
VR-Vantage support:	

Internet

MÄK web site home page:	www.mak.com
License key requests:	www.mak.com/support/licenses/get-licenses
Product version and platform information:	www.mak.com/support/product-versions
For the free, unlicensed MÄK RTI:	www.mak.com/resources/bonus-material
MÄK Community Forum:	www.mak.com/connect/forum

Post

Send postal correspondence to:	VT MÄK 150 Cambridge Park Drive, 3rd Floor Cambridge, MA, USA 02140

When requesting support, please tell us the product you are using, the version, and the platform on which you are running.

Document Conventions

This manual uses the following typographic conventions:

`Monospaced`	Indicates commands or values you enter.
`Monospaced Bold`	Indicates a key on the keyboard.
Monospaced Italic	Indicates command variables that you replace with appropriate values.
Blue text	A hypertext link to another location in this manual or another manual in the documentation set.
`{ }`	Indicates required arguments.
`[ ]`	Indicates optional arguments.
|	Separates options in a command where only one option may be chosen at a time.
(|)	In command syntax, indicates equivalent alternatives for a command-line option, for example, `(-h | --help)`.
/	Indicates a directory. Since MÄK products run on both Linux and Windows PC platforms, we use the / (slash) for generic discussions of pathnames. If you are running on a PC, substitute a \ (backslash) when you type pathnames.
Italic	Indicates a file name, pathname, or a class name.
sans Serif	Indicates a parameter or argument.
➤	Indicates a one-step procedure.
Menu → Option	Indicates a menu choice. For example, an instruction to select the Save option from the File menu appears as: Choose **File → Save**.
	Click the icon to run a tutorial video in the default browser.
i	Indicates supplemental or clarifying information.
!	Indicates additional information that you must observe to ensure the success of a procedure or other task.

Directory names are preceded with dot and slash characters that show their position with respect to the SensorFX home directory. For example, the directory *vrvantagex.x2.1/doc* appears in the text as *./doc*.

DI-Guy Conventions

Table 2-1 lists the conventions used for entity coordinates in DI-Guy documentation.

Table 2-1: Coordinate system conventions

Convention	Indicates
XYZ	X = forward, Y = to the left Z = up
Yaw, Roll, Pitch	Orientation is applied in the order YRP. Yaw = rz – orientation about the vertical axis Roll = rx – orientation about the fore-aft axis Pitch = ry – orientation nose down, nose up

Mouse Button Naming Conventions

An instruction to click the mouse button, refers to clicking the primary mouse button, usually the left button for right-handed mice and the right button for left-handed mice. The context-sensitive menu, also called a popup menu or right-click menu, refers to the menu displayed when you click the secondary mouse button, usually the right button on right-handed mice and the left button on left-handed mice.

Third Party Licenses

MÄK software products may use code from third parties. This section contains the license documentation required by these third parties.

Boost License

VR-Link, and all MÄK software that uses VR-Link uses some code that is distributed under the Boost License. All header files that contain Boost code are properly attributed. The Boost web site is: www.boost.org.

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libXML and libICONV

VR-Link and all MÄK software that uses VR-Link, links in libXML and libICONV. On some platforms the compiled libraries and header files are distributed with MÄK Products. MÄK has made no modifications to these libraries. For more information about these libraries please see the following web sites:

- The LGPL license is available at: http://www.gnu.org/licenses/lgpl.html.
- Information about IconV is at: http://www.gnu.org/software/libiconv/.
- Information about LibXML is at: http://xmlsoft.org/.

Lua

Some MÄK products use the Lua programming language (www.lua.org). Its license is as follows:

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LizardTech

Freefont OpenType Font Set

VR-Vantage applications and VR-Forces use the Freefont OpenType font set from the Free Software Foundation. It is covered by the General Public License (GPL). For details, please see: http://www.gnu.org/licenses/gpl.html

osgoculusviewer Library

Third-Party Licenses for VR-Vantage Applications

VR-Vantage applications use a variety of third-party libraries. Developers who want to use these libraries may be required to purchase developer's licenses. Please see Section 1.2, "Third-Party Software and Content,", in *VR-Vantage Users Guide* for details.

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.

SensorFX supports only one observer at a time being fully sensorized. If you open additional windows that use different observers, for example, inset views, they will show a sensor view similar to that provided by the VR-Vantage CameraFX sensors. (However, note that when you run the SensorFX version of VR-Vantage , the CameraFX sensors are not directly available as user options.)

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. To request a license, contact keys@mak.com. For information about installing the license, please see Chapter 2 in *VR-Vantage Users Guide*, which is in the *./doc* 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 2.1** → **VR-Vantage with SensorFX**.

SensorFX does not support geocentric terrains if they are part of a terrain that does not include an osgEarth terrain patch.

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 11.2, "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 11, *Using Sensors*, in *VR-Vantage Users Guide*.)

Clouds and precipitation are not correlated between the sensor modes and visual or no sensor modes.

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 11.3, "Configuring Sensors," in *VR-Vantage Users Guide*.)

To add a sensor:

1. Choose **Settings** → **Display**. The Display Settings dialog box opens.
2. Select the Sensor Settings page.
3. Select a sensor mode that is similar to the one you want to create.
4. On the Sensor Mode line, click the Add button (+). A new sensor called sensor_*number* is added. It copies the settings of the sensor you selected. (To rename the sensor, click the Rename button (✎) and enter a new name.)
5. Change the settings for the new sensor as desired.

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.

Table 1-1: Effects tab, Sensor Effects

Option	Description
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.
% 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.

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

Option	Description
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.

To change the environment settings:

1. Choose **Settings** → **Scene**. The Scene Settings dialog box opens.
2. Select the SensorFX Environment Settings page (Figure 1-1).

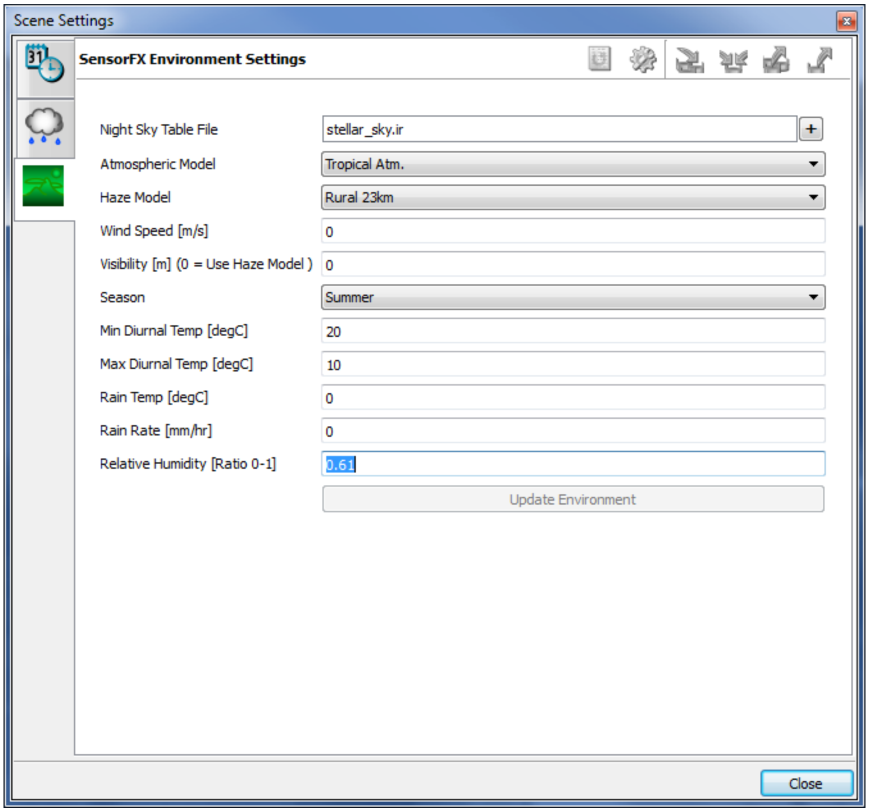

Figure 1-1. SensorFX Environment Settings page

3. Change settins as desired. 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]	This setting affects objects in the scene, not the actual temperature of rain. Increasing the temperature leads to a brighter scene.

Table 1-7: SensorFX Environment tab

Option	Description
Rain Rate [mm/hr]	The precipitation rate per hour. Increasing the rain rate reduces the contrast in the scene.
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.

4. Click Update Environment. It can take 30 seconds or longer for the changes to affect the scene.

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 2.1** → **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 1-2).

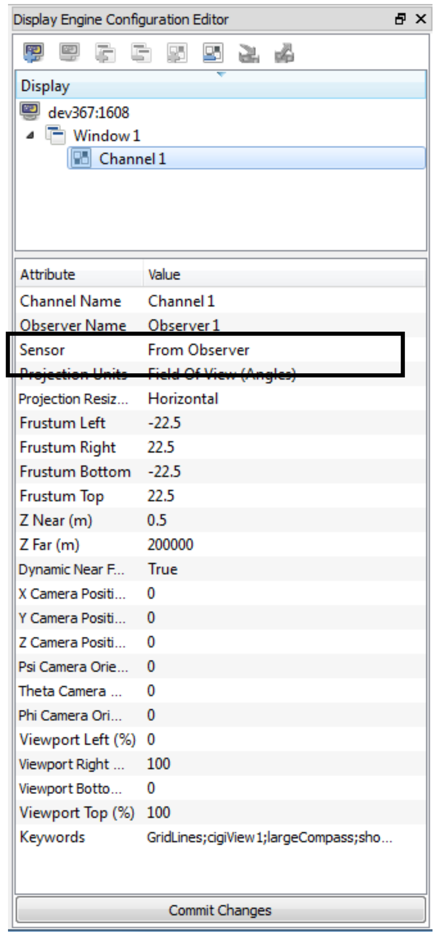

Figure 1-2. Display Engine Configuration Editor

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

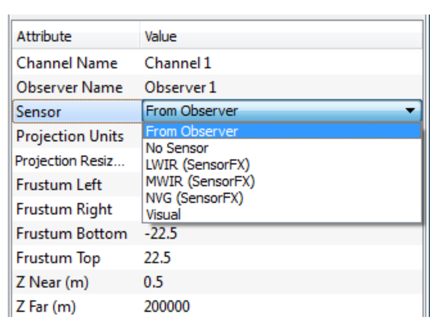

Figure 1-3. Sensor list

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 shapefile.
- 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.

1.9. Streaming Sensorized Imagery

SensorFX supports streaming imagery. It is set up through the earth file. Create an image section with a name that contains emat. For example:

```
<image name="streaming emat2" driver="gdal" lod_blending="true"
  shared="true" visible="false">
  <shared_sampler>jrmuSensorTex2</shared_sampler>
  <shared_matrix>jrmuSensorTexMatrix2</shared_matrix>
  <url>../../Data/Terrain/DATABASENAME/imagery/emat2</url>
</image>

<image name="streaming emat3" driver="gdal"  lod_blending="true"
  shared="true" visible="false">
  <shared_sampler>jrmuSensorTex3</shared_sampler>
  <shared_matrix>jrmuSensorTexMatrix3</shared_matrix>
  <url>../../Data/Terrain/DATABASENAME/imagery/emat3</url>
</image>
```

Emat2 and emat3 should be in separate directories. They need to be geoTiff versions of the emat textures so that osgEarth has the location information to correctly place the textures.

To specify an ms file, do the following:

```
<external>
  <msfile>../../Data/Terrain/DATABASENAME/databaseEmat.ms</msfile>
</external>
```

This ms file can be used with streaming imagery, MCOD, or osgEarth terrains that are not material classified at all.

For information about ms files and emat files, please see Chapter 2, *Adding GenesisMC Models to SensorFX*.

The example HawaiiTifExample has a sample earth file called *HawaiiTifExample.earth* and an *.mtf* file called *HawaiiTifExample.mtf*. It shows how to set up the earth file and the terrain directory for using geotiff's directly.

2. Adding GenesisMC Models to SensorFX

This chapter explains how to integrate materially classified models generated by GenesisMC into SensorFX.

2.1. Introduction

GenesisMC is an application created by JRM Technologies that processes models and creates the files needed by SensorFX to render them based on material classification. This chapter assumes you have generated material classified versions of your models using GenesisMC and explains how to set up the files for SensorFX to use them.

2.2. Model File Setup

SensorFX uses the following types of files to load the materially classified version of a model:

- Material classification file (*.emat*).
- Material system file (*.ms*).
- Intensity modulation file (*.imod*) (optional).
- Active regions file (*.ar*) (optional).

The *.emat*, *.ms*, and *.imod* files are generated by GenesisMC. The *.ar* file is created by the model developer or someone who understands the location of hotspots on the model.

These files are generated by GenesisMC.

SensorFX uses the names of the textures and models to look for the material classified configuration files. For example, the base set of files for the SH-60 SEA-HAWK (in *./data/Vehicles/RotaryWing/SH-60 SEA-HAWK*) before material classification is:

- DB_ROTOR_4PALES_128_rgba.meif
- DB_SH60L_1024_DESERT_CAMO_NML_rgb.meif
- DB_SH60L_1024_DESERT_CAMO_RFL_rgb.meif
- DB_SH60L_1024_DESERT_CAMO_rgb.meif
- DB_SH60L_1024_DESERT_CAMO_SPC_rgb.meif
- DB_SH60L_1024_rgb.meif
- DB_SH-60L_DESERT_CAMO_V7.0.medf
- DB_SH60L_FLOOR_256_rgb.meif
- DB_SH60L_INTERIOR_512_rgb.meif
- DB_SH60L_SHADOW_256_rgba.meif
- DB_SH60L_WINDOW_512_RFL_rgba.meif
- DB_SH60L_WINDOW_512_rgba.meif
- DB_SH60L_WINDOW_512_SPC_rgba.meif

2.2.1. The .emat Files

EMAT files are materially classified versions of the visual RGB textures. One of the RGB textures for the SH-60 is DB_SH60L_1024_rgb.meif. After processing the textures, GenesisMC creates three EMAT textures for *DB_SH60L_1024_rgb.meif* – *DB_SH60L_1024.emat1.dds*, *DB_SH60L_1024.emat2.dds*, and *DB_SH60L_1024.emat3.dds*. SensorFX does not use the emat1 file. In order to save texture memory, SensorFX uses the *.imod* file to fulfill the same purpose.

Copy the **.emat2.dds* and **.emat3.dds* files to the same directory as the RGB textures so that SensorFX can find them. The complete list of *.emat* files for the SH-60 is as follows:

- DB_ROTOR_4PALES_128.emat2.dds
- DB_ROTOR_4PALES_128.emat3.dds
- DB_SH60L_1024.emat2.dds
- DB_SH60L_1024.emat3.dds
- DB_SH60L_1024_DESERT_CAMO.emat2.dds
- DB_SH60L_1024_DESERT_CAMO.emat3.dds
- DB_SH60L_FLOOR_256.emat2.dds
- DB_SH60L_FLOOR_256.emat3.dds
- DB_SH60L_INTERIOR_512.emat2.dds
- DB_SH60L_INTERIOR_512.emat3.dds
- DB_SH60L_WINDOW_512.emat2.dds
- DB_SH60L_WINDOW_512.emat3.dds.

2.2.2. Material System File (.ms)

SensorFX uses the material system file to map a channel of the emat texture to a particular material. There might be multiple material system files in the GenesisMC output directory. The one that SensorFX needs ends in *Emat.ms*. The contents of the file will be nine lines that define six materials. In the SH-60 example, this file is *DB_SH-60L_-DESERT_CAMO_V7.0Emat.ms*.

There are two ways to point to a material system file. The simplest way is to give the file the same name as the model file name minus the extension and add *Emat.ms*. This file must be in the same directory as the model file. In the SH-60 example, the model filename is *DB_SH-60L_DESERT_CAMO_V7.0.medf*. Therefore, the material system file is *DB_SH-60L_DESERT_CAMO_V7.0Emat.ms*.

The other way to point to a material system file is in a model definition. For details, please see "The msFilename Parameter," on page 2-5.

2.2.3. Intensity Modulation File (.imod)

An intensity modulation file or *.imod* file is an optional file that defines how much of the RGB texture to mix with the Sensor response in the final result. It allows the intensity modulation to be defined on a per-material and per-sensor band level. The file must have the same name as the material system file, except that the extension must be *.imod* instead of *.ms*. This file must be in the same directory as the material system file. In the SH-60 example the material system file is *DB_SH-60L_DESERT_-CAMO_V7.0Emat.ms* which corresponds to intensity modulation file *DB_SH-60L_-DESERT_CAMO_V7.0Emat.imod*.

2.2.4. Active Region File (.ar)

The active region file is an optional file that lets you define which materials are dynamic. (Active regions are also called hotspots.) The file defines a material for the off state and another material for the on state. If the model does not have any active regions then it does not need an active region file.

The active region file is a text file that you create. It is not created by GenesisMC.

See *DB_SH-60L_DESERT_CAMO_V7.0Emat.ar* for an example of an active region file. For a more complex example, see *./data/Vehicles/Tracked/T72/T72aEmat.ar*.

The *.ar* file must have the same name as the *.ms* file it corresponds to, except that the extension is changed to *.ar*. For example *DB_SH-60L_DESERT_CAMO_V7.0Emat.ar* corresponds to *DB_SH-60L_DESERT_CAMO_V7.0Emat.ms*.

2.3. Model Definitions for Materially Classified Models

If you have generated material classification files for a model that is already configured in VR-Vantage, all you have to do is put the required files in the model directory as described in previous sections. You do not have to edit the model definition.

If you have created a new model, you must create a model definition, as described in Section 28.3, "Creating and Editing Model Definitions," in *VR-Vantage Users Guide*.

SensorFX supports an optional parameter, msFilename, that you can add to schemas and model definitions.

SensorFX supports the following optional parameters that you can add to schemas and model definitions: msFilename, powerPlantActiveRegions, movingActiveRegions, and weapon-FireActiveRegions.

2.3.1. The msFilename Parameter

The **msFilename** parameter lets you point to a material system file that does not use the naming convention described in "Material System File (*.ms*)," on page 2-3. Possible reasons for this are if there are two models that need to use the same material system file or there are multiple variations of the same model that need different material systems.

The **msFilename** parameter is not available by default. You must be added to the model's schema before you can use it. Please see Section 28.2.4, "Adding a Parameter to a Schema,"in *VR-Vantage Users Guide* for information about how to add a parameter to a schema.

The parameter must be called **msFilename** and have its type set to string.

To determine which schema to edit, look at the schema listed for the model definition for the model you are editing. The most likely schemas are Entity and Watercraft.

2.3.2. The powerPlantActiveRegions Parameter

The power plant active regions are active regions that should be turned on when the model's power plant is turned on and turned off when the model's power plant is turned off.

In the active region file, the first column of each line specifies the name of an active region. The SH-60, has two active regions, EngineGlass and EnginePaint. In order to map them to the power plant active state in VR-Vantage, the model definition needs a parameter added called **powerPlantActiveRegions**. The value of that parameter is a comma separated list of active regions that should map to the power plant state. For the SH-60, the value for **powerPlantActiveRegions** is EngineGlass,EnginePaint. This maps the EngineGlass and EnginePaint active regions to the power plant state.

2.3.3. The movingActiveRegions Parameter

The moving active regions are active regions that should be turned on when the model is moving and turned off when the model is stationary. *./data/Vehicles/Tracked/T72/T72aEmat.ar* is an example of an active regions file that has a moving active region. The Track active region corresponds to the material on the tracks of the tank. Therefore it must be mapped to the moving active region in the model definition. The **movingActiveRegions** parameter in the model definition for the T-72 has a value of Track. It maps the Track active region to the moving state of the tank.

2.3.4. The weaponFireActiveRegions Parameter

The weapon fire active regions are active regions that should be triggered when the model fires its weapon. *./data/Vehicles/Tracked/T72/T72aEmat.ar* is an example of an active regions file that has a weapon fire active region. The Artillery active region corresponds to the material on the weapon of the tank. It must be mapped to the weapon fire active region in the model definition. The weaponFireActiveRegions parameter in the model definition for the T-72 it has a value of Artillery. It maps the tank's main large gun active region to the weapon fire event in VR-Vantage.

Index

Link - Simulate - Visualize

VRV-2.1-11-160210

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