

IMAGE GENERATOR PERFORMANCE AND MODERN HARDWARE IN THE LOOP STIMULATION

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Jean Latger ⁽¹⁾, Thierry Cathala ⁽¹⁾

⁽¹⁾OKTAL Synthetic Environment, 11 Avenue du Lac, 31320 Vigoulet-Auzil (France)
Email: jean.latger@oktal-se.fr, thierry.cathala@oktal-se.fr

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ABSTRACT

IR projectors are now available on the market. For instance, the MIRAGE system is currently used by French DGA and by German BWB. These sophisticated devices cast IR fluxes of photons directly onto the IR camera of a given weapon system, typically a missile seeker head. Though in laboratory, the missile is so stimulated exactly like in the real world, provided a realistic simulation tool enables to perform synthetic images to be displayed by the IR projectors. The key technical challenge is to render the synthetic images at the required frequency. This paper explains the constraints on refresh rate and on time delay in particular. It shows the methodology applied in OKTAL-SE to assess an infrared Image Generator for HWIL application. Examples are given, in the frame of the SE-WORKBENCH, through the SE-FAST-IR product, based on Open GL shaders to perform high realism infrared images. The new SE-FAST-HWIL package is described. The first set of example focuses on test cases made of simple grids of polygons. The second example is a trial on a real operational complex 3D airport database. The conclusion describes the current state of the art, the current bottlenecks and the technical perspectives for SE-FAST-HWIL.

1. SE-WORKBENCH-EO

1.1. Overall presentation of the SE-Workbench

The SE-WORKBENCH is a multi-sensor battlefield modelling workbench mainly used by - Defence agencies as French DGA, German BWB, South Korea MoD, Singapore DSO/DSTA and Swedish FOI, - research centres as ONERA, IOSB Fraunhofer Institute and - industrials in and out of France as MBDA, Dassault, LG, STC.

SE-WORKBENCH-EO is the infrared sensor dedicated part of the SE-WORKBENCH that achieves the synthesis of 3D scene observed by a sensor, in four steps:

- first, the physical characterization of the 3D scene behaviour,
- then, the scenario edition (definition of the objects of the scenario, of the 3D scene and objects, assignment of trajectories to moving objects, definition of atmospheric and thermal conditions, parameterization of the sensors),
- then, the computation of the physical radiance signal received by the sensor
- at last, the sensor effects modelling.

The SE-WORKBENCH is entirely based on software products developed by OKTAL-SE and realizes the multi-spectral unification of optronics, electromagnetism and more recently GNSS (Global Navigation Satellite System), using a common kernel and physical extensions assignment both aimed at a unique 3D scene and a common technology. The SE-WORKBENCH is a winning initiative for sharing R&D efforts and federating a user group community that intends to exchange experience and knowledge.

The first development was in 1994 and has been strongly boosted by the French SCALP missile program and the qualification of the IR tracking system. At the beginning, the SE-WORKBENCH was focused on the IR domain. In 2001, an electromagnetic version of the workshop was initiated, with the help of ONERA French research centre, mainly focused on millimetre waves and wide scenes, typically for SAR applications. A new GNSS version for satellite application has started in 2009.

The control of the SE-WORKBENCH-EO validity domain is based on both a theoretical validation approach (development of physical models, general modelling and simulation knowledge, elementary tests and validity assessment) and a validation process based on comparisons with

experiments (SCALP/EG missile [FR], AASM missile [FR]).

1.2. The SE-WORKBENCH-EO architecture

The SE-WORKBENCH-EO is made of different components, as described hereafter, corresponding to the successive steps of a IR sensor simulation that are the modelling of the synthetic environment, the scenario edition, the rendering without the sensor effects and finally the sensor transfer function simulation. Furthermore, the user can do software integration in order to control the generated scenario execution from a remote or custom application. This can be achieved with the help of the SE-TOOLKIT consisting of a set of dedicated libraries and application programming interfaces (API) to help the complex application design and integration.

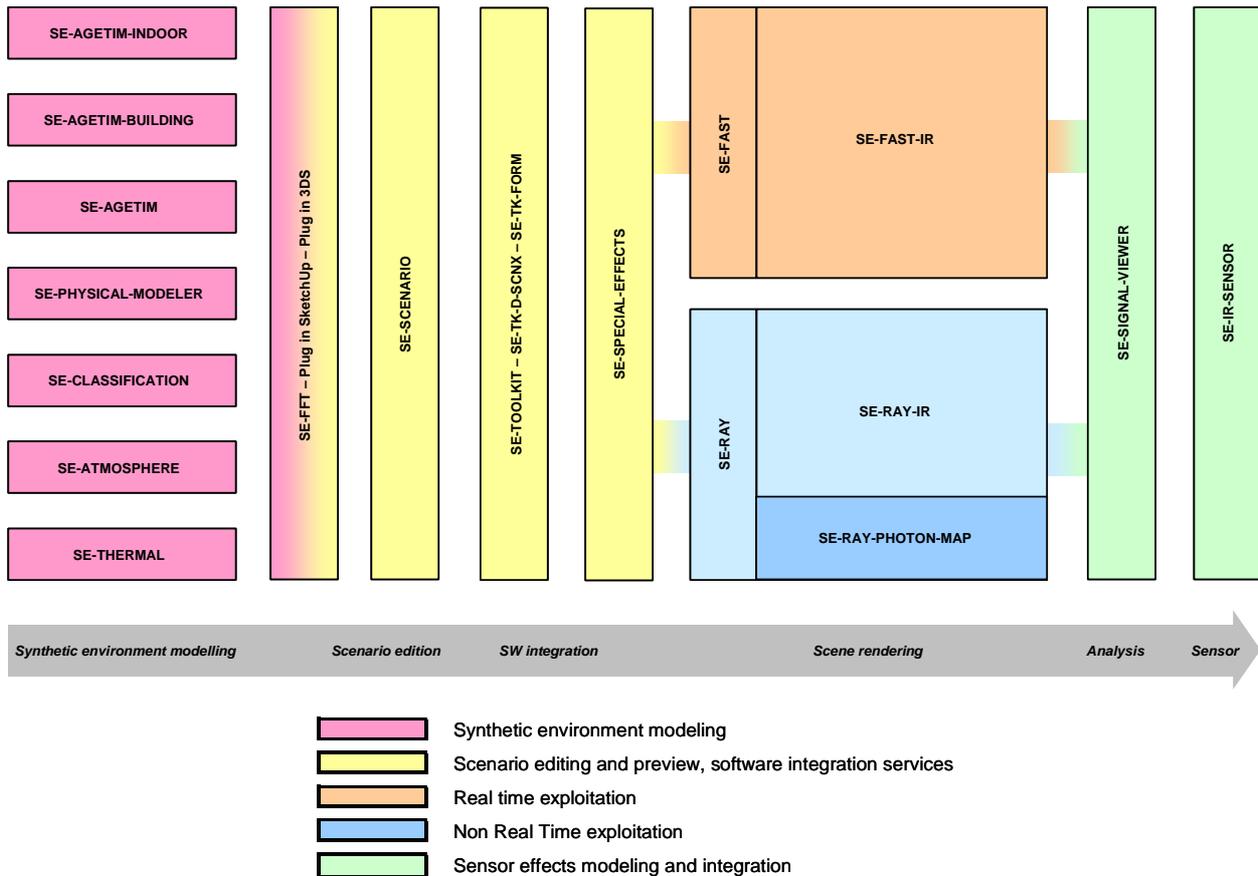


Figure 1: The SE-WORKBENCH-EO components

1.3. Real-time rendering based on SE-FAST-IR package

The SE-FAST-IR package is made of a major product (SE-FAST-IR) and additional modules depending on the considered application.

With the help of some pre-calculation steps, real-time images are computed with the SE-FAST-IR solution. It is dedicated to the rendering of images for near infrared sensors (light intensifying) and thermal infrared systems with short, medium or long waves (SWIR, MWIR, LWIR). The products

make use of the results of the SE-CLASSIFICATION tool, the SE-PHYSICAL-MODELER modeller and the SE-ATMOSPHERE atmospheric files computation product. The thermal pre-calculations are based on SE-THERMAL code.

SE-FAST-IR brings a technological rupture by using OpenGL pixel shaders enabling direct calculation on 3D graphic cards. A shader is a procedure written in a special purpose C like language that replaces a part of the graphic pipeline of a 3D graphic board. The new core of

SE-FAST-IR is based on the open source “Open Scene Graph” layer upon Open GL.

When the ray tracing image is constructed pixel by pixel, the rasterized image is constructed by projection of the polygons. A given 3D polygon is projected in the screen 2D space, the varying data that characterize this polygon, being associated to

this projection. Then the polygon is split into 2D sets of pixels, called fragments, that are stored and sorted (frame buffer) in function of their depth i.e. the distance to the screen.

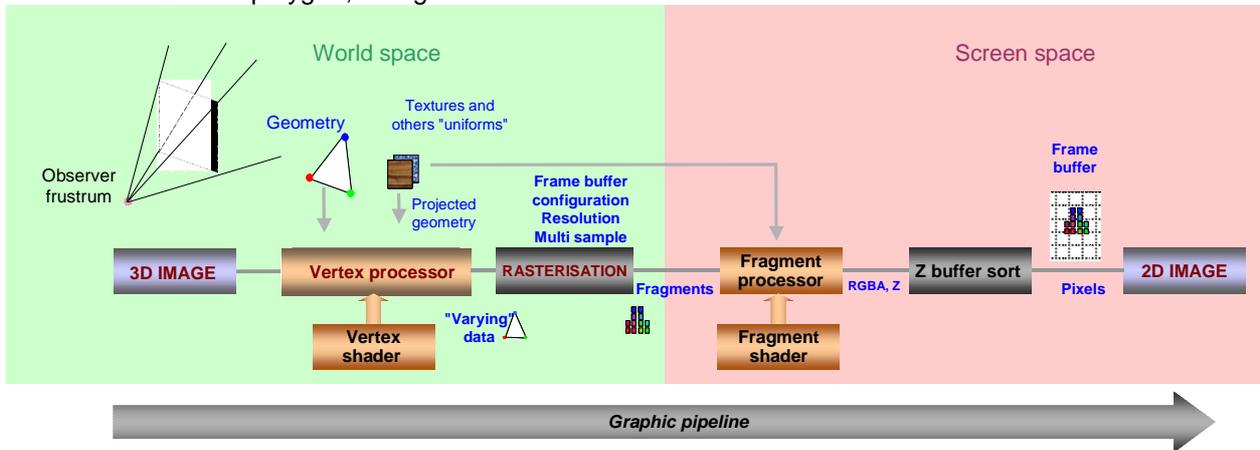


Figure 2: Rasterization process

2. INTRODUCTION TO CONCEPTS

2.1. Non-real-time and Real-time duality

The SE-WORKBENCH-EO workshop, also called CHORALE by the French MoD/DGA, is used to perform multi-sensors simulations on complex 3D synthetic environments. The SE-WORKBENCH-EO enables the user to create virtual and realistic multi spectral 3D scenes, and generate the physical signal received by an infrared sensor. This article describes the recent enhancements of the SE-WORKBENCH that aim at better representing. One key feature of SE-WORKBENCH-EO is the **Non-real-time and Real-time duality**. The technique associated to Non-real-time solution is called “ray tracing”. It runs on the CPU (Central Processor Unit) of the computer and now also on the GPU (Graphical Processor Unit), in the frame of General Purpose GPU. Ray tracing consists in tracing plane waves of electromagnetic field, called rays, and, through the 3D scene, thanks to geometrical optics, managing multiple bouncing of rays and scattering effects on surfaces.

The advantage of the Non-real-time approach is that the computation is made wavelength by wavelength, that the transmission within atmosphere can be done atmosphere segment by atmosphere segment and that the interaction with surfaces can take into account very sophisticated angle and wavelength dependent models. Typically, radiative coupling between surfaces or thermal shadows (in addition to normal shadows) can be accurately simulated. Besides, Non-real-

time pre-computations can be used to enrich Real-time rendering. In other words, this kind of simulation is very close to Physics.

The technique associated to Real-time solution is called “rasterization”. It runs on the GPU using pixel “shaders”. A shader is a piece of code that enables to control the way of drawing pixels. Rasterization consists in projecting triangles of the 3D scene onto the 2D screen and then to draw pixels to fill the triangles. It has no correlation at all with any physical process.

The advantage of real-time is the performance. For simple images, frequency of some hundreds Hz can be reached.

For HardWare In The Loop (HWIL) simulation, both techniques can be used. For open loop simulation, pre-computed sequences of images can be prepared and replayed in real-time. In this case, non-real-time rendering tools can be used. For closed loop simulation, which is the most common case, real-time rendering is compulsory. In all cases, this Non-real-time and Real-time duality is very important in order to assess the simplification made in the field of Real-time rendering with regards to Non-real-time rendering.

2.2. 3D scene constraints

One other very important feature for achieving real-time aggressive performances is the full control of the 3D scene modelling. To do so, the SE-FAST-HWIL package can include three complementary modelling tools.

SE-AGETIM product line, is self consistent with the

whole SE-Workbench-EO. SE-AGETIM is a 3D terrain and modelling tool. It directly generates the complex scenes with all the Physics inside.

SE-PHYSICAL-MODELER tool is a physical dedicated modelling tool that gives opportunity to control the material Physics and the accuracy of definition.

Besides, the SE-FFT product includes a plug-in to the standard free SketchUp Google 3D modelling tool and a plug-in 3DS Autodesk 3D modelling tool to import/modify/export 3D objects

Thanks to these tools, the 3D database can be deeply optimized in order to reach real-time performances.

2.2.1. Geometry constraints

The first step of simplification concerns geometry. One important part of the polygon budget concerns the terrain. SE-AGETIM includes special algorithms in order to adapt the vertices density of the meshing to the local terrain complexity. Beyond that, Level Of Detail (LOD) on the terrain are automatically computed. The terrain is first tiled. SE-AGETIM prepares several representation of these tiles from a very complex one (near observation) to a very rough one (long range observation).

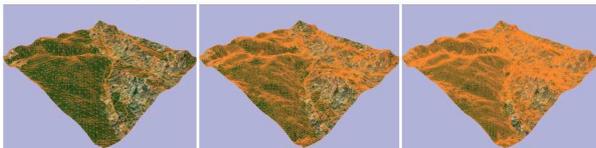


Figure 3: Level Of Detail on the terrain

This is a complex process since it must take into account the features commutation (rivers, roads, forests, buildings) and avoid any hole when associating several representations at different level of detail in the same frustum. Level Of Detail are also very important for the other features as for linear elements, surfaces and 3D objects. Concerning 3D objects and buildings in particular, several modes of representation are possible:

- the object can be geo-specific
- the object can be an instance with many occurrences and, in this case, the LOD must be well prepared in order to save lots of polygons
- the object footprint can be geo-specific but the elevation template can be instanced. To do so OKTAL-SE uses a special module of SE-AGETIM (SE-AGETIM-BUILDING) that automatically generates the buildings with LODs, using a template definition that contains the LOD definition for any footprint shape:

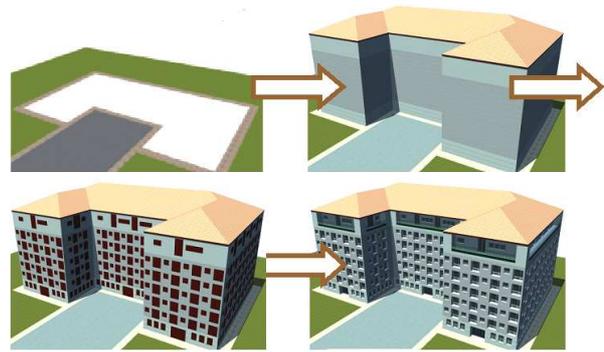


Figure 4: Generation of buildings using SE-AGETIM-BUILDING

Besides, the way a 3D object, as a building, is merged to the ground heavily conditions the amount of vertices on the terrain itself. The nominal way consists in integrating the object i.e. to add the building footprint vertices to the terrain mesh, which is very polygon consuming. The optimized way consists in superposing the 3D object on to the sloppy terrain. In that case, SE-AGETIM-BUILDING automatically creates a groundwork volume that interpenetrates the terrain without creating any polygon.

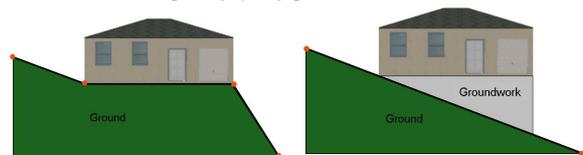


Figure 5: Creation of groundwork for a building

2.2.2. Texture constraints

The first constraint is due to the 3D graphic board and Open GL optimization. The worst situation for graphics is to change the material context for each polygon. The best way is to share the same graphic context for a lot of polygons. One important part of the material context is the texture itself. As a consequence, typically for objects, the idea is to put all the necessary image information in the same memory texture. This texture is called an "atlas". This is done automatically by SE-AGETIM-BUILDING, as illustrated here after, on the left the texture atlas, on the right the mapping on one building:

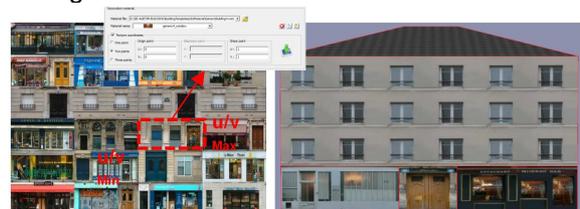


Figure 6: Use of a texture "atlas" for the mapping

Besides, for Infrared rendering in real-time, we use

pixel shaders. A shader is a small piece of software, directly implemented on the graphic board in order to process the pixels in a user-defined way. Pixels shaders directly rely on the texture memory and no more on the RAM. SE-FAST-IR uses pixel shaders to simulate the black body law, to access to MODTRAN or MATISSE atmospheric tables ... The only constraint is to limit for one texture the amount of needed physical material. Beyond this limit, the real time performance collapses. OKTAL-SE products include specific tools that warranty that the limit is respected, which is fundamental for HWIL.

2.2.3. DataBase structure constraints

As already explained for textures, it is important to share the same graphic context for a lot of polygons. Typically in case of multi occurrences objects (for example 3D trees), it is better to group several trees into a same Open GL node, i.e. object. If not, for each tree object, a change of context is due, which is catastrophic for real time. On the opposite, gathering all the objects in the same super object is not a solution. Firstly, it is not good for Level Of Detail computation and betweening . Secondly, it is bad for "culling". The culling is the Open GL operation that consists in sending to the graphic pipe line only the polygons within the viewing frustum. OKTAL-SE tools perform a trade-off in between these two extreme strategies that provides the best real time performance.

3. THE SE-FAST-HWIL package

In order to provide a solution to customer aiming at testing Hardware In the Loop IR sensors, OKTAL-SE has dedicated a special packaging of its tools called SE-FAST-HWIL.

3.1. SE-FAST-HWIL what for ?

The ideal situation for HWIL is the following: Everything is real (the missile, the IR seeker, the Image Processing algorithm). The only virtual components are the Image Generation and the movement platform. The Image Generation provides the scene perception by the IR seeker and the movement platform simulates the movement of the weapon system, for example a missile. In most of the cases, it is a closed loop simulation, which is very interesting to assess the IR seeker behaviour and efficiency.

Two basic cases must be differentiated:

- First with the real IR camera in the loop, which is the most interesting case. It is called the "projection mode":



Figure 7: Projection mode

- Then, without the real IR camera in the loop. It is called the "injection mode":



Figure 8: Injection mode

In the "projection mode" the synthetic Image Generator sends radiance information through the DVI interface of the SE-FAST-IR PC platform, to an IR projector that emits photons that vibrate at the real infrared wavelength. The projectors are made of a matrix of micro bolometers that are commanded in temperature and emit all the more photons as the "pixel" is hotter. The well-known Mirage projector of Santa Barbara Inc is used by French and German governments for instance. In the new generation, these projectors can provide something like 1000 x 1000 pixels at some hundreds of HZ. In the "injection mode", the IR sensor is squeezed and replaced by SE-IR-SENSOR simulation. In this case, the DVI output must be adapted to the weapon system private bus, by customer.

3.2. SE-FAST-HWIL validation

The core of the IG is based on SE-FAST-IR. Thanks to the Non-real-time and Real-time duality we focus the validation on the SE-RAY-IR, the ray tracing physical rendering and measure the difference in between SE-RAY-IR and SE-FAST-IR for exactly the same conditions.

The images below show an experimental validation of SE-RAY-IR by French DGA.



Figure 9: SE-RAY-IR validation

They show the way comparison is made between SE-RAY-IR and SE-FAST-IR. In this case, Black Body law gives the theoretical reference solution:

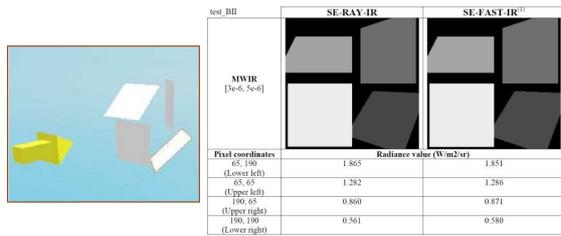


Figure 10: SE-RAY-IR / SE-FAST-IR comparison

3.3. SE-FAST-HWIL what is it ?

3.3.1. SE-FAST-HWIL packaging

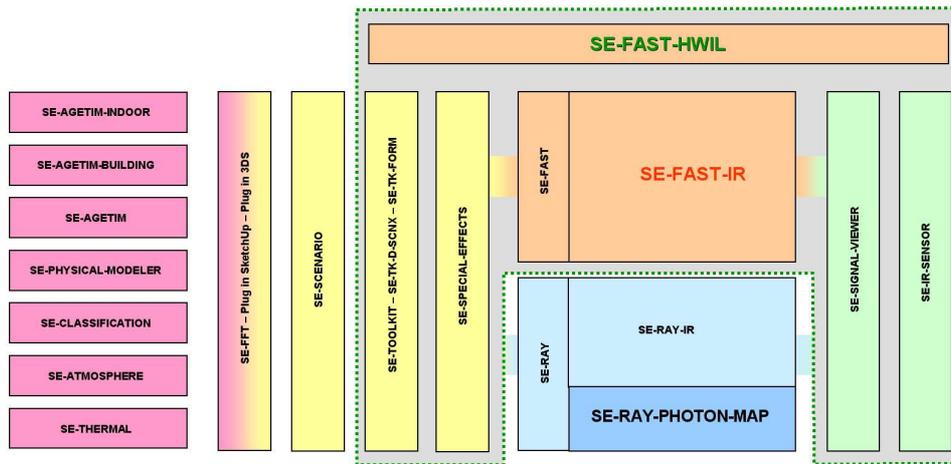


Figure 11: SE-FAST-HWIL packaging

SE-TOOLKIT is the SE-WORKBENCH C/C++ API that is enhanced, in the frame of HWIL, by the SE-TK-D-SCNX API (for dynamic scenario edition) and by the SE-TK-FORM API (for interfacing to internal file formats). SE-SPECIAL-EFFECT library allows to create

efficient particle systems and to model flares and clouds.

Let us note that even if SE-RAY-IR is not part of this HWIL packaging, it is quite important, in order to assess the simplification made in the frame of SE-FAST-IR.

3.3.2. SE-FAST-HWIL detailed architecture

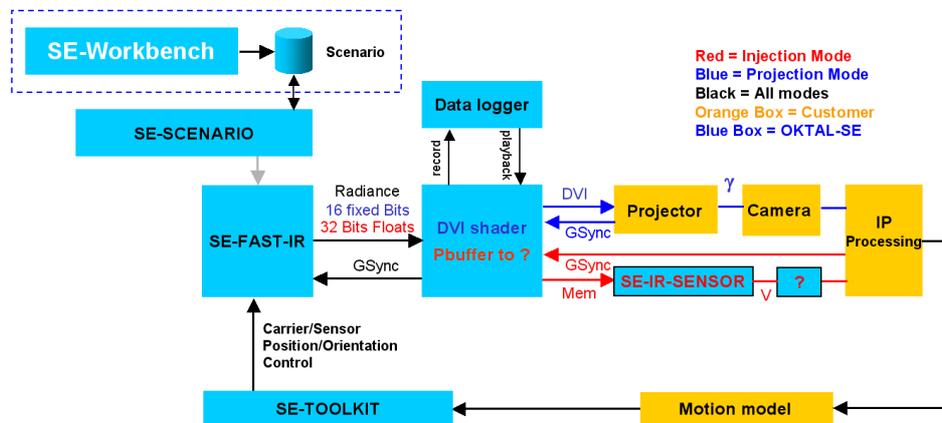


Figure 12: SE-FAST-HWIL detailed architecture

3.3.3. Scenario edition

The initialization is made using SE-SCENARIO that delivers a scenario file. The scenario file contains the entities reference (objects and cameras) and the atmospheric and thermal data needed for infrared realistic representation.

The dashed rectangle of the previous figure concerns the pre computations. It is more detailed in the following figure:

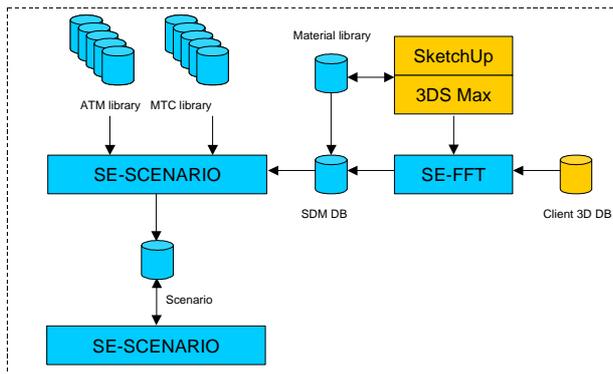


Figure 13: Pre computation process

The customer can transform an existing 3D meshed database from standard formats using SE-FFT converters.

3.3.4. Data Input

SE-FFT (File Format Transfer) product is a 3D geometric data converter, from and to the SDM format, inherent to SE-WORKBENCH tools. It handles meshed databases (polygons characterised by textures, colours, etc.) used to describe terrains, objects and targets. Therefore, SE-FFT is an open product, whose use is necessary to import and export user data from and to SE-WORKBENCH tools.

SE-FFT enables the conversion from OpenFlight, OpenInventor, VRML, 3DS Max, SketchUp or TDF formats, towards the SDM format and vice versa (except for the TDF and SketchUp formats). It also enables the conversion from the SDM format to the BSG format. BSG is a proprietary OKTAL-SE format that is optimized both for speeding files loading initialisation duration and for improving real-time GPU performance. Therefore, SE-FFT interfaces applications at all exploitation levels of the SE-WORKBENCH tools. Indeed, SE-WORKBENCH tools all use the SDM format to describe the geometry of objects and their physical characterisation in a coherent format. The SDM format is the open ASCII

OKTAL-SE format of Synthetic Environment.

Moreover, most of those formats (OpenFlight, OpenInventor, VRML and 3DSMax) do not integrate the physical characterisation of geometric data, necessary to their exploitation by SE-WORKBENCH tools. Therefore, SE-FFT enables to associate a physical characterisation to the data during the conversion to SDM format.

3DS Max is a world class 3D modelling tool.

SketchUp is a free modelling tool very simple to use.

OKTAL-SE has developed special plug-ins within these tools. This enables the customer to modify the database.

Thanks to this plug-ins, the customer can modify the geometry of a given 3D DataBase and attribute physical materials ready for infrared rendering thanks to a library of physical materials. This library of physical materials contains ready to use classified textured materials (such as wall of bricks, roof of tiles, asphalt ...) for most of the material one can find in a 3D scene.

3.3.5. Atmospheric conditions

Concerning atmosphere, a set of pre computed atmospheric files are available. These files have been compiled using SE-ATMOSPHERE & MODTRAN.

The following conditions are delivered:

- Summer day fine weather/sun
- Summer day bad weather
- Summer night fine weather/moon
- Summer night bad weather
- Summer night bad weather/fog
- Summer night bad weather/rain
- Winter day fine weather/sun
- Winter day bad weather
- Winter night fine weather/moon
- Winter night bad weather
- Winter night bad weather/fog
- Winter night bad weather/rain

3.3.6. Output interface

The full DVI interface is provided. The special DVI "shader" (source code directed implemented in the graphic board) is provided in source code and can be easily modified by the customer. Concerning the injection mode, where the Image Processing module is directly stimulated (strapping the camera), OKTAL-SE provides all the necessary software inputs (shaders) to the Image Processing module.

Concerning the injection mode, as the camera is

no more in the loop, OKTAL-SE provides SE-IR-SENSOR.

3.3.7. The data grabbing function

The basic need is to analyse a HWIL session and make an archive.

For this requirement, we propose to rely on a very important feature of SE-Workbench: SE-Workbench-EO is completely deterministic. It means that if you play a simulation twice, you get exactly the same rendered images. Indeed a scenario agenda in SE-SCENARIO gives a "frame by frame" very precise scheduling of time (simulation time), including full animation control. Even the random like effects such as particles systems or SE-IR-SENSOR noises for injection mode rely on deterministic seeds.

Any events of the simulation process go through the API interface. Simulation can be recorded and turned in a scnx scenario file. All events that go through the interface, typically positions and Lines of Sight (LOS) of entities (sensors + objects) can be captured and easily transformed into scnx SE-SCENARIO file. Then, it is very comfortable to replay exactly the same HWIL scenario (using SE-SCENARIO and/or SE-TOOLKT) and to use SE-SCENARIO capabilities to analyse the simulation results, and of course the SE-SCENARIO capabilities to automatically create compressed movies or frame by frame records.

3.4. SE-FAST-HWIL Success story

3.4.1. MBDA

For several years, MBDA has been using OKTAL-SE products in the frame of several missile programs.

For HWIL, and closed loop simulation, MBDA uses SE-FAST-IR under Linux and has obtained very impressive results.

In that frame MBDA main purpose is to generate in real time radiance images both projected in front of sensor and injected after sensor head on system data bus. MBDA also aims at simulating currently existing or new synthetic complex scenarios. The application goes from Performance test to Firing preparation without omitting Validation, for various situations (Ground, Air, Sea) and various wavelengths.



In this context, last year, the "HWIL and IR Image Generation Teams" of MBDA FR, using the SE-WORKBENCH-EO, have been awarded internally for the quality and the innovative aspect of their job.

3.4.2. BWB

For some years, BWB/WTD81 has been using OKTAL-SE products in the frame of several military programs. For HWIL and open loop simulation, OKTAL-SE has supported the BWB/WTD81 to interface SE-WORKBENCH-EO to the Mirage IR projection system. Lot of works have been done by WTD81 in that frame. In their trials using the MIRAGE system, they have observed considerable non-uniformities, especially at high temperatures. To overcome the non-uniformity problem they have performed a non-uniformity correction (NUC) using SE-IR-SENSOR API. A dedicated terrain database has been prepared using SE-AGETIM suit.

4. SIMPLE TEST CASES PACKAGE

4.1. Description

HWIL is a very tricky activity because it is very hardware dependent. In that frame, Image Generation is the bottleneck because every customer wants to simulate more and more complex 3D scenes, with more and more special effects, for more and more high frequency and accurate sensors. Actually, it is very difficult to assess the trade-off that is necessarily made between the PC hardware performance, and the DataBase complexity.

In order to help the Client to assess this complexity, OKTAL-SE provides within the SE-FAST-HWIL package a set of tools that enables one to prototype the expected performance for a given hardware and a given 3D DataBase complexity.

To do so, OKTAL-SE provides a special set of Python scripts that automatically create tests 3D databases in ".bdd" format so that SE-SCENARIO scenario files in ".scnx" format. In this case, the rendering is based on SE-TK-RENDER (which is part of the SE-WORKBENCH-EO delivery) that is a special SE-TOOLKIT optimized implementation that relies on SE-FAST-IR directly.

4.1.1. Geometrical part

To automatically create sets of polygons and

textures, we use the Python scripts approach, which is now directly available in SE-SCENARIO. In this example, we focus on a 400 000 polygons database. To be in the worst case, we consider that the full database is seen in the frustum (no Field of View limitation, no FAR limitation) and that there is no level of details at all. We can easily play on the quadSize i.e. the size of the polygons, and on the gridSize i.e. the amount of polygons. In this example we have 447 x 447 = 199 809 quadrangles i.e. 399 618 triangles. The result is a flat grid made of overlapping triangles. Simply playing on the polygon size, we can control the ratio of over-writing i.e. the total number of pixels drawn as shown hereafter:

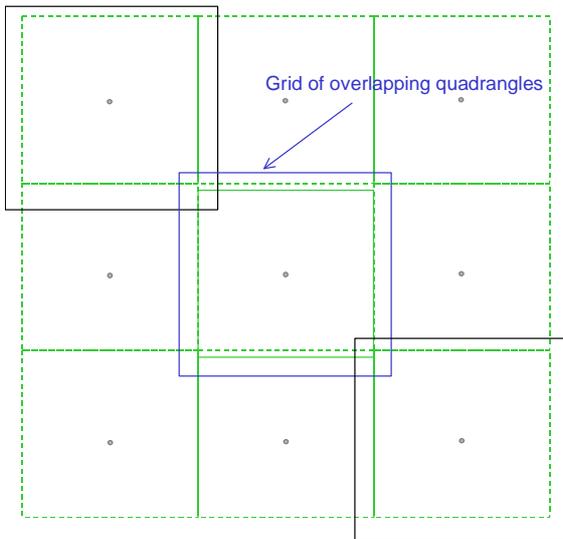


Figure 14: Grid of overlapping quadrangles

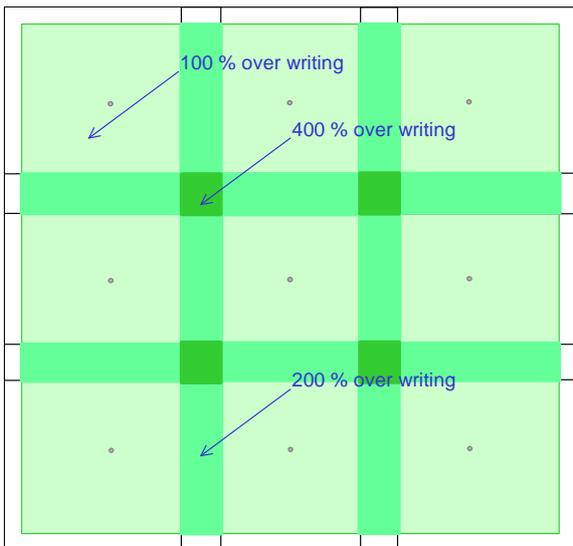


Figure 15: Percentages of overwriting

The overlap is interesting to simulate a 3D terrain with partial masking (Z buffer) and so overwriting in case of strong relief. It is controlled by the polygon size in the Python script.

The total 3D DataBase can be observed using SE-SCENARIO:

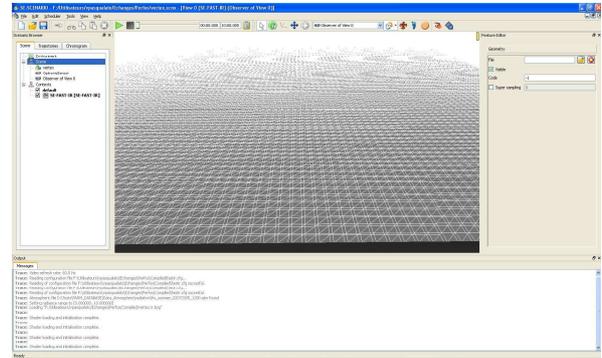


Figure 16: Test 3D database

4.1.2. Physical part

The same material is applied to the grid, which is very important in term of performances. SE-AGETIM uses this approach called "texture atlas" both for terrain and object (buildings). It is a way to have only one texture (with all the information in the same texture), using the texture mapping for selecting the useful zone within the texture. It is very important (for real time performance), to avoid changing the polygon attributes (variants) too many times.

The texture is a test texture made of 8 classified materials (the maximum authorized for SE-FAST-IR) for one texture.

The figure below shows the actual texture that is used in this test. It is made of the 8 materials given by 2 rgb files after SE-FAST-IR-COMPIER:

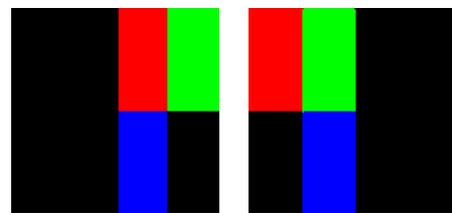


Figure 17: compiled 8 materials texture

The scenario context is a mono band MWIR (3-5μ) for this example. The texture is applied in ground mapping mode over all the polygon. The texture resolution is 8192*4096 texels i.e. $8192 \cdot 4096 \cdot 4 \cdot 2 = 268 \text{ Mb}$.

The atmospheric file (.atm) is for fine weather conditions. It is a MODTRAN based pre-computation
 The temperatures are pre-computed via SE-THERMAL

4.2. Results

4.2.1. Framework

The test is quite representative of operational SE-FAST-IR situation. The physical model is active. The atmospheric propagation per pixel is active. The diffuse reflection and specular reflection model is active. Nevertheless, there is no light point nor special lights management (flares ...), there is no 2D cloud layers nor 3D volume clouds. There is no cast shadow. There is no bump nor mirroring effects. We consider this situation as an average situation.

With SE-FAST-HWIL package, the customer can play on several parameters:

- The type of PC and especially of 3D graphic board
- The type of OS (Windows versus Linux)
- The type of antialiasing and 3D graphic board configuration
- The amount of polygon
- The size of polygons
- The amount of texture

4.2.2. Examples of results

In this example, several tests are passed that assess the type of Graphic Board, the amount of polygons, the image resolution in pixels, the level of antialiasing (AA0 means no AntiAliasing, AA4x means 4 fragments by pixels, AA8x means 8 fragments by pixels).

The first tested graphic board is a 8800 GT Nvidia GB that is a very common model.

The second tested graphic board is a 480 GTX that is still one of the most powerful graphic board from Nvidia currently.

The following results have been obtained:

Graphic Board type	Polygons amount	Pixels amount	Antialiasing Type	Refresh rate frequency
480 GTX	400 000	1280x1280	AA0	351
480 GTX	1 200 000	1280x1280	AA0	134
480 GTX	400 000	1024x768	AA0	410
480 GTX	400 000	512x512	AA0	399
480 GTX	400 000	1280x1280	AA4x	270
480 GTX	400 000	1280x1280	AA16x	157
8800 GT	400 000	1280x1280	AA0	101
8800 GT	400 000	1280x1280	AA4x	82

This shows that it is now possible to reach 300 Hz real time performances, with high infrared fidelity, with standard PC platforms, which

was definitely impossible some years ago.

5. COMPLEX OPERATIONAL ASSESSMENT PACKAGE

5.1. Description

The advantage of user defined test databases is a full control of the scene complexity. The drawback is that it is too much theoretical.

To fight this difficulty, OKTAL-SE delivers with SE-HWIL-PACKAGE an “off the shelf” 3D database that has been optimized for real time application.

The scene is an airport, the Toulouse Blagnac airport, with a semi urban zone in the vicinity:



Figure 18: Toulouse Blagnac airport

The scenario context is band MWIR [3-5μ]. The atmospheric file is a MODTRAN based computation. The temperature are precomputed via SE-THERMAL.

It uses a SE-SCENARIO scnrx file that plays a trajectory.

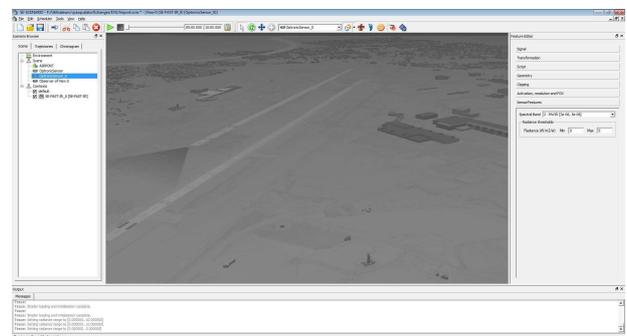


Figure 19: MWIR view in SE-SCANARIO

5.2. Results

Refresh rate is measured along the trajectory.
The configuration is a 480 GTX board, 1024 x 1024, AA4x.

The best refresh rate is 865 Hz:

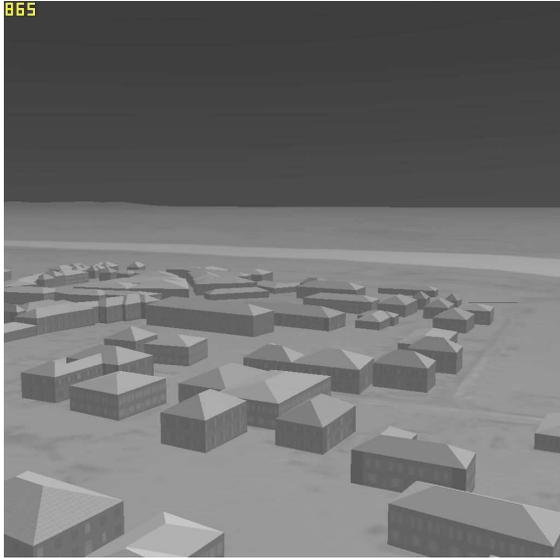


Figure 20: MWIR view at best refresh rate

The worst refresh rate is 239 Hz:

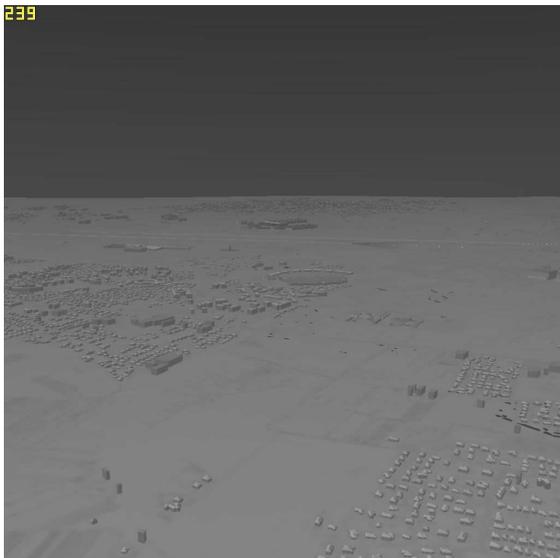


Figure 21: MWIR view at worst refresh rate

6. CONCLUSION AND PERSPECTIVES

Thanks to these recent developments fully supported by MBDA France and other players, **the SE-WORKBENCH-EO is now fully operational for HWIL simulation.**

A large community uses SE-WORKBENCH-EO: army, research and industry.

SE-WORKBENCH-EO constitutes a unique solution in the world that merges non-real-time and real-time rendering.

The new axis for development in that frame are the following:

- Reinforcing the test bench
- Optimizing 3D DataBase
- Optimizing moving objects rendering
- Optimizing special effects (clouds, flares, plumes...)
- Looking for a hardware partner for IR projection and injection

7. REFERENCES

1. A. Le Goff, J. Latger, *Realistic multi spectral simulation including IR simulation*. SPIE Proceedings., Vol. 3694, April 1999.
2. Thierry Cathala, Nicolas Douchin, Jean Latger, Karine Caillault, Sandrine Fauqueux, Thierry Huet, Luc Labarre, Claire Malherbe, Bernard Rosier and Pierre Simoneau, (2009) *The coupling of MATISSE and the SE-WORKBENCH: a new solution for simulating efficiently the atmospheric radiative transfer and the sea surface radiation*, SPIE Proceedings., April 2009.
3. E. Martin, HIGH-END Engineering, 82234 Wessling, Germany Wehrtechnische Dienststelle für Informationstechnologie und Elektronik (WTD 81), 91171 Greding, Germany - *Synthetic environment testing of infrared sensors using the OKTAL-SE workbench suite* – ITBM&S 2010
4. J. Latger, V. Pasqualato, *Image Generator performance and modern HardWare In the Loop stimulation*, ITBM&S 2011
5. J.M. Fevre, MBDA F, *HWIL experience with SE-FAST-IR*, OKTAL-SE UGM11