ISO/IEC SC 24/WG 8 Meeting
19 August 2014

New SEDRIS requirements in the frame of multi-physics sensor simulation

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OKTAL-SE

OKTAL-SE Synthetic Environment

Topics:

- An Overview of OKTAL-SE
- Current uses of SEDRIS in SE-WORKBENCH
- OKTAL-SE first implementations and modeling of infrared and other sensor data
- State of the art and the required data for expressing new multi-domain physics-based sensor information
- Ideas for existing or new SEDRIS capabilities in this context

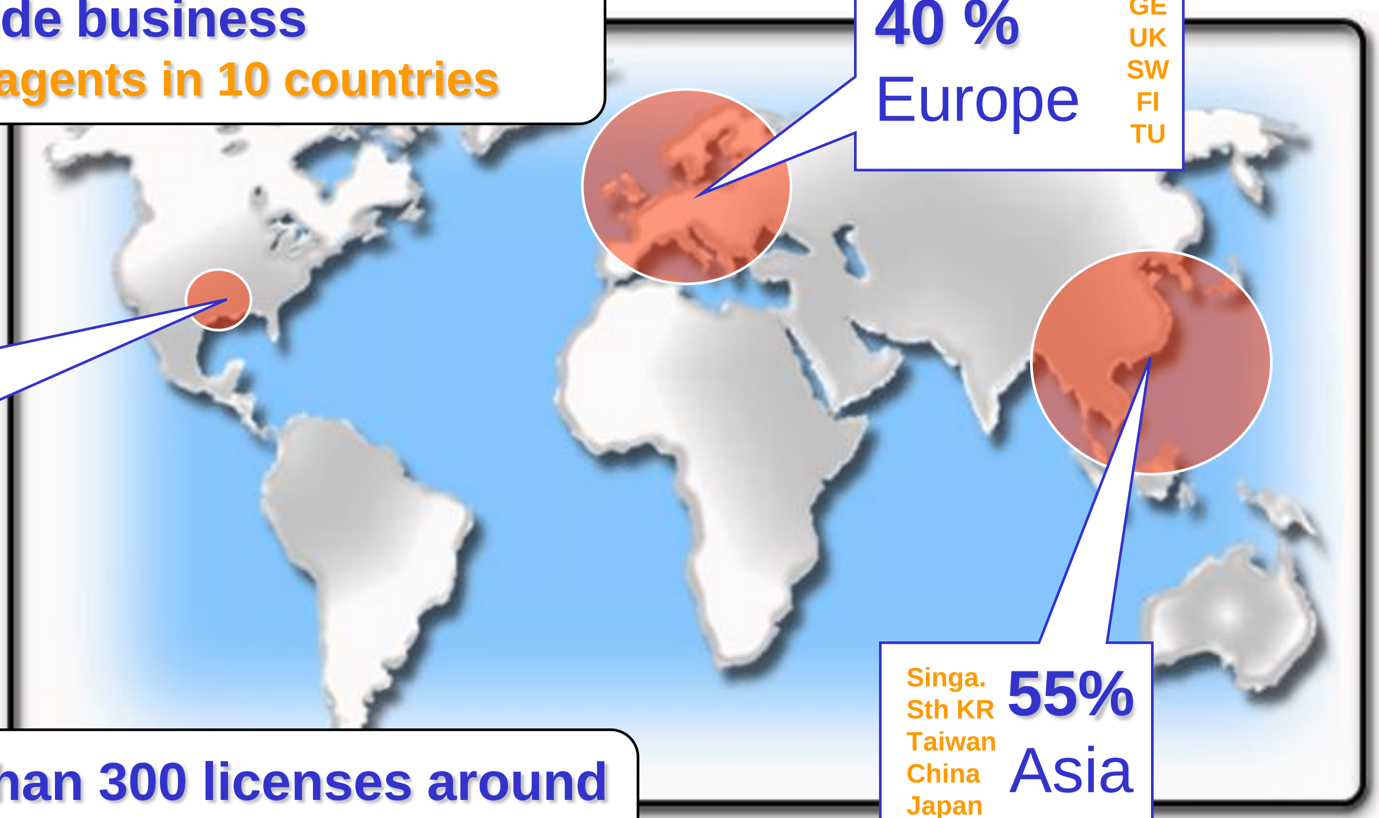
- ## An Overview of OKTAL-SE

  - Before 1989: Thalès Training Simulation in Paris
  - 1989: OKTAL => Railwail simulators / Automotive simulators
  - 2001: OKTAL-SE Defence and Research simulation
  - 2005-2007: French MoD projects involving SEDRIS
  - 2011: GNSS (Ergospace – GUIDE innovation platform)

- ## An Overview of OKTAL-SE

2011-2012-2013 percentage
of SE-WORKBENCH sales (COTS + maintenance + formation)

Worldwide business
10 sales agents in 10 countries



5 %
America

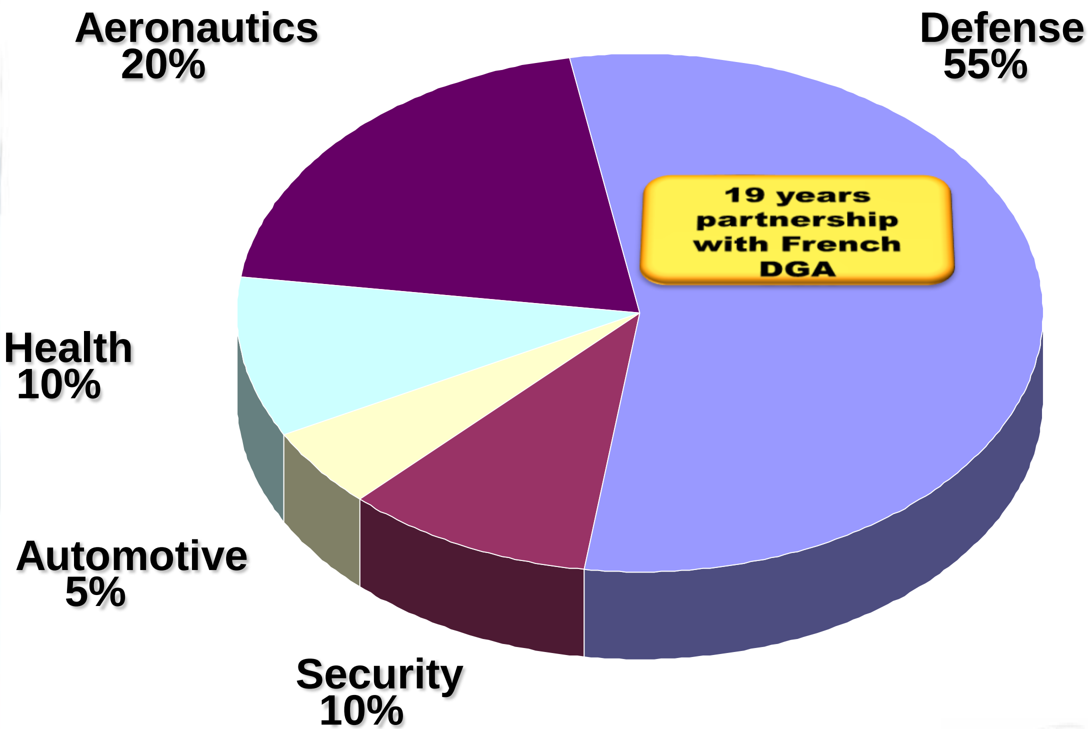
40 %
Europe
FR
GE
UK
SW
FI
TU

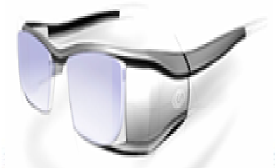
55%
Asia
Singa.
Sth KR
Taiwan
China
Japan
India
Malay.

More than 300 licenses around the World

An Overview of OKTAL-SE

Targeted applications for the major markets segments

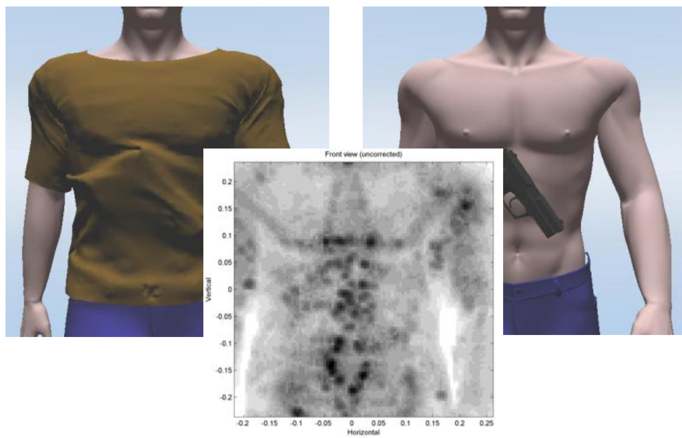




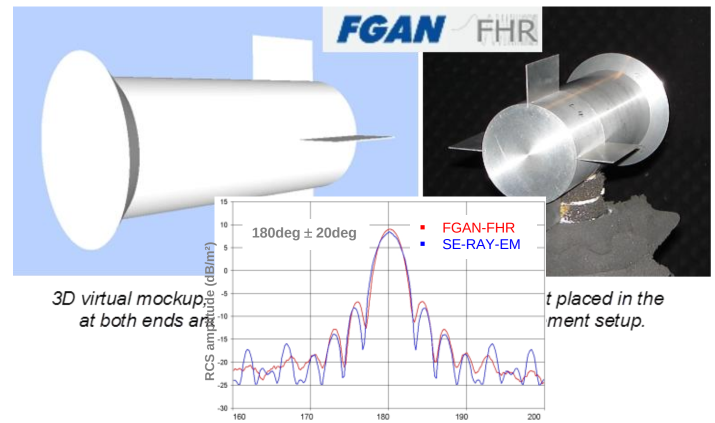
Synthetic Environment

▪ An Overview of OKTAL-SE

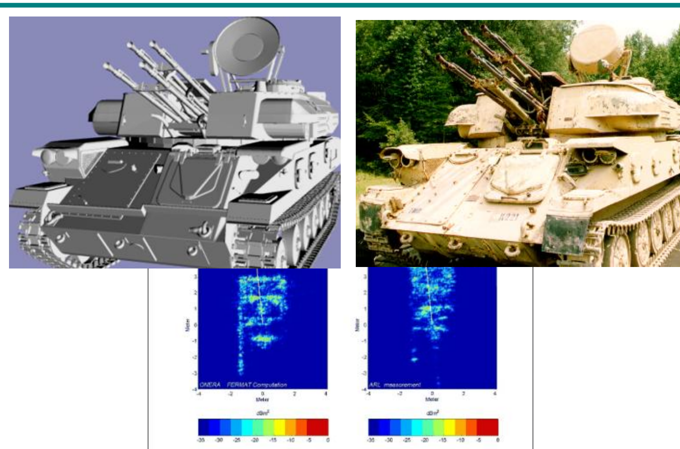
Strategic alliances for software results validation



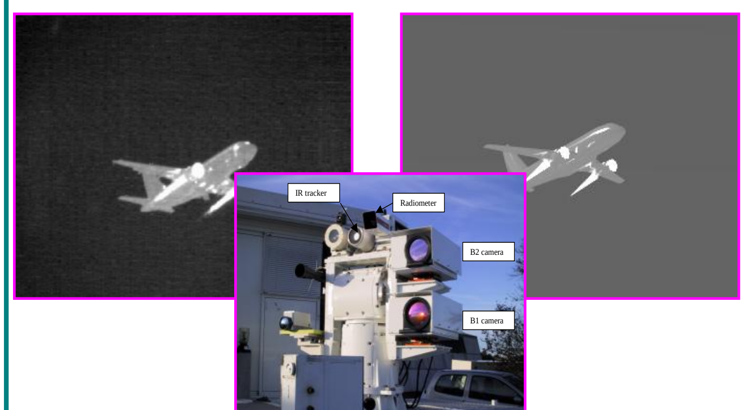
FOI - Sweden



Fraunhofer - Germany



ONERA - France



DGA - France

- # An Overview of OKTAL-SE

The SE-WORKBENCH interface to third-parties

- SketchUp
- BB3D (Bionatics Blueberry3D ™)
- SCANER (OKTAL)
- OSG
- Global Mapper (Blue Marble Geographics – Mind the Gap Between World and Map)
- 3DMax (Autodesk)
- GeoConcept
- SEDRIS
- MODTRAN (Ontar Corporation)
- RadTherm (ThermoAnalytics)
- STK (Agenium Informatique & Systèmes)
- TESS (Tactical Technologies Inc)
- SPIRENT (Spirent SimGEN ™)

SE-Workbench

OKTAL-SE Synthetic Environment

▪ An Overview of OKTAL-SE

Long term partnerships with customers

- *French DGA:* ***19 years of collaboration***
- *MBDA Fr and UK:* ***15 years of collaboration***
- *ONERA:* ***13 years of collaboration***
- *SAGEM:* ***10 years***
- *Korean ADD:* ***9 years***
- *Swedish FOI:* ***8 years***
- *German FGAN :* ***7 years***
- *Singapore DSTA:* ***6 years***
- ***…***

All under multi-years maintenance contracts

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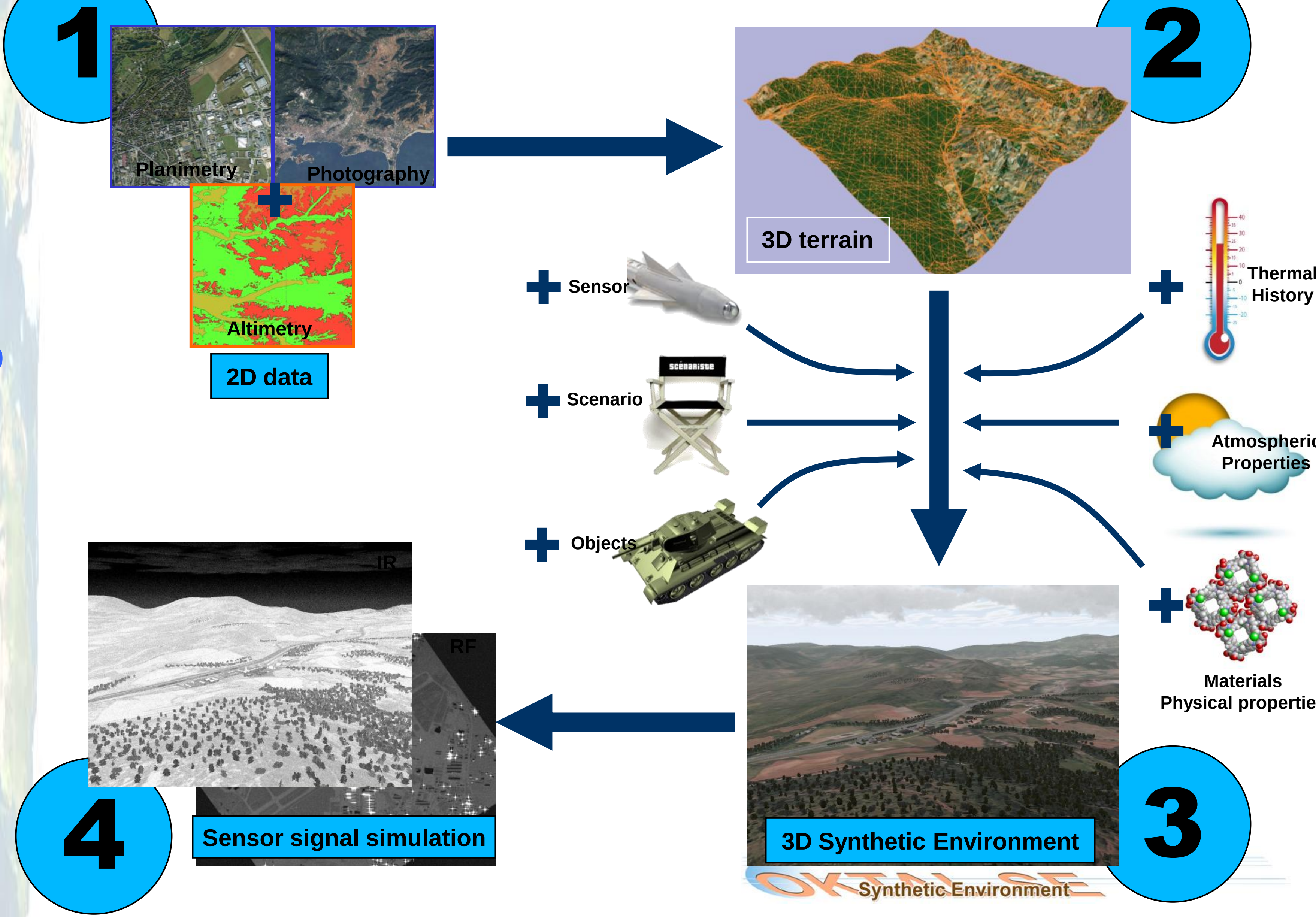
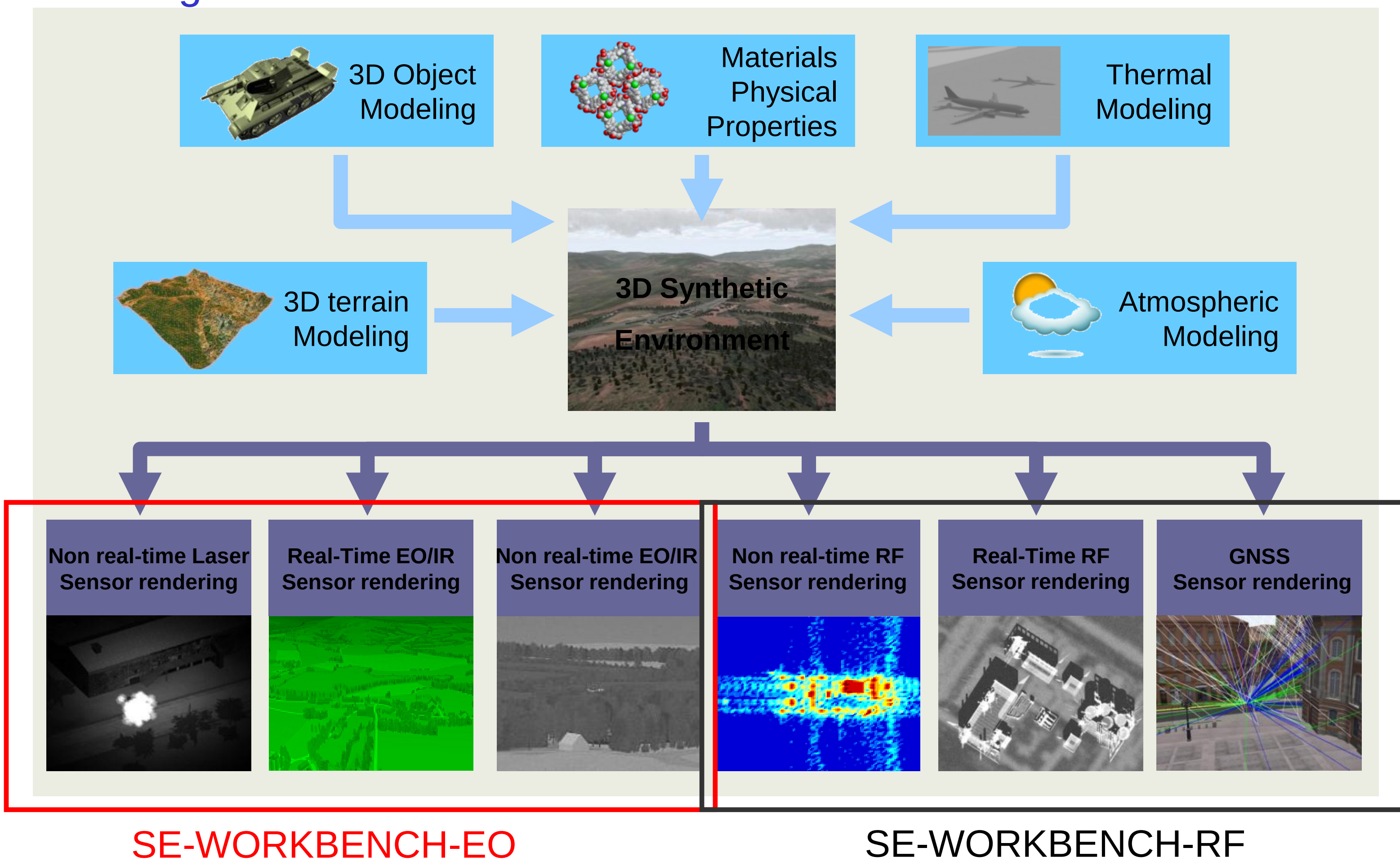
An Overview of OKTAL-SE

An overview of data preparation and fusion stages in providing sensor simulations



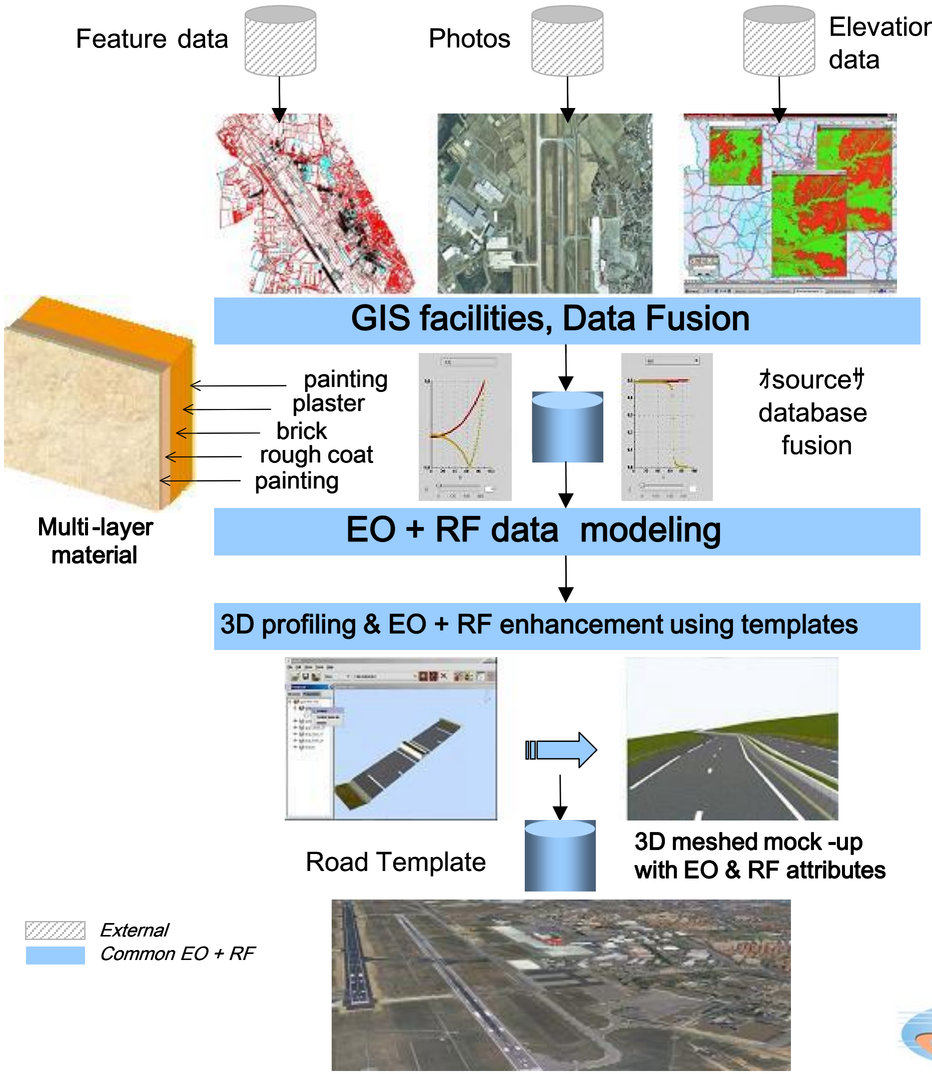
▪ An Overview of OKTAL-SE

The SE-WORKBENCH™: A single kernel for multi-sensor environment modeling



Dual real-time and non real-time solutions

- **Current uses of SEDRIS in SE-WORKBENCH: SE-AGETIM**



SE-AGETIM = Integrated software tools enabling rapid and realistic 3D synthetic environment generation for multi sensors simulation application (OTW, EO, RF)

▪ Current uses of SEDRIS in SE-WORKBENCH: SE-AGETIM

SE-AGETIM uses SEDRIS for:

- Importing source data from DFAD and GeoTiff databases
- Importing planimetry and altimetry from SEDRIS databases
- Creating SEDRIS databases from altimetry grids

- **Current uses of SEDRIS in SE-WORKBENCH: SE-FAST-IG**

SE-FAST-IG = OKTAL-SE real time image generator for rendering synthetic environments in the visible and EO domain

Used one specific SEDRIS component: the SRM.

Provides a robust and complete description of the spatial coordinates system as defined by SEDRIS: abstract coordinates system and spatial referential.

Also provides functionalities for spatial transformations (coordinates, directions and orientations conversions)

- **Current uses of SEDRIS in SE-WORKBENCH: SE-FAST-IG**

SE-FAST-IG use the communication standard CIGI (Common Image Generator Interface).

The CIGI piloting frames are geographic (latitude/longitude/altitude coordinates, local tangent orientations) while the database visualised use a local Cartesian frame

⇒ The SRM API allows precise and efficient conversions

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- Current uses of SEDRIS in SE-WORKBENCH: SE-FAST-IG

▪ OKTAL-SE first implementations and modeling of infrared and other sensor data: CQCEGC

Software for:

- controlling the quality
- correcting
- exchanging
- managing configurations

for **Environment Database for Simulation** (EDS)

OKTAL-SE first implementations and modeling of infrared and other sensor data: CQCEGC

Mains goals :

- checking conformity of SIF-France EDS with the format specification
- visual control on elements and parts of EDS
- gathering tools for automatic, supervised and interactive correction of EDS
- exchanging EDS in standard formats such as VMAP, DLMS, SIF-France, SEDRIS, Digitised Terrain and Open Flight
- manage configuration of the various versions of EDS

- **OKTAL-SE first implementations and modeling of infrared and other sensor data: CQCEGC**

Quality control → checking the conformity of data with the format and content specifications

Exchange → importing and exporting (with some restriction)

Correction → modifying the data and metadata

Configuration management → EDS versions catalogue (PostGreSQL database)

- **OKTAL-SE first implementations and modeling of infrared and other sensor data: CQCEGC**

Quality control, exchange and correction

➲ **SEDRIS data model**

Able to host data coming from the various formats handled :

- SIF-France v2
- SEDRIS 4.0 (and now 4.1)
- DLMS DFAD
- DLMS DTED
- Open Flight 15.6
- VMAP1
- Digitised Terrain MNT CELAR

- **OKTAL-SE first implementations and modeling of infrared and other sensor data: CQCEGC**

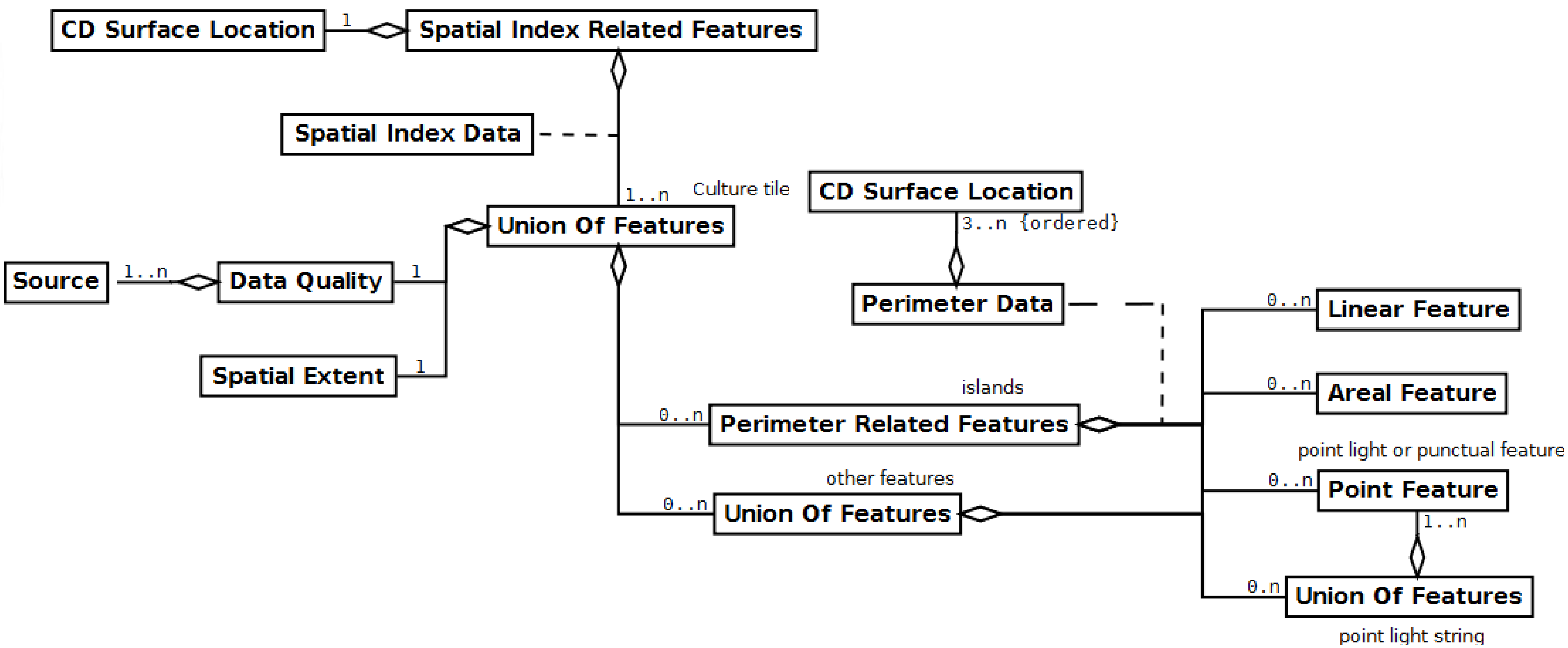
SEDRIS is used here as a pivot data container and representation.

Every data of a work session is converted to SEDRIS and organised in the data model.

Corrections are done in the SEDRIS structure and then exported in the input format or another compatible format.

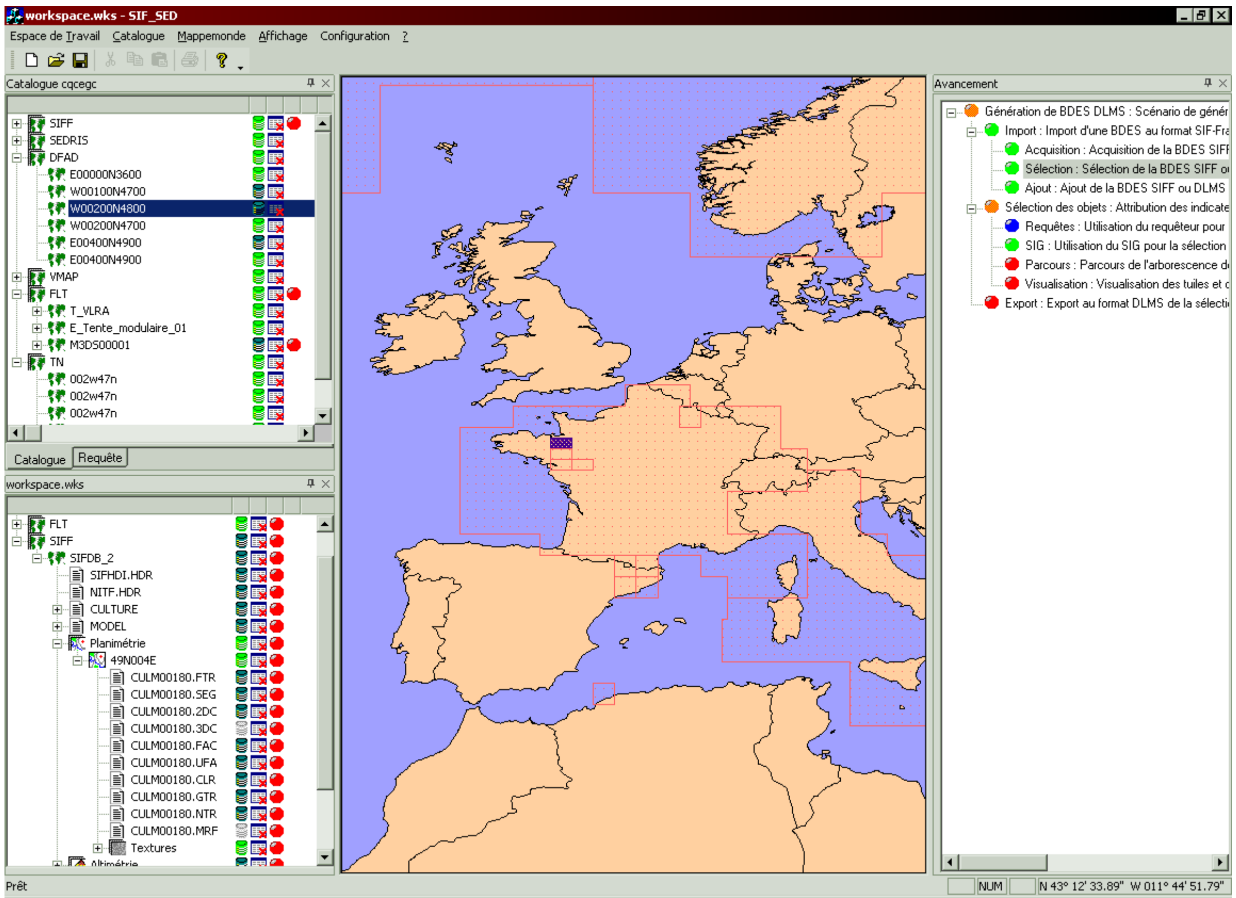
- OKTAL-SE first implementations and modeling of infrared and other sensor data: CQCEGC

Excerpt of the SEDRIS data model : planimetry



- OKTAL-SE first implementations and modeling of infrared and other sensor data: CQCEGC

CQCEGC GUI



- **OKTAL-SE first implementations and modeling of infrared and other sensor data: PROVIDENS**

PROVIDENS = assistance system for the Interactive PROduction and Validation of Synthetic ENvironment Data

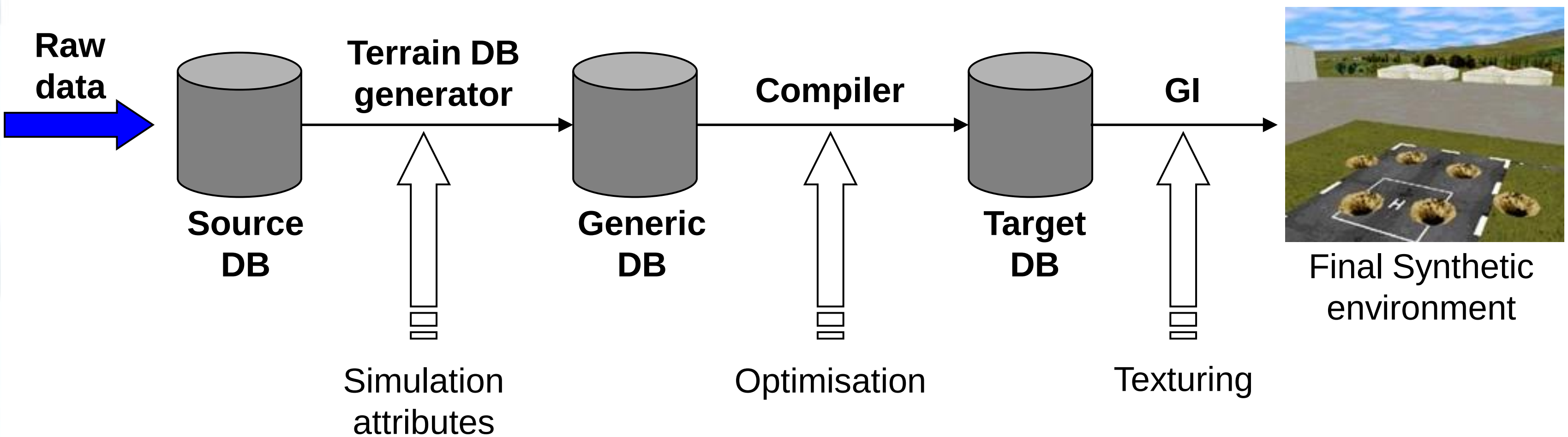
Plugin for the ITCS (Joint Technical Simulation Architecture)

Based on **SEDRIS as pivot data container and representation**

- **OKTAL-SE first implementations and modeling of infrared and other sensor data: PROVIDENS**

Environmental data = various and disparate

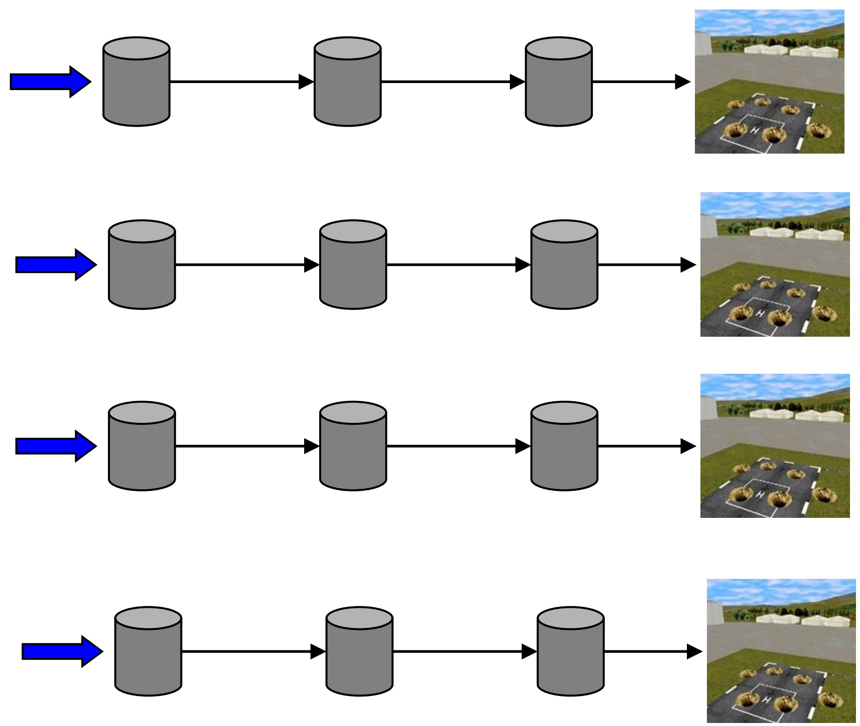
Usually need to be processed through various steps before being exploitable by simulation applications



- **OKTAL-SE first implementations and modeling of infrared and other sensor data: PROVIDENS**

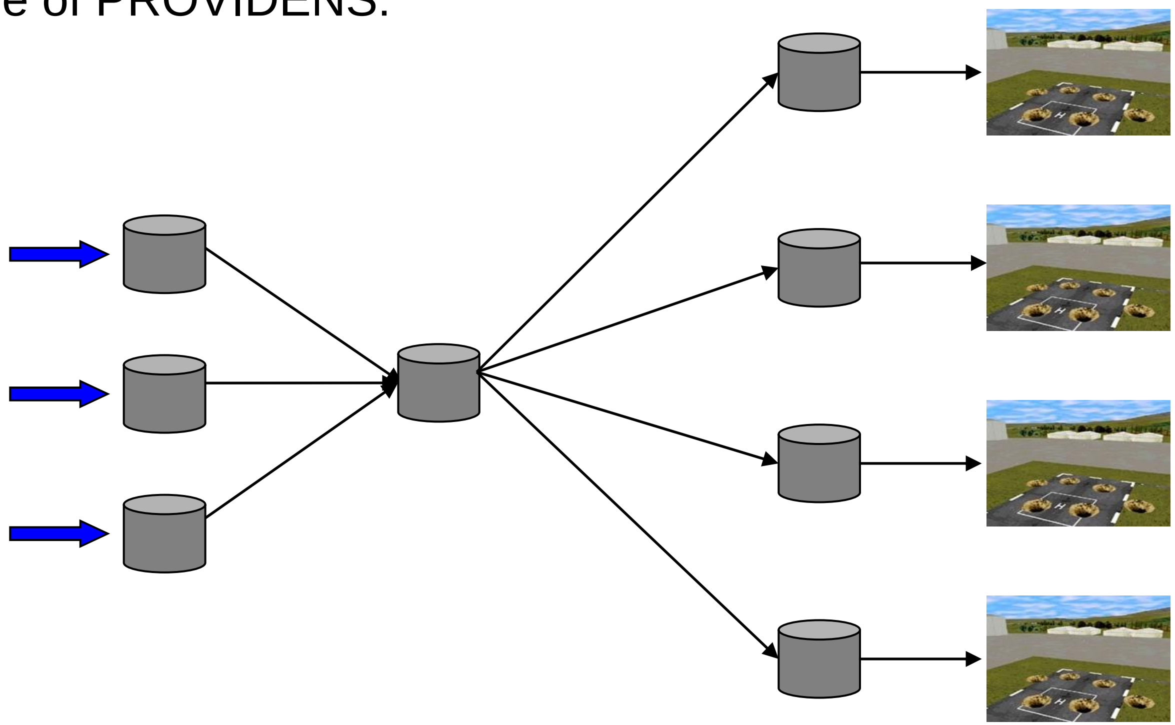
Most expensive step : transform source databases into generic databases… that are not generic.

So…



- OKTAL-SE first implementations and modeling of infrared and other sensor data: PROVIDENS

Objective of PROVIDENS:



▪ OKTAL-SE first implementations and modeling of infrared and other sensor data: PROVIDENS

Interoperability ⇒ Facilitate the exchange and reuse of data

➲**SEDRIS as a pivot data container and representation for source, generic and target database.**

- corrected source data or validated target database → **SEDRIS → capitalisation** → retrieval → import → exploited by applications using different native formats

- **SEDRIS** = very comprehensive data representation : only available format/representation able to describe data as various as planimetry or altimetry data, geo-localised photographs, 3D models, atmospheric data, physical properties, etc.

OKTAL-SE first implementations and modeling of infrared and other sensor data: PROVIDENS

- Integration of existing tools in the PROVIDENS platform
- Development and integration of new converters
- Enhancement and integration of existing tools (Focus)
- SEDRIS expertise
- Basis for exchanging terrain modelling tools “work data”

- **OKTAL-SE first implementations and modeling of infrared and other sensor data: PROVIDENS**

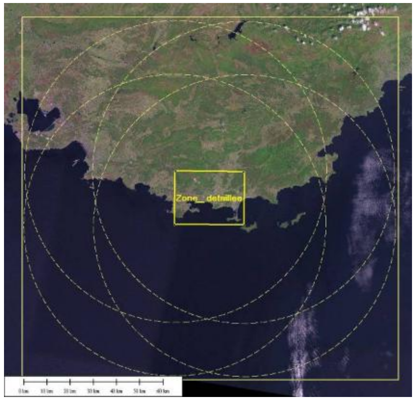
PROVIDENS user can :

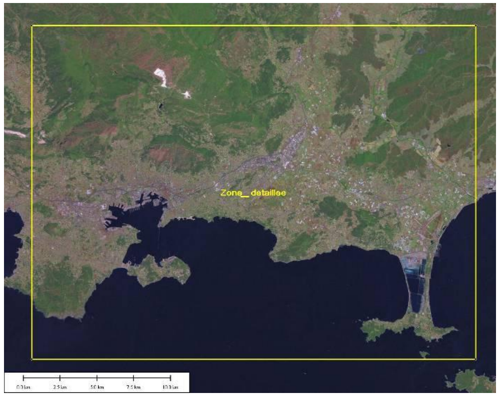
- retrieve (source or generic) databases in the capitalisation database
- convert them to the native format they need
- request a production plan: best way to perform the data processing needed to produce new (generic or target) databases
- extract and edit their metadata
- capitalise those new databases

▪ OKTAL-SE first implementations and modeling of infrared and other sensor data: PROVIDENS

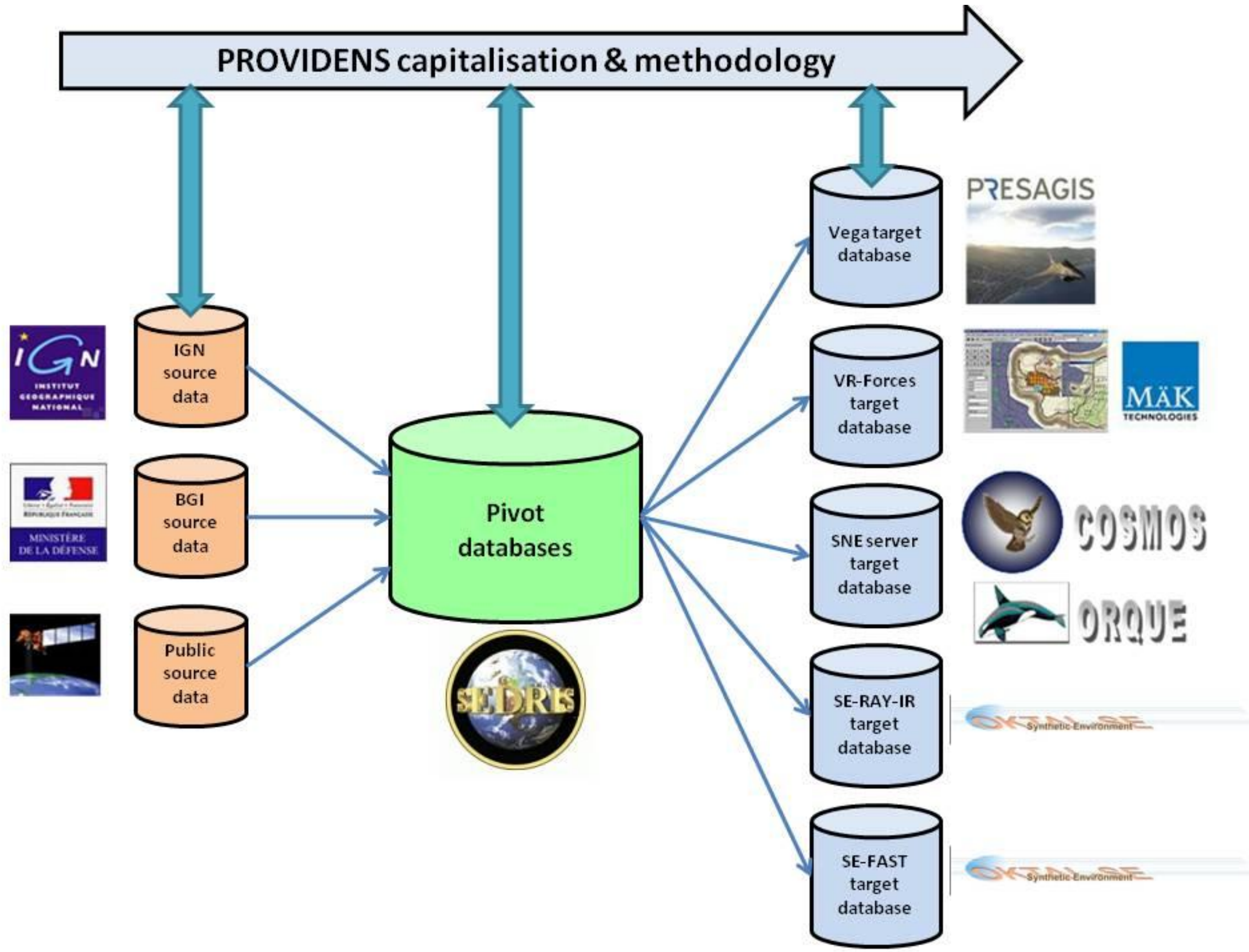
Experimentation to validate the process:

- three zones of a same area: large, semi-detailed and detailed.
- various source data



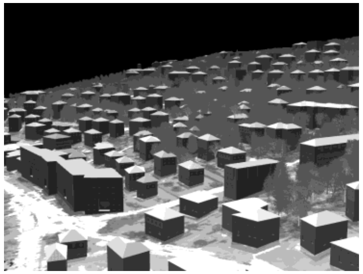
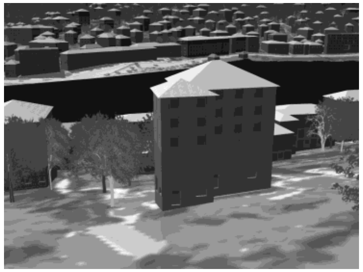


- OKTAL-SE first implementations and modeling of infrared and other sensor data: PROVIDENS



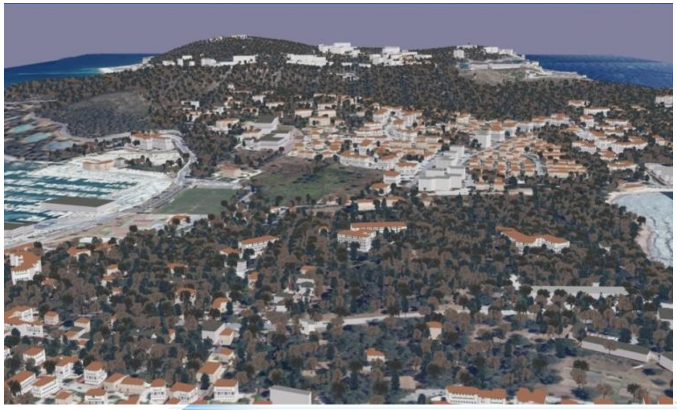
Synthetic Environment

- OKTAL-SE first implementations and modeling of infrared and other sensor data: PROVIDENS

Results:





OKTAL-SE first implementations and modeling of infrared and other sensor data: ITCS

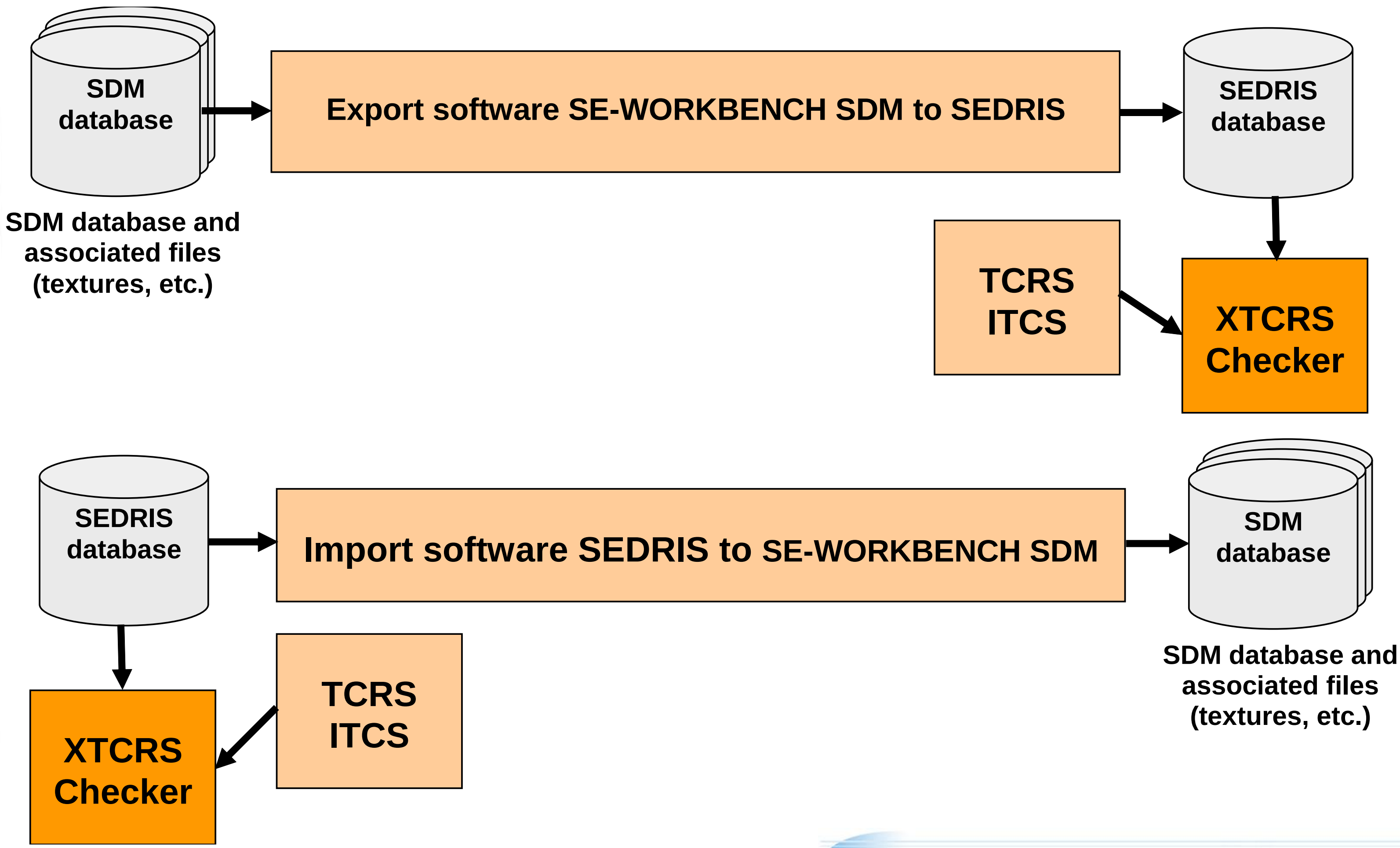
After CQCEGC, before PROVIDENS, the most complete attempt to model OKTAL-SE synthetic environment databases in SEDRIS

ITCS = Joint Technical Simulation Architecture: providing support environment for conceiving and realising simulations

OKTAL-SE for ITCS :

- software for exporting EDS in the SDM format (OKTAL-SE format) to SEDRIS and importing SEDRIS EDS in the SDM format
- providing SEDRIS tools
- providing SEDRIS expertise

- OKTAL-SE first implementations and modeling of infrared and other sensor data: ITCS



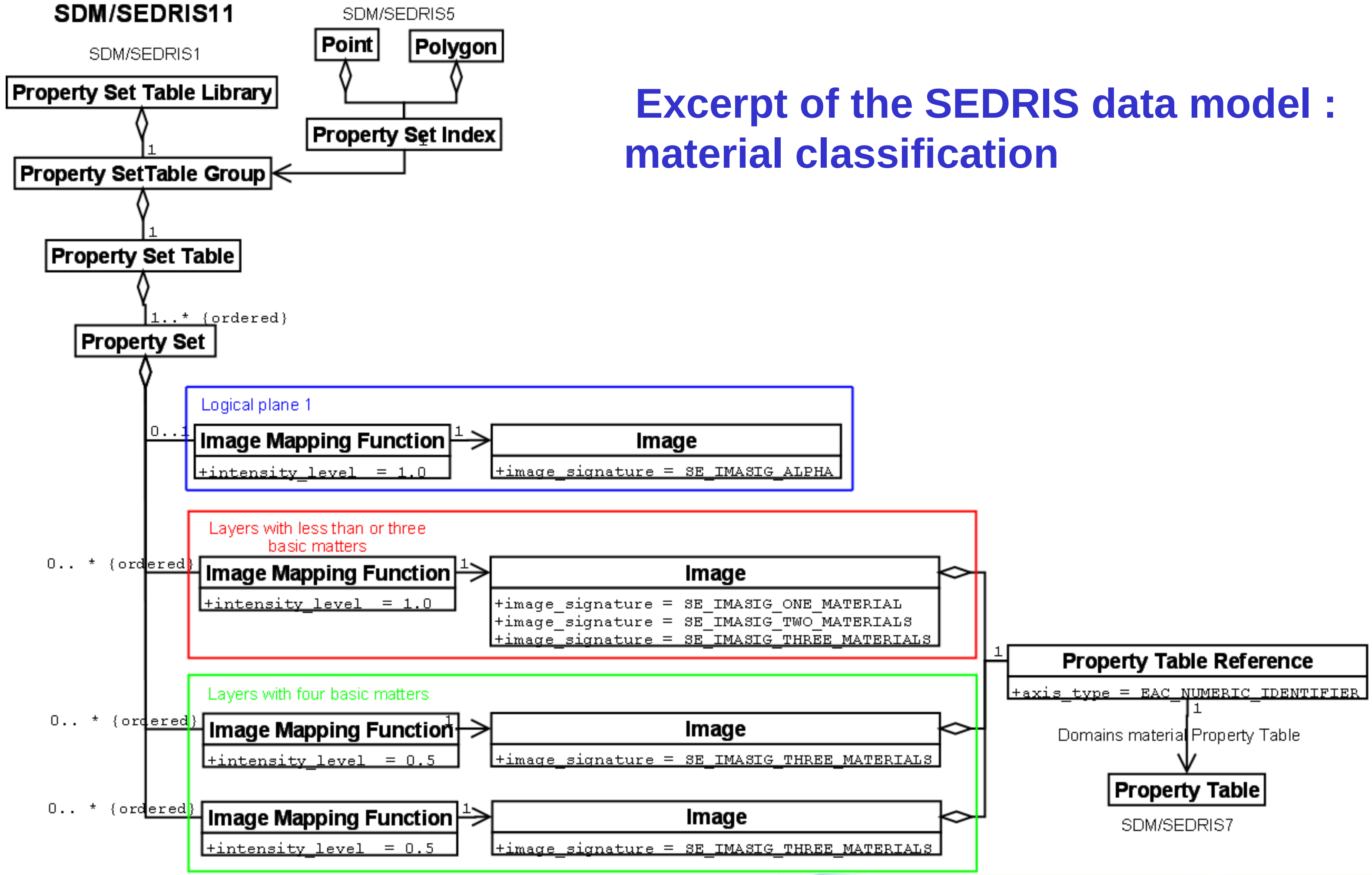
▪ OKTAL-SE first implementations and modeling of infrared and other sensor data: ITCS

- modelling of the meshed geometry (easy)

- modelling of the physical properties

- modelling of complex SDM mechanisms:
  - material classification (physical properties of any pixel of a texture) through material images
  - multi-domains materials (materials defined by the association of elementary materials defined on one domain) through data tables

- OKTAL-SE first implementations and modeling of infrared and other sensor data: ITCS



Excerpt of the SEDRIS data model : material classification

- **State of the art and the required data for expressing new multi-domain physics-based sensor information**

In the frame of :

- electro-optics
- active electro-optics
- radio-frequency
- GNSS (Global Navigation Satellite System)

what is the needed information to be added to current synthetic environment modeling ?

Example:

- roughness description for optics, thermal and radio frequency
- multi-texturing
- sea modeling
- DTH (THermal Description)

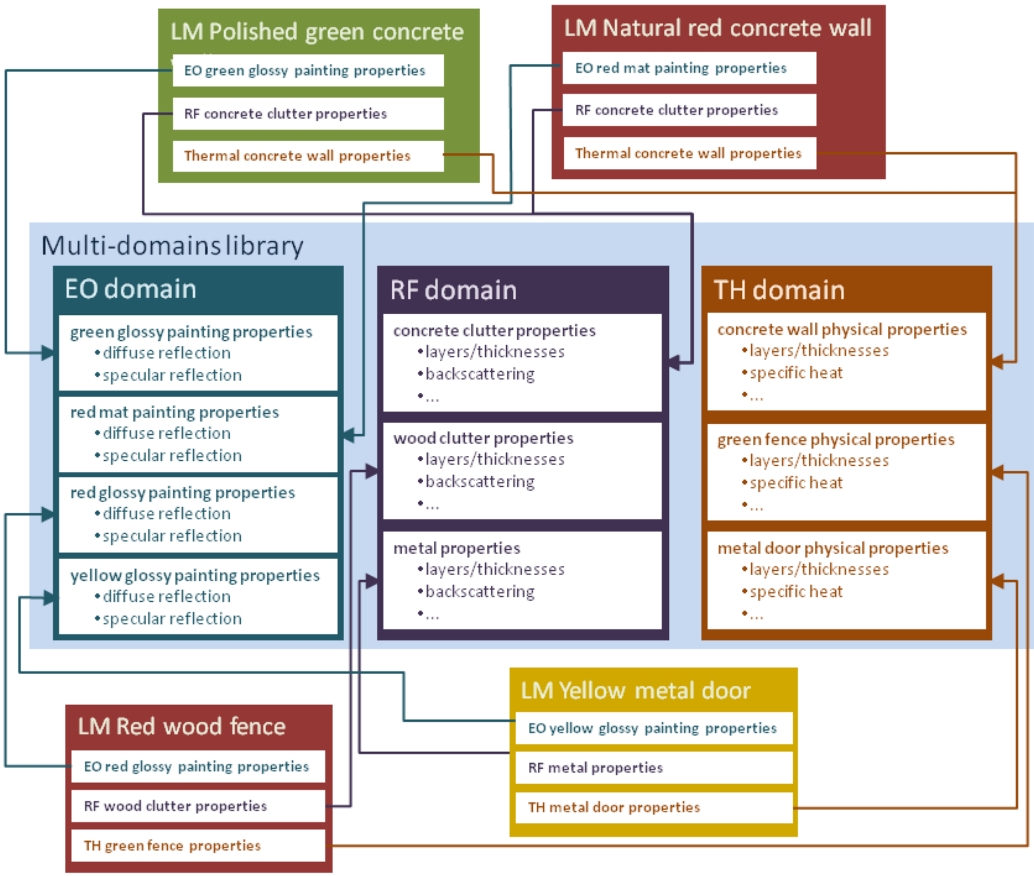
- State of the art and the required data for expressing new multi-domain physics-based sensor information

Green concrete wall	Green wood fences	Green metal door
EO green glossy painting properties •diffuse reflection •specular reflection	EO green glossy painting properties •diffuse reflection •specular reflection	EO green mat painting properties •diffuse reflection •specular reflection
RF concrete clutter properties •layers/thicknesses •backscattering •...	RF wood clutter properties •layers/thicknesses •backscattering •...	RF metal properties •layers/thicknesses •backscattering •...
TH concrete wall physical properties •layers/thicknesses •specific heat •...	TH green fence physical properties •layers/thicknesses •specific heat •...	TH metal door physical properties •layers/thicknesses •specific heat •...

Red concrete wall	Red wood fence	Yellow metal door
EO red mat painting properties •diffuse reflection •specular reflection	EO red glossy painting properties •diffuse reflection •specular reflection	EO yellow glossy painting properties •diffuse reflection •specular reflection
RF concrete clutter properties •layers/thicknesses •backscattering •...	RF wood clutter properties •layers/thicknesses •backscattering •...	RF metal properties •layers/thicknesses •backscattering •...
THconcrete wall physical properties •layers/thicknesses •specific heat •...	TH green fence physical properties •layers/thicknesses •specific heat •...	TH metal door physical properties •layers/thicknesses •specific heat •...

Examples of “complete” physical materials: a lot of properties are duplicated. “EO” stands for electro-optics, “RF” stands for radio-frequency and TH stands for thermal

- State of the art and the required data for expressing new multi-domain physics-based sensor information



Example of material descriptions using the multi-domains library: the properties are shared.
"LM" stands for logical material

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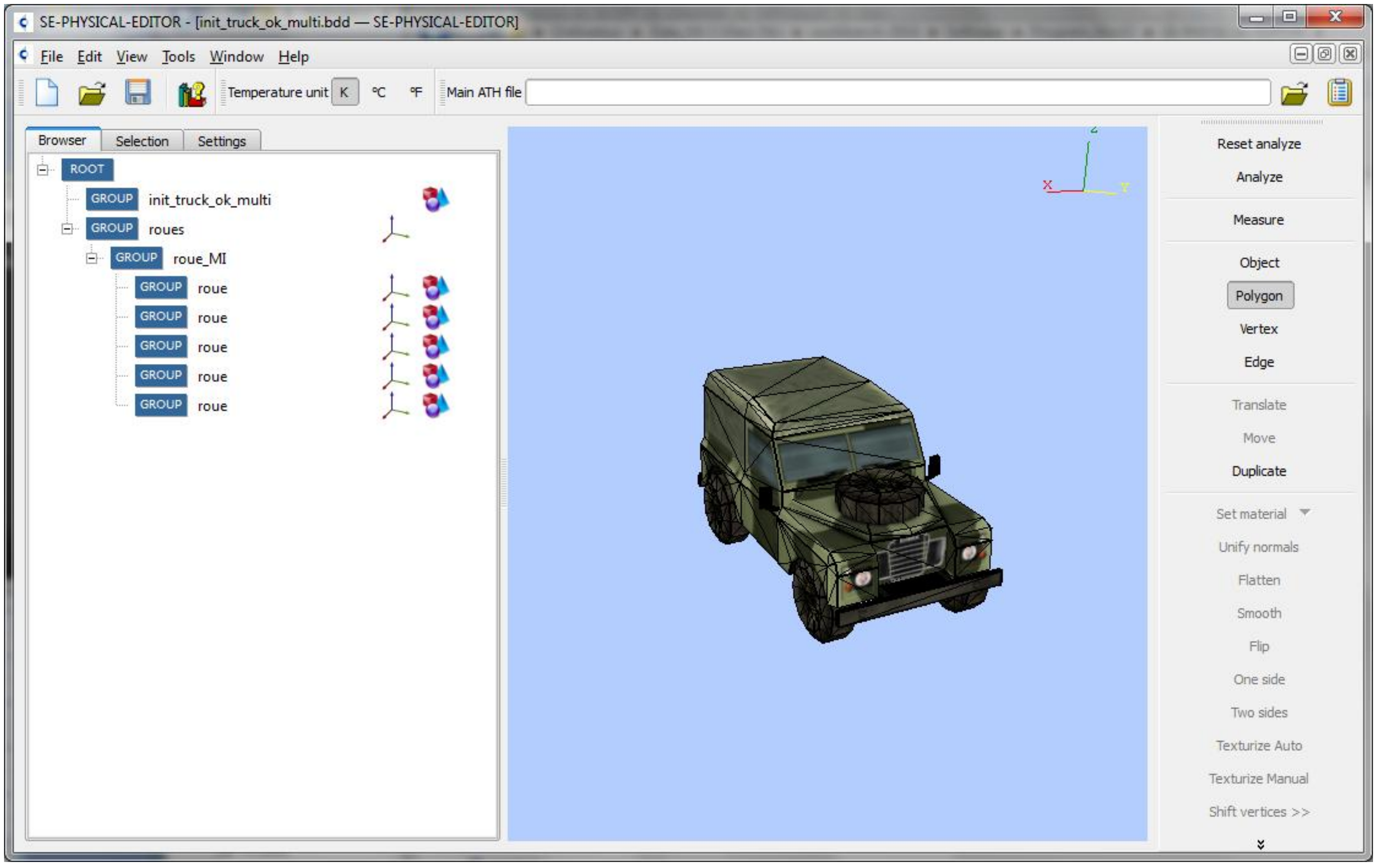
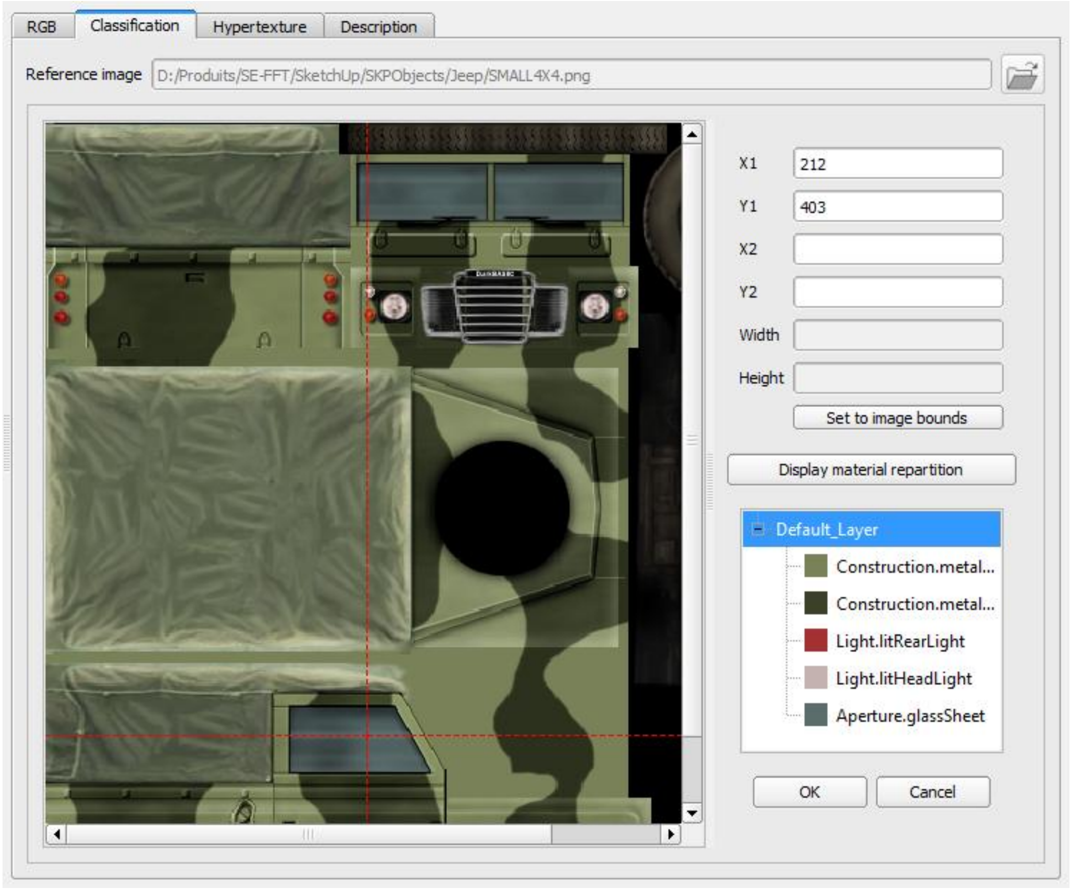
- State of the art and the required data for expressing new multi-domain physics-based sensor information



Example of classification with logical materials

- State of the art and the required data for expressing new multi-domain physics-based sensor information



Example of classification with logical materials

- State of the art and the required data for expressing new multi-domain physics-based sensor information

Logical materials | Domains

Material name	Optronic	Thermal	EM	Roughness
Construction.lightAsphalt	EO_Matter.Road.lightAsphalt	TH_Material.Construction.asphalt	EM_Matter.Clutter2.Soil.Asphalt	H_6
Construction.metalSheet	EO_Matter.Construction.buffedMetalSheet	TH_Material.Construction.iron	EM_Matter.metal	H_20
Construction.metalSheet2-blackPainting	EO_Matter.Painting.black	TH_Material.Construction.iron	EM_Matter.metal	H_20
Construction.metalSheet2-blackishBrownPainting	EO_Matter.Painting.blackishBrown	TH_Material.Construction.iron	EM_Matter.metal	H_16
Construction.metalSheet2-bluePainting	EO_Matter.Painting.skyBlue	TH_Material.Construction.iron	EM_Matter.metal	H_16
Construction.metalSheet2-greenPainting	EO_Matter.Painting.kellyGreen	TH_Material.Construction.iron	EM_Matter.metal	H_15
Construction.metalSheet2-greyPainting	EO_Matter.Painting.grey	TH_Material.Construction.iron	EM_Matter.metal	H_20
Construction.metalSheet2-mintGreenPainting	EO_Matter.Painting.mintGreen	TH_Material.Construction.iron	EM_Matter.metal	H_16
Construction.metalSheet2-mustardYellowPainting	EO_Matter.Painting.mustardYellow	TH_Material.Construction.iron	EM_Matter.metal	H_16
Construction.metalSheet2-redPainting	EO_Matter.Painting.lightRed	TH_Material.Construction.iron	EM_Matter.metal	H_16
Construction.metalSheet2-whitePainting	EO_Matter.Painting.white	TH_Material.Construction.iron	EM_Matter.metal	H_16
Construction.metalSheet2-yellowPainting	EO_Matter.Painting.canaryYellow	TH_Material.Construction.iron	EM_Matter.metal	H_16
Construction.oxydizedAluminium	EO_Matter.Construction.oxydizedAluminum	TH_Material.Construction.aluminium	EM_Matter.metal	H_20
Construction.pineWoodPanels	EO_Matter.Construction.pineWood	TH_Material.Construction.woodenBoard	EM_Material.Dielectric.wood	H_20
Construction.polystyrene	EO_Matter.Construction.polystyrene	TH_Material.Construction.polystyrene	EM_Material.Dielectric.plywood	H_20
Construction.polystyrene-green	EO_Matter.Painting.kellyGreen	TH_Material.Construction.polystyrene	EM_Material.Dielectric.plywood	H_20
Construction.polystyrene-lightBrown	EO_Matter.Painting.lightBrown	TH_Material.Construction.polystyrene	EM_Material.Dielectric.plywood	H_20

Add | Remove

Example of classification with logical materials

State of the art and the required data for expressing new multi-domain physics-based sensor information

multi-domains material library = open format toward the number and the kind of domains it contains

This possibility may be used in future release of the SE-WORKBENCH, but for now, the current domain names and contents are static:

- Optronic
- Thermal
- EM
- Roughness

Roughness problem : three models in our material descriptions… that we were not able to store using the SEDRIS DRM

- # State of the art and the required data for expressing new multi-domain physics-based sensor information

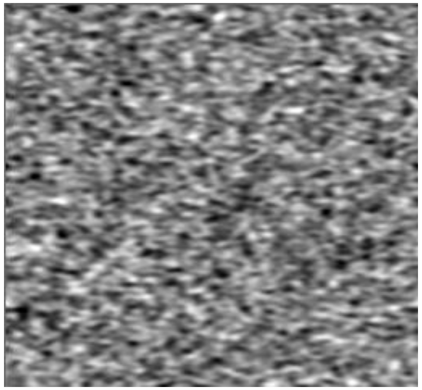
Statistic model

The statistic model is based on roughness properties that are used by He-Torrance and Li-Torrance BRDF models:

- the RMS roughness height of
- the roughness correlation lengths.

This is quite logical since the BRDF and the roughness are related: the way a material reflects light is directly linked to its roughness.

Considers roughness as a set of hollows and bumps with infinitesimal heights (the order of magnitude is the micron) forming a pattern. The correlation lengths (in X and Y) are the sizes of the roughness pattern. This defines the pattern repetitions number on a surface mapped by this material.



Height map with quadratic height of roughness of 6µm, a correlation length of 1 in X and 2 in Y

- **State of the art and the required data for expressing new multi-domain physics-based sensor information**

Natural convection

The natural convection is a mechanism, or type of heat transport, in which the air motion is not generated by any external source (like a pump, fan, wind, etc.) but only by density differences in the air occurring due to temperature gradients.

air surrounding a heat source → becomes less dense and rises → surrounding air cooler air moves to replace it → heated by the heat source…

The link between natural convection is quite easy to understand: that is why radiator is non-planar. The natural convection depends on the surface state: the more there are bumps and hollows, the greater the air exchange surface is. So if a material has a low natural convection, chances are that its surface is quite smooth. If its natural convection is high, chances are that the material is rough.

- State of the art and the required data for expressing new multi-domain physics-based sensor information

Bump multi-texturing

The bump multi-texturing: a way to associate a bump material (that is a material using the height map model) to another material. To do that the user must use a multi-texturing technique of type “Bump”. This is a useful way to create, for example, a roof material with a tile texture and relief created by the bump.

➲ SEDRIS OK for natural convection but not for statistic model (or at least we were not able to model it)

State of the art and the required data for expressing new multi-domain physics-based sensor information

Sea models : Sinus sea model Swan sea model

Sinus sea model

This model is defined as a sum of sinusoidal waves. A wave "i" is characterised by:

- a wavelength λ_i
- an amplitude A_i
- an initial phase $\phi_i(0)$
- an orientation θ_i
- a speed c_i

The description of all the waves is given in an hypertexture file.

- State of the art and the required data for expressing new multi-domain physics-based sensor information

- State of the art and the required data for expressing new multi-domain physics-based sensor information

SWAN sea model
SWAN (Simulating WAves Nearshore) = third-generation wave model, developed at Delft University of Technology

SWAN computes random, short-crested wind-generated waves in coastal regions and inland waters.
SWAN takes into account the “shoaling” and the refraction due to current and depth, wave generation by wind, 3 and 4 wave interaction, white capping, bottom friction and depth-induced breaking, dissipation due to vegetation, wave-induced set-up, transmission through and reflection (specular and diffuse) against obstacles, diffraction.

For the OKTAL-SE SE-SEA product, 2 SWAN output files are used (.spc file and .tab file)

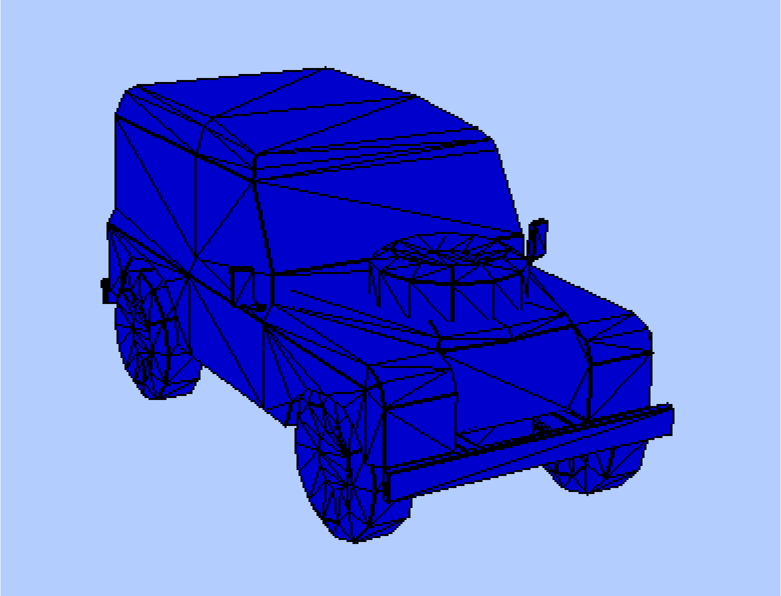
➲ How to store such data in SEDRIS ?
(the source data and the way to interpret them)

- State of the art and the required data for expressing new multi-domain physics-based sensor information

Influence Thermal Description

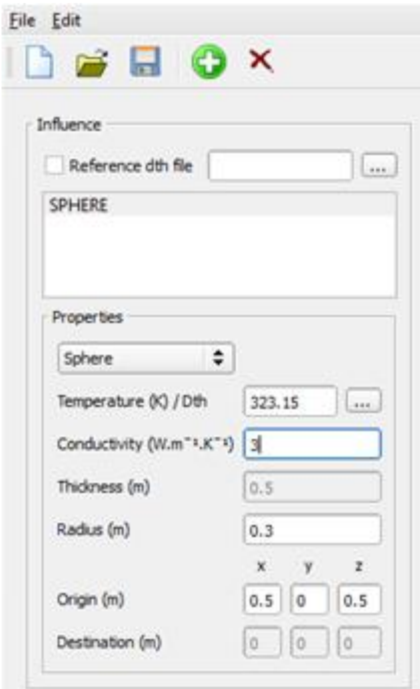
Thermal Description : element describing the thermal law of an object or a material

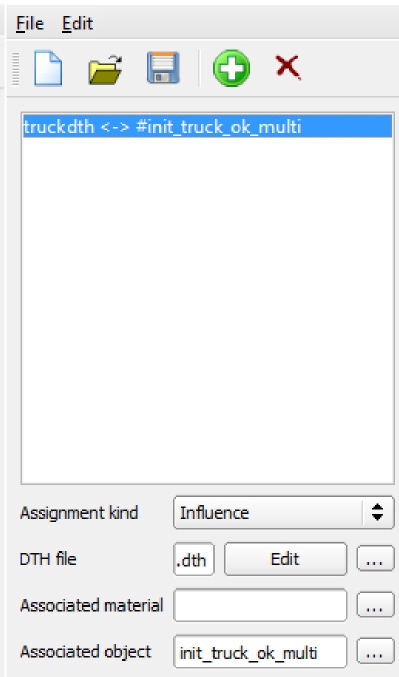
Influence Thermal Description : thermal law using influence volumes

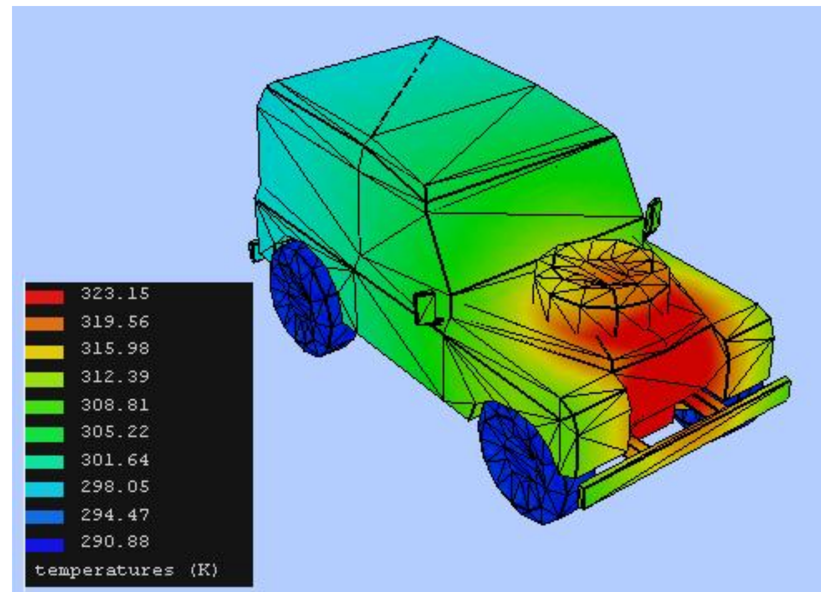


- State of the art and the required data for expressing new multi-domain physics-based sensor information

Influence Thermal Description







➲ How to store such data in SEDRIS ?

- Ideas for existing or new SEDRIS capabilities in this context
  - **roughness**
  - **sea model**
  - **influence thermal description**
  - **procedural generated geometry**
  - **…**