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Transforming the *Vocabulaire de la Sigillographie* into a Semantic Web Resource

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This paper describes the current situation in the area of digital sigillography that focuses on creating data sets. It observes the possibility of aligning these data sets and suggests developing the Vocabulaire Internationale de la Sigillographie (created in 1990) further for this purpose. It presents the conversion of the printed version into an SKOS (Simple Knowledge Organisation System) resource. It highlights the opportunities offered by Semantic Web technologies, which can begin with sharing descriptive vocabularies. Data interchange between the various European sigillographic resources can be further promoted by shared semantics. This paper proposes a CIDOC-CRM-compliant OWL ontology built on top of the VIS. This is organized around the events of creating the matrix, applying the matrix, handling the impression (e.g., destroying, cutting off), conservation and description. The proposed basic entities map well to existing major seal databases, with the effect that the French Sigilla and the British DigiSig database could merge, and a common European database of medieval seals seems possible.

Cet article décrit la situation actuelle dans le domaine de la sigillographie numérique, qui se concentre sur la création de jeux de données. Il examine la possibilité d'aligner ces jeux de données et propose de développer davantage le Vocabulaire International de la Sigillographie (créé en 1990) à cette fin. Il présente la conversion de la version imprimée en une ressource SKOS (Simple Knowledge Organisation System). Il met en évidence les opportunités offertes par les technologies du Web sémantique, qui peuvent commencer par le partage de vocabulaires descriptifs. L'échange de données entre les différentes ressources sigillographiques européennes peut être davantage favorisé par des sémantiques partagées. Cet article propose une ontologie OWL conforme au CIDOC-CRM construite sur le VIS. Celle-ci est organisée autour des événements de création de la matrice, d'application de la matrice, de gestion de l'impression (par exemple, destruction, découpage), de conservation et de description. Les entités de base proposées correspondent bien aux principales bases de données de sceaux existantes, avec pour effet que le Sigilla français et la base de données britannique DigiSig pourraient fusionner, et qu'une base de données européenne commune des sceaux médiévaux semble possible.

Introduction

§ 1 This paper contributes to the area of digital sigillography that focuses on creating data sets. It observes the theoretical possibility of aligning these data sets and suggests developing the Vocabulaire Internationale de la Sigillographie (VIS) into a formal knowledge representation as controlled vocabularies encoded in the W3C standard SKOS (Simple Knowledge Organisation System) (Bautier et al. 2022; Miles and Bechhofer 2009) and a sharable database model ("ontology") following the W3C standard OWL (Web Ontology Language). These formalizations can support data exchange between the various existing seal databases by shared content of descriptors in a controlled vocabulary expressed in SKOS and by mapping the respective database models to the shared ontology expressed in OWL. In the following, I will introduce the VIS (section 1), describe its conversion into SKOS (section 2), and discuss what an ontology of seal descriptions based on the VIS could look like (section 3). This includes considerations regarding how to make the ontology compliant with widely distributed upper-level ontologies (section 3.2) and how existing seal databases could be mapped to the proposed ontology (section 3.3).

1 The Vocabulaire Internationale de la Sigillographie

§ 2 The archival community is well aware of the need to establish standards for exchanging knowledge—about archival practice in general (Walne 1988; SAA 2005–2025, Duranti et al. 2018) and seals in particular. In 1960, the Conseil international des Archives assembled a group of experts to foster communication between archives and scholars of history. The "Comité international de sigillographie" initially planned to discuss conservation of seals and to publish a bibliography and—in 1968—to work on a terminological reference. The Comité joined forces with the Comité international de Diplomatique. An intermediate result of this work was the publication of preliminary terminology in 1984 (Bautier 1984). The final version was published as the "Vocabulaire Internationale de la Sigillographie (VIS)" in 1990 (Ricci-Noè and Bautier 1990).

§ 3 Information science has identified this kind of resource as a valuable tool to enhance retrieval from databases: a thesaurus of the terms used during description helps the users of catalogues to formulate their queries in keeping with their search interest. In fact, a multilingual thesaurus enhances search possibilities by bringing them into a multilingual realm (ISO 1985). The database can store alternative terms for the same concept and thereby automatically expand the search space. A German user entering the search term "Siegelmäßigkeit" is able to find French descriptions using the French equivalent "capacité sigillaire" or the English "Right to use a seal." This is possible by abstracting the meaning of the terms into abstract identifiers to

which the database assigns all possible labels by which the concept is addressed in the target languages (Collinson 1939). The VIS provides this identifier by numbering its entries (e.g., “no. 45” identifying the entry on “Right to use a seal”). By distinguishing between label and concept, the VIS also allows disambiguation of terms. The “bulle” is either “Une bulle (lat. bulla) est une disque de métal qui porte, normalement sur les deux faces, l’empreinte obtenue par l’apposition de la matrice” (VIS 11a), that is, the metal seal, or “Une bulle est l’acte qui porte cette empreinte,” the papal document carrying a metal seal (VIS 11b). This is achieved by describing each term in such a way that it can be handled as a definition of the concept. The VIS adds another layer of information that can be useful for researchers to find their way through databases: It organizes the terms in chapters by subject, creating a hierarchy to navigate the intellectual realm of sphragistics.

§ 4 Technologically, these four features of the VIS can be translated easily into a model proposed by the W3C, the Simple Knowledge Organisation System (SKOS) (Isaac and Summers 2009). SKOS is modelled in the manner of library authority control systems, offering a preferred entry point (`skos:prefLabel`), alternative entries (`skos:altLabel`) and an abstract identifier for each concept (`skos:Concept/@rdf:about`). Concepts can reference each other by generic relationships (`skos:related`) or graded identity declarations: `skos:exactMatch` asserts that two concepts share their extension, while `skos:closeMatch` only asserts a large overlap. `skos:broader` and `skos:narrower` indicate hierarchical relationships. The vocabulary allows a more explicit organization of knowledge by defining and describing the extent of the concepts: `skos:definition` gives a formal definition, while `skos:scopeNote` describes edge cases. The property `skos:example` points to application cases. SKOS has good tool support, for example, skosmos (Suominen et al. 2015), a tool to display the controlled vocabularies, or “skos-play” by Thomas Francart (Francart 2024), a tool set to convert, test, and verify SKOS data.

§ 5 SKOS is used in a wide range of thesauri. The BARTOC database, set up by the UB Basel and maintained by the German Verbundzentrale (GBV), provides a good overview of the wealth and range of this adoption of the standard (GBV 2024a). It includes, for example, 162 records with vocabularies from the Dewey Decimal Classification section 9 “History and Geography” (GBV 2024b). An Example of SKOS applied to a subject close to the field of sigillography is the FISH (Forum on Information Standards in Heritage) vocabularies (FISH 2021), which assigns the URI `http://purl.org/heritagedata/schemes/mda_obj/concepts/95398` to a seal, and references “cloth seal” and “bull” as narrower concepts. The seal matrix carries the URI `http://purl.org/heritagedata/schemes/mda_obj/concepts/95402` in this controlled vocabulary. SKOS is not the

only possible vocabulary used, with the Getty Arts and Architecture Thesaurus (Getty Research Institute 2021) describing museum objects, for example, extending the vocabulary. However, the basic descriptors assigned to the URI `http://vocab.getty.edu/page/aat/300028877` are similar to SKOS, for instance, referring to seals in a field called "ScopeNote," and declaring:

> Objects bearing designs, emblems, letters, names, words, etc. in intaglio that are used for stamping a flat surface or for making an impression in relief on some soft, tenacious substance such as clay or wax. They may be flat or cylindrical, the impression made by rolling the seal over the surface. Seals may be used to authenticate documents or for decoration. (Getty Research Institute 2021)

For the images on a seal, the IconClass vocabulary (Posthumus and Brandhorst 2006) might be of particular interest, as it covers Western art in particular. IconClass was conceived by Henri de Waal in the 1950s, published in 1973–1985, is maintained by the Royal Netherlands Academy of Arts and Sciences (KNAW), the Rijksinstitut voor Kunstgeschiedenis (RKD), and finally transferred into an independent foundation (Henri-de-Wall Foundation) since 2022, which took charge of building an international community to continue work on the thesaurus. It identifies, for instance, saints and parts of their legends (e.g., `https://iconclass.org/11H(GEORGE)68` references to St George with a list of motifs in which he occurs).

2 Transformation of VIS into SKOS

§ 6 As the VIS fits very well into this world of formal descriptions, conversion of the printed book into a SKOS resource seems to be useful. Together with Selina Galka and Sabrina Strutz, I converted the VIS to SKOS. We built on the model of our conversion of Vocabulaire Internationale de la Diplomatique to SKOS in 2011–2012 (Vogeler 2013). The conversion is based on simple OCR of the PDF made available by the Italian Direzione generale Archivi. The OCR quality was particularly poor with Slavic languages and the French description. The main entries are good enough to annotate them semi-automatically with pattern matching. The regular expression `/^\d+/` helps to identify where an entry starts. Bold face is used for French terms. The language codes can be matched with the regular expression `/^[A|AN|E|…]/`, multiple translations with `/; [a-z]\./`. These automatic methods were checked by Selina Galka and Sabrina Strutz, who additionally annotated the sections of the VIS. All these annotations were made in XML with a vocabulary based on the standards of the Text Encoding Initiative (TEI). Code Listing 1 gives an example.

```
<vis>
<pb n="43"/>
  <div>
    <head>I. GÉNÉRALITÉS</head>
    <p n="1">
      <idno>1.</idno>
      <desc>La <term lang="fr">sigillographie, appelée également
sphragistique,</term> est la discipline historique qui a pour objet
l' étude des sceaux sous tous leurs aspects et quelle qu' en so i
t la date. Elle décrit *matrices et * empreintes et l es étudie de
façon critique, du point de vue historique, artistique, technique
et de la valeur probatoire: *types, *légendes, *modes d'apposition
et l'nature diplomatique et juridique, ainsi que les méthodes de
conservation. </desc>
      <term lang="A">Siegelkunde, Sphragistik</term>
      <term lang="AN">Sigillography, sphragistic</term>
    </p>
</vis>
```

Listing 1: Example from the XML representation of the OCRed VIS.

§ 7 This XML contains all necessary information to convert the text into a SKOS resource: The `<p>` annotation represents one `skos:Concept`, the number in the VIS is stored in the n-attribute and can be used to build a URI. The `<term>` annotation can be translated into `skos:prefLabel` combined with the language information in the lang-attribute, as exemplified in Listing 2.

```
<skos:Conconcept rdf:about="#1">
  <skos:prefLabel xml:lang="fr">sigillographie</skos:prefLabel>
  <skos:prefLabel xml:lang="de">Siegelkunde</skos:prefLabel>
  <skos:definition xml:lang="fr"> La sigillographie, appelée également
sphragistique est la discipline historique qui ...</skos:definition>
</skos:Concept>
```

Listing 2: Sample from the SKOS representation of the VIS in RDF/XML (here VIS 1).

§ 8 Considering the problems with the OCR, we extracted only terms from selected languages (French, German, English, Spanish, Latin, Romanian, and Norse),

the hierarchical organization, and the French definitions. The basic XML additionally contains the page breaks to reference the source in more detail, and the poor OCR of Hungarian, Italian, Dutch, Portuguese, Polish, Swedish, and Russian terms. The data set is published open access in the University of Graz's long-term repository and DH publication system GAMS that adheres to the FAIR principles (Institut für Digitale Geisteswissenschaften, Universität Graz 2018; Stigler and Steiner 2018). The website includes a basic navigation and search, and offers some API functionalities to access the full SKOS source in XML (Conseil International des Archives – Comité de Sigillographie 2022) and to extract the XML/SKOS fragment of a single concept (`https://gams.uni-graz.at/o:vis/sdef:SKOS/getConceptByURI?uri=http%3A%2F%2Fgams.uni-graz.at%2Fo%3Avis%233a`). The XML source is also available in a GitHub repository (Vogeler 2017a), which allows continuous update tracking responsibility for every single change. In fact, I propose that the sigillography community should use this to maintain resources for adding terms and definitions from other languages. The Czech, Slovakian, Hungarian, and Polish communities have already provided this kind of extension in the *Vocabularium internationale sigillographicum* (Müller and Vrtel 2016). As the current version does not cover the internal references that the printed version marks in the description with an asterisk, one could extract this and add it to the living version in the GitHub repository by `skos:related` annotations. The SKOS version would certainly profit from example images such as the SKOS version of the Vocabulaire de la Codicologie provides (Geoffroy et al. 2018–2021, based on Muzerelle et al. 2011 and Muzerelle 2002–2003, which is the digital version of Muzerelle 1985 and Bobichon 2009). Certainly, the living version could also include new concepts not yet covered by the VIS.

§ 9 We used this SKOS version in two seal databases created at our university: the collection of seals from the Salzburg Archbishopric realized by Rudolf K. Höfer and Martin Feiner from the sphragistics side (Höfer and Feiner 2020) documents all seals of the archbishops and suffragans from the tenth century up to the present. The seal cast collection of the institute of history at the University of Graz (Bernhard 2017) includes samples of various seals from the ninth to the twentieth century collected for teaching purposes. Both datasets use the exchange standard for museum data, the "Lightwight Information Describing Objects" (LIDO) (ICOM CIDOC 2025), for their description. This standard is generic for all types of museum objects. It can include domain specific knowledge (e.g., about seals) by referencing external identifiers whenever a keyword is used (`<conceptID>`). In the data set, general keywords encoded as a `<lido:objectWorkType>` are assigned to specific descriptive categories taken from the VIS: the work type with the `<lido:conceptID lido:source="vis">9 </lido:conceptID>` refers to `http://gams.uni-graz.at/skos/scheme/o:vis#9` (i.e., the owner of the seal). Material features (`lido:materialsTech`) can use terminology

from the VIS section VI (matière, couleur et forme des sceaux, no. 154–181). The application of the seal to the document is described as a case of VIS 62 (Sealing).

§ 10 These are examples of how the SKOS version of the VIS can be used in seal databases. Other systems could simply use the resource to enhance their descriptors with multilingual terms and links to the definitions, helping to more easily interpret the terminology. Using the URIs from the SKOS version would also make it easier to link databases with each other.

§ 11 With the use of SKOS, the VIS has become a part of the Linked Open Data web. Identical concepts can be identified by a shared URI, usable, for instance, as authority data in the description of seals, and the vocabulary can be reused on other rich data models that go beyond flat tables (e.g., in the DigiSig Vocabulary). Finally, re-use of the terms and unique identifiers can help to merge data (e.g., in an aggregated European seal database).

§ 12 However, it is obvious that the VIS does not cover all needs for controlled vocabularies in the field of sphragistics. The integration of later additions into the original structure of the terminology is easy to solve. To achieve this, I started to enhance the existing data by inserting terms from the "Appendix" into the general hierarchy of the VIS and published this updated version in a GitHub repository (Vogeler 2017b). Storage and publication on GitHub allows easy tracing of changes and, in particular, tracking of proposals for change. With the git-system, you can create a copy—a *fork*—from the data in your own repository and create a local copy of the file to do the modifications necessary to fit it into your database (Chacon and Straub 2014). When uploading your modifications to your fork, the git system traces what you've changed, making it easy to discuss each change. You can then submit your changes as a proposal to the main repository—a *pull request*. These pull requests to the git repository could then be reviewed by the sphragistics community before accepting or rejecting them (e.g., in a future workshop). In fact, the community that gathered for the *EuroSeal 2022* workshop in Brussels seems well suited for this purpose, with the addition of further colleagues from Scandinavia, central and eastern Europe.

§ 13 The need for an update of the VIS becomes clearer when comparing the VIS data with other seal databases. In particular, the DigiSig descriptive index already provides a basic RDF/SKOS representation of its entries (McEwan 2022). The shape index of DigiSig is based on Paul Harvey's terminology in the computer catalogue of seals in the Public Record Office, London (Harvey 1996). John McEwan and Elizabeth New created the DigiSig motif index as a method to identify seal fragments in the Medieval Wales project. Only afterwards did DigiSig integrate it as a search tool. A simple string comparison with a manual check of the proposals is an easy method to check overlap: Out of the 161 terms in DigiSig, 23 are easily mapped to VIS entries. They

are, in particular, allocated in the fields of Support Types (http://www.digisig.org/page/term/10001377), which is mappable to the VIS category of "Tradition" (http://gams.uni-graz.at/o:vis#10), and the shapes (http://www.digisig.org/page/term/10001477) are mappable to the VIS category "shape of the seal" (http://gams.uni-graz.at/o:vis#175) (Vogeler 2017c).

§ 14 From this, one can conclude that the VIS in its digital form still serves as a reference for terminology, but that seal databases use a much richer vocabulary than the VIS provides. The VIS cannot replace these vocabularies but could—and should—be included as a reference: the SKOS properties `skos:closeMatch` or `skos:exactMatch` provide very good categories to accomplish this: exact match can be used for mapping VIS 3 (Seal) to DigiSig 10001287 (Seal). Cases like the partial overlap of DigiSig term 10000717 (seated person) with VIS 212 (Seal with a seated figure) and VIS 214 (Seal with a seated prelate) can be described as a closeMatch.

§ 15 However, there is overlap in that `skos:closeMatch` does not work precisely. In VIS, visual features are conceptualized as types (VIS TOC VII B): VIS 223 "Ship seal," while DigiSig uses a taxonomy of motifs: http://www.digisig.org/page/term/10000707 "boat," which allows, for example, to assign multiple motifs to a single seal (e.g., a human in a boat: https://www.digisig.org/page/sealdescription/10362213). For these instances, the VIS is too strict, forcing the describer to highlight a single feature in the motif of the seal, and mixing two different analytical categories. In formal knowledge organization systems, relationships like these are best described as a combination of assertions: A ship seal (VIS 223) is (1) an iconographic seal (VIS 192); (2) showing a boat (`digisig:10000707`). SKOS cannot handle this kind of combined definition. The W3C web of data standards provides other technologies in the RDF world to express this formally. One of them is the "Shape Constraint Language" (SHACL) (Knublauch and Kontokostas 2017) that uses patterns ("shape") to describe required features of an RDF class in such a way that it can be translated directly into a query in a triple store.

```
vis:ShipSealShape a sh:NodeShape ;
  sh:targetClass vis:223 ;
  sh:property [
    sh:path vis:depicts ;
    sh:value digisig:10000707 ;
    sh:minCount 1
  ] ; sh:closed true .
```

Listing 3: SHACL notation describing the VIS 223 seal type "Ship Seal" as a seal that shows at least one item from the DigiSig motif terminology for "boat."

The code in Listing 3 states that you can assign the class `vis:223` to an object only when this fulfils the requirement to link to `digisig:10000707` by a `vis:depicts` property at least once in the data set. This is a minimal condition, which is rather strict. There are other methods to formalize the relationship less strictly, such as the vocabulary of the Web Ontology Language (OWL), which supports inference of concepts and relationships by the given definition and the given data.

3 VIS as an ontology?

3.1 Conceptual modelling derived from the VIS

§ 16 If we take a deeper look at the VIS, it seems to be more than just a thesaurus of descriptive terms: it is a description of the knowledge domain of sphragistics. Information science describes this as an "ontology." An ontology in this context is a formal description of a subject area (Gruber 1993; Gruber 2008; Hitzler 2021). It usually consists of object classes and individuals ("entities"). These are described by data properties and relationships between the objects. Semantic networks are the basic method underlying this formalization in information modelling (Quillian 1967). The resulting question—whether VIS can be modelled as an ontology—can be translated into a more practical question: can the VIS serve as a shared data model for seal databases? Can we convert the logics of existing seal databases into a shared model?

§ 17 Taking the schema of the DigiSig database as a starting point, I would like to suggest the following basic entities of a common seal database: The seal *matrix* (VIS section V); any *impression* from this (VIS 7, 8, Section IX A 2); a *cast* (VIS 20–23) taken from an existing impression; the *description* by a curator or scholar (VIS 314–319); activities of *conservation* (VIS section IX); and the *actors* related to the seal legally, to their production, curation, and description (VIS 9, 320–321, 323–324). Not covered are properties and relationships: The references show that these main entities are covered by the VIS, maybe not as a single entity, but at least with enough terms to summarize them under these basic entities. The VIS is not good at expressing relationships between these entities. It is important to distinguish between the generalized seal—as it is usually represented in the matrix—and the single item carrying the impression, a distinction which in information science is usually denoted with "type" and "token." The VIS does not provide terms for "impression of" or "cast from." The same is true of the relationship between the seal and the persons or organizations represented by the seal. VIS offers functional distinctions (e.g., "seal of majesty," "Fisherman's ring," or "Seal of regency") but no individual relationships.

§ 18 I discussed above the conceptualization of type and feature for the motifs: the term "ship seal" refers to any "seal depicting a ship," and is therefore non-exclusive

to a hagiographical seal, when the seal depicts a saint on the ship. The VIS applies the same conceptual merge to the legal function of the seal: a "seal of validation" is not a single item but any seal that validates legal content of this document. First, we should not consider these types to be disjunct classes in a conceptual model. Second, we should not model them as classes at all, but as pointers to descriptive features.

§ 19 Other minor issues arise from an inconsistent hierarchy: As the VIS considered natural language as its main scope, it suggests hierarchies to serve as terminological distinctions, not as memberships in classes: VIS 11 distinguishes between the object "Bull" (11a = metal seal) and the document "Bull" (11b = document bearing metal seal). A different type of inconsistency is illustrated by the term VIS 319 "publication status," which includes two possible values in 319a and 319b. As the VIS was not planned to be a consistent hierarchy of terms, some of the VIS entries are duplicates: VIS 7 (Seal matrix) covers the same content as VIS 3b, where it is inserted to distinguish two possible interpretations of VIS 3 "Seal," as VIS 8 is the same as VIS 3a (Seal impression). For all these reasons, we cannot convert the VIS automatically into a formal ontology, but rather need human modelling intervention.

3.2 Formalizing the VIS ontology compliant with the CIDOC-CRM

§ 20 Extending the VIS into a formal ontology requires a conceptual modification of the resource, moving it away from a controlled vocabulary. This fresh model should start from previous work to enhance interoperability (Beretta 2020). For historical physical objects, the Conceptual Reference Model of the International Council of Museums (CIDOC-CRM; ICOM CIDOC CRM SIG 2025a) is a good starting point (ISO 2006; Bekiari et al. 2022). It has been developed as a museum description standard by the ICOM/CIDOC documentation standards group since 2000, being adopted as an ISO Standard in 2006 (ISO 2006). Seals and matrices are museum objects, so we can expect a significant overlap. Museum data exchange standards like LIDO (ICOM CIDOC 2025) are modelled in a way that data can be mapped to the CIDOC-CRM. Historical studies have identified the CRM as a good choice for an upper-level ontology and built a research group "Data4History" that tries to support this kind of mapping (Data for History 2017). The archival community is about to create semantic web-based ontologies for the archival community in the Records in Context Ontology to be compatible with CIDOC-CRM (EGAD 2021; EGAD 2023). The CIDOC-CRM working group itself has proposal several compatible models useful for archaeology (CRMarchaeo; ICOM CIDOC CRM SIG 2025b) or for the library community (Functional Requirements for Bibliographic Records [FRBRoo; IFLA LRM_{oo} & ICOM CIDOC CRM SIG 2025]).

§ 21 This wide adoption is grounded in one particular advantage of the CIDOC-CRM: its generalization into an "upper level ontology," which might be able to cover all activities and artefacts of human culture. This generalization facilitates data exchange: one should be able to map domain-specific concepts to more generic ones from the CIDOC-CRM. For instance, it does not create any problems that CIDOC-CRM has no specific entity defined for seal impressions or matrices. Both can easily be mapped to the more generic class of physical human-made things (the entity with the identifier E24 in the CIDOC-CRM).

§ 22 In the following, I will try to describe an ontology derived from the VIS in a way that it is compatible with the VIS and with CIDOC-CRM. Its development does not follow a specific ontology creation pattern, like UPON (De Nicola, Missikoff, and Navigli 2005), SAMOD (Peroni 2016), or MOMo (Shimizu, Hammar, and Hitzler 2022). This is possible as the functioning of the central classes of the proposed ontology rely on established knowledge and practices of sigillography. The ontology development mainly follows a top-down approach, starting with basic matches between CIDOC-CRM and the VIS. In fact, many of the classes and relationships described will just be shortcuts from more complex definitions in pure CIDOC-CRM. As this would involve reusing identification numbers from the VIS but not using it as a simple hierarchical list of terms, the namespace for this ontology should be different: `vis-skos = <https://gams.uni-graz.at/o:vis#>, vis-crm = <https://gams.uni-graz.at/o:vis-ont#>`. In this ontology, the VIS entries serve as explanation and definition.

§ 23 CIDOC-CRM is built mainly around events happening with the museum objects. This can be any kind of activity that has a set of participants (e.g., actors, objects, and materials). Taking a top-down approach, I propose the following four activities to translate the VIS into a CIDOC-CRM compatible model: creating the matrix (including design of the type); applying the matrix (and the underlying administrative process); handling the impression (e.g., destroying, cutting off); and later manipulation in conservation and description. Actors like the keeper of the seal or the seal owner are involved in these activities. The physical objects "matrix" and "impression" are involved in these activities. They can be described by their physical features. However, the model should maintain a clear separation between features of the "type" (e.g., image) and features of the physical object (e.g., condition, attachment, material). Finally, the activities have a purpose, in particular, representation and legal functions.

§ 24 This abstract model could have the following formal structure. Capitalized VIS references should be read as references to the basic concept defined in the VIS, not as a technical implementation or as an explicit namespace. ">" denotes a super-/subclass-relationship.

- Creating the matrix: E12 Production > VIS 109a (Seal engraving)
- Applying the matrix: E12 Production > VIS 64 (to seal)
- Handling the impression (e.g., destroying, cutting off):
  - E68 Dissolution > VIS 57 (removal)
  - E6 Destruction > VIS 59 (breaking)
- Conservation: E7 Activity > VIS TOC IX (Conservation)
- Description: E13 Attribute Assignment > P140 assigned attribute to VIS 3 (Seal), P141 assigned VIS 314 Description of seal

Less straightforward is the mapping of a description. VIS in itself does not provide an appropriate class, as VIS 314 references are only the result of the description (VIS 314). Therefore, we need a new class that we can consider a subclass to CIDOC-CRM E13 Attribute assignment. This class is defined by the relationships to the seal described (VIS 3) and the content of the description. We have to be aware that VIS 314 is not precisely identical to its description, with the consequence that each single description might include single attributes assigned to the seal (e.g., classification, attribution to a seal owner, etc.) VIS 314 is in reality much closer to this "Attribute Assignment" subclass, as it carries the author of the description and bibliographic information as attributes of the describing activity.

§ 25 The main persistent items in the model are rather obvious: The Matrix (VIS 3b) and the Seal impression (VIS 3a) are both subclasses to CIDOC-CRM E22 Human-made object. The Sigillant (VIS 9) is a special case of the CIDOC-CRM E39 Actor: the document to which the seal is attached can be mapped to E31 Document. As attributes like the image on the seal can be described on the impression and on the matrix, I would propose modelling the seal itself (VIS 3) as a conceptual item (CIDOC-CRM E28 Conceptual Object). The physical objects can be considered materializations of this conceptual item. The relationship is similar to the relationship in the CIDOC-CRM compatible interpretation of the FRBR model between the manifestation and the item "R7 is materialized in" (IFLA LRM_{oo} & ICOM CIDOC CRM SIG 2025, based on Madison et al. 1998). FRBRoo considers this as a subproperty of a formal statement "E18 Physical Thing. P128 carries (is carried by): E90 Symbolic Object," which can be used as a modelling pattern for `vis-crm:materializes`.

§ 26 Analyzing the VIS conceptually shows that there are some classes of terms that have no explicit VIS-equivalent term. This is the case with the function and purpose of the seal. It is a common category to the terms in the section III "legal and diplomatic nature" of the VIS (25–60). They deal with variants of the purpose and social context of their usage: the seal of recognizance (VIS 42) or the seal of corroboration (VIS

53, 54) describe special purposes of a seal. The seal ad causas (VIS 39 and VIS 40) or the sigillum secretum (VIS 30), the privy seal (VIS 32), the borrowed seal (VIS 49), or the seal of corroboration (VIS 53, 54) reflect specific social situations for which specific seals are used: royal acts considered to be of minor importance, documents of legal acts in which the seal owner is only involved for authentication. The papal fisherman's ring (VIS 31) is a good example of where the VIS merges function and form. The CIDOC-CRM provides properties separating the form from the function: Legal functions and purposes can be described as `<P103 was intended for>` for objects or `<P21 had general purpose>` for activities. The general relationship between the seal and its owner ("represents") can be considered a subproperty to the CIDOC-CRM `<P67 refers to>`.

§ 27 Authentic seals (VIS 51) could then be modelled as a seal (`vis-crm:Seal`) with the intended use (P103) for authentication in court; however, the relationship to the CIDOC-CRM models on rights (E30) and the ongoing work on a CIDOC-CRM compatible model on social phenomena (Alamercery et al. 2019) might yield better-defined proposals. This is also true for other risks in modelling the seal as a conceptual item, materialized in matrix and impressions in relationship to the purpose of the seal: materializations of the seal share social purposes, when, for instance, the matrix is controlled by the seal owner himself to use it as a secret seal, while the matrix of a seal of majesty is controlled by the chancery. In each case, the impression shares with the matrix its usage for a type of legal act. However, the materialization of the seal as impression can have different purposes from the matrix: the main purpose of the matrix is—obviously—the creation of an impression; however, it can be used as a physical object to authenticate personal contact between the carrier of the seal and the seal owner, for instance. The purpose of the impression can be closure or authentication of the legal content of a document. Therefore, the conceptual model cannot simply inherit the purpose of a single seal impression from the purpose of the conceptual object "seal."

§ 28 Separating these social and legal features of the seal from features of the image helps to further model vis-crm in the conceptual framework of the CIDOC-CRM: P128 carries (E90 symbolic object) describes images and texts engraved in the seal matrix ("design"). The parts of the seal (VIS TOC VII A) are incorporated (P165) in the seal, the impression of the matrix. The method of attachment (VIS 61) is a type of a technique applied during sealing (P33 used specific technique). Many terms from the VIS can be considered types (E55) of material, measurement, or product. Additionally, CIDOC-CRM offers several properties that are not covered by the VIS, for instance, organizational information like the shelf mark (P1 is identified by) or the repository (P52 has current owner, P55 has current location). The same is true for generic features of the physical objects, for example, size, condition, material (VIS 154), or attachment

(VIS 62), which can be mapped to CIDOC-CRM properties like P43 has dimension, P44 has condition, P45 consists of, P46 is composed of, or P56 bears feature.

§ 29 From these considerations, the following conceptual model can be derived (**Figure 1** and **Figure 2**).

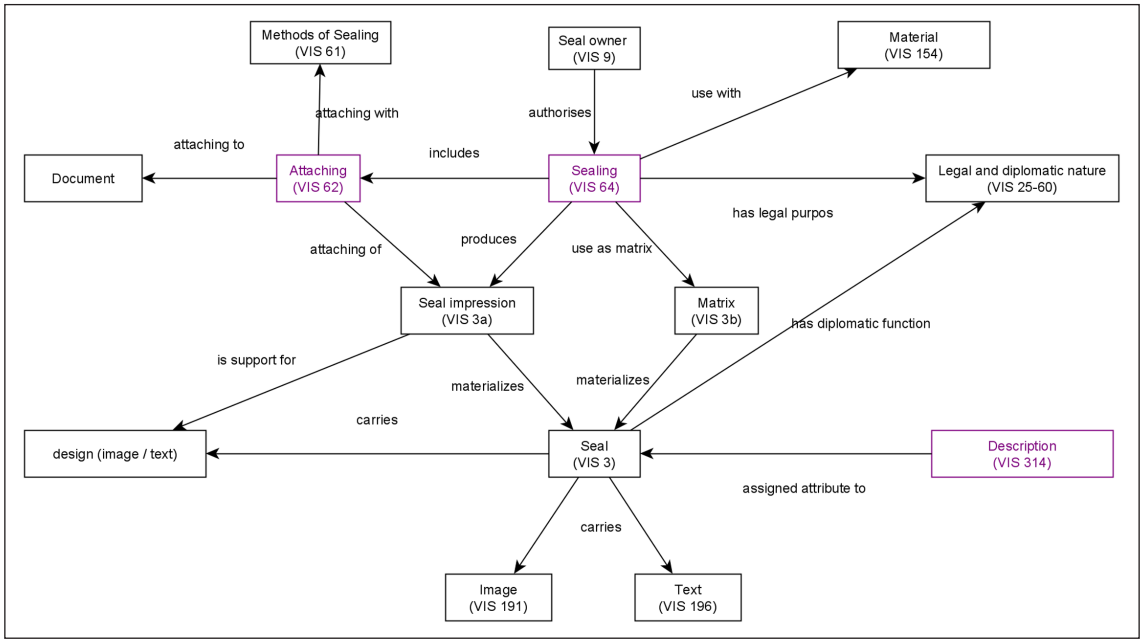

Figure 1: Sketch of the conceptual model derived from the VIS.

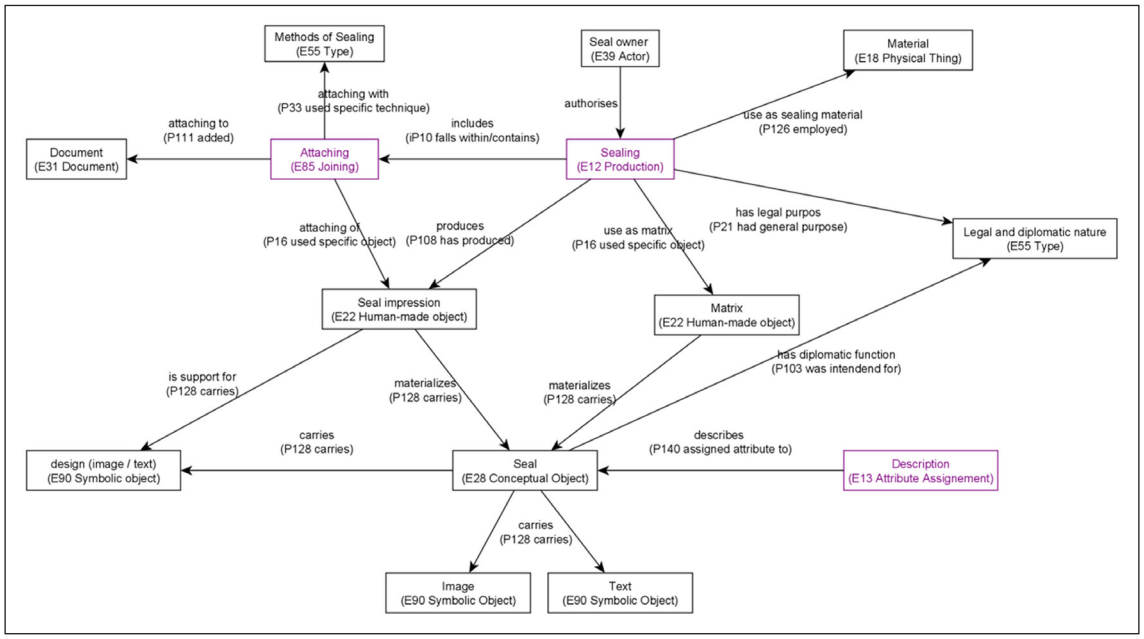

Figure 2: Sketch of the conceptual model derived from the VIS and its relationship to the CIDOC-CRM (classes starting with E and Properties starting with P).

3.3 Mapping of existing seal databases

§ 30 This model might be used as a data model for a new seal database—independently from the technology applied. The formal descriptions of many seal databases are not very extensive, so the following proposal for mapping is based on experience with data and descriptions on the respective website. DigiSig (**Figure 3**; drawn from the information available on the website and the slides of McEwan 2020) almost covers it: `digisig:Seal` maps to `vis-crm:Seal`, `digisig:Seal-Description` maps to `vis-crm:Description`. DigiSig considers the matrices, casts, and seal impressions as manifestations of the single item. In practice, the item is identified by the document to which the seal impression is attached, which means that `digisig:item` might be mapped to `vis-crm:Impression` or `vis-crm:Matrix` and to `vis-crm:Document`. However, as `digisig:Support` describes the physical attachment, it seems to be the best map to `crm:Impression`.

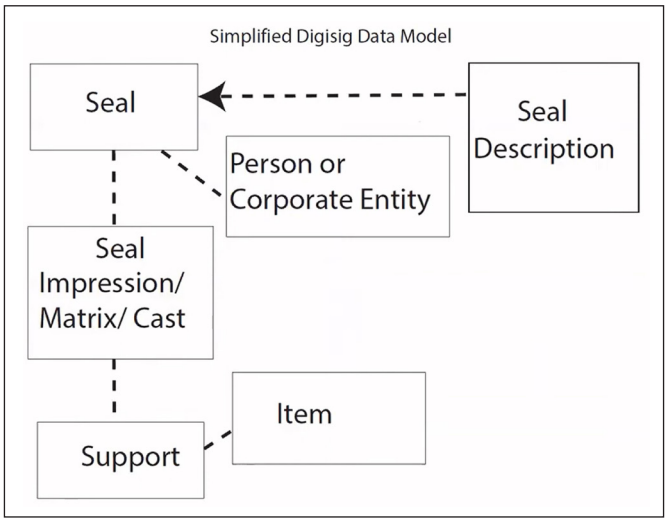

Figure 3: DigiSig Model as presented by John McEwan in the Linked Pasts conference in December 2020 (McEwan 2020).

The model of the French Sigilla database is further away. Judging by the data and descriptions on Sigilla's website, it includes an entity "sceau-type," defined as the "avatar numérique de la matrice." This theoretical surface is close to the concept of the `vis-crm:Seal`. Additionally, the data model includes the actors (sigillants described by their name, function, and title), which map to `vis-crm:Seal_owner`, the seal impressions (including their places of conservation) mapping to `vis-crm:Seal_impression`, and the documents to which they are attached, mappable to a `vis-crm:Document`. Sigilla has no entity for the matrix. The image (`vis-crm:Design`) on the seal is represented by the special case of coat of arms.

§ 31 The model of the Portuguese Sigillvm database is rather flat, as it is a single table with several columns. However, they contain the main entities of the

vis-crm: the `vis:Sigillant` with their title and social function, the document (`vis-crm:Document`) described by date, location, shelf mark, and the abstract of the document, physical features of the seal impression (`vis:Seal_impression`) with information on the condition of the seal/conservation, and the physical features (`vis-crm:has_physical_feature`), that is, its size, the type as single/two-faced, its shape, its protection. The attachment and position of the seal on the document can be mapped to `vis-crm:Attaching`, connecting it to `vis-crm:Methods_of_sealing` employed in the act of creation (`vis-crm:attaching_with`). The seal carries (`vis-crm:carries`) visual and textual objects described by columns on the image, legend, and language of the legend. Finally, the table contains references to a matrix (`vis-crm:Matrix`) and descriptions (`vis-crm:Description`) in images references to publications.

§ 32 All these databases fail to cover the core activities from the vis-crm. However, the events of sealing can be introduced as anonymous entities. They can be inferred from the document to which the seal impression is attached; that is, whenever there exists a relationship between a document and a seal impression in the root database, it will create a `vis-crm:Attaching` with ad hoc-defined URI.

§ 33 The following is an example of how two of these databases could be linked by means of the semantic web. Having the Sigilla and DigiSig available as RDF following the common semantics proposed by the VIS-CRM.

§ 34 From Sigilla, we learn that the Abbey of the Holy Trinity in Lessay is represented by a seal, from which we have an impression attached to a document in the Archives Nationales (AN J 345 n° 109 bis). We can translate this into the RDF code in Listing 4. The act of attaching is an anonymous entity labelled here for convenience "attach221365to215494."

```
sgla_sigillant:abbaye-sainte-trinite-lessay-198661 vis-crm:represents
sgla:Seal_abbaye-sainte-trinite-lessay-198661 .
sgla_empreinte:abbaye-sainte-trinite-lessay-an-paris-j-345-ndeg-
109-bis-221365 vis-crm:materialises sgla:Seal_abbaye-sainte-
trinite-lessay-198661.
sgla:attach221365to215494 vis-crm:attaching_of sgla_empreinte:abbaye-
sainte-trinite-lessay-an-paris-j-345-ndeg-109-bis-221365 ;
   vis-crm:attaching_to sgla_acte:an-paris-j-345-ndeg-109-bis-215494 .
```

Listing 4: vis-crm expression of the Sigilla records on the seal impression of the Abbey of the Holy Trinity in Lessay.

DigiSig records two seal impressions of the same abbey, one of them attached to a document in the National Archives (DL 35/319). DigiSig describes this impression as a manifestation of a seal described by Harvey's computer catalogue with the identification 2827, in use in 1217 depicting a full-length seated human (http://www.digisig.org/page/seal/10247801). Listing 5 translates this into RDF, introducing the anonymous entity for the activity of attaching the seal to the document with attach "attach10296092to10273250."

```
digisig_place:50013257 skos:prefLabel "Abbaye de la Sainte-Trinité
de Lessay" .
digisig_seal:10247801 vis-crm:represents digisig_place:50013257 .
digisi-manifestation:10296092 vis-materializes digisig_seal:10247801 .
digisig_description: 10049803 vis-crm:describes digisig_seal:10247801 ;
  rdfs:label "Lessay Abbey: common seal" ;
  dc:isPartOf digisig_collection:30000037
  schema:author <http://viaf.org/viaf/94851848> .
digisig:attach10296092to10273250 vis-vrm:attaching_of digisig_
manifestation:10296092 ;
  vis-crm:attaching_to digisig_item:10273250 .
```

Listing 5: Sample RDF data (Turtle mutation) from DigiSig set modelled along the vis-crm.

With an RDF representation of both databases in the semantic web, a shared identifier for the sigillant in both databases would be sufficient to merge them. The abbey is mentioned in DigiSig as a "Place." If the concept of place in DigiSig denotes an institution that can own a seal, we can declare the relationship by an `owl:sameAs` property. To be cautious, a `skos:closeMatch` seems to be the better solution (Listing 6).

```
sgla_sigillant:abbaye-sainte-trinite-lessay-198661 skos:closeMatch
digisig_place:50013257 .
```

Listing 6: Equivalence statement for the Abbey of the Holy Trinity in Lessay as recorded in Sigilla and in DigiSig.

4 Conclusion

§ 35 The VIS in SKOS format can certainly serve as multilingual resource for terminology (i.e., for descriptive values in seal databases). It can also serve as a shared vocabulary, but comparing it with existing seal databases, it becomes apparent that the VIS covers

only a subset of terms used as descriptors in those databases. In particular, modelling the motifs as a typology makes it rather hard to rely only on the VIS, even if there are formalisms that would allow inference between the typology and a more detailed description of motifs. The VIS, however, provides a start for building a conceptual model of seal descriptions. Modelling it as a "VIS-CRM" in a way compatible with the CIDOC-CRM makes it easy to include it in the growing Linked Open Data Cloud. The proposed basic entities map well to existing seal databases. An example could show that with a shared ontology, the Sigilla database and the DigiSig database could merge their data.

§ 36 In fact, downloading the OWL representation and populating it with instances of the classes and data values is already a seal database in itself. An ontology management tool like Stanford Protégé (Musen 2015) might not be the easiest to use, but if offers a basic user interface to add instances and describe them. Plugins allow SPARQL queries or support the import of relational databases, XML files, or spreadsheets. The RDF data created by Protégé can be stored in any triple store on top of which full web front-ends could be developed.

§ 37 Establishing a solid conceptual model for sharing sphragistical data would need further tests with real-world databases, like those available in the GAMS Digital Humanities repository, currently modelled according to LIDO standards (ICOM CIDOC 2025). However, a shared conceptual and formal model can only be successful as a community effort. I hope the model presented here can be a good start to this discussion.

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The author has no competing interests to declare.

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