

## **SEDRIS on the Test Bench – The Future of Exchanging Environmental Data to become Part of M&S as a Service**

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### ***Abstract***

*Environmental data plays a central role in many simulation applications. Thus the representation and sharing of environmental data are a key task in the interoperation of heterogeneous systems and applications that use such data. In the 1990's the Synthetic Environment Data Representation and Interchange Specification (SEDRIS - ISO/IEC 18023) was developed. The SEDRIS specification had two fundamental objectives: First the representation of environmental data and second the interchange of environmental data sets.*

*Meanwhile the valuation of that approach is ambivalent. On the one hand SEDRIS' Data Representation Model (DRM) and the Environmental Data Coding Specification (EDCS) are still sufficient for today's simulation applications. Especially if considered both of them are expandable. So they provide a mature approach for representing the data.*

*On the other hand the supposed interchange of data is sort of outdated. It is not state of the art to generate and read binary files using a particular API compiled for a special development environment, which may be difficult to integrate in heterogeneous systems.*

*To preserve the achievements of SEDRIS in data representation and to tackle the issue of data interchange, the SEDRIS DRM and the EDCS (STANAG 4664) must be transferred into modern and standardized techniques of data management.*

*For that the Geography Markup Language (GML – ISO 19136) defined by the Open Geospatial Consortium (OGC) provides the technical framework for the description of the data model. A major benefit of GML-structured data is its compatibility to the OGC-Standard Web Feature Service (WFS – ISO 19142) for data access and data interchange and other services like the Web Mapping Service (WMS – ISO 19128).*

*This idea was implemented in the German project VIntEL. In combination with a database management system the resulting Synthetic Environment Service (SES) includes a component for data storage, OGC-compliant services for data distribution based on standards.*

*In summary this is ideal to provide environmental data in the field of Modelling and Simulation as a Service (MSaaS) and is used in the MSG-136, which deals with the subject of MSaaS.*

## **1. Introduction**

The Synthetic Environment Data Representation and Interchange Specification (SEDRIS - ISO/IEC 18023) is an infrastructure which was designed to enable the interchange of synthetic data including terrain, features and (3d-) models. The SEDRIS infrastructure deals with the representation of the data itself on the one hand and the interchange of the data on the other hand.

Modelling and Simulation is an important tool for NATO and its nations in the domains of training, analysis and decision making. Looking at the capabilities of Service Oriented Architectures (SOA) and Cloud-Computing, the idea of Modelling and Simulation as a Service (MSaaS) was born. MSaaS offers opportunities to share and combine M&S capabilities throughout the NATO members.

MSaaS infrastructures still require mechanisms for handling environmental data including the representation and the exchange of the data. As this issues are the main concern of SEDRIS, this paper explores the opportunity of using it as a whole or parts of it in the recent MSaaS world.

## **2. Modeling and Simulation as a Service (MSaaS)**

### **2.1. General Idea**

As mentioned above Modelling and Simulation (M&S) plays an important role in the domains of training, analysis and decision-making. M&S solutions have to be integrated seamlessly in future IT infrastructures to ensure increased efficiency, affordability, interoperability and reusability. Technical developments in the area of Service-Oriented Architectures (SOAs) may offer opportunities for providing M&S solutions that address current NATO critical shortfalls.

The application of a ‘services’ model to Modelling and Simulation, promises to greatly reduce the barriers of cost and accessibility and to result in greater acceptance and utility of M&S throughout NATO and the nations [10].

In combination with the capabilities of cloud computing MSaaS is a very promising approach for implementing simulation environments where M&S products can be accessed simultaneously and spontaneously by a large number of users for their individual purposes.

A main conclusion of MSG-131 is that M&S is a critical technology for NATO and the nations, independent of whether it is provided “as a service” or not. However, service-based approaches to M&S offer many potential benefits. In addition to that MSG-131 describes various open issues with regards to MSaaS, spanning a broad range from technical to organizational questions. In accordance with its Technical Activity Description, MSG-131 recommends investigation of MSaaS in more detail. To do that and to step forward in pushing MSaaS to practical use the NATO MSG-136 was set up.

### **2.2. The MSG-136 – the MSaaS Think-tank**

NATO MSG-136 (“Modelling and Simulation as a Service – Rapid deployment of interoperable and credible simulation environments”) is the follow-on group of MSG-131 and investigates the concept of MSaaS with the aim of providing the technical and organizational foundations for a future permanent service-based M&S environment. Thus the Allied Framework for M&S as a Service was invented there. This framework collects and offers existing M&S services that are available on-demand and delivers them as plugins in a defined service infrastructure. So potential users can share their services and combine them to execute common experimentations. As that idea is based on services and cloud resources, the opportunity of doing distributed simulation is included by the chosen technical means.

To make MSaaS available the MSG-136 defines the Allied Framework for M&S as a Service. It aims to provide the user with discoverable M&S services that are readily available on-demand and deliver a choice of applications in a flexible and adaptive manner. It offers advantages over the existing M&S paradigm in which the users are highly dependent on a limited amount of industry partners and SMEs. [9]

### **2.2.1. M&S as a Service**

An M&S service is a specific M&S-related capability delivered by a provider to one or more consumers according to well defined contracts including service level agreements (SLA) and interfaces.

M&S products are highly valuable to NATO and military organizations and it is essential that M&S products, data and processes are conveniently accessible to a large number of users as often as possible. Therefore a new M&S ecosystem is required where M&S products can be accessed simultaneously and spontaneously by a large number of users for their individual purposes. This “as a Service” paradigm has to support stand-alone use as well as integration of multiple simulated and real systems into a unified simulation environment whenever the need arises.

M&S as a Service (MSaaS) is an enterprise-level approach for discovery, composition, execution and management of M&S services.

To disseminate the Idea of MSaaS, the MSG 136 defines four objectives:

1. To provide a framework that enables credible and effective M&S services.
2. To make M&S services available on-demand to a large number of users.
3. To make M&S Services available in an efficient and cost-effective way.
4. To provide the required level of agility to enable convenient and rapid integration of capabilities.

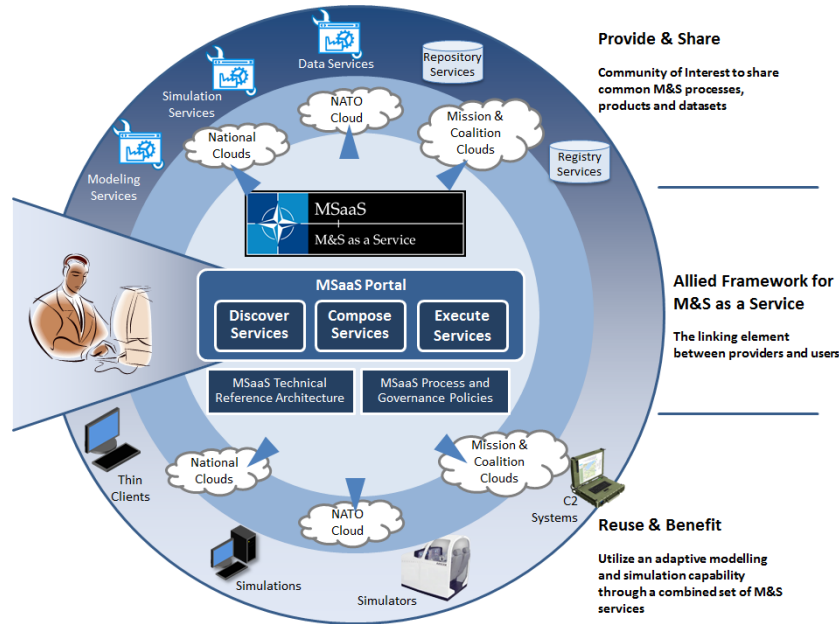
### **2.2.2. The allied Framework for M&S as a Service**

To meet the objectives mentioned above and to bring service providers and possible users of M&S Services together, the MSG-136 invented a framework called Allied Framework for M&S as a Service, which allows service providers to offer their simulation services on it.

For discovering the available services the Allied Framework for MSaaS provides a meta-service to search and discover M&S services and assets (e.g., Data, Services, Models, Federations, and Scenarios). A registry is used to catalogue available content from NATO, national and academic organizations as well as industry. This registry provides a set of information on available services and assets which enable the user to evaluate the services for his pursued goal. The registry also delivers information how to obtain the data and the costs which may be due for the usage of the service.

A major point of the framework is the ability to compose discovered services to perform a given simulation use case. The opportunity of setting up a composition of services, which build new simulation applications, is a major benefit of the Allied Framework for MSaaS.

From the consumer’s perspective the Allied Framework for MSaaS acts as an app store known from smartphones. The user can explore the offered M&S capabilities and select the useful services that best suit their needs.



**Figure 1: The Allied Framework for MSaaS from the MSG-136**

For execution the framework provides the ability to deploy the composed services automatically on a cloud-based or local computing infrastructure. The automated deployment and execution allow exploiting the benefits of cloud computing (e.g. scalability, resilience). Once deployed and executed the M&S services can be accessed on-demand by a range of users (Live, Virtual, Constructive) directly through a simulator (e.g., a flight simulator consuming a Web Map Service), or may be provided by a thin client or by a dedicated application (e.g., a decision support system utilizing various services like terrain data service, intelligence information service etc.).

### 2.2.3. Environmental data

Environmental data or more literally spoken terrain data is needed for many kinds of simulation and is even essential for most live simulations. To meet the requirement of having composable services for running a simulation together, these services have to rely on common terrain information. Otherwise the results of the single simulation components working together very likely will not match, so no fair fight conditions will exist and the result may be inapplicable.

Thus a service has to be build-up to provide common environmental data to all participating services which can be composed in the Allied Framework. For being suitable for MSaaS applications the environment service has to fulfil two demands:

1. The service must be able to be integrated into the NATO Allied Framework proposed by the MSG-136.
2. The data itself has to be delivered in an easy to handle manner and if possible in a standardized data model and a standardized architecture.

As SEDRIS is an ISO standardized infrastructure for exchanging environmental data, SEDRIS is put on the test-bench to analyse whether it is meeting the requirements described above.

## 3. SEDRIS

### 3.1. Introduction

SEDRIS is an infrastructure technology that enables information technology applications to express, understand, share, and reuse environmental data. SEDRIS technologies provide the means to represent

environmental data (terrain, ocean, air and space) and to promote the unambiguous, loss-less and non-proprietary interchange of environmental data.

Since its start, SEDRIS has maintained several fundamental objectives. The most notable of these are

- a. to provide a powerful methodology for articulating and capturing the complete set of data elements and the associated relationships, needed to fully represent environmental data;
- b. to provide a standard interchange mechanism to distribute environmental data and to promote database reuse among heterogeneous systems;
- c. to support the full range of applications across all environmental domains that span ocean, terrain, atmosphere and space [11].

To achieve the first, SEDRIS offers a data representation model augmented with its environmental data coding specification and spatial reference model (SRM), so that any environmental dataset can be described clearly. Therefore the data representation aspect of SEDRIS is about capturing and communicating meaning and semantics.

As indicated above SEDRIS has gone through ISO standardization and was adopted to STANAG 4664. The most important are the standards

- ISO/IEC 18023-1:2006(E), SEDRIS: Part 1: Functional specification (DRM, APIs, and STF),
- ISO/IEC 18025:2005(E), Environmental Data Coding Specification (EDCS) and
- ISO/IEC 18026:2006(E), Spatial Reference Model (SRM).

The standards mentioned above contain the functional specification of SEDRIS whereas the others deal with the technical programming language bindings, which are of interest, when working on implementations using SEDRIS.

Relating to the main aspects of SEDRIS the two - data representation and interchange of data - are examined in the two following sections.

## **3.2. Data Representation**

SEDRIS differentiates between classes and their semantics and comes with an abstract class model called Data Representation Model (DRM). It describes all kinds of objects the same way and sorts them in a kind of scene graph. The components of the scene graph are described by an abstract meaning library called Environmental Data Coding Specification (EDCS) [15].

The most prominent part of the DRM structure describes the environment, including terrain data, aerial photos, buildings, vegetation and so on. This environment part of the DRM is completed by four libraries which provide content that can be reused in the entire environment because this content has no geo-specific characteristics.

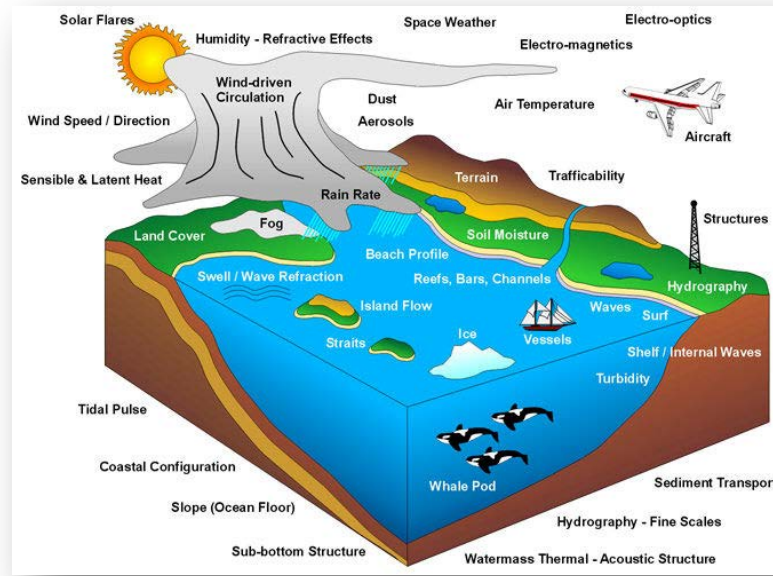
### **3.2.1. Environment**

As mentioned above the representation of the environment is the largest part of the SEDRIS-DRM. For being capable to supply the range of Command and Control to virtual simulators, the description of the environment is divided into two branches. The first is the so called feature branch and the second is the so called geometry branch.

The feature branch contains two-dimensional, cartographic data. This data is useful for the creation of location maps and for the description of operational situations. All geometry types – aerial, linear, point – are supported. Examples for this in the mentioned order are land use data, traffic infrastructure and positions of facilities like light points and so on.

The structure of the geometry branch is more complex. The reason for that are especially the requirements coming from virtual simulation systems.

In a nutshell the geometry branch contains 3-dimensional objects that aggregate to the whole environment. All objects can be stored in several Levels of Detail (LoD). That enables delivering them in a resolution that fits the required application or the technical capabilities of the supplied simulation



**Figure 2: The extent of the SEDRIS data schema [12]**

system. The definition of states allows the description of object versions representing discrete damage situations or different setups of objects.

Every object should be represented in both branches and the corresponding objects have to be associated. This is necessary to keep different simulation systems that rely on the different branches synchronously.

The components of the scene graph are described by an abstract meaning library called Environmental Data Coding Specification (EDCS – ISO 18025).

### **3.2.2. Quality information**

Besides that there is a metadata section which contains ISO-19115 compliant data quality information. ISO 19115 defines the schema required for describing geographic information and services by means of metadata. It provides information about the identification, the extent, the quality, the spatial and temporal aspects, the content, the spatial reference, the portrayal, distribution and other properties of digital geographic data and services.

### **3.2.3. Libraries**

#### **3.2.3.1. Model Library**

The Model Library is designed to serve two types of objects. In the first place there are geo-typical objects which are stored once and which are reused as often as required by defining their positions by transformation matrices. Vegetation, buildings with regional characteristics, street lamps and so on are examples for that.

Second models of vehicles, vessels, planes and weapon systems can be described. This description is not as detailed as it is required for simulating the models themselves but the definition of degrees of freedom to define movable parts is possible. The intention is to deliver uniform entities to other

systems in a federation. So all federates can include and present these entities in the same way, which supports preserving fair-fight conditions.

### **3.2.3.2. Image Library**

All imagery of the represented environment is stored here. The image library holds the image data in different resolutions and provides metadata. The pre-processed image pyramids are important for the ability to supply images fast and in the best possible resolution for several types of simulation according to their requirements.

### **3.2.3.3. Sound Library**

Sounds can be linked to all objects of the environment data and to all models. The sound data is stored in the sound library. As any library objects sounds – a siren for example – can be reused.

### **3.2.3.4. Symbol Library**

Especially C2-Simulations require cartographic information. For providing uniform cartographic information, the needed symbology can be stored in the symbol library.

## **3.3. Interchange of environmental data sets**

The SEDRIS specification introduces the SEDRIS Transmittal Format (STF) as a platform independent interchange mechanism for SEDRIS transmittals. SEDRIS transmittals mean an instantiated SEDRIS class structure. STF is a binary file format that defines the structure of a SEDRIS transmittal stored on a data volume.

In order to bring any existing environment database into a SEDRIS transmittal, the SEDRIS API has to be used. The API delivers the functionality to populate the DRM and to hold it in memory alongside raw data like imagery or sound data. The SEDRIS Transmittal API is provided to finally store the gathered information to an STF-File.

With that APIs an application has to perform a conversion from its own native database format to the SEDRIS DRM. This process is termed “in-memory conversion”. The data is then available for SEDRIS-based consumer applications [12].

The big issue of that way of exchanging data is the fact that hard coded API implementations - like provided by SEDRIS - are platform as well as format dependent. This means that any software, which shall use those APIs has to be built in the same (C or sometimes C++) development environment like the SEDRIS API is provided or has to be able to integrate it using appropriate interfaces.

Further on the API is directly connected to the data structure. Thus any change of the data format means a change in the API and with that a programmatic change of the using application. In addition to that is a quite complex task to preserve at least downwards compatibility, which is important to keep older transmittal files usable.

## **3.4. Conclusions**

The data representation part of the SEDRIS infrastructure provides a complete data structure which is suitable for supplying most modelling and simulation applications. The SEDRIS data structure allows to represent almost every aspect of environmental data including terrain, land cover, weather, underwater data and much more. The specified object orientated class model is compliant to modern data modelling, database and programming techniques. Because of that the standard ISO/IEC 18023-1:2006 which includes the data representation part is still up to date and delivers a mature data structure which is worth to be kept in focus for today’s applications.

The second part – data interchange – is still a possible way of interchanging data but it doesn’t comply with recent technology. The first major issue is the so called “in memory conversion”. This means that any conversion is limited to the size of the available working memory. This problem can be tackled by working tile based, but that brings other problems with it. As a simple example the handling of

libraries which are used in the entire dataset can be mentioned. The choice is between exporting them redundantly or having transmittal files which are invalid, because the references are not satisfied.

Where the problems related to memory issues or tiling the data may be solved somehow, the problem of integrating SEDRIS infrastructure into a service environment seems to be an insuperable barrier. There are no services defined and the file based approach of the STF-Files is neither a useable data source for running services nor a convenient medium to be exchanged using services.

To bridge that gap the SEDRIS standard was picked up and developed towards usability in MSaaS infrastructures. The way that was done is outlined in the next chapter.

## **4. SEDRIS' way to MSaaS**

The detected requirements of MSaaS to an environmental data service and the determined capabilities of the SEDRIS infrastructure only match in one of the two aspects. SEDRIS provides a standardized data model to give a common structure to interchange terrain data in an MSaaS environment. But SEDRIS lacks any kind of service which is able to be integrated into a service based simulation. The next sections describe the way to lift the idea of SEDRIS to modern environments like MSaaS.

### **4.1. The OGC Framework**

A framework has to be found which can take the SEDRIS data model and includes a service approach, which can be integrated into MSaaS environments. In the field of Geographic Information Systems (GIS) the Open Geospatial Consortium (OGC) emerged. The OGC is an association of companies as well as representatives from universities, administrations and companies. Founded in 1994 several hundred commercial, governmental, and research organizations worldwide collaborate to support the development of standards and norms in the context of spatial data. Most of the OGC specifications relate to 2D and 3D vector data.

The OGC delivers a framework, which is able to integrate any data model and that delivers a set of standardized services for interchanging the data. Both aspects are introduced in the following.

#### **4.1.1. The Geography Markup Language**

The Geography Markup Language [7] as the core schema for describing multidimensional geospatial data is a perfect basis for building up a standard for simulation systems. GML – current version is GML3.3 – is an XML syntax, which allows the description and the exchange of spatial vector data. The basic modelling concept of GML offers 2- and 3-dimensional geometries with respect to the European Petroleum Survey Group (EPSG) [1] spatial reference systems, topological relations, object oriented metadata schemas, complex attribute types, linking spatial and non-spatial objects and relations based on the Unified Modeling Language (UML) like aggregations or compositions. The basic types of the GML syntax refer to specifications of the ISO 19100 series. An application needs to define its application schema in a GML based XML-Schema to ensure ISO compliant data modeling. In other words, every GML based application consists of its own application schema, which is fixed in the language of XML Schema Definitions (XSD) [7].

#### **4.1.2. The OGC Web Services**

As GML is an abstract data modelling framework where any semantic data model can be integrated, the OGC Web Services (OWS) specify any common aspect of the services which rely on GML structured data or at least geographic data. These common aspects are primarily some of the parameters and data structures used in operation requests and responses. Secondly the way of machine to machine communication is specified, which includes the automated request for the service's capabilities for example. Basing on that each implementation standard must specify the additional aspects of that interface, including specifying all additional parameters and data structures needed in all operation requests and responses.

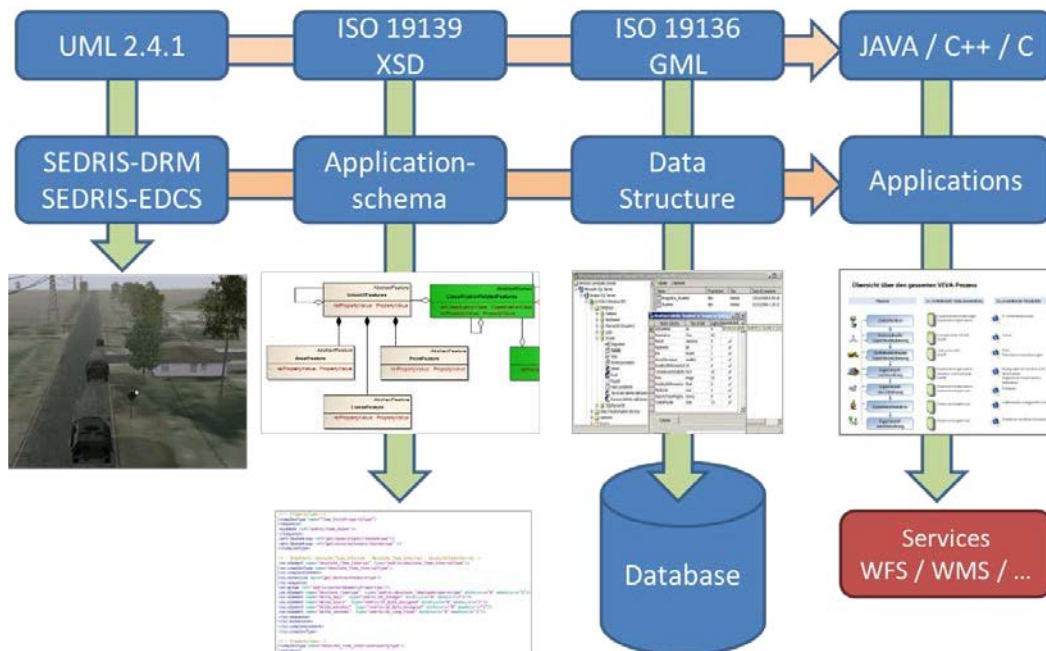


The Web Feature Service (WFS) as an instance of OWS-Services is a service for interchanging data objects, called features, with all semantic as well as geometric information in a standardized way. The standard describes the access to database content in two directions. The first direction is the specification of queries. They define the requested dataset and can be processed by the service. To express queries the OGC provides the ISO 19143 standard OpenGIS Filter Encoding [8] for the access to any object or any subset of objects in the database.

In the other direction the response of the query is a well-structured XML/GML document. This can be handled with a variety of standard tools, existing in any programming language on any platform.

## 4.2. SES-GML

The first step on the way to an OGC compliant terrain service is to create a GML based application scheme. The UML (Unified Markup Language) definitions provided by SEDRIS were the source for the new SES-GML data schema. The retrieved diagrams were reevaluated so that they were sufficient to bring them into a translation process towards an Extended Schema Definition File (XSD). An XSD file is the standardized description of a GML data structure. It can be used to build-up for example an object relational database or any other appropriate data container complying with the requested ISO/OGC-standards.



**Figure 3: Workflow from SEDRIS to SES-GML**

Having a data container like that, the OGC services can be implemented upon that. The SES-GML data structure, a data container and services form the three pillars of the Synthetic Environment Service.

## 5. The Synthetic Environment Service (SES)

The implementation of that approach is called Synthetic Environment Service (SES). It consists of several components. First there is a data container, which is represented by an object relational database. For bringing that database into effect, the SES-GML scheme is used to provide the structure to store the required environment for running virtual or constructive simulation. Then interfaces for accessing and manipulating the data are required. Among others standardized services are used for that task. These components starting from the database management system, continuing with the SEDRIS-

GML schema and concluding with the mechanisms for the data access will be described in the next paragraphs.

## 5.1. Components

### 5.1.1. Database

The concept of the SES specifies that the data is stored centrally. This generates a number of demands towards storing technology employed for the data container. As the SES is supposed to be capable for extensive environments and for a wide range of simulation systems, it must be able to store, maintain and distribute large amounts of data. Because of the central position of the SES simultaneous read and write access to the database content for a large number of clients must be rolled out.

These requirements lead to database management systems. Oracle and PostgreSQL are two well-known instances of suitable DBMS. Both of them have spatial extensions. PostgreSQL in combination with PostGIS was the choice for the SES. The main reason is that this technology is for free and can be used at any place without extra costs. The performance is on the Oracle level at least under the circumstances of the SES implementation. The system meets the requirements described above with its performant spatial and semantic search operations using appropriate spatial and table indexes.

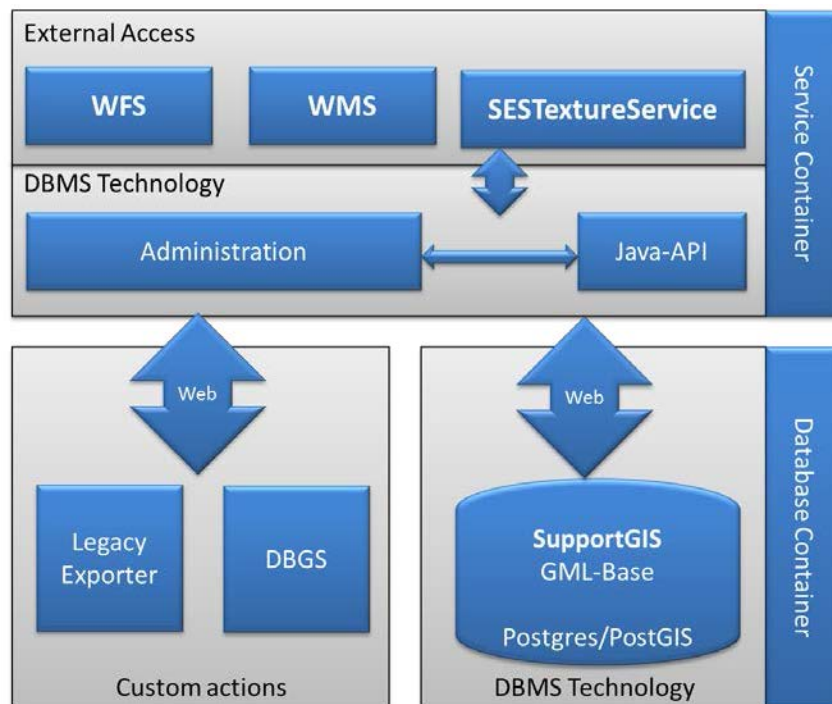


Figure 4: The components of the SES

### 5.1.2. Services

Services are the main interface for the access of the environment, model and image data. The remote information interchange is a great advantage of that approach. Any system on any platform running on any operation system can retrieve data without integrating any special programming library or any other proprietary software which may base on a different runtime environment. In combination with the GML-structured data the information is easy to handle as there are many free resources for working with GML/XML-structured data.

The SES delivers its data via three services. The core service is the OGC-standardized Web Feature Service. It is accompanied by a Web Map Service for providing aerial imagery. In addition the SESTextureService is required for accessing other related imagery.

#### **5.1.2.1. Web Feature Service (WFS)**

The Web Feature Service is a service for interchanging feature data including all semantic as well as geometric information in a standardized way. In the case of the SES the delivered content comes in the SES-GML format, which is - as outlined before - an easy to read and easy to use XML-Notation.

Except the imagery all objects or entities, which are stored in the underlying database container can be retrieved by calling the WFS.

The integrated Filter concept allows receiving the data in any subset the using application requires. This can be a geographic selection like the request for all content in a user defined area. But also semantic selections are possible. A query for all tared roads in the SES would be an example for that.

#### **5.1.2.2. Web Map Service (WMS)**

The Web Map Service (WMS) delivers georeferenced imagery stored in the SES. This can be aerial imagery itself, which is part of the environmental dataset or cartographic information, which can be derived from the vector data contained in the SES. The concept for that is calls Styled Layer Descriptors (SLD).

In any case the result will be a raster image of the requested area, which can be used in any application. As this service is a well-known standard, many applications deliver connectivity to is off-the-shelf.

#### **5.1.2.3. SESTextureService**

The SESTextureService was added to the SES, because a Web Map Service is designed for strictly georeferenced data. The only task of the SESTextureService is to provide image data out of the image library.

The URL which leads to the required image is given in the GML-data delivered by the Web Feature Service. The information comes alongside the geometry the image is linked with. When it is more comfortable to get the whole library at once, the user can order the complete library in an archive file instead.

### **5.2. Direct Access**

The current implementation of the SES provides a Java programming interface. This interface is generic, which makes it usable for any application schema. Thus SES-GML databases can be handled by it as well.

The programming interface allows reading, writing and changing any objects, attributes and geometry. It provides interfaces for bringing images into the database, calculate the image pyramids for the different solutions and generate the metadata.

Several convenience functions are contributed as a plugin. They combine frequent operations into one interface call like adding a classified 3D geometry to the geometry branch or calculating and integrating crater geometries.

This way of access is important for database generating systems, which need to have a direct connection to the database. But even for them a communication via GML-Interfaces and services is possible.

### **5.3. Examples of Application**

The SES technology is being used in national and international research and development activities. The VintEL should be mentioned separately because it brought up the demand of having a standardised central database for exchanging terrain data and the first version of an SES was developed in that project.

### **5.3.1. The VIntEL Project**

VIntEL (German: Verteilte integrierte Erprobungs-Landschaft) is a research and development project which was set-up by the German Federal Office for Defence Technology and Procurement. The translation of the title is “Distributed integrated test bed”. The project ended in late 2015.

The objective of this project was to run a joint exercise with several federates, operated by various simulation systems from different manufacturers. A major objective of the project was to have all participating simulation systems working with the same dataset provided by the SES.

To do this, all project partners agreed on a SEDRIS as the semantic data model, which was compiled to a SES-GML schema definition. An empty SES-Database was setup with this schema and filled with a test environment of the German Army facility in Meppen shown below.



**Figure 5: SES Meppen used in the SODB project**

Until the final experimentation the Synthetic Environment Service was primarily used during the initial phase of an experiment. Then all members of the federation were supplied with the environment in which the simulation was to be executed.

Regardless the way of data access, the SES made sure that all parties joining a distributed simulation relied on similar data even if they come from independent manufacturers. The second task in the final VIntEL experiment was the real-time calculation of crater geometries and to provide that new information using the Web Feature Service during the experiment. Thus the SES was updated continuously during the joint simulation. In the end the SES contained, for example, all craters generated during the experimentation. Therefore and for collecting all other manipulations of the environment including switched object states, transformed models and the tracks of moving objects, the SES was introduced to the VIntEL-HLA-Federation. With that, all information was evaluated and transferred to the central SES-Database. That information in combination with database versioning allowed to deliver the current state of the environment to late-joiners and to replay the changes of the terrain data during the simulation experiment.

The VintEL experiments showed, that the combination of a DBMS driven SES-GML database, standardized services and HLA (or DIS), are well suited to operate joined simulations from the initial data supply, over data update to the handling of dynamic actions during simulation.

### 5.3.2. The SODB Project

After the SES was built up including the image library and model library with dynamic objects there was a demand for a lightweight and agile platform for doing a proof-of-concept. The practical idea is to have a small system that is highly portable and easily connectable for being able to do distributed training for a mission right on the way to the operation.

For that purpose a project was set-up, which has two objectives. The first is to have a small simulation application that shows all features of the recent SES version. The second is to enable this software to build-up a federation as simple as possible using the free and open source, cross-platform, fully supported HLA/RTI implementation of Portico.

In combination with the terrain simulation, the developed software presents the features of the SES and gives the opportunity to validate the content and the quality of the SES-GML data structure.

The sample simulation demonstrates an easy composition of a federation and the exchange of multiple events inside of it. This ranges from the simple use of switches over the processing of so called degree of freedom to the complete substitution of terrain in a federation.

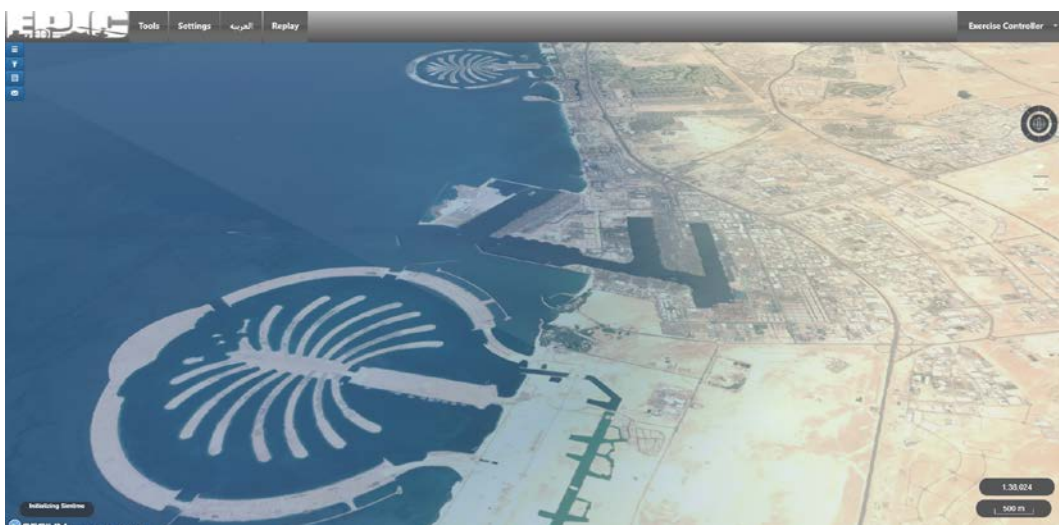
### 5.3.3. The SES as a component of the MSG-136

The SES as it emerged from the German projects is a standard service which can be deployed on any server infrastructure. But an installation on such a server needs some expertise from the vendor of that system. This does not comply with the idea of the Allied Framework for MSaaS, which demands the user to be able to compose the services on his own. Furthermore the MSaaS components shall be prepared to be used in modern cloud computing environments to exploit the benefits of cloud computing like scalability and resilience.

So the SES implementation was enhanced to meet these requirements. The database part as well as the services were virtualized and packed into Docker containers. The Docker infrastructure provides the abstraction and automation of operating-system-level virtualization [17]. Assuming a running Docker environment, the containerized services are runnable on almost any system including the major cloud computing platforms like the Amazon Cloud (AWS) for example.

For one of the final experiments of the MSG-136 in late 2017, a new SES instance with imagery from the gulf region was setup, virtualized and pushed to the MSG-136 Docker registry.

The image below shows the EPIC service from Lockheed Martin Rotary Mission Systems which provides a flight simulation and is connected to the dockerized SES which delivers the terrain imagery.



*Figure 6: Lockheed Martin EPIC Flight Simulator consuming SES imagery*

## 6. Summary

Putting SEDRIS on the test bench the inspection showed that the SEDRIS infrastructure as a whole does not fit in modern service environments. On the one hand the SEDRIS data model delivers an ISO standardized data structure, which is mature, complete, and stable. Thus it is an obvious agreement for the interchange of environmental data in infrastructures like the Allied Framework for MSaaS which is developed in the MSG-136. On the other hand the delivered file-based data interchange infrastructure is not up to date and does not fit into cloud and service based approaches. This gap can be bridged by the achievements of the OGC, that brings a standardized abstract data modelling framework and based on that a set of MSaaS compliant services. The suitable SEDRIS data model lifted to SES-GML, a database container and the mentioned services Web Feature Service, Web Map Service and the SESTextureService form the SES infrastructure. The SES can be implemented as a classic service in any network infrastructure. The other option is to provide virtualized containers to add the SES service to a service registry and to become a part of Modelling and Simulation as a Service.

The upcoming step being discussed at the moment is to bring the SES-GML definition to the OGC-Consortium and to initiate a standardization process. Then the fusion of the standards of SEDRIS and GML would define a new clear and usable standard as well.

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