A contribution to the "Semantic Universe"

http://www.semanticuniverse.com/articles-axis-conceptual-reference-model-concepts-and-implementation.html

The 'AXIS – Conceptual Reference Model'
(*Concepts and Implementation*)

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Summary

A new modular and tailorable approach for the semantic modeling of static and dynamic knowledge has been elaborated under the name "**AXIS Conceptual Reference Model**" (**AXIS-CRM**). It organizes that modeling as networks of 'Autonomous Semantic Objects' (**ASO**). In turn, each ASO is expressed as a network of 'Elementary Semantic Entities' (**ESE**). The ASO wraps the instances and their models to become 'autonomous'.

Through that modeling, the AXIS-CRM is a frame for constructing and managing the **interoperability** between independent systems (such as for the migrations of assets to semantics, interchanges and predictable persistence) and for **managing the evolutions and migration** of systems.

AXIS-CRM has been implemented, experimented and validated by the creation of native ASO and by migrating 'Flat' records to ASO, by interchanging them and by constructing persistent archives.

The AXIS-CRM and an associated Tool-kit will be soon released, in **open source**, on the UNESCO repository of the 'Memory of the World' program.
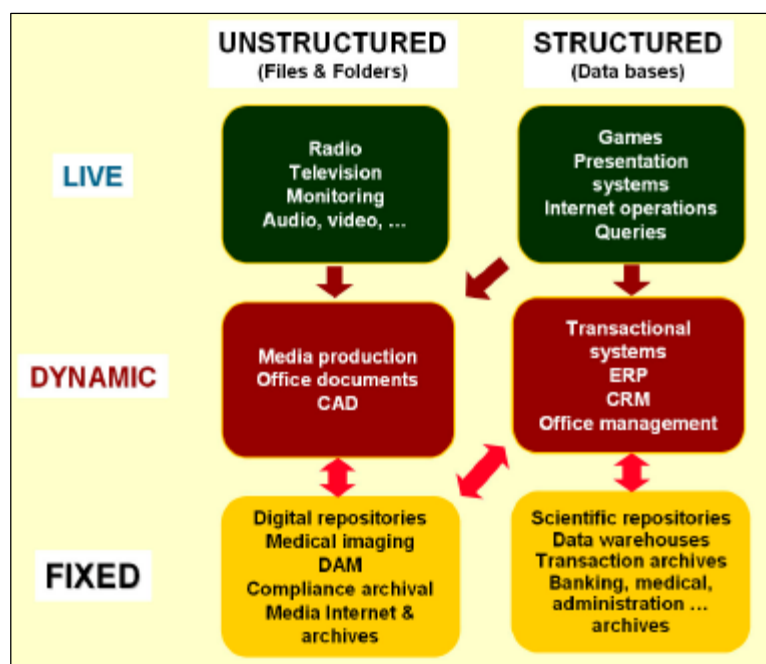
Introduction to
The **AXIS** **C**onceptual-**R**eference-**M**odel
(Concepts and Implementation)

1. The AXIS-Conceptual Reference Model

1.1 Generalities

A new modular and tailorable approach for the semantic modeling of static and dynamic knowledge has been elaborated under the name "**AXIS** **C**onceptual **R**eference **M**odel" (AXIS-CRM). AXIS organizes that modeling as networks of Autonomous Semantic Objects (ASO). In turn, each ASO is expressed as a network of Elementary Semantic Entities (ESE). The ASO wraps the instances and their models to become 'autonomous'. At Elementary Semantic Entity level (simply called 'Entities') the modeling uses four constructors: Term; Document; Relation; Profile. The knowledge models and their instances are represented by a collection of Documents (among with the OWL files expressing the models) bundled by Configuration Management Documents (based on RDF). These collections are semantic Entities that can represent any topical subject or object. These Entities are linked through typed Relations. The dynamic aspects (events) and the imports / exports are also managed by dedicated Entities.

AXIS-CRM permits the covering of any semantic domain. One of its innovative contributions is the introduction of the "AXIS-CORE" ontology and profile (see below) and of an "Ontology Plug-in" mechanism required for addressing specific domains, whether in economic, cultural or scientific assets. The methodology has been tested by derivation of existing ontologies such as the FOAF and IAML. Native new profiles have been developed, in particular to cover the Audio-Visual Interviews and the News network according to the NewsML-G2 format. The authoring of these specific ontologies is made according to a strict procedure involving experts of the domain, assisted by a "Knowledge Modelling Tool". At the semantic level, the AXIS-Core presents what the Dublin-Core has presented at the term level. The AXIS-Core could be used as seed for easy extensions according to specific needs although keeping the interoperability. The approach is ideal for distributed operations, collaborative work and evolution / migrations.

The approach is totally fitting in the SNIA model of acquisition, operations and fixing of the knowledge. The "Storage Networking Industry Association" is an initiative of all the majors' players in the domain: EMC, SUN, HP, IBM …!

Furthermore, the approach resolves the famous opposition between 'Unstructured' ? 'Structured'. In the current SNIA model, in 'Structured' the data are represented in databases; while in 'Unstructured' the data are represented as documents conforming to external formats (standard or proprietary). When the formats of the documents and database-records are explicitly defined in semantics models, both representations can be used and converted to each other. Further, the SNIA model can be extended to the "LIVE"! The extended SNIA model becomes:

Figure 1: *<The extended SNIA model>.*

1.2 The DATA MODEL

The data model is based on **E**lementary **S**emantic **E**ntities [**ESE**] represented according to a **uniform modelling technology** which covers as well the **modelling** of the **assets**, the **work-flows**, the **presentations** and the **agreements** and as well their **instances.**

The **modelling** used for constructing and validating the instances is called 'PROFILE'. It includes six components covered in a multi-linguistic way:

1. The **ONTOLOGY**
2. The **URN / URI / URL** system
3. A set of specific '**TERMS**' classes
4. A set of specific '**DOCUMENT**' classes
5. A set of specific 'Lists of authority **properties/values**'
6. A set of specific '**GUI frames**'

A specific 'profile' covers the '**UNIVERSALS**', i.e. the constructs which are commonly recognised as not being dependent of a specific domain of knowledge, nor dependent of a specific designated community. That universal profile is called 'AXIS-Core': the classes defined in the AXIS-Core profile are illustrated by the figure below:
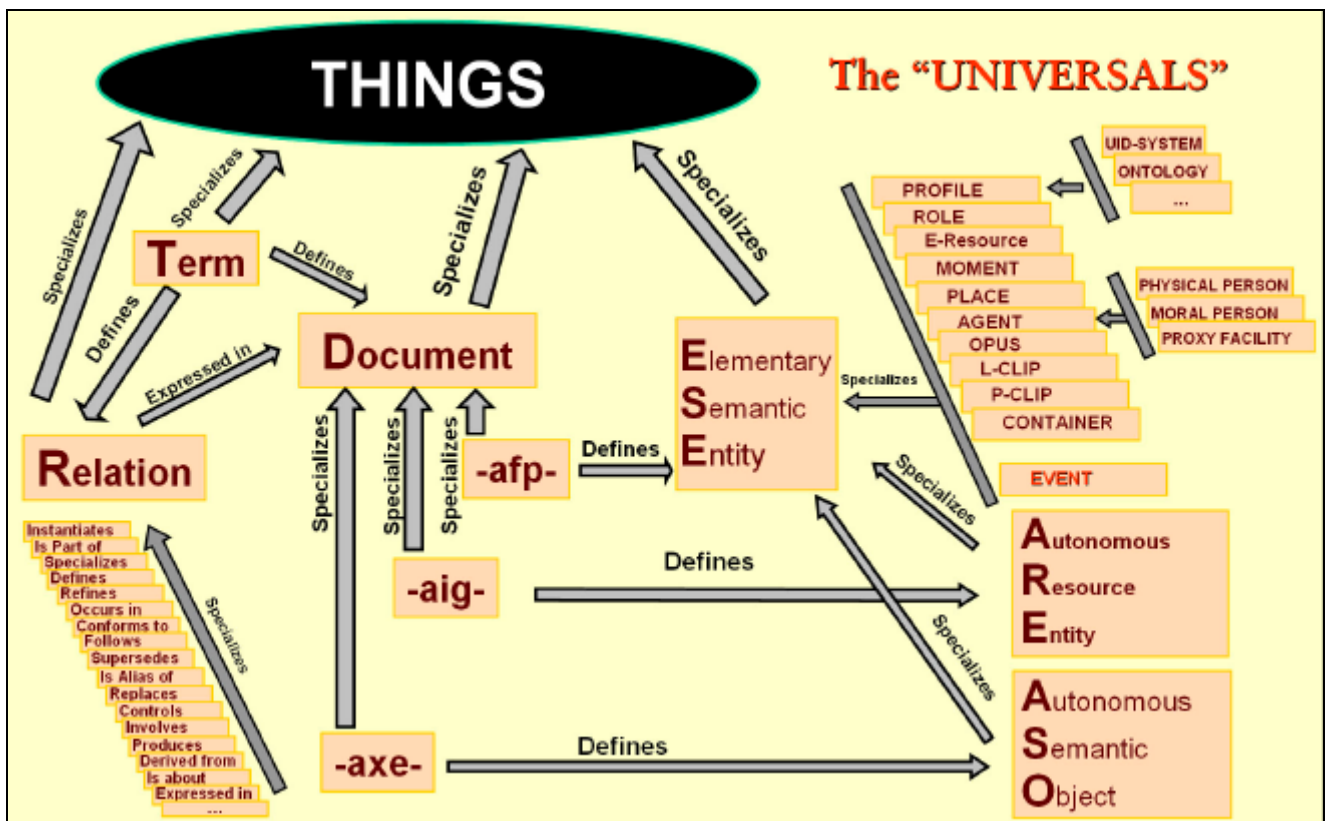

Figure 2: <AXIS-Core classes>

The cornerstone construct of the AXIS-Core is the 'Elementary Semantic Entity' [**ESE**] which is of general purpose: the existence of an instance of an ESE is expressed by an instance of a document of the class named 'Axis Foot-Print', represented in short by the string '**-afp-**' (the two hyphens '-' are used as separator in the naming convention and meta-model). The -afp- is a kind of combination of the identification tag, the table of contents and the change control register of all the documents, files and typed relations used for representing the ESE. In particular, the ID-Tag part includes the 'ESE-Class' linking the ESE instance to the ESE instance where is represented the model of the 'ESE-Class' (included, for example in an OWL file). The -afp- is the cornerstone of the 'Configuration Management' model introduced in the section 1.4.

In AXIS the configuration controlled operations are assumed performed in 'Local Operation Centres' [LOC's] which will be further introduced at the next section (Functional model). Each LOC includes one dedicated specialisation of ESE called 'Autonomous Resource Entity' [**ARE**] which has the dedicated purpose of controlling the status of the LOC. The expression of that control is made in a dedicated document class called 'Axis Identification & loG', represented in short by the string '-aig-'. That document is owned by the -afp- document controlling the ARE instance. The -aig- control will be introduced further in the 1.4 section.

The LOC's can acquire contents, metadata and structures and placing them in the AXIS frame under the scope of the AXIS-Core profile and of the Domain/Community profile(s) by attaching or linking them to ESE (through the -afp- document). The LOC's can export and import 'Autonomous Semantic Objects' [ASO] trough a control document and mechanisms that will be introduced in the next sections (1.3 and 1.4). The expression of that control of the ASO is made in a dedicated document class called 'Axis eXchange Entry', represented in short by the string '-axe-'. That document is owned by the -afp- document controlling the ASO instance which, for its autonomous import/export, plays the same role as the ARE in its LOC. The -axe- control will be introduced further in the 1.4 section.

The **static instances** are constructed according to the applicable assembly of the 'AXIS-Core' profile with the domain/community specific profile(s) [in the next example, a 'Music' profile (derived from the IAML ontology proposal)]. The example of the instances and class associations is illustrated according to the figures below:
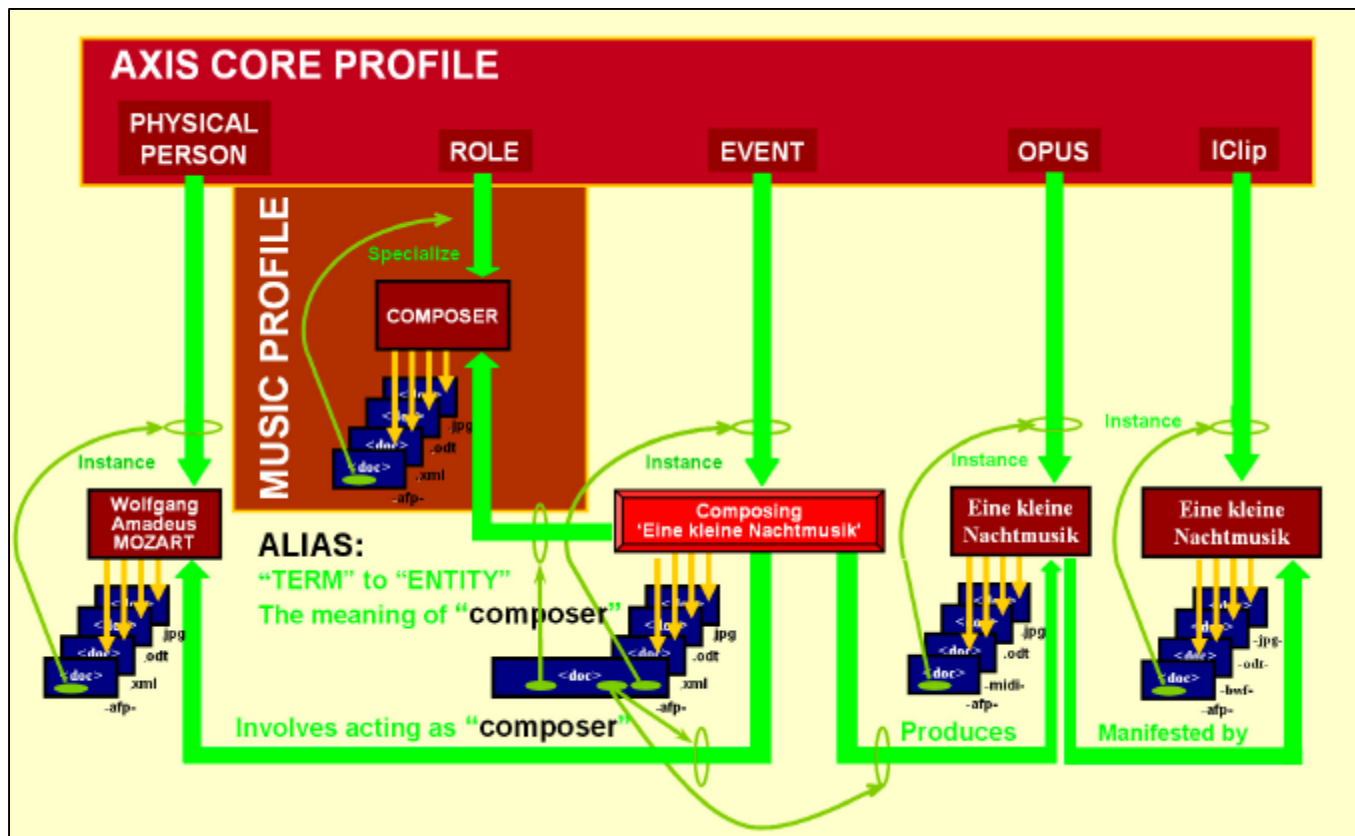

Figure 3: <Example of application at instance level>

The **dynamic instances** (work-flows) are constructed according to the applicable assembly of the Core profile with the domain specific profile: 'Finite-State-Machine". The example of the instances and class associations is illustrated according to the figures below as a chaining of elementary processes controlled by state vectors. Each of the processes can be decomposed in a hierarchy of semantic machines. Their states are controlled by a configuration management document, called -asv- [Axis State Vector] which can be frozen when constructing the ASO for exporting.
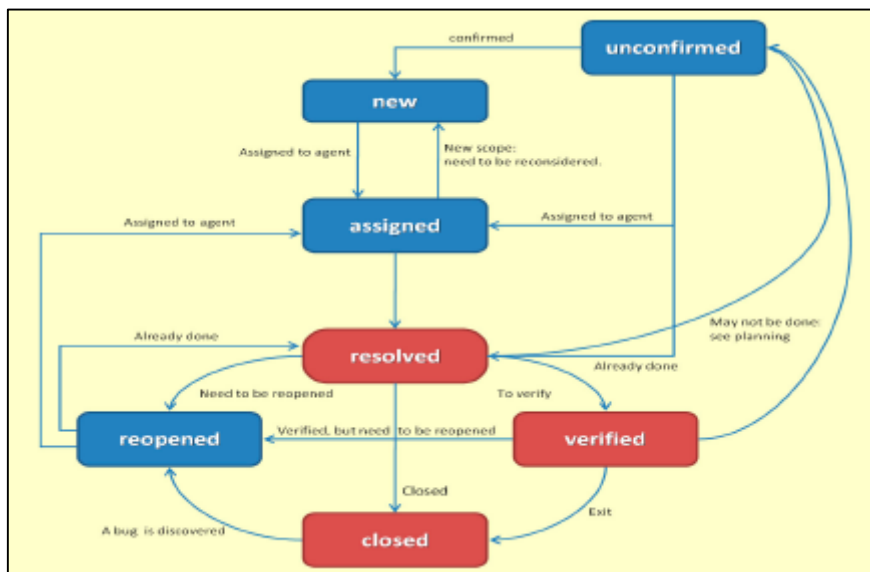

Figure 4: <Example of States in Work-Flow>

1.3 The FUNCTIONAL & INTEROPERABILITY MODEL

The interoperability model is based on **A**utonomous **S**emantic **O**bjects [**ASO**] generated in and exchanged between **L**ocal **O**peration **C**entres [**LOC**]. The ASO are represented as a static network of ESE which covers (at model and instance levels) a semantically coherent network set of **assets**, **work-flows**, **presentations** and **agreements**.

The LOC are managed (as it will be introduced in the next section) by an instance of a special class of Entity called 'Autonomous Resource Entity' (**ARE**). Similarly, the ASO are managed by an instance of a special class of document called 'Autonomous eXchange Entry' (**AXE**).

The ASO can be exported or imported to other LOC. The ASO can also be converted to another semantic format or migrated to non semantic formats (like MXF or METS or MPEG-21) trough 'Inter-Operability Wickets' [**IOW**].
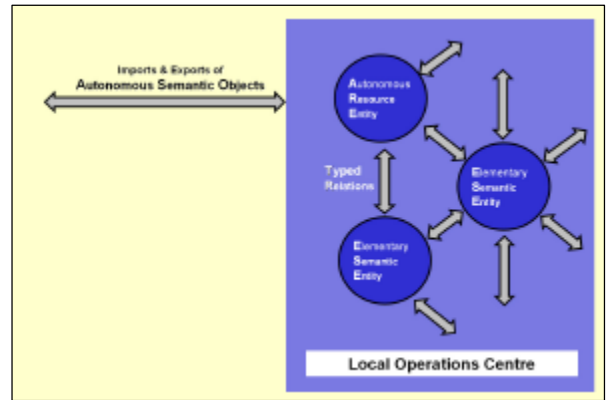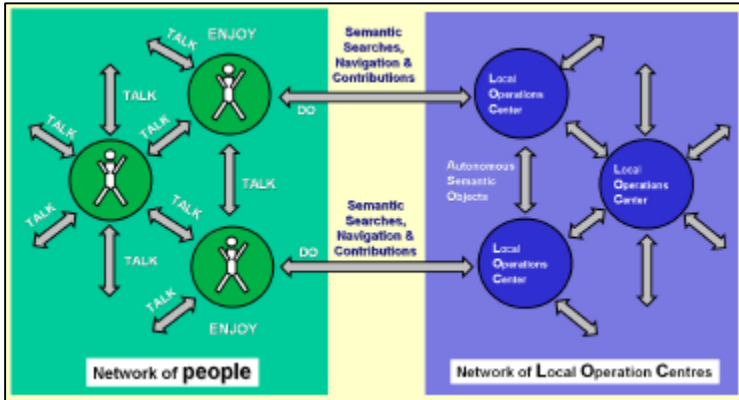

Figure 5: <Example of Network of LOC exchanging ASO>

Figure 6: <The network of 'Entities' in a LOC>

As each of the LOC can be managed independently, their semantic models could differ, even when they cover the same semantic domain of knowledge. It could be due to a simple versioning, to changes in the modeling languages, to the richness of the models, to different semantic modeling approaches or others. The AXIS-CRM gives a frame for managing the interoperability. By combining an explicit semantic modeling of the assets & processes and of their instances it allows constructing the interoperability and isolating the situations where automatic processes cannot be further used giving place to human adaptations or validations.

The "**Inter-Operability Wickets**" [IOW] could be organised in a two modes. In the first mode, a first IOW express the objects in the form of ASO's. This intermediate semantically complete "neutral" representation is in-turn used for expressing the objects in the target format. In the second mode, the whole of the process is made using an integrated IOW. Both modes are illustrated at the left figure.

Figure 7: <The Inter-Operability Wickets>

The four functional modules shown are illustrative but they cover the main functions of any Semantic IT system: 'Modelling' of the semantics; applying the semantic models in 'Authoring' modules; 'Exploiting' the authored objects and ensuring the 'Persistence' of the models, of the instances and of the exploitation protocols.

By definition of what is a "Conceptual Reference Model", it is obvious that the ASO could be created according to the AXIS-CRM as a 'neutral' construct for ensuring the interoperability between existing systems or for reloading old archives in current systems. The interconnected systems are not based on AXIS! Only their interchanges!

Usually, the three main types of interoperability's are identified:

o The **migration** of data models, in particular 'enrichments'. Most of the current information objects are currently represented by "Flat" models usually as record in a relational data base. Usually, the migration with enrichment is made by a two steps process. First 'enhancement' with alias; then 'enrichment' by the addition of the semantic data and the insertion of the Information Objects in the semantic network.

o The **interchange** of Information Objects between independent systems.

o The **preservation** of Information Objects. The Information Technologies are permanently changing! The data representations of the Information Objects become then quickly obsolete. The preservation of the value and the access to the Information Objects is essential. Here the interoperability solution is simply the same as the previous one. The interoperability of the representations between their representation formats valid a few years ago and those according to the current today standards or practices. It is the interoperability in time which paves the way to the persistence! It means that the assets have to include constructs that implies their capacity of evolving according to the properties expressed for the persistence, in particular in the ISO standard OAIS.

The 'Interoperability' model is based on a five layers approach with interfaces and protocols at such that at each layer is an orthogonality level that could be used of constructing the interoperability. The migrations, interchanges and preservation processes should be 'isentropic' [*the conversions are made without loosing one bit*] in the layers 1 and 2. In the higher layers, the three cases (entropic [*conversions with loss of information*]; isentropic and negentropic [*conversion with enrichment by using existing or induced knowledge*]) are applicable. The details are outside the scope of this introductory document.
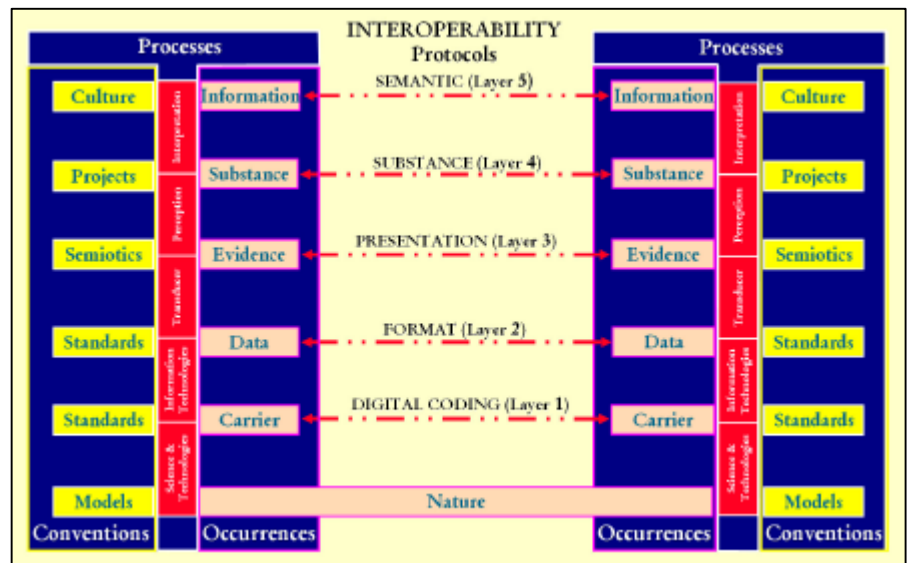

Figure 8: <The Interoperability model>

1.4   The CONFIGURATION MANAGEMENT MODEL

The 'Configuration management' model is based on the four classes of documents introduced in the Data Model (Section 1.2) and on the LOC resource introduced in the Functional & Interoperability model (Section 1.3).

Four AXIS configuration management documents ensure the registration of existence and change control of the documents and relations pertaining to the instances of the ESE's; of the construction of Autonomous Semantic Objects and of their exchanges between LOC's and from external to LOC's:

1. The '**Axis Foot Print**' document class [-afp-] ensures the configuration management of the data used for representing one instance of ESE. These data covers mainly:
   a. The naming, typing, identification and status control of the ESE
   b. The status control of the logical documents and physical documents (files) uses a workflow control having ten state-classes (the management of the existence and of the versioning of the documents).
   c. The status control of the relations (with their classes and properties) uses a workflow control having five state-classes (the management of the existence of the relations and of the activations to the resources).

2. The '**Axis Identification and loG**' document class [-aig-] ensures the configuration management of the data used for representing the contents of a 'Local Operation Centre'. These data covers mainly:
   a. The naming, typing, identification and stage control of the LOC.
   b. The status control of the ESE uses a workflow control having height states covering their existence (imports or newly created in the LOC), their releases, their exports, their isolations, their activation, their closing and their deletes.
   c. In particular, through the status control of the ESE representing the profiles (AXIS-Core and Domain/Community profiles) the -aig- controls the links between the instances, their models and their capabilities of being exploited by the IT or by the humans.

3. The '**Axis eXchange Entry**' document class [-axe-] ensures the configuration management of the data used for representing the contents of the 'Autonomous Semantic Objects' [ASO]. An ASO is representing (in a wrapped form [Folder / ZIP / …]) a semantically coherent set of instances of ESE including the ESE representing the profile(s) required for 'understanding' the instances of ESE representing the target topical subjects. The -axe-document is a special case of the -aig- document where all the covered ESE are in the 'Released' state (for the passive ESE's) or in the 'Closed' state (for the activated ESE's). The ASO represents the static representation of a LOC. In particular, when closing a LOC, all of its data could be wrapped in the form of an ASO for import to a other LOC (for archiving, further processing, fusion or other purposes).

4. The '**Axis State Vector**' document class [-asv-] ensures the modelling of the state of processes at the moment of exporting in ASO. This is outside of the scope of this introductory document.

The creation of LOC's and their delete implies configuration management functions and facilities:

1. The use of **bootstrap** mechanisms relying on the availability of the required resources, in particular a 'Semantic Data base', a 'ID-Fountain, Import & Export facilities, an acquisition module for the essences, the metadata, structures and other data representing the topical subjects. Its is also assumed that dedicated LOC's provide the frame for developing and representing the domain/community profiles to be hooked to the AXIS-Core profile representing the 'Universals'. The bootstrap consist mainly in creating an unique instance of an ARE (though its -afp- and -aig- documents); then importing the AXIS-Core profile and the intended Domain/Community profile(s); then importing and creating the first ESE's.

2. The use of **identification and naming** systems ensuring the capacity of uniqueness of the resources. This implies the capacity of identification of domains and resources within domains (in particular in LOC's); of versioning; of coping with the redundancy of the data; of coping with parameters in the formats; …

The mechanisms for the **access** (including the associated cryptographic functions), the **traceability** of the resources (including the traceability of the ownership of the 'Intellectual Property Rights' associated with a specific contents) and their **retrieval**.

2.   Domains of application of the AXIS-CRM

The applications of the AXIS-CRM are, by definition, covering any domains of the knowledge management. For some of the most immediate area of application an opportunity analysis has already been made. In particular have been covered typical semantic Web applications such as the 'Enterprise Management' (SAP based on knowledge control); the traceability of the 'Intellectual Property Rights'; the representation, retrieval and access of 'Collection Objects' in the culture and science ; the 'Secured Banking Transactions'; the 'Archiving'; the 'Software engineering'; the production of the 'Subjects' in the media domain, in particular the television, radio and web; the public services and the interactions with the citizen.

3.   The implementations of the AXIS-Conceptual Reference Model

AXIS-CRM has been implemented by a **demonstrator** and extensively evaluated in three challenging applications:
- Migration of existing flat models and associated media to ASE
- Open Interchange of ASE between heterogeneous systems
- Creation of native persistent archives conformed to the **OAIS** (ISO).

The demonstrator has been made using standard languages (mainly OWL, RDF, METS, MXF and SMIL) and on standard reference models (mainly OAIS, FRBR and CRM). The evaluations have been conducted by extensive user's tests and scientific analysis.

In particular, it has been demonstrated that AXIS-CRM is a superset of FRBR-oo.

The implementation has been made in two European Projects (MEMORIES and MediaMap) makes use of **existing achievements**, in particular from European Union projects (PrestoPrime, Europeana, Film-Gateway, Video-Active, AceMedia …) and is largely based on solid **open-source software**.

The demonstrator includes a 'Semantic Profile Modeling System', an 'ID-Fountain', a 'Semantic Authoring System' (called IPI-Manager) interacting with a 'Semantic database' (called ISIS) and with a 'Finite State Machine' and includes a generator of ASO (built within an 'Inter-Operability Wicket'). The implementation has been made by MEMNON. The focus is on the opening (public availability under open license) of the formats and protocols of the import/export of the systems (the ASO).

The three main interoperability targets (migration, interchange and preservation) have been validated through a proof of concept of the key elements in the context of the MediaMap project.

4 Availability of AXIS and ownership of its intellectual rights:

4.1 Ownership of the AXIS-Conceptual Reference Model (Chapter 1)

The AXIS-CRM is owned by the Non Profit Association TITAN   www.titan.be

Contacts: M. Roger Roberts (President)   rro@rtbf.be
         M. Guy Maréchal (Administrator)   gmarechal@brutele.be

4.2 Ownership of product rights related to the first implementation (Chapter 3)

The first implementation of the AXIS-CRM is owned by MEMNON   www.memnon.eu

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4.3 Open Availability of the AXIS-Conceptual Reference Model & Tool kit

Under the scope of the MEMORIES and MediaMap projects, TITAN, MEMNON and the UNESCO have agreed for releasing under open license the full AXIS Conceptual Reference Model [AXIS-CRM] and an associated Tool-Kit. The current intention is of releasing it, mid 2010, in English and French, under the **UNESCO** open repository of the "Memory of the World" program. Other languages should be supported shortly after.

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Guy MARECHAL ends his career (after 36 years) at **Philips Electronics** as Manager of its Research & Development Laboratory on Cryptography and Professional Audio Applications. Retired, he has created a one person Consulting Company called PROSIP.

He is senior adviser for many public and private organizations, in particular the UNESCO, the European Union, the British Library, the Norwegian Institute for Recorded Sound, MEMNON and Siemens. Currently, for the Non Profit Association **TITAN** and for the **UNESCO,** he is the System Architect of the **AXIS-CRM** and is collaborating with **MEMNON** for its implementation.

<Photo of Guy MARECHAL (2010>)