



OKTAL SE **The Synthetic Environment and** **SEnsor Company**

**Use of SEDRIS for multi sensors cues
in battlefield simulation**

Contacts in France ...

April 2005

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SOGECLAIR
Ingénierie de haute technologie

Simulated Optronic, Acoustic and Electromagnetic Battlefield (CHORALE)

What is CHORALE:

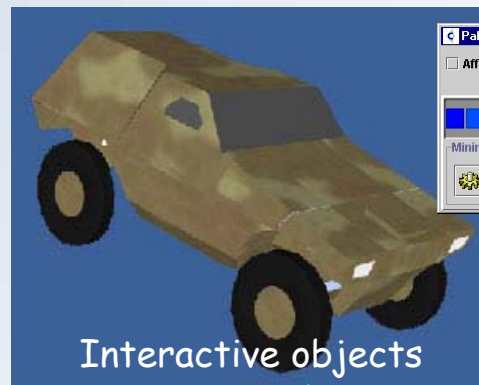
CHORALE is a comprehensive workbench including physical modelling tools for material characterisation, atmospheric tools, thermal software, ray tracing rendering engine and Open GL rendering engine

Duration :

From 1993

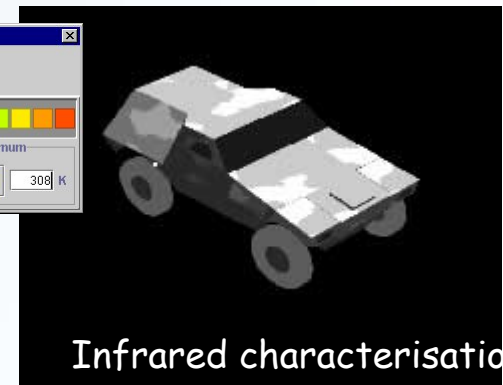
Main French users :

DGA/CELAR - ETBS - LRBA
ETAS - CTSN - CEG - CTSN



Interactive objects

texturation



Infrared characterisation

OKTAL SE has a special agreement with French DGA : CHORALE is a transversal set of tools that is recommended by French DGA - French DGA founded OKTAL SE for maintaining the tools - OKTAL SE accepts to share all its R&D upgrades with DGA in the scope of CHORALE



Exemples of CHORALE Application:

IR Application

SIGS : Synthetic Image Generation System

SIGS is a set of IR modelling and rendering tools that enables to simulate IR sensor environment typically for missile application. SIGS is used both for Image Processing algorithm definition (Reference Model) and for hybrid simulation with the real equipment (HardWare In the Loop)

EM Application:

FERMAT :

FERMAT is a comprehensive workbench including physical modelling tools for material EM characterisation, and ray tracing EM rendering engine. The physical model has been developed with French ONERA and mixes Geometrical Optics and Physical Optics. The application field is wide : EMC, RCS, Antennas, Propagation, Telecommunication.

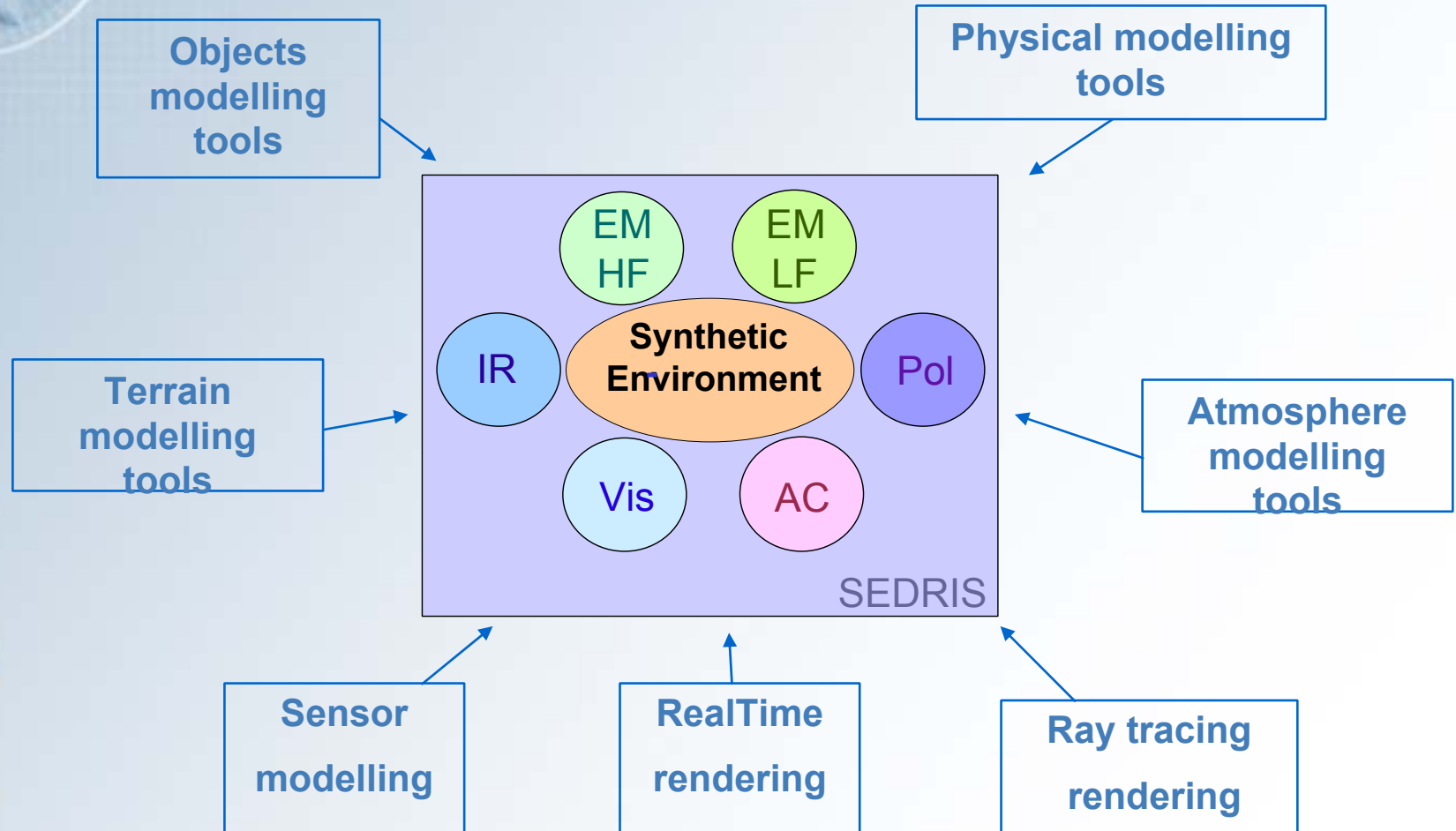
AC Application:

CHORALE AC :

CHORALE AC is a comprehensive workbench including physical modelling tools for material acoustic characterisation, atmospheric tools and ray tracing acoustic rendering engine. CHORALE AC enables to simulate acoustic detection of targets in open field.



Synthetic Environment Requirements





Synthetic Environment Questions

3D representation: Generic, Geotypical or Geospecific

- What are the input data available ?
- Which interchange format ?

Physical information: How to enhance the Synthetic Environment with physical data

- Which physical information ?
- What to enhance ?
- Which format?

Unified environment for multi sensor simulation

- *Same **core data structure** with specific extensions*
- *Unified **API** for writing and reading*
- *A single synthetic environment for several sensors*
*(**Infrared, Electromagnetic, Acoustic**)*



Multi Sensor Synthetic Environment Content

3D representation creation

Terrain Meshing

3D Templates

**Object Modelling
Tool**

Synthetic Environment enhancement with physical data

Atmosphere

Physical material

**Texture/ material
association**

Temperatures





SEDRIS Investigation

Oktal-SE has performed a study about the **SEDRIS** possibilities to manage geometrical data structures with physical extensions, especially for IR, EM and AC materials and for atmospheric data.

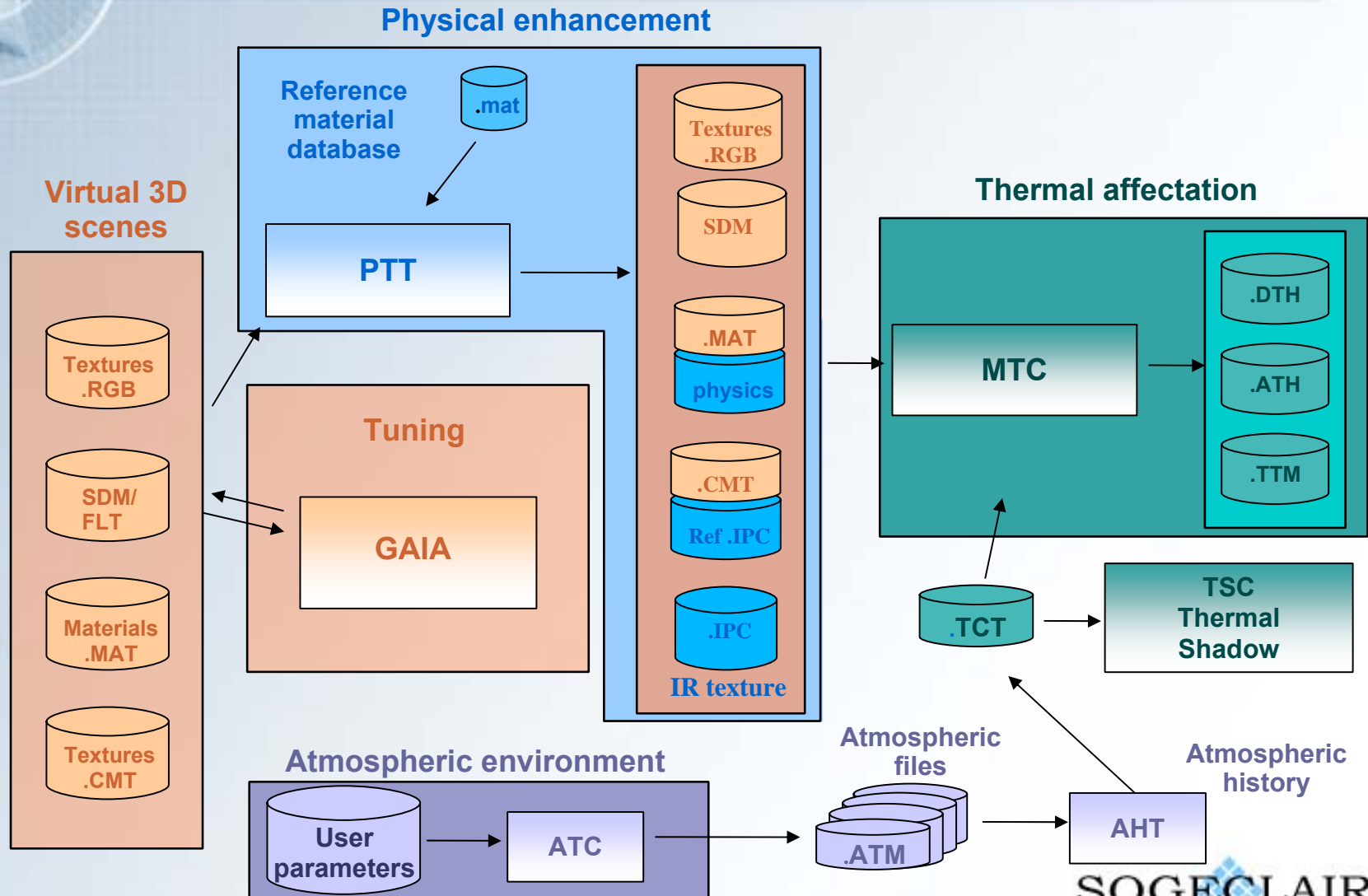
Oktal-SE wants to apply **SEDRIS** concept for its 3D modelling tools and also for the way to extend geometrical data structures with physical extensions, especially for IR, EM and AC materials and for atmospheric data.

Oktal-SE: « **SEDRIS** associate » that represents French DGA.

Oktal-SE has developed **SEDRIS** import/export modules and convertors to other french standards like SIF France.

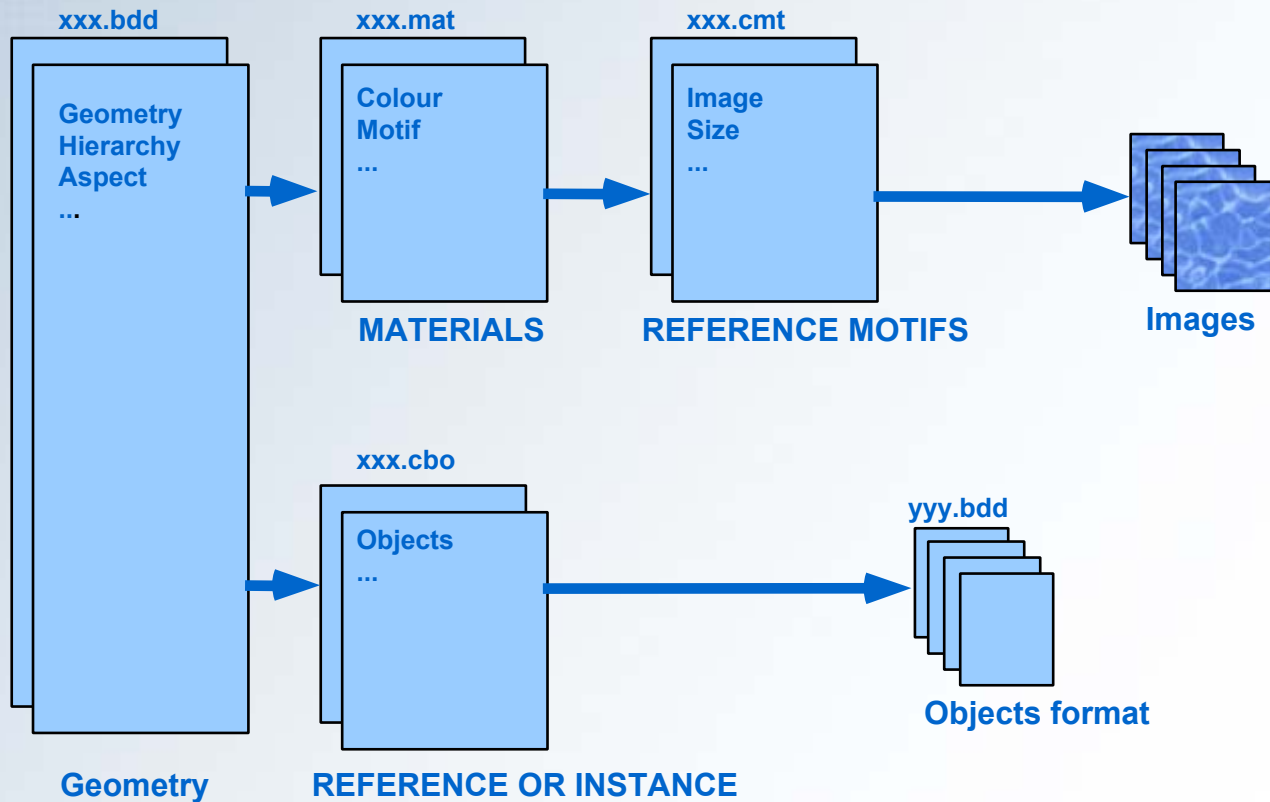


Multi Sensor Synthetic Environment Content



3D Modeling Data Structure

General description of virtual 3D scene



A material is a couple (colour, motif).

A motif of texture is an image associated to a metric size.



Infrared data in materials library

Materials palette → materials editing

Optronic attributes

Functionalities:

Editing:

- . Radiation type
 - Emissivity
 - Intensity ($\text{w} \cdot \text{sr}^{-1} \cdot \text{m}^{-1}$)
 - Radiance ($\text{w} \cdot \text{m}^{-2} \cdot \text{sr}^{-1} \cdot \text{m}^{-1}$)
- . Spectral sampling for each spectral attribute
- . Radiation values (emissivity or intensity or luminance) for each wavelength
- . Diffuse BRDF values for each wavelength
- . Specular BRDF values for each wavelength
- . Transmission for each wavelength
- . Interpolation mode for each physical attribute





Infrared Data in materials library

Materials palette → materials editing

Layers

Functionalities:

- Modifying thermal attributes

The layer type (surface, normal, ground) :

- A surface material (a layer of paint)
- A ground material (infinite layer such as the ground)
- A normal material thickness specified by the user.

Limitations:

- ⇒ "surface" type: Upper or lower layer only
- ⇒ type "sol" : Lower layer only





Electromagnetic Data in material library

Importance of material description in EM

Dielectric materials (defined by: ϵ , ϵ' , thickness)

Metallic materials (defined by infinite conductivity)

Natural surfaces (classification with 30 sub-classes): defined by the mono-static reflectivity, surface reflectivity and mean angular reflectivity (depending on the incidence angle with an associated statistical fluctuation law)

Surface state: (defined with multi-dimensional textures)





Electromagnetic Data in materials library

Materials palette → Electromagnetic attributes

Attributes

- Spectral sampling for each spectral attribut
- Amplitude and phase values of reflection components
- Amplitude and phase values of backscaterring components
- Interpolation mode for each physical attributs

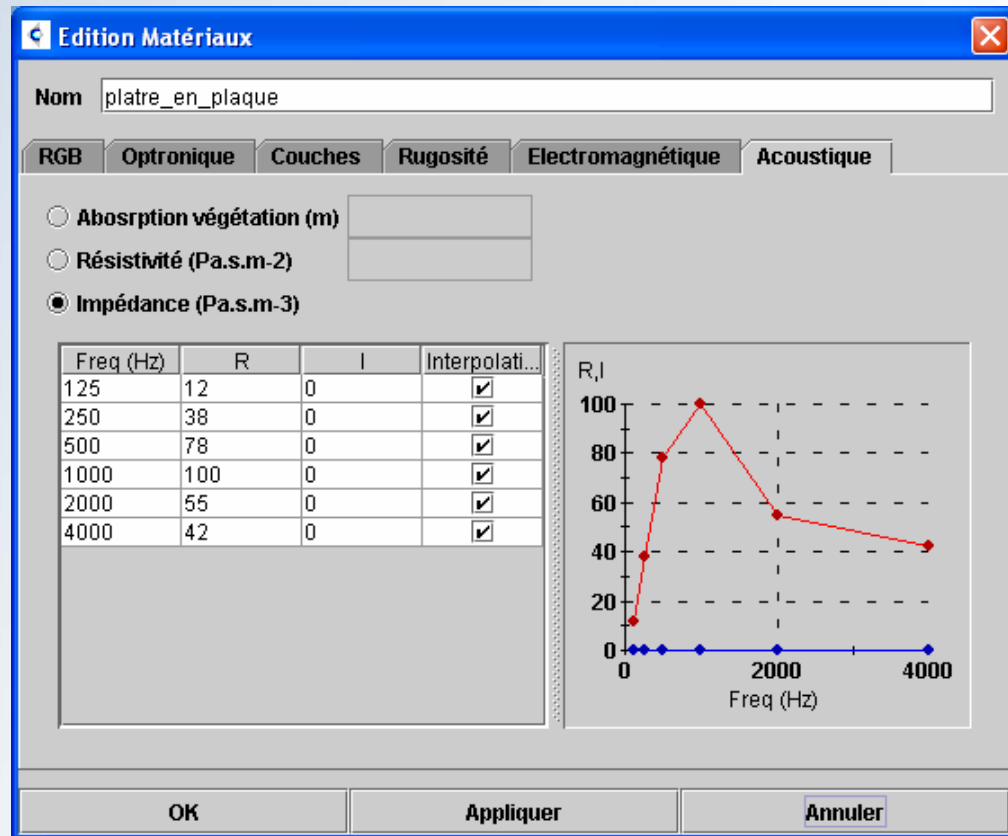


Acoustic Data in material library

Materials palette → Acoustic attributes

Attributes

- Spectral sampling for each spectral attribute
- Interpolation mode for each physical attribute





Atmospheric Data

Solar/lunar Irradiance panel

List of wavelength and altitude values for which the solar and lunar irradiance will be computed

Atmospheric attenuation panel

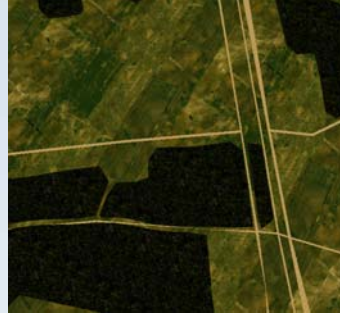
List of wavelengths, altitudes, elevations and range values for which the atmospheric attenuation will be computed

Sky radiance panel

List of wavelength, altitude, elevation, range and azimuth values for which the sky radiance will be calculated



Physical Enhancement through Texture Classification



Splitting the source picture into non overlapping layers. Each layer corresponds to a specific class of material



Then, for each layer, the last step consists in using colour interpolation, in order to generate a physical texture that contains, for each pixel, a specific mix of materials, that depends on the colour of this pixel in the initial picture



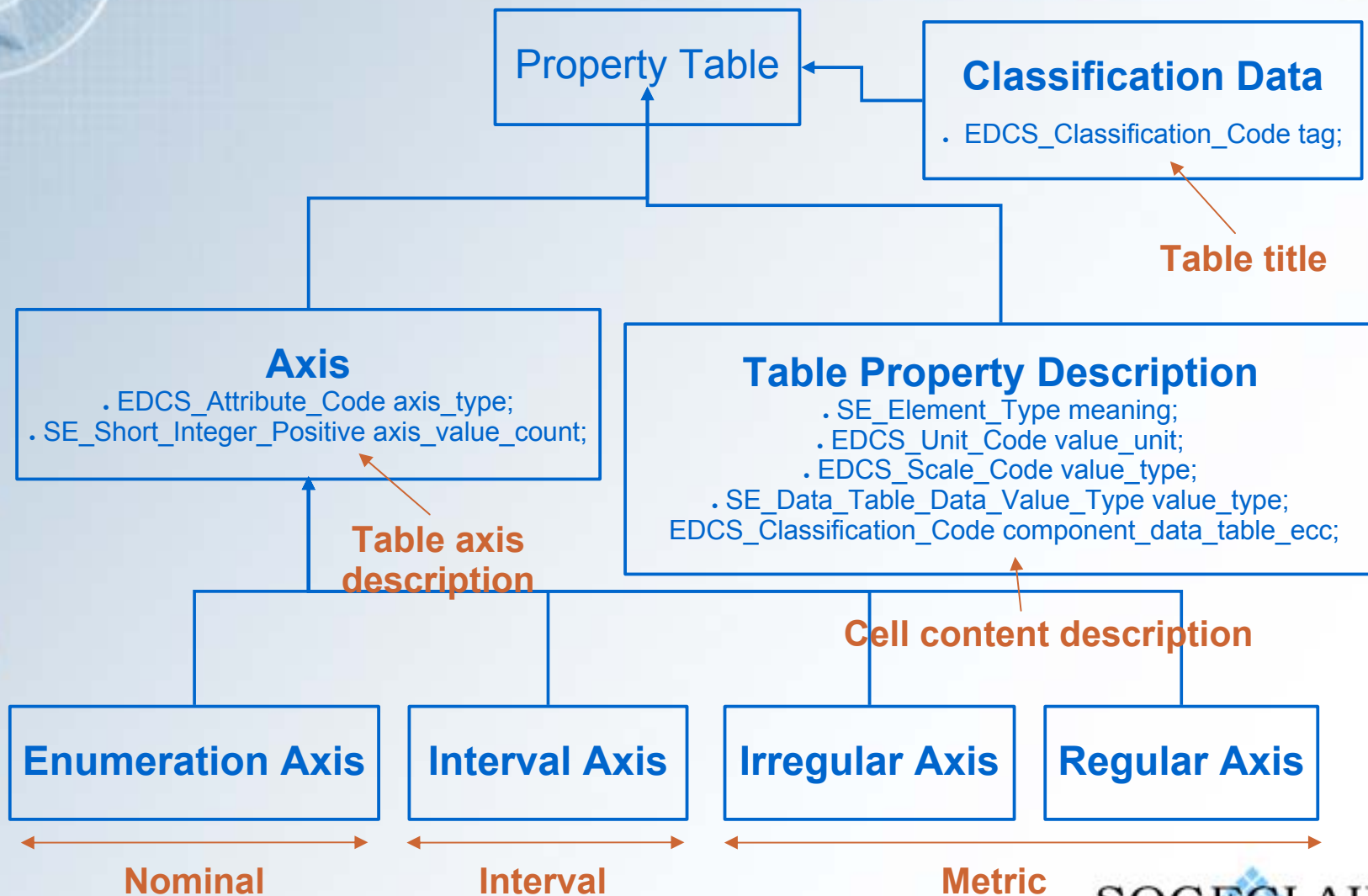
SEDRIS Modeling: Environmental concepts to model

Three kinds of environmental concepts to model for the infrared, thermal, electromagnetic and atmospheric properties:

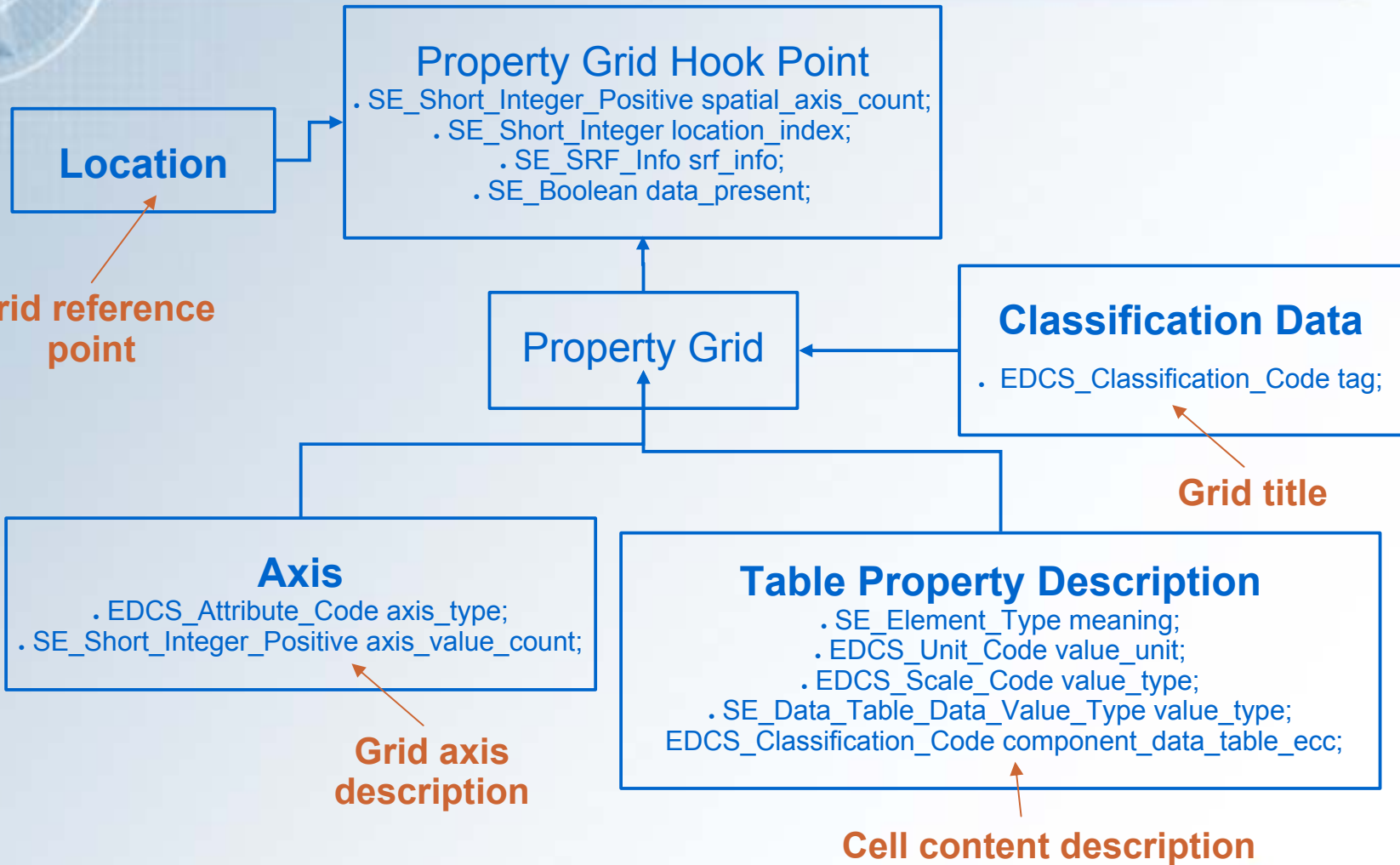
- **Non-spatial environmental concepts**
⑦ modelled as <Property Table>
- **Spatial environmental concepts**
→ modelled as <Property Grid>
- **Polygon specific environmental concepts**
→ modelled as <Property Value>



SEDRIS Modelling : Property Table



SEDRIS Modelling : Property Grid





Infrared properties

All the infrared <Property Table> have the same <Classification Data> with the tag **ECC_INFRARED_MATERIAL_PROPERTY_SET**

We only detail attribute codes but of course all the units, scales, and interpolation types have been studied.





Infrared properties: Non-spatial properties

Diffuse reflectivity ($\rho_{\text{diffuse}}(\lambda, \theta, \phi)$)

A <Table Property Description> with a **EAC_PHONG_DIFFUSE_PARAMETER** attribute

An <Irregular Axis> representing the wavelength λ with a **EAC_WAVELENGTH** attribute

An <Irregular Axis> representing the elevation angle θ with a **EAC_INCIDENCE_ELEV_ANGLE_LOCAL** attribute

An <Irregular Axis> representing the azimuth angle ϕ with a **EAC_INCIDENCE_AZIMUTH_LOCAL** attribute





Infrared properties: Non-spatial properties

Specular reflectivity ($\rho_{\text{diffuse}}(\lambda, \theta_i, \theta_r, \phi_i, \phi_r)$)

A <Table Property Description> with a **EAC_PHONG_SPECULAR_PARAMETER** attribute

An <Irregular Axis> representing the wavelength λ with a **EAC_WAVELENGTH** attribute

An <Irregular Axis> representing the incident elevation angle θ_i with a **EAC_INCIDENCE_ELEV_ANGLE_LOCAL** attribute

An <Irregular Axis> representing the reflected elevation angle θ_r with a **EAC_REFLECTANCE_ELEV_ANGLE_LOCAL** attribute

An <Irregular Axis> representing the incident azimuth angle ϕ_i with a **EAC_INCIDENCE_AZIMUTH_LOCAL** attribute

An <Irregular Axis> representing the reflected azimuth angle ϕ_r with a **EAC_REFLECTANCE_AZIMUTH_LOCAL** attribute





Infrared properties: Non-spatial properties

Emissivity ($\epsilon(\lambda, \theta, \phi)$)

A <Table Property Description> with a **EAC_EMISSIVITY** attribute

An <Irregular Axis> representing the wavelength λ with a **EAC_WAVELENGTH** attribute

An <Irregular Axis> representing the elevation angle θ with a **EAC_REFLECTANCE_ELEV_ANGLE_LOCAL** attribute

An <Irregular Axis> representing the azimuth angle ϕ with a **EAC_REFLECTANCE_AZIMUTH_LOCAL** attribute





Thermal properties

All the thermal <Property Table> and <Property Grid> have the same <Classification Data> with the tag

ECC_THERMAL_MATERIAL_PROPERTY_SET

We only detail attribute codes but of course all the units, scales, and interpolation types have been studied.





Thermal properties: Non-spatial properties

Latent heat fusion

A <Table Property Description> with a **EAC_LATENT_HEAT_FUSION** attribute

An <Irregular Axis> representing the air temperature with a **EAC_PLANETARY_SURFACE_AIR_TEMPERATURE** attribute





Thermal properties: Non-spatial properties

Latent heat vaporization

A <Table Property Description> with a **EAC_LATENT_HEAT_VAPORIZATION** attribute

An <Irregular Axis> representing the air temperature with a **EAC_PLANETARY_SURFACE_AIR_TEMPERATURE** attribute





Thermal properties: Non-spatial properties

Latent heat sublimation

A <Table Property Description> with a **EAC_LATENT_HEAT_SUBLIMATION** attribute

An <Irregular Axis> representing the air temperature with a **EAC_PLANETARY_SURFACE_AIR_TEMPERATURE** attribute





Thermal properties: Face properties

Face temperature

A <Property Value> with a **EAC_PLANETARY_SURFACE_AIR_TEMPERATURE** attribute

Face thermal conductivity

A <Property Value> with a **EAC_THERMAL_CONDUCTIVITY** attribute

Face thermal specific heat

A <Property Value> with a **EAC_SPECIFIC_HEAT** attribute





Thermal properties: Face properties

Face total emissivity

A <Property Value> with a **EAC_EMISSIVITY** attribute

Face material density

A <Property Value> with a **EAC_MATERIAL_DENSITY** attribute





Thermal properties: Spatial properties

Convection coefficient

A <Table Property Description> with a **EAC_CONVECTION_COEFFICIENT** attribute

An <Irregular Axis> representing the altitude with a **EAC_SPATIAL_LINEAR_TERTIARY_COORDINATE** attribute





Thermal properties: Spatial properties

Thermal flux density $\phi(z, t)$

A <Table Property Description> with a **EAC_INFRARED_HEAT_FLUX** attribute

An <Irregular Axis> representing the altitude with a **EAC_SPATIAL_LINEAR_TERTIARY_COORDINATE** attribute

An <Irregular Axis> representing the cycle over a day with a **EAC_TIME_COORDINATE** attribute





Electromagnetic properties

All the electromagnetic <Property Table> have the same <Classification Data> with the tag **ECC_RADAR_MATERIAL_PROPERTY_SET**

We only detail attribute codes but of course all the units, scales, and interpolation types have been studied.





Electromagnetic properties: Non-spatial properties

Emissivity ($\epsilon(\lambda, \theta, \phi)$)

A <Table Property Description> with a **EAC_EMISSIVITY** attribute

An <Irregular Axis> representing the wavelength λ with a **EAC_WAVELENGTH** attribute

An <Irregular Axis> representing the elevation angle θ with a **EAC_REFLECTANCE_ELEV_ANGLE_LOCAL** attribute

An <Irregular Axis> representing the azimuth angle ϕ with a **EAC_REFLECTANCE_AZIMUTH_LOCAL** attribute





Electromagnetic properties: Non-spatial properties

Radar cross section ($\sigma(\lambda, \theta)$)

A <Table Property Description> with a **EAC_RADAR_CROSS_SECTION** attribute

An <Irregular Axis> representing the wavelength λ with a **EAC_WAVELENGTH** attribute

An <Irregular Axis> representing the elevation angle θ with a **EAC_RADAR_REFLECTOR_ANGLE** attribute

An <Enumerant Axis> representing the polarization with a **EAC_ELECTROMAGNETIC_POLARIZATION_TYPE** attribute and the values **EEC_EMPOLRTY_LINEAR_VERTICAL**, **EEC_EMPOLRTY_CROSSED_VERT_HORIZ**, **EEC_EMPOLRTY_CROSSED_HORIZ_VERT**, **EEC_EMPOLRTY_LINEAR_HORIZONTAL**





Atmospheric properties

All the atmospheric <Property Grid> have the same <Classification Data> with the tag **ECC_ATMOSPHERE**

We only detail attribute codes but of course all the units, scales, and interpolation types have been studied.





Atmospheric properties: Spatial properties

Solar zenith angle

A <Table Property Description> with a **EAC_SOLAR_RADIANCE_ELEV_ANGLE_HORIZONTAL** attribute

An <Irregular Axis> representing the latitude with a **EAC_SPATIAL_ANGULAR_PRIMARY_COORDINATE** attribute

An <Irregular Axis> representing the longitude with a **EAC_SPATIAL_ANGULAR_SECONDARY_COORDINATE** attribute





Atmospheric properties: Spatial properties

Air temperature

A <Table Property Description> with a **EAC_PLANETARY SURFACE_AIR_TEMPERATURE** attribute

An <Irregular Axis> representing the altitude with a **EAC_SPATIAL_LINEAR_TERTIARY_COORDINATE** attribute





Atmospheric properties: Spatial properties

Atmospheric transmission $\tau_{latilongi}(\lambda, t, d, \theta, z)$

A <Table Property Description> with a **EAC_TRANSMISSIVITY** attribute

An <Irregular Axis> representing the wavelength λ with a **EAC_WAVELENGTH** attribute

An <Irregular Axis> representing the distance d with a **EAC_LENGTH** attribute

An <Irregular Axis> representing the elevation angle θ with a **EAC_INCIDENCE_ELEV_ANGLE_HORIZONTAL** attribute





Atmospheric properties: Spatial properties

Atmospheric transmission $\tau_{latilongi}(\lambda, t, d, \theta, z)$

An <Irregular Axis> representing the altitude z with a
EAC_SPATIAL_LINEAR_TERTIARY_COORDINATE attribute

The time component is handled by grouping several grids in a
<Time Related Geometry>





Atmospheric properties: Spatial properties

Atmospheric radiance $L_{latilongi}(\lambda, t, d, \theta, \phi, z)$

A <Table Property Description> with a **EAC_RADIANCE** attribute

An <Irregular Axis> representing the wavelength λ with a **EAC_WAVELENGTH** attribute

An <Irregular Axis> representing the distance d with a **EAC_LENGTH** attribute

An <Irregular Axis> representing the elevation angle θ with a **EAC_INCIDENCE_ELEV_ANGLE_HORIZONTAL** attribute





Atmospheric properties: Spatial properties

Atmospheric radiance $L_{latilongi}(\lambda, t, d, \theta, \phi, z)$

An <Irregular Axis> representing the elevation angle ϕ with a **EAC_INCIDENCE_AZIMUTH_GEODETIC** attribute

An <Irregular Axis> representing the altitude z with a **EAC_SPATIAL_LINEAR_TERTIARY_COORDINATE** attribute

The time component is handled by grouping several grids in a <Time Related Geometry>





Atmospheric properties: Spatial properties

Direct solar irradiance $E_{latilongi}(\lambda, t, \theta, z)$

A <Table Property Description> with a **EAC_SOLAR_DIRECT_IRRADIANCE** attribute

An <Irregular Axis> representing the wavelength λ with a **EAC_WAVELENGTH** attribute

An <Irregular Axis> representing the elevation angle θ with a **EAC_INCIDENCE_ELEV_ANGLE_HORIZONTAL** attribute

An <Irregular Axis> representing the altitude z with a **EAC_SPATIAL_LINEAR_TERTIARY_COORDINATE** attribute

The time component is handled by grouping several grids in a <Time Related Geometry>





Atmospheric properties: Spatial properties

Diffuse solar irradiance $E_{latilongi}(\lambda, t, \theta, z)$

A <Table Property Description> with a **EAC_SOLAR_DIFFUSE_IRRADIANCE** attribute

An <Irregular Axis> representing the wavelength λ with a **EAC_WAVELENGTH** attribute

An <Irregular Axis> representing the elevation angle θ with a **EAC_INCIDENCE_ELEV_ANGLE_HORIZONTAL** attribute

An <Irregular Axis> representing the altitude z with a **EAC_SPATIAL_LINEAR_TERTIARY_COORDINATE** attribute

The time component is handled by grouping several grids in a <Time Related Geometry>





Soon to be migrated in the 4.0 version

