Foresight Technical Report

OIMS basic documentation

Technical documentation of the OIMS Base self-describing metadata schema, the high-level OIMS structure and their validation schemas

version 2.3.3.0

Gideon Kruseman, Marie Angelique LaPorte

December 7, 2023

Contents

Executive summary

The Open Ontology-Based Interoperable Information Asset Metadata Schema (OIMS) is a flexible and extensible metadata schema designed to standardize and organize metadata for various information assets like datasets, documents, models, and publications, making them more accessible, transparent, and reusable.

The purpose of this document is to provide the technical documentation for the self-describing metadata schema at the core of OIMS.

This technical documentation is intended for its primary audience of metadata schema developers and related tool developers.

OIMS is a comprehensive and structured approach to managing and organizing valuable information assets. Designed with a strong foundation in ontology, OIMS ensures efficient organization and retrieval of data resources within complex information systems. By leveraging standardized metadata schema, OIMS promotes interoperability, consistency, and clarity across various data domains. Its adaptable and extensible structure allows for seamless integration into a wide range of applications, empowering organizations to harness the full potential of their information assets and drive data-driven decision-making processes.

This technical documentation is limited to the self-describing metadata schema and the high-level structure of any OIMS-compatible metadata file and includes the JSON schema validation files.

The introduction effectively sets the context for OIMS, discussing the challenges of metadata management and the necessity for a standardized approach. The mention of existing standards like DataCite and Dublin Core provides a good reference point for understanding where OIMS fits in the broader landscape. The chapter emphasizes the role of open-source libraries and collaborative development, aligning well with the principles of open science. This is particularly relevant given the growing importance of open data and transparency in research and data management.

The introductory chapter is followed by a glossary of terms and the technical chapters detailing the relevant schemas.

High-Level OIMS Structure

The chapter on "High-Level OIMS Structure" provides a comprehensive and detailed overview of the OIMS (Open Ontology-based Interoperable Information Asset Metadata Schema) structure, emphasizing its technical and functional design. It covers various aspects of the OIMS framework, from its general overview to specific details of its implementation in JSON format.

The chapter starts with a technical factsheet offering essential information about the OIMS structure, such as its version, language, contact details, and license information. It then delves into the functional design, highlighting the necessity of a template containing key components for developing OIMS-compatible metadata files. The chapter emphasizes the lightweight and user-friendly nature of the JSON format, underscoring its suitability for the OIMS structure.

A significant portion of the chapter is devoted to technical design and implementation, thoroughly detailing the OIMS structure at the highest level. It includes specific JSON code snippets and figures illustrating the structure, along with explanations of each section, such as the OIMS header and content sections. The document meticulously outlines various

components like mapping information, metadata schemas, file descriptors, and the actual metadata, providing examples and explanations for each.

The chapter serves as a thorough and informative guide for understanding and implementing the OIMS structure, particularly beneficial for data management metadata schema developers and advanced, tech-savvy individuals interested in open data.

Key strengths of the chapter include:

- Detail-Oriented Structure: The chapter meticulously covers every aspect of the OIMS structure, offering both high-level overviews and detailed explanations of specific components.
- Technical Clarity: The use of JSON code snippets and clear, descriptive text helps in understanding the structure and functionality of OIMS.
- Practical Examples: Inclusion of examples, especially in the mapping information section, aids in comprehending how the OIMS structure can be implemented in real-world scenarios.
- Focus on Interoperability and Open Data: The chapter consistently emphasizes the importance of interoperability and open data practices, aligning with the overall goals of the OIMS framework.

Areas for improvement or further elaboration:

- User Guidelines: While the chapter is comprehensive, the absence of specific user guidelines might be a gap, especially for new users. Including a section with step-by-step guidelines or best practices for implementing the OIMS structure could enhance its practical utility.
- Exploration of Use Cases: The chapter could benefit from a section discussing various use cases or scenarios where the OIMS structure can be applied. This would provide readers with a clearer understanding of its applicability in different contexts.
- Updates on Known Issues: While the chapter mentions that the entity management section is a work in progress, providing regular updates or a roadmap for these sections could be useful for users to understand the current state and future developments of OIMS.
- Community Engagement and Feedback Mechanisms: Encouraging community engagement and setting up mechanisms for feedback and contributions can foster a collaborative development environment for the OIMS structure.

High-Level OIMS Structure validation schema

The JSON Schema for the Open Ontology-Based Interoperable Information Asset Metadata Schema (OIMS) represents a significant advancement in standardizing metadata across diverse information assets like datasets, documents, models, and publications. The schema, meticulously aligned with OIMS version 2.3, plays a pivotal role in ensuring metadata consistency, validity, and interoperability.

This technical documentation outlines the structure and functionality of the OIMS_structure.schema.json, providing a comprehensive guide for its implementation and usage. Key features of the schema include top-level and field-level validation, ensuring that metadata files conform to the OIMS's stringent standards. The schema is designed for flexibility and extensibility, accommodating evolving metadata requirements while maintaining core OIMS compatibility.

A vital tool for metadata authors, data curators, and quality assurance teams, this schema facilitates the creation of OIMS-compliant metadata files and assists in their validation process. Implemented in JSON for universal compatibility, the schema is easily integrated into various data management and publishing tools. Its design underscores a commitment to clarity, efficiency, and broad accessibility, addressing common issues in metadata management such as lack of commenting systems in JSON.

As the OIMS evolves, this schema stands as a foundational tool, essential for maintaining the integrity and standardization of metadata across various platforms and applications. It opens up opportunities for community-driven improvements and adaptations, reflecting the dynamic nature of data management practices in the digital age.

Areas for improvement or further elaboration:

- User guidelines for further development of schemas based on this high-level schema.

OIMS base self-describing metadata

The OIMS self-describing metadata schema represents the foundational framework for annotating diverse data assets with metadata that adhere to FAIR principles—ensuring that data is Findable, Accessible, Interoperable, and Reusable. The schema is built on a JSON format for its lightweight and human-readable characteristics, and is enhanced by GTREE tags for improved readability and structure. This approach guarantees ease of use across various programming languages and platforms.

Critical to the schema are its attributes, which are meticulously defined to ensure transparency and adaptability. These include required core attributes, context-specific required attributes for incorporating controlled vocabularies and ontology terms, and optional attributes that enhance usability and transparency, such as comments and attribute statuses.

The schema is designed to be ontology agnostic, allowing flexibility in tagging and cross-domain application, while also setting the stage for incorporating comprehensive ontology terms in the future. Importantly, the schema is structured to support backward compatibility, recognizing the need to manage legacy data effectively.

No significant issues or bugs have been identified, reflecting the robustness of the current schema. However, community feedback is encouraged to facilitate continuous improvement, with the anticipation of further enriching the schema's ontology linkage and enhancing its applications.

The schema is readily available for download, with no special installation requirements, underscoring its ease of integration into existing systems. While specific user guidelines are not provided, the schema's self-describing nature serves as its own guide, promoting an intuitive understanding and implementation.

OIMS base metametadata validation schema

This chapter introduces the OIMS_base.schema.json, a JSON Schema specifically developed to validate OIMS-compatible metametadata files. This schema is a critical component of the Open Ontology-Based Interoperable Information Asset Metadata Schema (OIMS) framework, ensuring that metadata files are consistent with OIMS standards for structure, integrity, and FAIR principles.

Key highlights of the chapter include:

- Technical Factsheet: The schema, OIMS_base.schema.json, is in JSON Schema format, currently under review, and is designed to validate the structure and content of OIMS-compatible metametadata files.
- Functional Design: This section outlines the schema's role in confirming the compliance of metametadata files with OIMS standards. It emphasizes the schema's capabilities in validating essential elements like attribute definitions, data types, controlled vocabularies, and ontology terms.
- Technical Design and Implementation: Detailed insight into the schema’s construction is provided. Key components like the "OIMS" root object, conditional validation mechanics, and data type enforcement are discussed. The schema's unique approach to incorporating comments and handling metadata content validation is highlighted.
- User Engagement and Development: The chapter underscores the importance of community feedback and contributions for the ongoing refinement of the schema.
- Future Prospects: Looking ahead, the chapter discusses the potential for growth and adaptation of the OIMS framework, aligning with evolving technology and data management practices.

The chapter concludes by emphasizing the schema's pivotal role in enhancing the reliability and consistency of metadata management, inviting readers and users to actively engage in its development and application.

Introduction

The Open Ontology-Based Interoperable Information Asset Metadata Schema (OIMS) is a flexible and extensible metadata schema designed to standardize and organize metadata for various information assets like datasets, documents, models, and publications, making them more accessible, transparent, and reusable. To understand the importance of OIMS, let's first discuss some basic concepts.

In our data-driven world, we often deal with large amounts of information. To make sense of this information and use it efficiently, we need metadata. Metadata is like a label or a description that provides details about the data itself, making it easier to find, understand, and use.

Different industries and organizations use various standards to manage their data and metadata, which can create challenges when trying to share or combine data from multiple sources. These standards are often specific to certain contexts and can become outdated as the information landscape evolves.

To address these challenges, the OIMS approach focuses on standardizing the metadata's structure, rather than the data itself. Think of it as creating a common language for describing data, even if the data comes from different sources or domains. This common language helps ensure that the metadata remains flexible and adaptable, even as new attributes or changes occur over time.

Some efforts have been made to standardize general descriptive metadata, like DataCite and Dublin Core. However, more specialized metadata often lacks standardization, leading to inconsistencies across different data sources. This is where OIMS comes in, offering a standardized structure for the "metadata of the metadata."

In simpler terms, the OIMS approach is like creating a universal system for organizing information about data, regardless of where it comes from or how it's structured. By having a consistent way to describe and manage metadata, it becomes easier for people and organizations to share, understand, and reuse information assets in a more efficient manner.

The role of open-source libraries in this context is invaluable. By fostering a collaborative development environment, open-source resources enable continuous improvement and innovation in tool development. This collaborative ethos aligns perfectly with the principles of open science, encouraging community-driven enhancements and adaptations of tools to meet diverse and evolving needs. Open-source libraries not only accelerate the development of new functionalities and features but also ensure transparency and reliability, essential in scientific and research-oriented applications. Ultimately, the synergy between OIMS and a robust suite of open-source tools can catalyze a transformative shift in how agricultural data is managed, shared, and utilized, driving forward the goals of global food security and sustainable agricultural practices.

The CGIAR Initiative on Foresight combines state-of-the-art analytics, innovative use of data, and close engagement with national, regional and global partners to offer better insights into alternative transformation pathways that can inform choices and sharpen decision-making today, leading to more productive, sustainable and inclusive food, land and water systems in the future.

The foresight initiative is dedicated to making data and metrics and models and tools that are needed for foresight analysis available, accessible, transparent and usable for decision-makers regarding policies and investment decisions with respect to the transformation of food, land and water systems under global change and the on-going climate crisis. As part of this endeavor for radical democratization of foresight analysis the Foresight Initiative provides as much tools and models through the Initiative's GitHub repository https://github.com/ForesightInitiative.

Purpose

The purpose of this document is to provide the technical documentation for the self-describing metadata schema at the core of the Open Ontology-based Information Asset Metadata Schema (OIMS). OIMS is a comprehensive and structured approach to managing and organizing valuable information assets. Designed with a strong foundation in ontology, OIMS ensures efficient organization and retrieval of data resources within complex information systems. By leveraging standardized metadata schema, OIMS promotes interoperability, consistency, and clarity across various data domains. Its adaptable and extensible structure allows for seamless integration into a wide range of applications, empowering organizations to harness the full potential of their information assets and drive data-driven decision-making processes.

Structure of the report

In the various chapters of the report, we provide the technical documentation of the JSON structures and schemas related to OIMS. Each component covered by this report has a Chapter with a common structure. After a brief introduction to the software, model or tool or relevant technical component we provide a technical factsheet highlighting the key characteristics of the tool. Next, we provide the functional design. After that we provide the technical design and implementation. Before these technical chapters we provide a chapter with definition of terms for the benefit of the readers.

Version history of OIMS and its technical documentation

The first versions of OIMS were developed as part of the community of practice on socio-economic data of the CGIAR Platform for Big Data in Agriculture. The initial version was published on GitHub in 2019 and a paper was published (Kruseman 2022). The version history highlighted here provides the major milestones. Details are found on the GitHub Repository[1]

Version 2.0 added the standard header section to the schema to ensure that the nested approach to tagging metadata with metametadata is machine readable.

Version 2.1 improved the “OIMS content” section.

Version 2.2 are subtle but not inconsequential changes to the basic structure of OIMS self-describing metadata.

The initial technical documentation under the Foresight Initiative was written for OIMS version 2.2.

The main change in version 2.3 is the conversion of all OIMS_properties to snake-case. Furthermore, the structure was changed to allow better tracing of nested features, both for metadata as well as entities and more rigorous testing for internal consistency was implemented.

Scope

This technical documentation is limited to the self-describing metadata schema and the high-level structure of any OIMS-compatible metadata file and includes the JSON schema validation files.

Intended audience

The primary users of this document are data management metadata schema developers and developers of OIMS related tools. Secondary audience are all advanced and tech-savvy people interested in Open Data from a technical perspective.

[1] https://github.com/ForesightInitiative/OIMS

Glossary of terms

In this report we try to balance technical detail with broader context. Especially for those new to the subject or not well versed in metadata schema development and use, we provide a glossary of terms. While the primary audience is well-versed in technical language, the secondary audience might benefit from simpler explanations of complex terms.

Main and general terms

Terms	Definitions	Source(s)
Main terms		
Accessibility	Protocols for retrieving digital resources should be made explicit, for both humans and machines, including well-defined mechanisms to obtain authorization for access to protected data.	(Jacobsen et al. 2020)
Controlled vocabulary	A controlled vocabulary is an organized arrangement of words and phrases used to index content and/or to retrieve content through browsing or searching. It typically includes preferred and variant terms and has a defined scope or describes a specific domain.	
Data dictionary	A Data Dictionary is a collection of names, definitions, and attributes about data elements that are being used or captured in a database, information system, or part of a research project. It describes the meanings and purposes of data elements within the context of a project, and provides guidance on interpretation, accepted meanings and representation. A Data Dictionary also provides metadata about data elements. The metadata included in a Data Dictionary can assist in defining the scope and characteristics of data elements, as well the rules for their usage and application.	
Entity	In OIMS an entity refers to objects and concepts for which there is primary metadata. Entities can have relationships with other entities.	
FAIR	FAIR stands for findable, Accessible, Interoperable and Reusable. The FAIR data principles rely on assets being tagged with rich metadata.	(Wilkinson et al. 2016; Jacobsen et al. 2020)
Findability	Digital resources should be easy to find for both humans and computers. Extensive machine-actionable metadata are essential for automatic discovery of relevant datasets and services, and are therefore an essential component of the FAIRification process Digital resources should be easy to find for both humans and computers. Extensive machine-actionable metadata are essential for automatic discovery of relevant datasets and services, and are therefore an essential component of the FAIRification process.	(Jacobsen et al. 2020)

Interoperability	When two or more digital resources are related to the same topic or entity, it should be possible for machines to merge the information into a richer, unified view of that entity. Similarly, when a digital entity is capable of being processed by an online service, a machine should be capable of automatically detecting this compliance and facilitating the interaction between the data and that tool.	(Jacobsen et al. 2020)
JSON	JSON is a light-weight language-independent data format. It was derived from JavaScript, but many modern programming languages include code to generate and parse JSON-format.	(JSON.org n.d.; ECMA 1999)
Metadata	Metadata means "data about data". Metadata is defined as data providing information about one or more aspects of other data; it is used to summarize basic information about data that can make tracking and working with specific data easier. We expand this definition to include information about one or more aspects of digital assets, not only data, but also models and tools, and publications. Metadata can be subdivided into different types. The main types often identified are *descriptive metadata*, *technical metadata* and *structural metadata*. Metadata are essential in preventing data lakes from turning into data swamps.(see table on metadata types below). There exist data/metadata pairs where metadata is the descriptor, and data is the thing being described, unambiguously, within the context of that pair.	
Metametadata	Metametadata is the metadata of metadata.	
Metadata schema	A metadata standard or schema I a labeling, tagging or coding system used for recording data about assets or resources. A metadata schema establishes and defines data elements and the rules governing the use of data elements to describe a resource.	
OIMS	The open ontology-based interoperable information asset metadata schema (OIMS) is a flexible, extensible, ontology agnostic, human intelligible and machine-readable *metadata* schema approach based on nested metadata where metadata is described by metadata.	(Kruseman 2022)
Ontology	In information science, an ontology encompasses a representation, formal naming, and definitions of the categories, properties, and relations between the concepts, data, or entities that pertain to one, many, or all domains of discourse. In other words, an ontology is a way of showing the properties of a subject area and how they are related, by defining a set of terms and relational expressions that represent the entities in that subject area.	
Open data	Open data is data that can be freely used, re-used and redistributed by anyone - subject only, at most, to the requirement to attribute and *share-alike*.	(Open Knowledge n.d.)
Open science	Open science is the movement to make scientific research (including publications, data, physical samples, and software) and its dissemination accessible to all levels of society, amateur or professional.	

Open source	open source denotes software, scripts, models and digital tools for which the original source code is made freely available and may be redistributed and modified.	
Reusability	Digital resources are sufficiently well described for both humans and computers, such that a machine is capable of deciding: if a digital resource should be reused; if a digital resource can be reused, and under what conditions; and who to credit if it is reused.	(Jacobsen et al. 2020)
Self-describing metadata	Information describing the data contents of the metadata file are embedded within the metadata file itself.	
Schema	Schema in the context of data structures refers to how data is organized in a logical and structured way.	
Share-alike	Share-alike is a copyright licensing term, originally used by the Creative Commons project, to describe works or licenses that require copies or adaptations of the work to be released under the same or similar license as the original.	(Open Knowledge n.d.)
Version control	Version control is a class of systems responsible for managing changes to resources such as data, source code and publications.	

Metadata types

Terms	Definitions	Source(s)
Main types		
Descriptive metadata	Descriptive metadata enables discovery, identification, and selection of resources. It can include elements such as title, author, and subjects.	
Structural metadata	Structural metadata is metadata that describes the versions, and relationships of and between digital materials	(Arms, Blanchi, and Overly 1997)
Technical metadata	Technical metadata refers to the information that describes the technical aspects of data, such as data structure, storage, format, and data processing.	
More detailed metadata types		
Administrative metadata	Part of descriptive metadata: it is a broad term that captures information that is useful in managing resources. It provides information related to governance, access controls, and security. It includes technical data on copyright information, rights management, and license agreements.	
Definitional metadata	Part of technical metadata and descriptive metadata at the lowest level of aggregation: typically what is in a data dictionary.	
Ethics metadata	Part of descriptive metadata: it refers to information about ethical issues with the data being described. This includes the existence of both direct and indirect personally identifiable information, the presence of granular geospatial coordinates, the presence of sensitive information, such as attitudes, bio-medical information and certain types of preferences.	
Legal metadata	Part of descriptive metadata: this refers to metadata that has legal implications such as copyright information and license agreements.	
Provenance metadata	Part of descriptive metadata: it can refer to either the relationship between two versions of data objects for instance a derived dataset without personally identifiable information is linked to an underlying dataset that does contain this sensitive information. Or it can refer to metadata that underlies the resource, for instance if information has been reprocessed.	
Preservation or life-cycle metadata	Part of descriptive metadata: preservation metadata is an integral part of the data lifecycle. This includes information about maintenance routines.	
Quality assurance metadata	This refers to metadata that describes the processes of identification and elimination of any data anomalies via the processes of data profiling and cleansing that were employed.	

Entity classes and relationships

Terms	Definitions	Source(s)
Data entity classes		
Dataset or collection	A data set is a collection of related, discrete items of related data that may be accessed individually or in combination or managed as a whole entity. A collection in OIMS refers to a collection of datasets that somehow fit together. Datasets contain not only data, but also metadata and supplementary documentation.	
Data file	A data file is a computer file which stores data to be used by a computer application or system.	
Aggregate container	Data files can contain one or more tables. We refer to this as an aggregate container	
Container	A data container is often a variable or column in a tabular data file, but can take on other forms as well depending on the type of data and context.	
Model and tool entity classes		
Model framework	.A framework is broader and more general than a model and often contains models as its parts.	
Model, tool or ETL procedure	Self-contained set of rules that turns input data into output data	
Module	Part of a model, tool or extract, transform, load (ETL) procedure that can be standalone or part of a model. It has dependencies with other parts of the model, tool, or ETL procedure.	
Module component	Segment of code or script.	
Publication entity classes		
Collection	A collection is a set of related, discrete digital documents, which may include all types of digital assets.	
Document	A document is a piece of electronic matter that provides information or evidence or that serves as an official record.	
Supplementary documentation	This refers to documents that provide additional context to data assets.	
Entity relationships		
Parent child relationship	Refers to the hierarchical relationship between different related entities.	
Sibling relationship	This refers to relationships between digital resources where there is not a clear hierarchical relationship.	

High level OIMS structure

The high level OIMS structure provides a blueprint for any OIMS compatible metadata file. It highlights the main structure with the required elements and a description of key parts of the contents in human intelligible terms.

Technical factsheet

Key	Value
General information	
Name	OIMS_structure.json
Version	2.3.3
Language	JSON
Contact	Gideon Kruseman <g.kruseman@cgiar.org>
Status	Released
Latest release date	November 30, 2023
System requirements	
Operating system	Any
Software requirements	None
General information	
Key features	High level structure of OIMS compatible metadata files in JSON format
Key inputs	none
Key outputs	none
License info and acknowledgements	
License	GPL-3.0 license
Acknowledgements	Foresight Initiative

Functional design

To develop OIMS-compatible metadata files and to develop tools that create these files it is essential to have a template that contains the key components. Because OIMS is based on the light-weight JSON format the OIMS structure file should also be in JSON format.

The key functional requirements of the high-level OIMS structure file is that it presents the key OIMS components and that where possible the information in the JSON file will assist users to create their own files or templates.

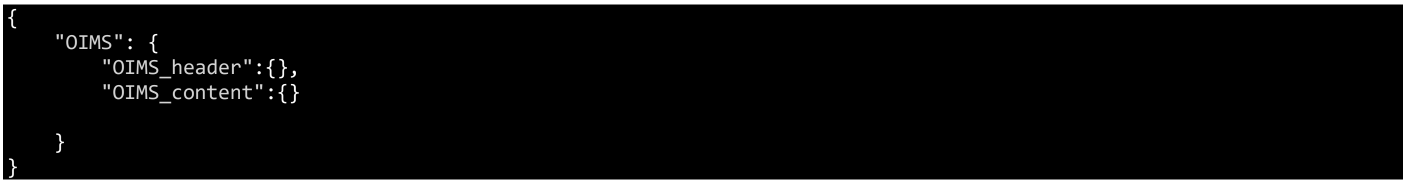
It should explain the header section which provides they key information about the metadata itself and the underlying schemas.

It should explain the main components of the content section.

In the end it should allow anyone to start developing metadata schemas with any additional support as indicated

Technical design and implementation

The technical design and implementation is straight forward. It is a JSON file. With the key elements. Any OIMS-compatible metadata schema has the same high-level structure. See Fig. 1 below. Note that "<" and ">" indicates start and finish of placeholders for property values, with either a description of content or an example denoted with "e.g.", Compound objects with content to be determined outside the scope of this chapter or discussed later are indicated with "{}". The same holds true for arrays denoted with "[]". The code snippets in the figures follow the color coding of Visual Studio (Visual Studio 2023).



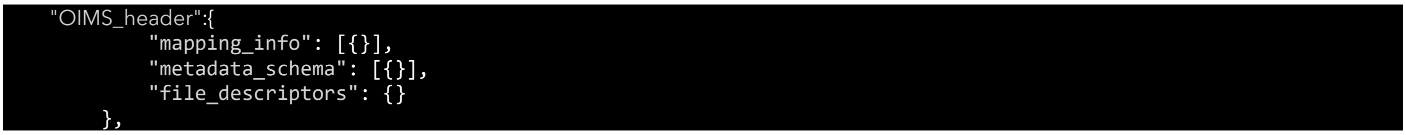
```
{
    "OIMS": {
        "OIMS_header":{},
        "OIMS_content":{}

    }
}
```

Fig 1: OIMS structure at the highest level

"OIMS" is the root element of the JSON file. This indicates that it is an OIMS-compatible metadata file. The root element "OIMS" has two required objects: "OIMS_header" and "OIMS_content". The OIMS header object has the purpose of providing information on the metadata of the metadata provided in the OIMS_content section.

OIMS header section

At the highest level of the OIMS header section there are three properties, see Fig 2 below.



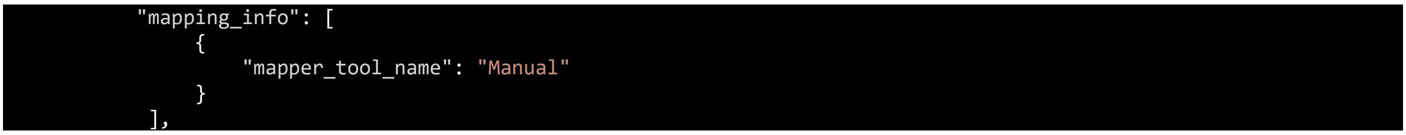
```
    "OIMS_header":{
            "mapping_info": [{}],
            "metadata_schema": [{}],
            "file_descriptors": {}
        },
```

Fig 2: OIMS header structure at the highest level

The OIMS header section has three main properties: "mapping_info", "metadata_schema" and "file_descriptors".

OIMS header section: mapping information

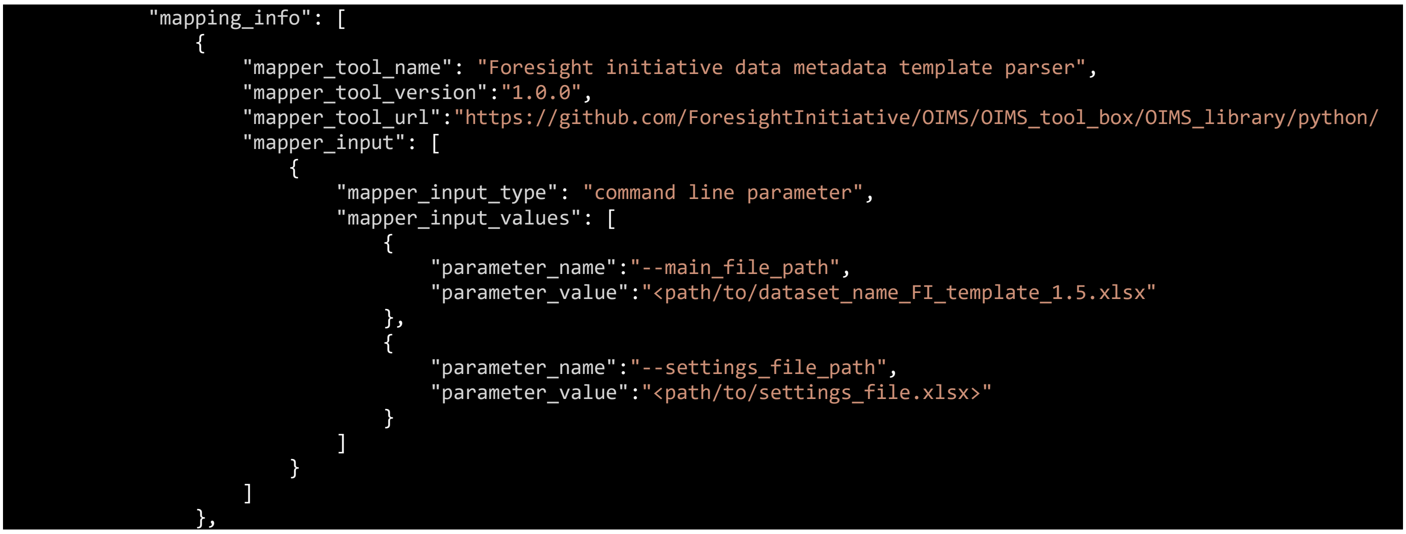
The mappng information section ("mapping_info") captures information about the processes used for generating the metadata. Itis an array of compound objects. The properties of the compound objects are "mapper_tool_name", "mapper_tool_version" and "mapper_tool_url". The simplest case is when the schema is created manually:



```
            "mapping_info": [
                 {
                     "mapper_tool_name": "Manual"
                 }
             ],
```

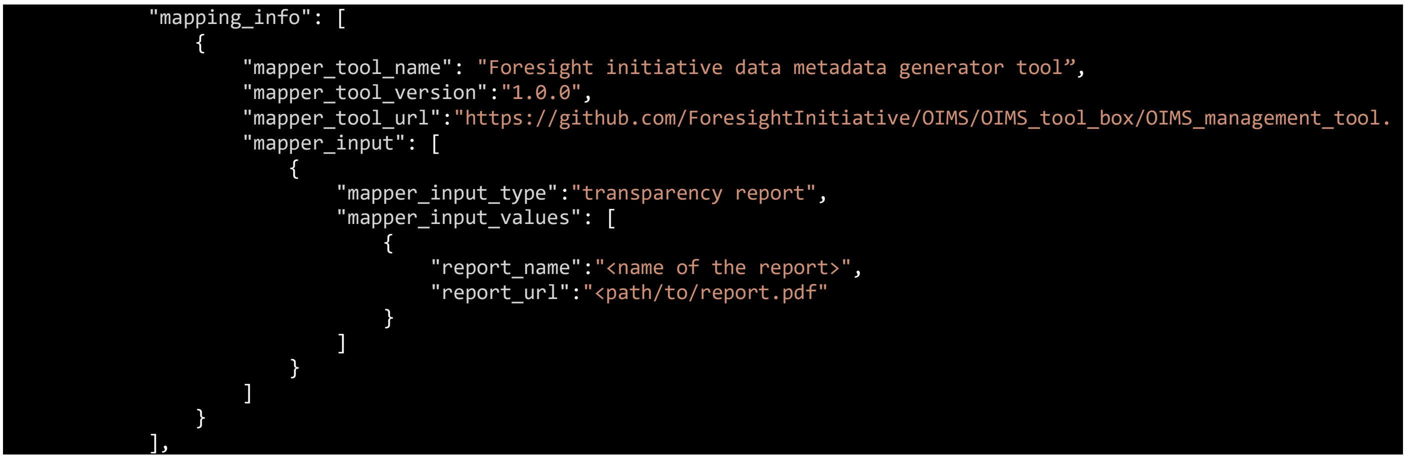
Fig 3: mapping information indicating the schema was generated by hand

If tools were used thr information should be provided. The example below are hypothetical but realistic as the tools are being tested and not yet available in open source. The "mapper_input" property is relatively new addition to OIMS and may be subject to change in upcoming versions. In the example in Fig 4, the mapper input property is filled with command line parameter and their values as used for generating the metadata in the OIMS-compatible metadata file in JSON format from a variety of sources containing relevnat metadata. In the example in Fig 5. the mapper input property is filled contains the url to location of the tool metadata report generated by the tools themselves as part of their transparency procedures. This report contains all the relevant information in a human intelligible form.



```
"mapping_info": [
    {
        "mapper_tool_name": "Foresight initiative data metadata template parser",
        "mapper_tool_version":"1.0.0",
        "mapper_tool_url":"https://github.com/ForesightInitiative/OIMS/OIMS_tool_box/OIMS_library/python/
        "mapper_input": [
            {
                "mapper_input_type": "command line parameter",
                "mapper_input_values": [
                    {
                        "parameter_name":"--main_file_path",
                        "parameter_value":"<path/to/dataset_name_FI_template_1.5.xlsx"
                    },
                    {
                        "parameter_name":"--settings_file_path",
                        "parameter_value":"<path/to/settings_file.xlsx>"
                    }
                ]
            }
        ]
    },
```

Fig 4: Partial and hypothetical example of how key information about tools used is provided using actual input.



```
"mapping_info": [
    {
        "mapper_tool_name": "Foresight initiative data metadata generator tool”,
        "mapper_tool_version":"1.0.0",
        "mapper_tool_url":"https://github.com/ForesightInitiative/OIMS/OIMS_tool_box/OIMS_management_tool.
        "mapper_input": [
            {
                "mapper_input_type":"transparency report",
                "mapper_input_values": [
                    {
                        "report_name":"<name of the report>",
                        "report_url":"<path/to/report.pdf"
                    }
                ]
            }
        ]
    }
],
```

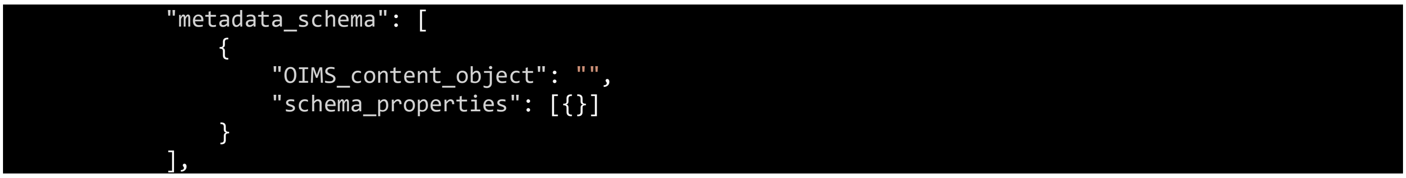
Fig 5: Partial and hypothetical example of how key information about tools used is provided using transparency report.

OIMS header section: underlying metadata schemas

The section devoted to the underlying metadata schemas is crucially important in the nested metadata approach of the OIMS philosphy. This section is called ”metadata_schema”. It offers information on how to read the OIMS content (”OIMS_content”) section.

The underlying metadata schema is an essential component of OIMS. Because metadata is nested any OIMS-compatible metadata file has a metametadata file in terms of an OIMS-compatible metadata file. After at most four iterations the metadata is described using the OIMS self-describing metadata. The self-describing metadata is described in technical terms further in this report.

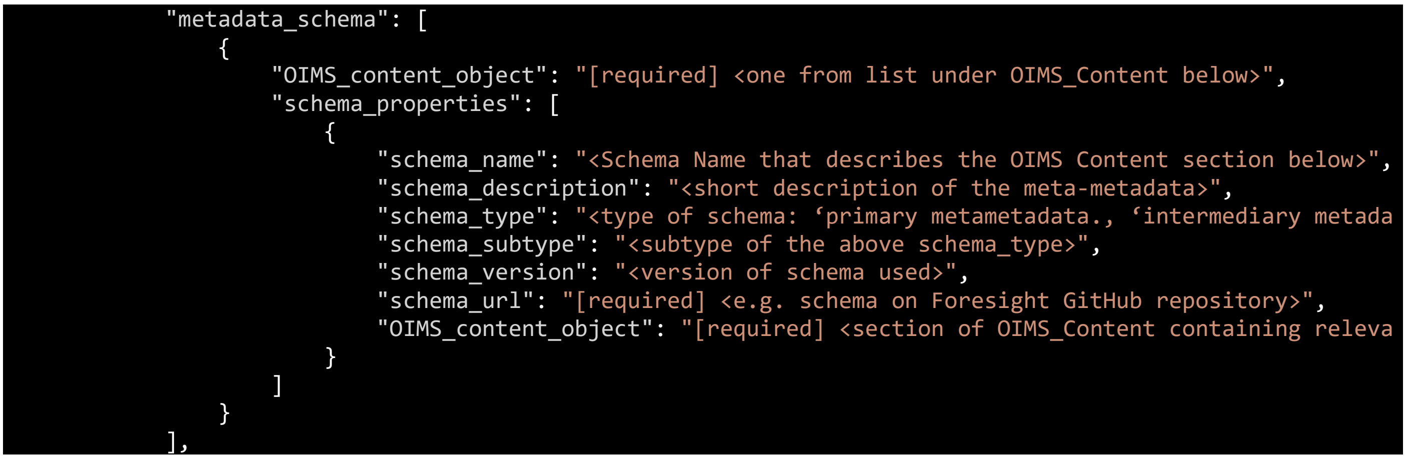
The high-level structure of the component can be found in Fig.6. What the section looks like overall in the high level OIMS structure file can be observed in Fig. 7. We will discuss each property in detail.



```
            "metadata_schema": [
                {
                    "OIMS_content_object": "",
                    "schema_properties": [{}]
                }
            ],
```

Fig 6: High level structure of the metadata schema section of the OIMS header.

The "OIMS_content_object" is a key identifier in the OIMS content section that comes after the header section of OIMS. It is a human intelligible and machine readable identifier that is unique within the relevant file. In the metadata schema section we find at least two instances of "OIMS_content_object" with distinct meanings. We first discuss the "OIMS_content_object" instance as indicated in Fig 6. At this level the "OIMS_content_object" refers to the identifier in this OIMS-compatible metadata file in the OIMS content section. The OIMS content section consists of an array of compound objects identidied by "OIMS_content_object". In the metadata schema section of the header the high-level instance of "OIMS_content_object" identifies the section in the OIMS content of thus file. The "schema_properties" section provides information on all direct underlying metametadata schemas.



```
            "metadata_schema": [
                {
                    "OIMS_content_object": "[required] <one from list under OIMS_Content below>",
                    "schema_properties": [
                        {
                            "schema_name": "<Schema Name that describes the OIMS Content section below>",
                            "schema_description": "<short description of the meta-metadata>",
                            "schema_type": "<type of schema: ‘primary metametadata., ‘intermediary metada
                            "schema_subtype": "<subtype of the above schema_type>",
                            "schema_version": "<version of schema used>",
                            "schema_url": "[required] <e.g. schema on Foresight GitHub repository>",
                            "OIMS_content_object": "[required] <section of OIMS_Content containing releva
                        }
                    ]
                }
            ],
```

Fig 7: Excerpt from the metadata schema section of the high level OIMS structure file

The "schema_properties" section is an array of compound objects. It is an array because the metadata in the OIMS content section identified by "OIMS_content_object" can in principle be described by more than one underlying metametadata schema. For each schema underlying the "OIMS_content_object" metadata the following key information is requested. The first two properties are intended for humans and provide information that humans can understand. The second three properties are required for machine readability.

The property "schema_name" is a human intelligible string that describes the OIMS content section for which the metadata is intended. The property "schema_description" provides further clarification.

The following properties are machine readable and human intelligible and are intended for quality control. The "schema_type" is a controlled vocabulary with three elements:

- "self-describing metadata schema"
- "primary metametadata"

- "intermediate metadata metadata"

The self-describing metadata schema is the basis of OIMS it describes "intermediate metadata metadata" and can also be used to describe "primary metametadata". "intermediate metadata metadata" describes "intermediate metadata metadata" and "primary metametadata". "primary metametadata" describes the primary metadata schemas. This implies that unless a schema is self-describing or describes primary metadata, it is considered to be "intermediate metadata metadata".

The “schema_subtype” provides additional information about the schema type. In the current version it is considered a text datatype with no strings attached, but could evolve into a controlled vocabulary.

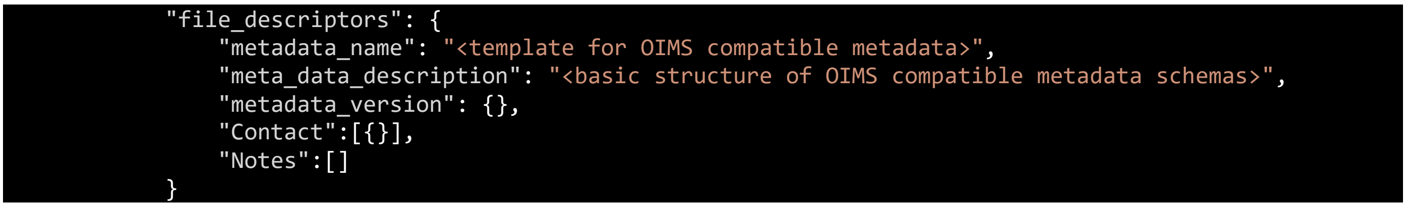
The schema version and schema url are used to find the underlying metadata schema and check if it is still valid.

The “OIMS_content_object” at this level refers to the “OIMS_content_object” in the OIMS content section of the OIMS_compatible underlying metadata schema file in JSON format.

Furthermore, there are two optional properties, namely “include_property” and “exclude_property” that indicate if there are specific properties in the metadata section linked to a specific “OIMS_content_object” that need to be included or excluded. This can be relevant if multiple underlying metadata schemas are used.

OIMS header section: file descriptors

The section related toi file descriptors contains information about the metadata file itself. It is a compound object with 5 properties, as can be observed in Fig. 8.



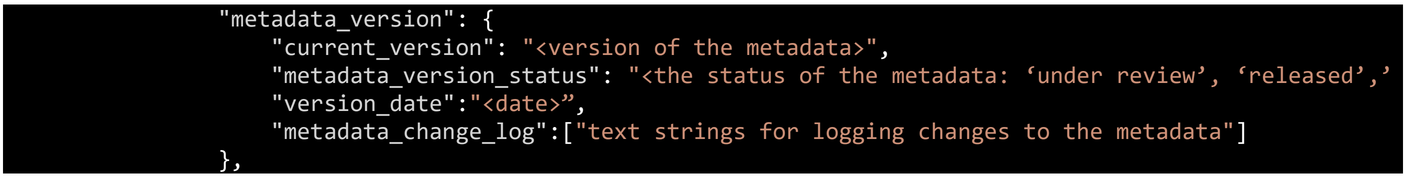
```
            "file_descriptors": {
                "metadata_name": "<template for OIMS compatible metadata>",
                "meta_data_description": "<basic structure of OIMS compatible metadata schemas>",
                "metadata_version": {},
                "Contact":[{}],
                "Notes":[]
            }
```

Fig 8: High level sructure of the file descriptor section

The metadata name and description are human intelligible. If it concerns a metametadata schema, this is the name and description that is used in the schema properties section discussed earlier. The metadata version information is a compound object discussed below and presented in Fig. 9. If the metadata file is not a primary metadata file, then there is a link between the version information provided here and the version information in metadata files that use the schema. Tools can check the consistency between the version identified as used and the current version of the schema.

The contact information discussed below, see Fig 10. provides information about who to contact about the metadata provided in the OIMS-compatible metadata file. If it concerns an underlying metadata-metadata schema, including self-describing metadata, then the developer of the schema or the developing and managing organization should be mentioned in the contact information.

Finally, there is the possibility of adding notes to file descriptors.



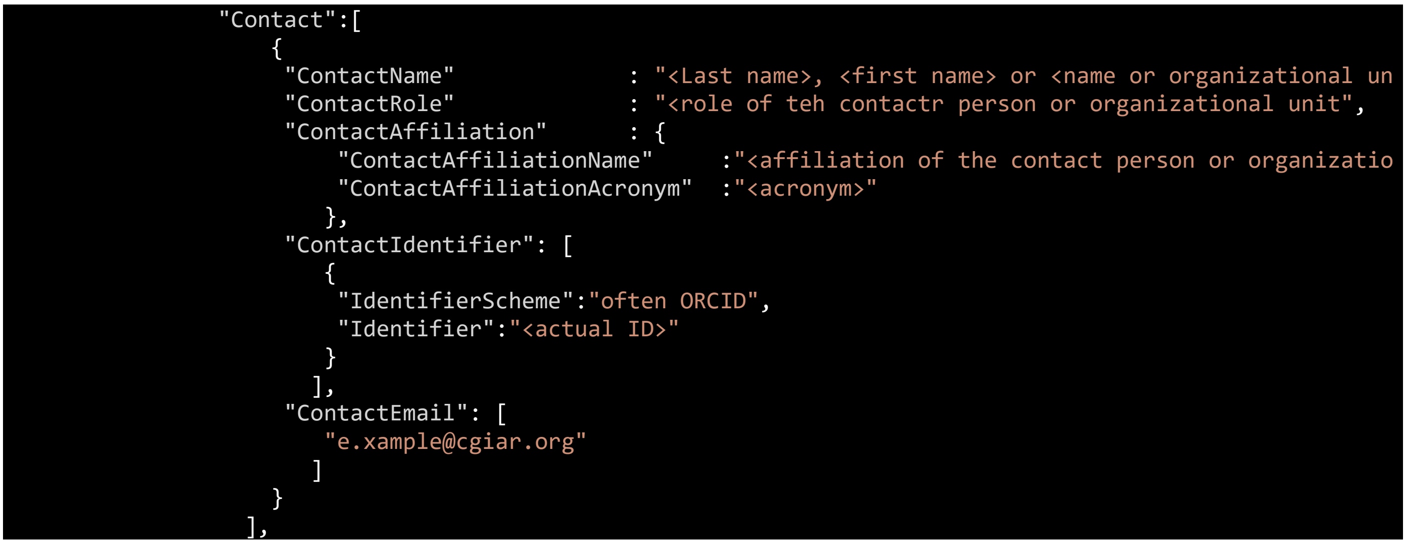
```
                "metadata_version": {
                    "current_version": "<version of the metadata>",
                    "metadata_version_status": "<the status of the metadata: ‘under review’, ‘released’,’
                    "version_date":"<date>”,
                    "metadata_change_log":["text strings for logging changes to the metadata"]
                },
```

Fig 9: Key elements of the metadata version property (excerpt)

The current version of the metadata file is the actual version op[tionally the ”previous_version” can be supplied as well. The status of the version is a controlled vocabulary with the following unique elements:

- development, this means the metadata file is not complete and cannot yet be used.
- testing, this means the metadata file is being tested for consistency
- under review, this means the metadata is being scrutinized for errors that were not captured ion the testing phase
- provisional publication, this means the metadata has been tested and sufficiently reviewed. It is OIMS-compatible but may still need revision.
- released, this means the metadata has been published.

The version date often refers to the release date of the version, but if it is not released yet it generally refers to the start of the phase it is in. The data gives an indication if work is progressing or not. The metadata change log is an optional property where changes in the metadat can be logged, including information ofn differences with previously released versions.



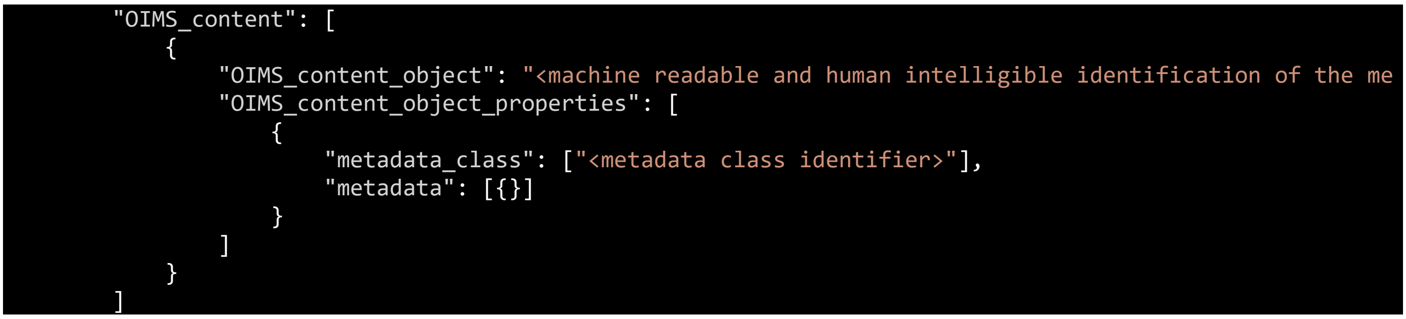
```
"Contact":[
    {
     "ContactName"              : "<Last name>, <first name> or <name or organizational un
     "ContactRole"              : "<role of teh contactr person or organizational unit",
     "ContactAffiliation"       : {
         "ContactAffiliationName"     :"<affiliation of the contact person or organizatio
         "ContactAffiliationAcronym"  :"<acronym>"
        },
     "ContactIdentifier": [
        {
         "IdentifierScheme":"often ORCID",
         "Identifier":"<actual ID>"
        }
       ],
     "ContactEmail": [
        "e.xample@cgiar.org"
       ]
    }
  ],
```

Fig 10: Key elements of the contact property (excerpt)

The contact section is an array of compound objects. There may be multiple contacts both in terms of individuals as well as organizations. Cotacts are identified by names, rol;es affiliations, any contact identifiers and an email address.

OIMS content section

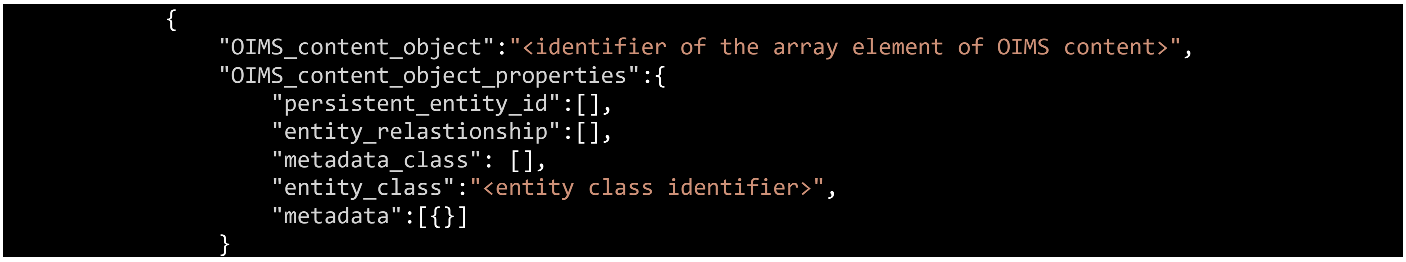
The OIMS content section is an array of compound objects. As mentioned earlier, the content section can contain different types of metadata that are identified by the “OIMS_content_object” identifier.



```
        "OIMS_content": [
            {
                "OIMS_content_object": "<machine readable and human intelligible identification of the me
                "OIMS_content_object_properties": [
                    {
                        "metadata_class": ["<metadata class identifier>"],
                        "metadata": [{}]
                    }
                ]
            }
        ]
```

Fig 11: High level structure of the OIMS content section (excerpt)

The "OIMS_contebnt_properties" contain the actrual metadata as well as aditional information such as the metadata class. For metadata of metadata the metadataclass is "metametadata" for primary metadata this can be descriptive metadata, technical metadata, administrative metadata, structural metadata, governance metadata, ethics metadata, amongst possible others. The actual metadata section is an array of compound objects, although in some cases the array will contain only one element.



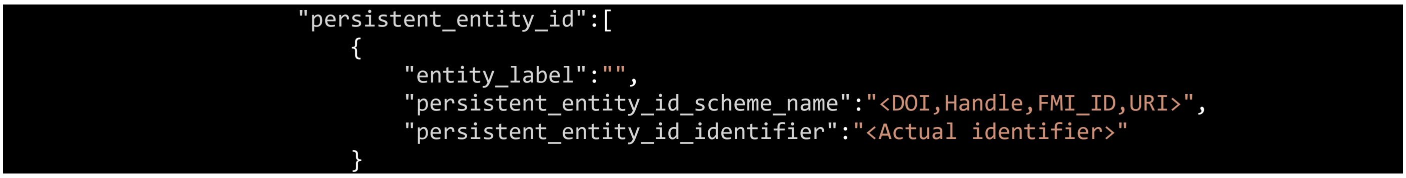
```
            {
                "OIMS_content_object":"<identifier of the array element of OIMS content>",
                "OIMS_content_object_properties":{
                    "persistent_entity_id":[],
                    "entity_relasionship":[],
                    "metadata_class": [],
                    "entity_class":"<entity class identifier>",
                    "metadata":[{}]
                }
```

Fig 12: High level structure of the OIMS content section of primary metadata files

Primary metadata OMS content objects do ***not*** have the metadata_class of "metametadata". Identifying an OIMS content object as structural metadata means that the actual metadata is an array of compound objects where each element in the array refers to a specific final container of data, such as a variable within an aggregate container such as a table.
Another main difference between metametadate objects and primary metadata objects is that primary metadata objects are linked to entities. These entities can be data and metrics assets such as datasets, datfiles and the tables and variables that these files contain. They can also be models, tools or ETL procedures and there subcomponents. They can also be documents, publications an on-line material not covered as data or tools.

OIMS content section: persistent entity identification

These entities as already alluded to in the narrative can be nested. An example is a dataset that is part of a collection and the dataset itself contains multiple files which in turn contain one or more data aggregate containers such as tables as well as the specific containers such as variables. These entities need to be identified with a persistent identifier. For digital objects such as datasets and data files that is not a problem, however the contents are not digitally identified. We therefore encourage organizations using the OIMS framework to set-up there own entity tracking system, ideally available and accessible through an open acces repository. An entity can have more than one persistent identities.



```
                      "persistent_entity_id":[
                          {
                              "entity_label":"",
                              "persistent_entity_id_scheme_name":"<DOI,Handle,FMI_ID,URI>",
                              "persistent_entity_id_identifier":"<Actual identifier>"
                          }
```

Fig 13: Identification of entities

The foresight initiative has opted for the followinbg approach for entity identification where the ”persistent_entity_id_schema_name” is ”FMI_ID” and the actual identifier is constructed as follows, with the first three elements always there and others as needed.

<organizational id>_<asset type id>_<collection or dataset id>_<file id>_<aggregate container id>

The structural metadata of aggregate containers can themselves or actually should provide a unique identifier for the elements if applicable, where an underscore and an integer is added.

A second proprty that is related to the entity identification is the peoperty ”entity_class“, which identifies the type of entity we are dealing with. Entity class is an attribute that has a controlled vocabulary for its elements. Entity classes include:

- Collection or dataset
- Dataset
- Datafile
- Aggregate data container
- Data container
- Model framework
- Model, tool, or ETL procedure
- Module
- Module segment
- Document
- Rules

OIMS content section: persistent entity nesting

For nesting persistent identities such as datasets that contain files, and data files that contain tables with variables, we need a way to tag how these entities are linked. We do that through identifying the relationship between the current entity and other entities. These relationships can be parent-child relationships or sibling relationships.

OIMS content section: actual metadata

The actual metadata is defined by the underlying schema. And is an array of compound objects. To facilitate understanding and searches, there is the property “metadata_class“, which provides one or more metadata class elements that are part of the metadata. These include:

- Descriptive metadata

- Technical metadata
- Administrative metadata
- Ethics metadata
- Provenance metadata
- Preservation or life-cycle metadata
- Structural metadata
- Definitional metadata
- Quality assurance metadata
- Legal metadata

Software and library requirements, and dependencies

The high-level OIMS structure is in JSON format(JSON.org n.d.). JSON (JavaScript Object Notation) is a lightweight data-interchange format. It is easy for humans to read and write. It is easy for machines to parse and generate. It is based on a subset of the JavaScript Programming Language(ECMA 1999). JSON is a text format that is completely language independent but uses conventions that are familiar to programmers of the C-family of languages, including C, C++, C#, Java, JavaScript, Perl, Python, and many others. These properties make JSON an ideal data-interchange language.

JSON is built on two structures:

- A collection of name/value pairs. In various languages, this is realized as an object, record, struct, dictionary, hash table, keyed list, or associative array.
- An ordered list of values. In most languages, this is realized as an array, vector, list, or sequence.

Many programming languages including R and python can handle JSON file formats.

Known issues and bugs

The section of entity management in OIMS is still work in progress.
There are no known bugs.

Recommended improvements

Specific high level structure templates for OIMS-compatible metadata files for specific categories of assets can be useful. The current high-level structure contains only the required elements and the description mentions some underlying components.

Currently no specific user guidelines exist beyond this technical documentation. User guidelines with for instance more explanation of entity classes and metadata classes could be useful.

There may be some additional tweaks to be made to the OIMS structure to align it even better with the implementation requirements (Jacobsen et al. 2020) for making resources FAIR.

Concluding remarks

As we conclude this exploration of the High-Level OIMS Structure, we reflect on the crucial role it plays in advancing metadata management and fostering open data practices. The OIMS framework, with its emphasis on accessibility, interoperability, and clarity, sets a benchmark in the field.

The high-level OIMS structure file in JSON format serves as a starting point for developers of schemas and tools related to the open ontology-based interoperable information asset metadata schema (OIMS). It provides the essential structural elements of any OIMS-compatible metadata schema. We encourage readers to contribute to the ongoing development and refinement of the OIMS structure. We cannot over-emphasize the importance of community feedback, sharing experiences, and collaborative development in improving and expanding the framework. We encourage our readers, the architects and enthusiasts of data management, to engage with this evolving framework actively. Your insights, experiences, and contributions are invaluable in shaping the future of OIMS.

We encourage users to share tools and schemas based on the OIMS structure JSON file on our GitHub repository: https://github.com/ForesightInitiative/OIMS/tree/main by contacting the contact person mentioned.

Looking ahead, the OIMS structure holds immense potential for growth and adaptation. As technology evolves and data management practices advance, OIMS is poised to embrace these changes, continually enhancing its relevance and efficacy.

Further reading

ECMA, 1999. ECMAScript Language Specification. 3rd edition Standard ECMA-262, ECMA, Genbeva, Switzerland.

JSON.org. nd. Introducing JSON. https://www.json.org/json-en.html retrieved November 2023.

Visual Studio Code. 2023. Visual Studio Code Docs. https://code.visualstudio.com/docs#vscode retrieved November 2023.

Installation instructions

The high-level OIMS-compatible metadata file structure in JSON format can be found here: https://raw.githubusercontent.com/ForesightInitiative/OIMS/main/BasicSchemas/OIMS_structure.json

User guidelines

No specific user guidelines exist.

JSON schema validation for OIMS structure

The Open Ontology-Based Interoperable Information Asset Metadata Schema (OIMS) represents a groundbreaking approach in standardizing and organizing metadata across a wide array of information assets including datasets, documents, models, and publications. The primary aim of OIMS is to enhance the accessibility, transparency, and reusability of these assets. The JSON schema documented here is developed to validate the metadata of information assets ensuring their compatibility with OIMS standards.

While JSON is probably the most popular format for exchanging data, JSON Schema is the vocabulary that enables JSON data consistency, validity, and interoperability at scale.

JSON Schema is a powerful tool that enables applications to validate data, ensuring it meets predefined criteria. With JSON Schema, one can make your JSON more readable, enforce data validation, and improve interoperability across different programming languages. It can help you define, document, and validate your data models. JSON schema suffers from the same weaknesses as JSON, namely that it has no built in security protocols and does not have a commenting system. Where OIMS has solved the commenting weakness, this is not the case in JSON Schema.

.

Technical factsheet

Some brief notes on the technical factsheet. The versioning aligns with the versions of OIMS main structure based on the underlying OIMS-base self-describing metadata schema described elsewhere in this report. Therefore a version history and change log is not included as this version can be seen as the first case of the JSON schema to validate metadata files to see if they are OIMS-compatible.

Factsheet

Key	Value
General information	
Name	OIMS_structure.schema.json
Version	2.3
Language	JSON Schema
Contact	Gideon Kruseman <g.kruseman@cgiar.org>
Status	Under review
Latest release date	-
System requirements	
Operating system	any
Software requirements	Various tools exist that can use JSON Schema to validate JSON files
General information	
Key features	Validation of OIMS-compatible metadata files
Key inputs	An OIMS-compatible metadata file
Key outputs	Depending on the tools used errors and exceptions are captured
License info and acknowledgements	
License	Text
Acknowledgements	Text

Functional design

This JSON schema serves as a tool to validate OIMS-compatible metadata files. It is designed to ensure that metadata associated with various information assets conforms to the established OIMS structure and data integrity requirements. The schema aids in identifying any deviations or errors in the metadata, thus ensuring consistent quality and structure across different assets.

Schema structure

Top-Level Validation:

Ensures that the metadata file adheres to the basic structure required by OIMS, including necessary top-level fields and data types.

Field-Level Validation:

Each field in the metadata file is checked for compliance with specific data types, value ranges, mandatory and optional status, and adherence to prescribed formats (like dates, URIs, etc.).

Extensibility and Flexibility:

The schema is designed to be both extensible and flexible, accommodating additional fields and structures as necessitated by evolving metadata requirements while maintaining core OIMS compatibility.

Error Reporting:

In cases of validation failure, the schema provides detailed error reports pinpointing the exact nature and location of the issue within the metadata file.

Use cases

This JSON schema is vital for:

- Metadata Authors: Assists in creating OIMS-compliant metadata files.
- Data Curators and Validators: Used in automated tools for validating metadata against OIMS standards.
- Quality Assurance: Ensures the integrity and standardization of metadata in systems that utilize OIMS.

Technical design and implementation

The schema is implemented in JSON, providing a lightweight, highly readable, and universally compatible format for metadata validation.

It is designed to be used programmatically, capable of being integrated into various data management and publishing tools.

The schema's versioning aligns with the updates and revisions of the OIMS, ensuring ongoing compatibility with the latest standards. The full schema can be found in Annex 2.

The schema is identified by its unique URI hosted on GitHub, ensuring easy accessibility and reference.

It conforms to the JSON Schema 2020-12 (indicated by $schema keyword), a widely adopted standard for describing the structure of JSON data.
At its root, the schema defines an OIMS object, which encapsulates all other metadata properties. It enforces a structured and hierarchical organization of metadata, reflecting the OIMS standards.

Schema structure overview

At its root, the schema defines an OIMS object, which encapsulates all other metadata properties.

It enforces a structured and hierarchical organization of metadata, reflecting the OIMS standards.

OIMS Header: Validates properties like mapping_info, metadata_schema, and file_descriptors, each with its nested structure and specific data types.

Metadata Schema: Focuses on validating the array of schema properties including OIMS_content_object, schema_name, schema_description, and other related fields.

File Descriptors: Ensures the presence and format of essential metadata file descriptors like metadata_name, metadata_version, and contact details.

OIMS Content: Validates the content structure, including OIMS_content_object and associated properties.

The schema distinctly marks required fields in various sections, ensuring that essential metadata components are always present.

Pattern Properties and Definitions:

Utilizes patternProperties to manage special cases, such as leading backslashes used for comments.

The definitions section provides a reusable standard for specific types like comments.

Top-level definitions

$schema and **$id**: Identification of the JSON schema version and the unique URI for the schema.

title and **description**: Brief description and title of the schema.

Properties

OIMS Object: The root object encompassing all metadata properties.

OIMS_header: Contains metadata mapping information, schema properties, and file descriptors.

mapping_info: Array of objects detailing mapping tools used.

metadata_schema: Array of objects describing the metadata schema properties.

file_descriptors: Object detailing metadata file descriptors including version and contact information.

OIMS_content: Array containing the content-specific metadata.

Required fields

Specifies mandatory fields within each section of the metadata, ensuring essential information is always included.

Pattern properties and definitions

Pattern Properties: Handling special formatting cases, like comments.

Definitions: Provides a standardized format for specific types, such as comments.

Software and library requirements, and dependencies

By adopting JSON Schema we open the schema to an expansive range of community-driven tools, libraries, and frameworks across many programming languages. The schema can be integrated into various data management systems, programming environments, or used standalone in JSON validation tools.

It supports automated validation processes, enabling efficient quality control of metadata files.

Known issues and bugs

No known issues or bugs.

We are currently not aware of any performance considerations such as issues arising from processing large files.

Recommended improvements

The schema can be used as a basis for other schemas for validating specific OIMS-compatible metadata. For this purpose, some improvements in the documentation can be foreseen.

Detailed Examples:

Including examples of both valid and invalid metadata files can be very helpful. This provides users with practical cases to reference.

Troubleshooting Section:

Common issues that users might encounter and their solutions can be a valuable addition. This could include common validation errors and tips for resolving them.

Extension Guidelines:

Users are allowed and expected to extend the schema for their specific needs. Therefore, providing guidelines on how to do this without breaking compatibility would be useful.

FAQ Section:
A Frequently Asked Questions section can address common queries, making it easier for users to find quick answers.

Concluding remarks

The provided JSON schema is a comprehensive tool for validating the structural integrity and compliance of metadata files with the OIMS version 2.3.3 standards. It plays a pivotal role in enhancing the quality and consistency of metadata across different information assets.

Users are encouraged to develop their own schemas based on their specific needs.

The JSON schema for validating high-level OIMS structure file in JSON format serves as a starting point for developers of schemas and tools related to the open ontology-based interoperable information asset metadata schema (OIMS). It provides the essential structural elements of any OIMS-compatible metadata schema validation schema using JSON schema. We encourage readers to contribute to the ongoing development and refinement of the OIMS structure JSON schema. We cannot over-emphasize the importance of community feedback, sharing experiences, and collaborative development in improving and expanding the framework. We encourage our readers, the architects and enthusiasts of data management, to engage with this evolving framework actively. Your insights, experiences, and contributions are invaluable in shaping the future of OIMS.

We encourage users to share tools and schemas based on the OIMS structure JSON schema file on our GitHub repository: https://github.com/ForesightInitiative/OIMS/tree/main by contacting the contact person mentioned.

Looking ahead, the OIMS structure holds immense potential for growth and adaptation. As technology evolves and data management practices advance, OIMS is poised to embrace these changes, continually enhancing its relevance and efficacy.

Further reading

More information on JSON schema at: https://json-schema.org/

Self-describing metadata

The self-describing metadata schema is the basis of OIMS. This Chapter assumes that the reader is familiar with the high-level structure of OIMS-compatible metadata files as described in the previous relevant Chapter in this report (see pages 14 to 23).

This Chapter is intended for metadata schema developers that want to create metametadata schemas. Any OIMS-compatible metametadata schema will contain the OIMS structure described earlier. The self-describing metadata schema captures the metadata of the OIMS structure as well as the heading section, using the key concepts of self-describing metadata. The full schema is in Annex 4.

OIMS self-describing metadata version 1 has been formally described and documented (Kruseman 2022). The current documentation of the self-describing metadata supersedes the previous documentation.

Technical factsheet

Factsheet

Key	Value
General information	
Name	OIMS basic self-describing metadata schema
Version	2.3.3
Language	JSON
Contact	Gideon Kruseman <g.kruseman@cgiar.org>
Status	Released
Latest release date	(2.3.2.0 October 25, 2023) 2.3.3 released December 1, 2023
System requirements	
Operating system	none
Software requirements	none
General information	
Key features	Self-describing metadata schema
Key inputs	none
Key outputs	none
License info and acknowledgements	
License	GPL-3.0 license
Acknowledgements	CGIAR Foresight Initiative

Functional design

The self-describing metadata should completely describe itself, so that it can be used to validate itself. If that is the case it can be use for describing high level metametadata.

It should adhere to the high-level OIMS structure for metadata files.

It has to meet the key design principles underlying the original ideas that led to the development of OIMS. These are:

- flexibility
- extenbsibility
- human-intelligibility
- machine-readability

The self-describing metadata schema is the basic background schema for all OIMS-compatible metadata schemas. It formally describes the structure of an OIMS-compatible metadata file as described in the Chapter on the OIMS high-level structure (see also Annex 1).

This implies that the OIMS contents section of the self-describing metadata should cover three areas.

- The OIMS structure
- The OIMS header section
- The core OIMS self-describing metadata that is used for describing itself as well as the OIMS structure and OIMS header

Technical design and implementation: overview

Starting point is the high-level structure of OIMS with its header and contents sections, as was previously highlighted in Fig. 1. The intricate design of OIMS_base.json is visually represented in Fig. 14 (below), which serves as a blueprint for the ensuing detailed discussion.

In the next sections of this Chapter we will delve in more detail into the technical implementation of OIMS_base.json. The detailed visual representation in Fig. 14 acts as a compass for navigating the complex architecture of the OIMS_base.json file. It breaks down the schema into manageable segments, each defined by its functional purpose within the larger framework. This structured approach not only simplifies the understanding of the schema's composition but also aids in the practical application and development of OIMS-compliant metadata files.

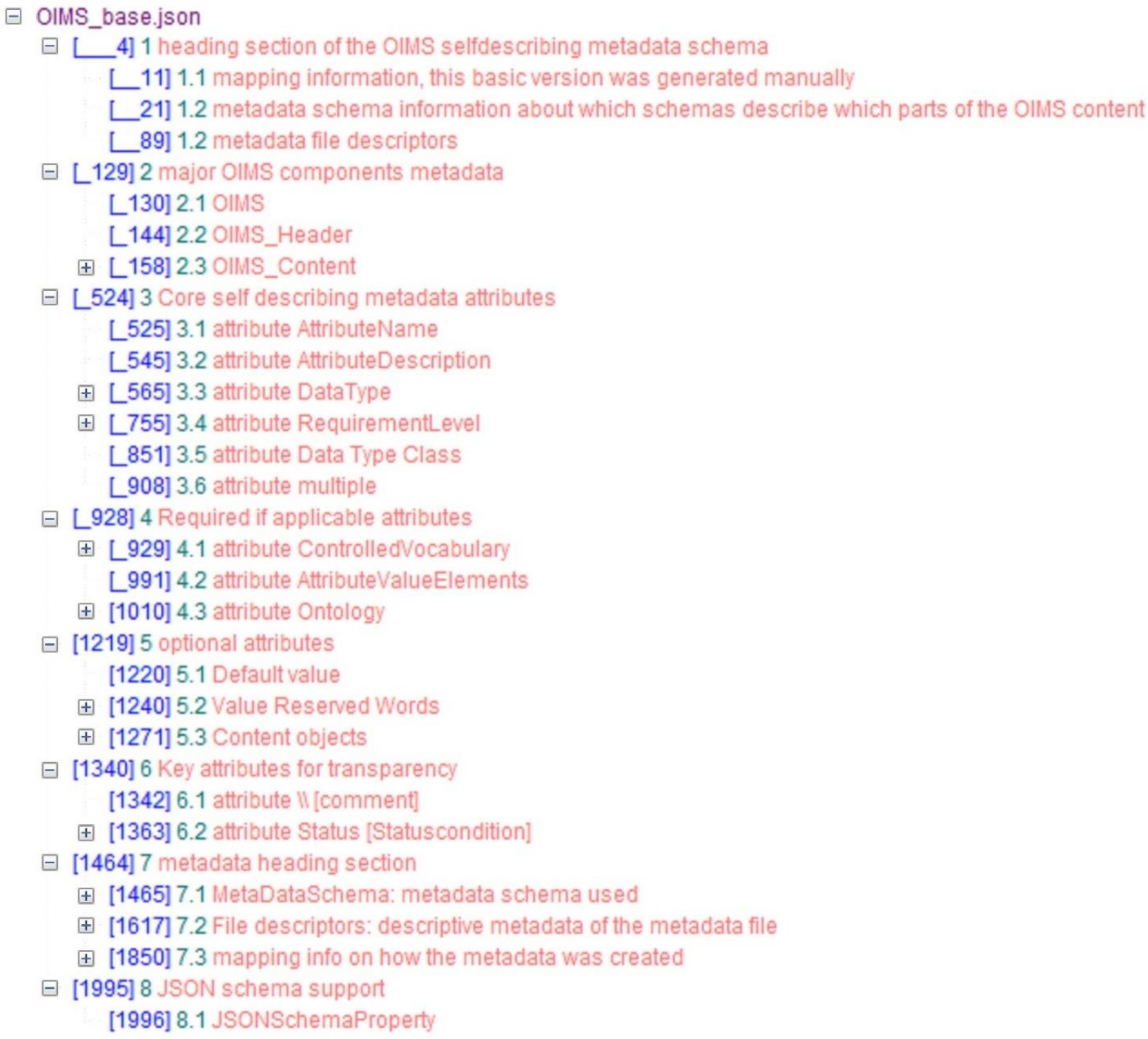
OIMS_header

This subsection delves into the construction of the OIMS_header, which furnishes the essential metadata describing the schema itself. It is tagged with the GTREE identifier "1 heading section of the OIMS self-describing metadata schema". this segment encapsulates mapping information, metadata schema definitions, and file descriptors. Each element within this section is purposefully designed to ensure that the schema is both comprehensive and comprehensible.

OIMS structure

Proceeding to the OIMS_content, we dissect the schema into its foundational components. The first component covers the description of the OIMS structure. It is tagged with the GTREE identifier “2 major OIMS components metadata” covering the overall structure of OIMS, the OIMS_header and the OIMS_content properties. This covers the complete section linked to the OIMS content object “OIMS_Structure_Metadata”.

The GTREE tagging system uses html like tags that can be viewed in GTREE[2]. GTREE is an integrated development environment for GEMPACK, GAMS and R but can handle other programming languages as well.



```
⊟ OIMS_base.json
    ⊟ [___4] 1 heading section of the OIMS selfdescribing metadata schema
          [__11] 1.1 mapping information, this basic version was generated manually
          [__21] 1.2 metadata schema information about which schemas describe which parts of the OIMS content
          [__89] 1.2 metadata file descriptors
    ⊟ [_129] 2 major OIMS components metadata
          [_130] 2.1 OIMS
          [_144] 2.2 OIMS_Header
      ⊞ [_158] 2.3 OIMS_Content
    ⊟ [_524] 3 Core self describing metadata attributes
          [_525] 3.1 attribute AttributeName
          [_545] 3.2 attribute AttributeDescription
      ⊞ [_565] 3.3 attribute DataType
      ⊞ [_755] 3.4 attribute RequirementLevel
          [_851] 3.5 attribute Data Type Class
          [_908] 3.6 attribute multiple
    ⊟ [_928] 4 Required if applicable attributes
      ⊞ [_929] 4.1 attribute ControlledVocabulary
          [_991] 4.2 attribute AttributeValueElements
      ⊞ [1010] 4.3 attribute Ontology
    ⊟ [1219] 5 optional attributes
          [1220] 5.1 Default value
      ⊞ [1240] 5.2 Value Reserved Words
      ⊞ [1271] 5.3 Content objects
    ⊟ [1340] 6 Key attributes for transparency
          [1342] 6.1 attribute \\ [comment]
      ⊞ [1363] 6.2 attribute Status [Statuscondition]
    ⊟ [1464] 7 metadata heading section
      ⊞ [1465] 7.1 MetaDataSchema: metadata schema used
      ⊞ [1617] 7.2 File descriptors: descriptive metadata of the metadata file
      ⊞ [1850] 7.3 mapping info on how the metadata was created
    ⊟ [1995] 8 JSON schema support
          [1996] 8.1 JSONSchemaProperty
```

Fig 14: Structure of the OIMS_base.json file

OIMS core

The next section of metadata in the OIMS self-describing metadata is the OIMS content object called “MetadataMetadata”. We functionally divide this using GTREE tags into sub-sections. The first subsection is tagged

[2] GTREE can be downloaded free of charge from: https://www.medictcare.nl/gamstools/

with the GTREE identifier “3 Core self describing metadata attributes”. This covers the key required metadata attributes responsible in any metametadata file for defining and describing other metadata attributes/properties.

OIMS required if applicable attributes

The next functional sub-section of metadata within the metadata linked to the OIMS content object called “MetadataMetadata” is tagged with the GTREE tag “4. Required, if applicable attributes”. These are context-dependent attributes that complement the core attributes but not always applicable or universally applicable.

OIMS optional attributes

The next functional sub-section of metadata within the metadata linked to the OIMS content object called “MetadataMetadata” is tagged with the GTREE tag “5 optional attributes”. Just as the name indicates these are not strictly necessary attributes but ones that can come in handy. Their inclusion is discretionary, depending on the specific metadata characterization requirements.

OIMS key attributes for transparency

The next functional sub-section of metadata within the metadata linked to the OIMS content object called “MetadataMetadata” is tagged with the GTREE tag “6.Key attributes for transparency”. For transparency purposes OIMS allows for commenting using a special attribute. This section also discusses an attribute on the status of properties.

OIMS metadata headings section

The next section of metadata in the OIMS self-describing metadata is the OIMS content object called “OIMS_Header_Metadata”. We functionally divide this using GTREE tags into sub-sections. The first subsection is tagged with the GTREE tag “7 metadata heading section”. This crucial subsection formally delineates every element within the header section, providing clear definitions and purposes for each.

OIMS JSON schema support

The last functional sub-section of metadata within the metadata linked to the OIMS content object called “OIMS_Header_Metadata” is tagged with the GTREE tag “8 JSON schema support”. It covers JSON schema attributes that have a place within the OIMS header section.

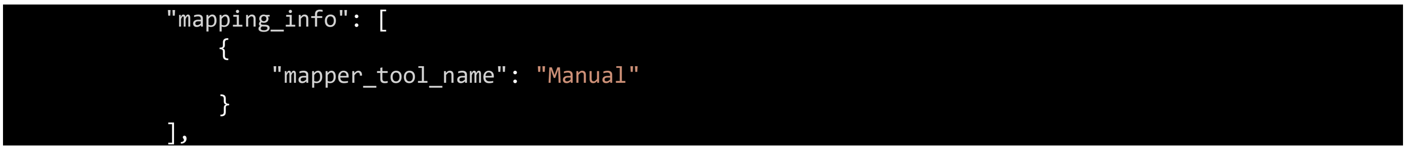
Technical design and implementation: OIMS header

In this section we discuss the OIMS header of the OIMS_base.json file. The OIMS_header is a critical component of the OIMS_base.json file, providing a meta-description of the schema itself. This section is divided into three main properties: mapping_info, metadata_schema, and file_descriptors, each offering unique insights into the structure and intent of the metadata schema.

Each property within the OIMS_header is designed to provide transparency and facilitate understanding of the OIMS schema’s construction. The inclusion of GTREE tags assists in navigating the schema, while the detailed descriptions ensure that users have a clear understanding of each component’s purpose and how they can engage with the schema for their specific needs.

mapping_info

The mapping_info property is key for understanding how the metadata schema is constructed. Tagged with the GTREE identifier “1.1 mapping information,” it indicates that the basic version was generated manually. The mapper_tool_name of "Manual" confirms the hands-on approach taken for the schema’s creation.

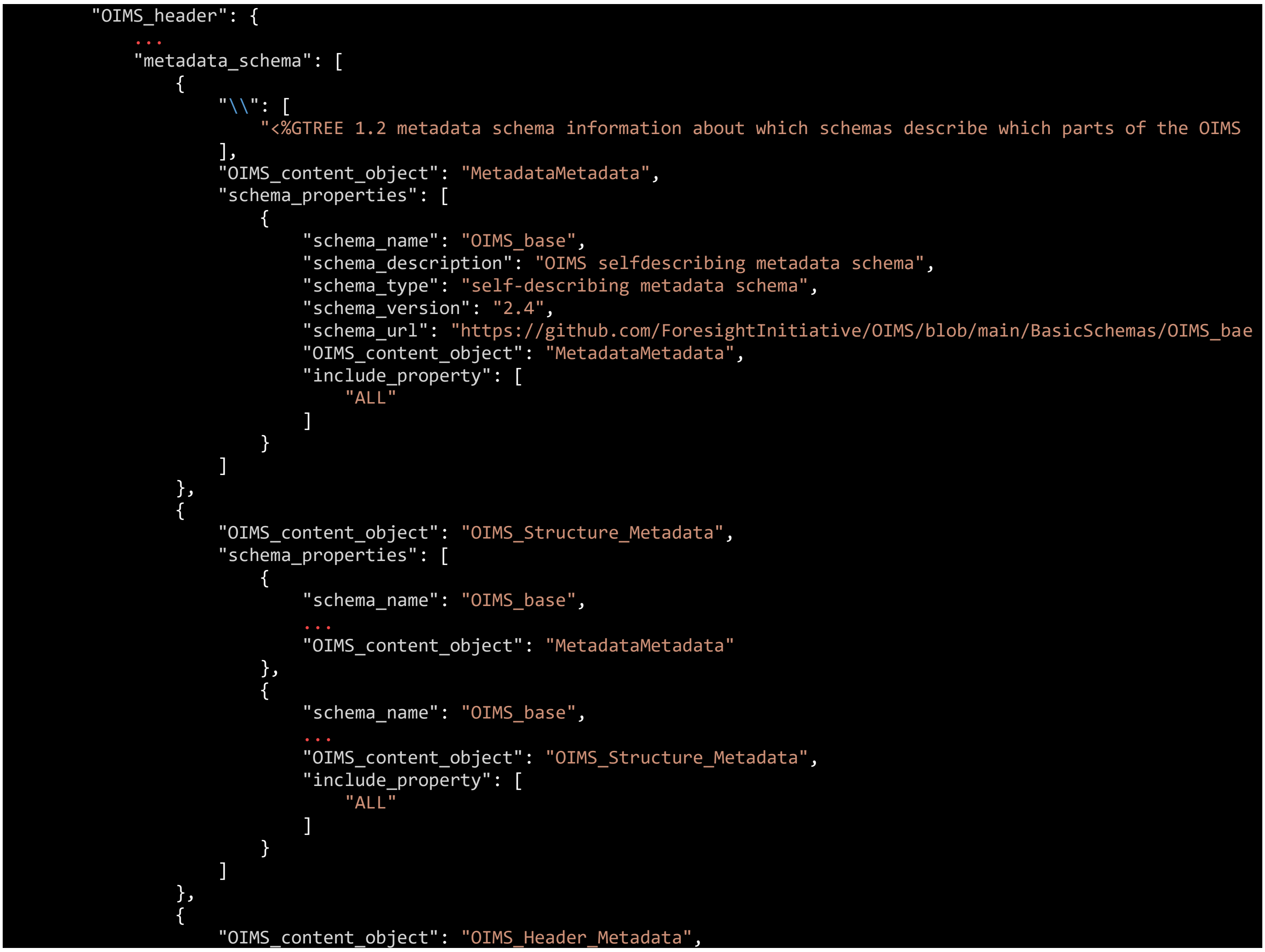


```
            "mapping_info": [
                {
                    "mapper_tool_name": "Manual"
                }
            ],
```

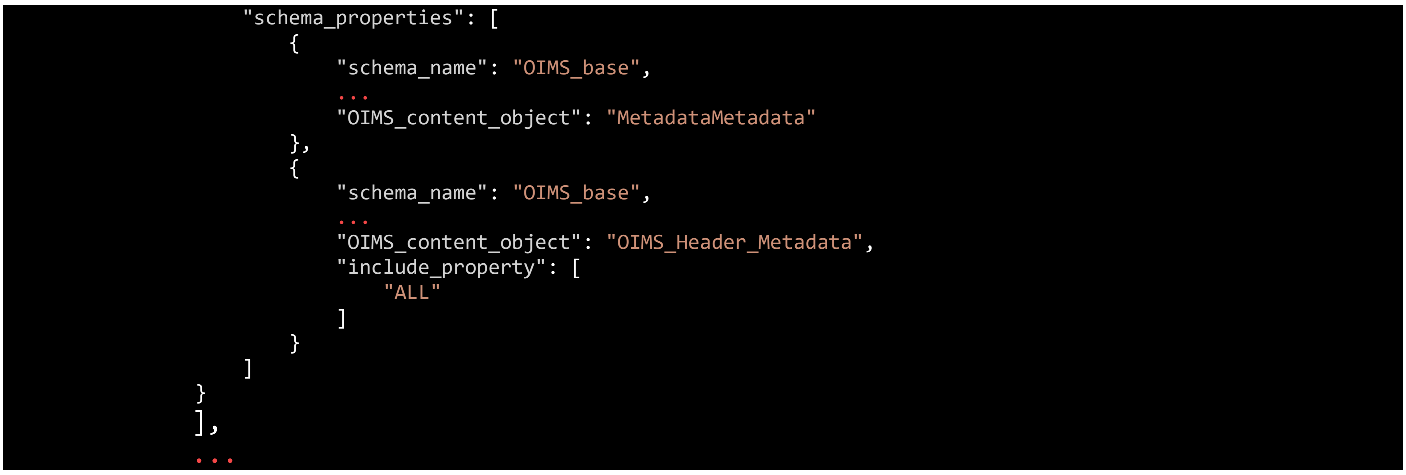
Fig 15: Mapping_info

metadata_schema

The metadata_schema arrays represent a recursive structure that describes the self-describing nature of the OIMS schema. Each array element begins with a GTREE comment, guiding the reader through the metadata schema information. The OIMS_content_object is a reference to the broader OIMS content, and the schema_properties array includes critical information about each schema, such as its name, description, type, version, persistent identifier, and the URL where the schema can be accessed. This recursive reference is essential for maintaining the integrity and traceability of the metadata.



```
        "OIMS_header": {
            ...
            "metadata_schema": [
                {
                    "\\": [
                        "<%GTREE 1.2 metadata schema information about which schemas describe which parts of the OIMS
                    ],
                    "OIMS_content_object": "MetadataMetadata",
                    "schema_properties": [
                        {
                            "schema_name": "OIMS_base",
                            "schema_description": "OIMS selfdescribing metadata schema",
                            "schema_type": "self-describing metadata schema",
                            "schema_version": "2.4",
                            "schema_url": "https://github.com/ForesightInitiative/OIMS/blob/main/BasicSchemas/OIMS_bae
                            "OIMS_content_object": "MetadataMetadata",
                            "include_property": [
                                "ALL"
                            ]
                        }
                    ]
                },
                {
                    "OIMS_content_object": "OIMS_Structure_Metadata",
                    "schema_properties": [
                        {
                            "schema_name": "OIMS_base",
                            ...
                            "OIMS_content_object": "MetadataMetadata"
                        },
                        {
                            "schema_name": "OIMS_base",
                            ...
                            "OIMS_content_object": "OIMS_Structure_Metadata",
                            "include_property": [
                                "ALL"
                            ]
                        }
                    ]
                },
                {
                    "OIMS_content_object": "OIMS_Header_Metadata",
```



```
                    "schema_properties": [
                        {
                            "schema_name": "OIMS_base",
                            ...
                            "OIMS_content_object": "MetadataMetadata"
                        },
                        {
                            "schema_name": "OIMS_base",
                            ...
                            "OIMS_content_object": "OIMS_Header_Metadata",
                            "include_property": [
                                "ALL"
                            ]
                        }
                    ]
                }
                ],
                ...
```

Fig 16: Metadata_schema (excerpt)

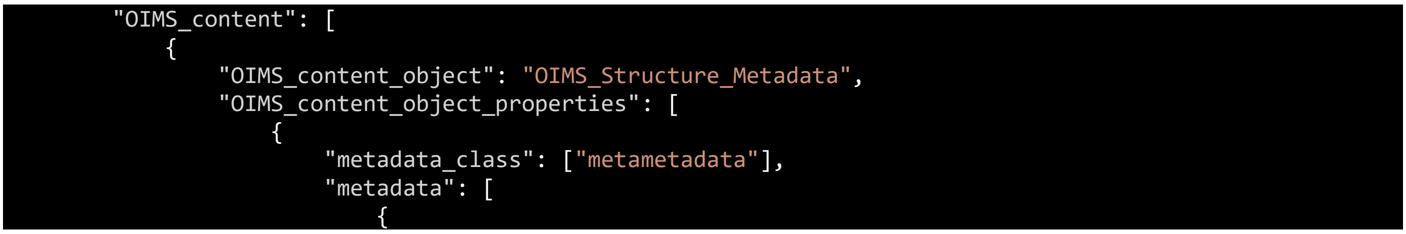
The "OIMS_content_object" proerty is lanked to the sections in the OIMS content identified by the corresponding value.

file_descriptors

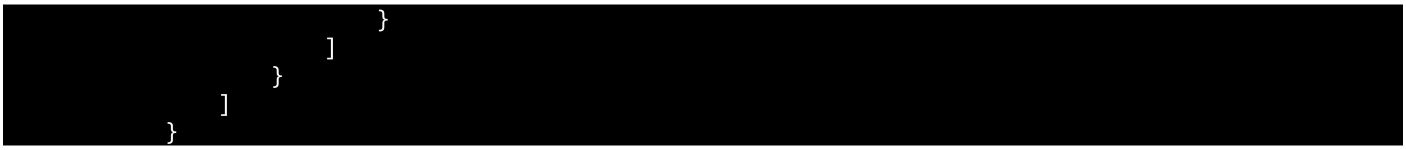
The file_descriptors property contains vital information about the metadata file itself, including its name, description, and version. This section also houses the schema's persistent identifier and contact information for the metadata schema developer, ensuring that users can reach out for support or collaboration. The inclusion of a detailed contact affiliation and identifier, such as an ORCID, underscores the schema's commitment to transparency and attribution.

Technical design and implementation: OIMS structure

We now come to the Content section of the self-describing metadata as mentioned earlier the first block is the metadata pertaining to the formal description of the OIMS structure itself in terms of its own key metadata. The structure of the JSON file can be observed in Fig. 17.



```
        "OIMS_content": [
            {
                "OIMS_content_object": "OIMS_Structure_Metadata",
                "OIMS_content_object_properties": [
                    {
                        "metadata_class": ["metametadata"],
                        "metadata": [
                            {
```

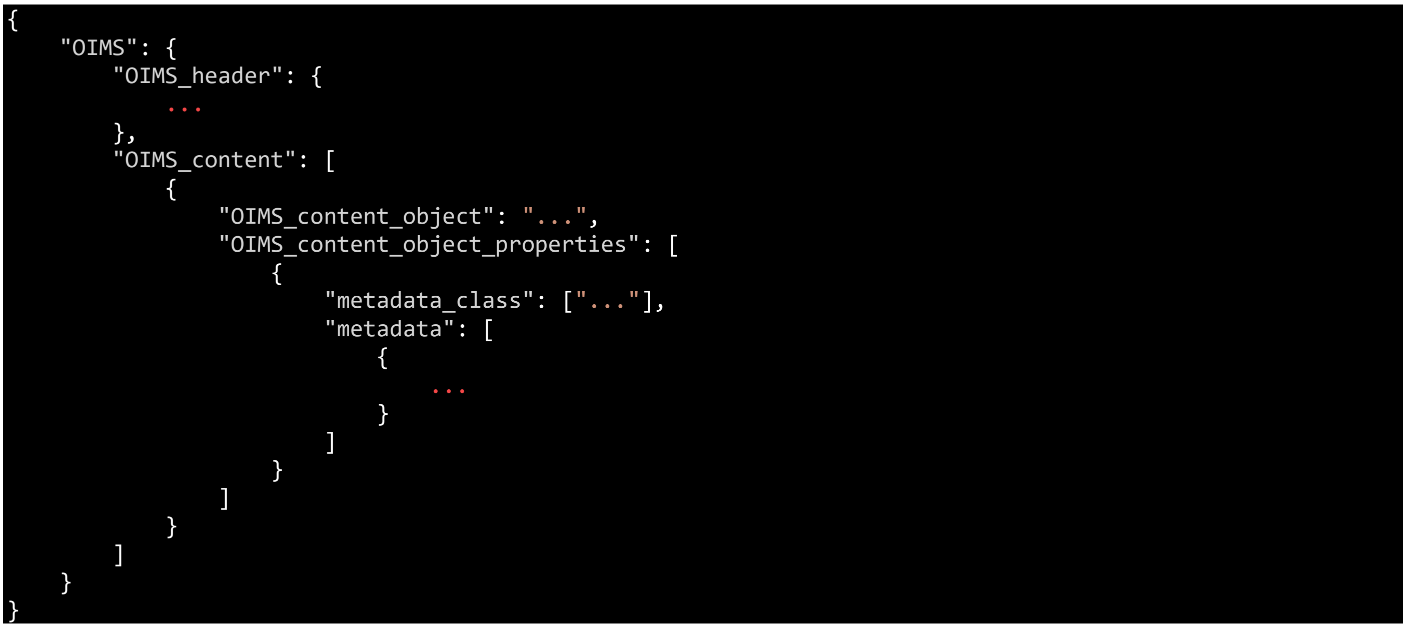


```
                            }
                        ]
                    }
                ]
            }
```

Fig 17: Structure of the OIMS structure metadata section

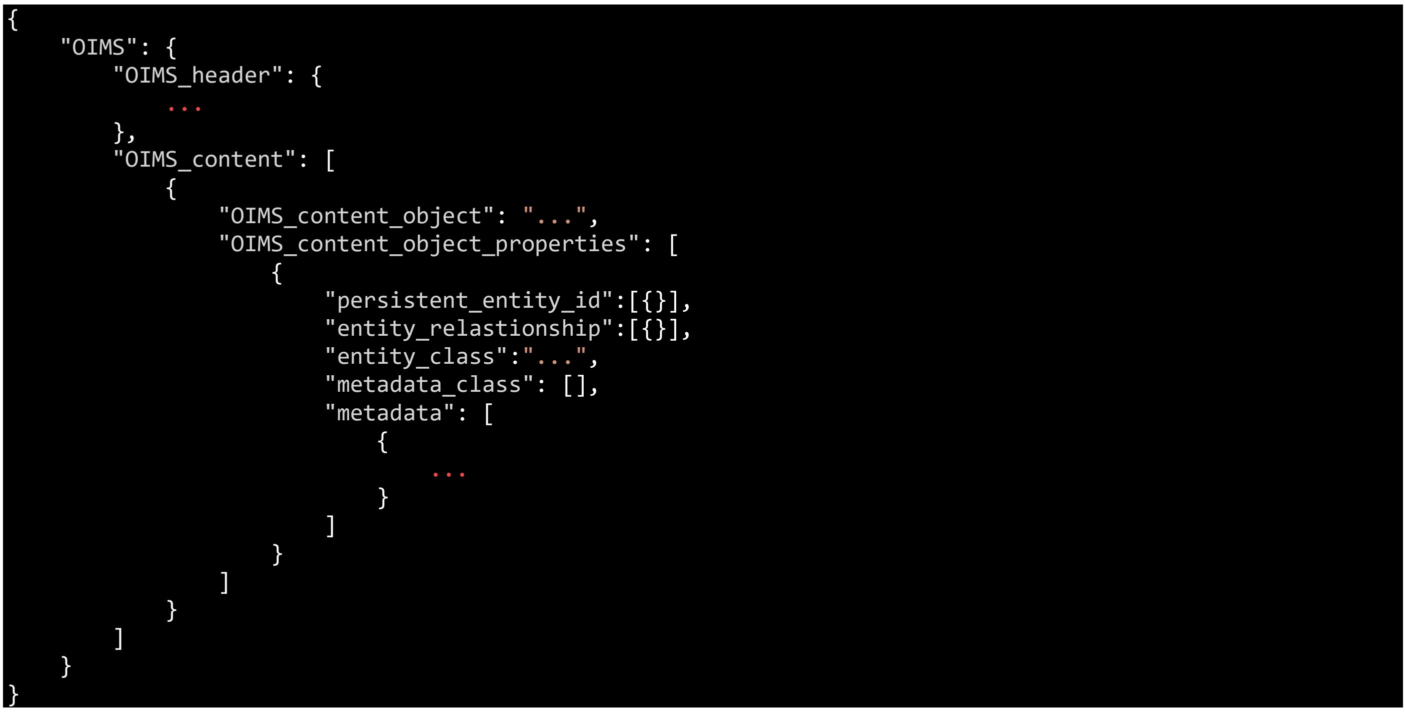
The contents of the section is observed in Fig. 18, which shows the contents using the GTREE tags. The high level components of the OIMS structure as already described in the Chapter on the high-level OIMS structure and summarized in Figs. 18 and 19 for OIMS-compatible metametadata files and OIMS-compatible primary asset metadata files.

In Fig. 19 Only the top-level attributes are shown. The full structure in terms of the GTREE tags that are present in the OIMS base self-describing metadata is presented in Fig 20.



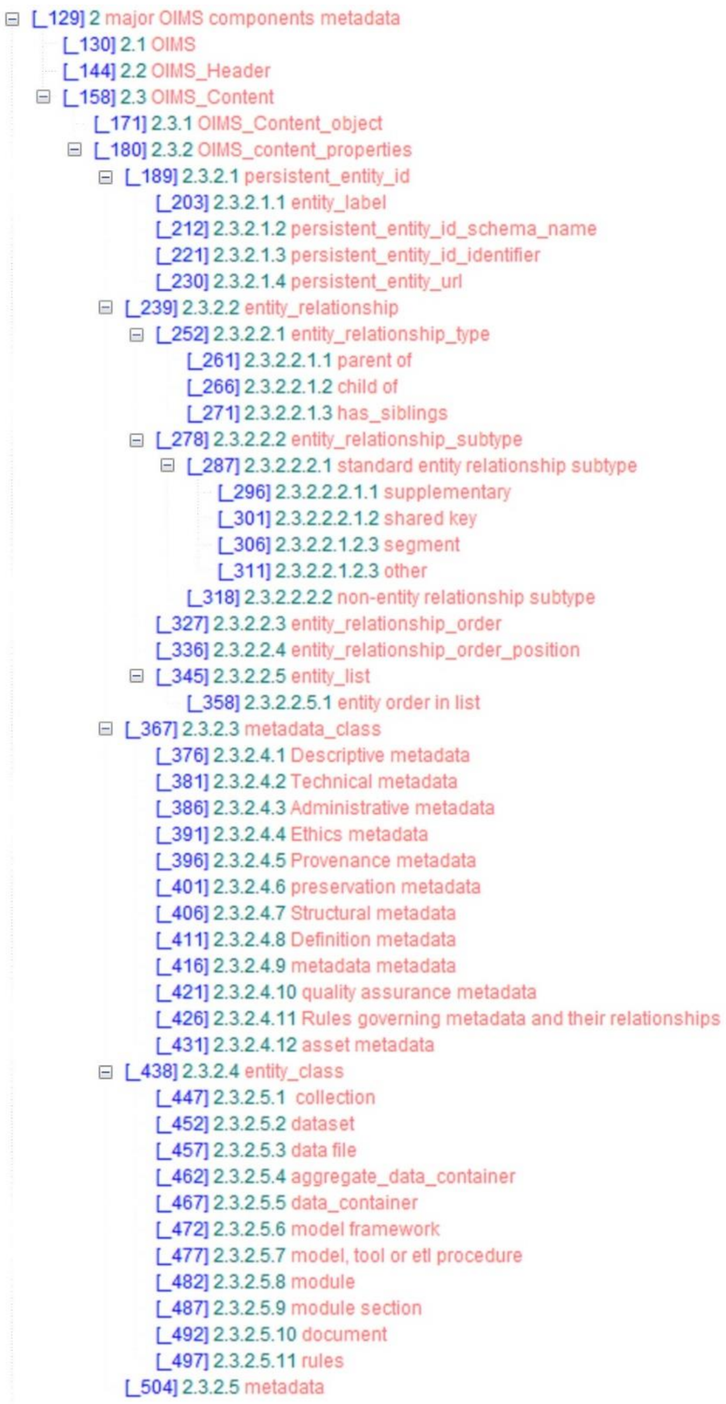
```
{
    "OIMS": {
        "OIMS_header": {
            ...
        },
        "OIMS_content": [
            {
                "OIMS_content_object": "...",
                "OIMS_content_object_properties": [
                    {
                        "metadata_class": ["..."],
                        "metadata": [
                            {
                                ...
                            }
                        ]
                    }
                ]
            }
        ]
    }
}
```

Fig 18: High level structure of an OIMS-compatible metametadata file



```
{
    "OIMS": {
        "OIMS_header": {
            ...
        },
        "OIMS_content": [
            {
                "OIMS_content_object": "...",
                "OIMS_content_object_properties": [
                    {
                        "persistent_entity_id":[{}],
                        "entity_relasionship":[{}],
                        "entity_class":"...",
                        "metadata_class": [],
                        "metadata": [
                            {
                                ...
                            }
                        ]
                    }
                ]
            }
        ]
    }
}
```

Fig 19: High level structure of an OIMS-compatible primary asset metadata file



```
⊟ [_129] 2 major OIMS components metadata
    [_130] 2.1 OIMS
    [_144] 2.2 OIMS_Header
  ⊟ [_158] 2.3 OIMS_Content
      [_171] 2.3.1 OIMS_Content_object
    ⊟ [_180] 2.3.2 OIMS_content_properties
      ⊟ [_189] 2.3.2.1 persistent_entity_id
          [_203] 2.3.2.1.1 entity_label
          [_212] 2.3.2.1.2 persistent_entity_id_schema_name
          [_221] 2.3.2.1.3 persistent_entity_id_identifier
          [_230] 2.3.2.1.4 persistent_entity_url
      ⊟ [_239] 2.3.2.2 entity_relationship
        ⊟ [_252] 2.3.2.2.1 entity_relationship_type
            [_261] 2.3.2.2.1.1 parent of
            [_266] 2.3.2.2.1.2 child of
            [_271] 2.3.2.2.1.3 has_siblings
        ⊟ [_278] 2.3.2.2.2 entity_relationship_subtype
          ⊟ [_287] 2.3.2.2.2.1 standard entity relationship subtype
              [_296] 2.3.2.2.2.1.1 supplementary
              [_301] 2.3.2.2.2.1.2 shared key
              [_306] 2.3.2.2.1.2.3 segment
              [_311] 2.3.2.2.1.2.3 other
            [_318] 2.3.2.2.2.2 non-entity relationship subtype
          [_327] 2.3.2.2.3 entity_relationship_order
          [_336] 2.3.2.2.4 entity_relationship_order_position
        ⊟ [_345] 2.3.2.2.5 entity_list
            [_358] 2.3.2.2.5.1 entity order in list
      ⊟ [_367] 2.3.2.3 metadata_class
          [_376] 2.3.2.4.1 Descriptive metadata
          [_381] 2.3.2.4.2 Technical metadata
          [_386] 2.3.2.4.3 Administrative metadata
          [_391] 2.3.2.4.4 Ethics metadata
          [_396] 2.3.2.4.5 Provenance metadata
          [_401] 2.3.2.4.6 preservation metadata
          [_406] 2.3.2.4.7 Structural metadata
          [_411] 2.3.2.4.8 Definition metadata
          [_416] 2.3.2.4.9 metadata metadata
          [_421] 2.3.2.4.10 quality assurance metadata
          [_426] 2.3.2.4.11 Rules governing metadata and their relationships
          [_431] 2.3.2.4.12 asset metadata
      ⊟ [_438] 2.3.2.4 entity_class
          [_447] 2.3.2.5.1  collection
          [_452] 2.3.2.5.2 dataset
          [_457] 2.3.2.5.3 data file
          [_462] 2.3.2.5.4 aggregate_data_container
          [_467] 2.3.2.5.5 data_container
          [_472] 2.3.2.5.6 model framework
          [_477] 2.3.2.5.7 model, tool or etl procedure
          [_482] 2.3.2.5.8 module
          [_487] 2.3.2.5.9 module section
          [_492] 2.3.2.5.10 document
          [_497] 2.3.2.5.11 rules
        [_504] 2.3.2.5 metadata
```

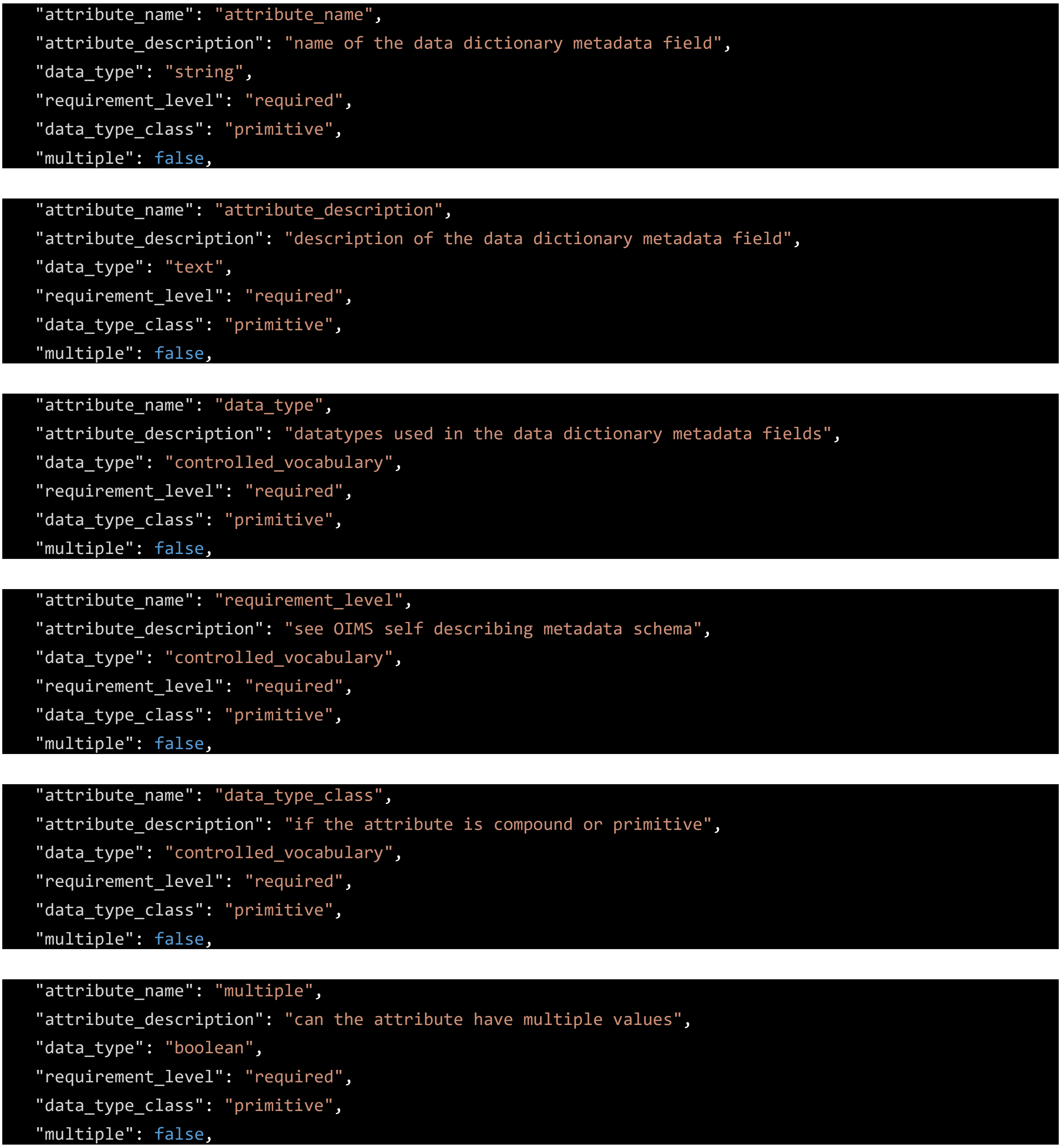
Fig 20: Contents of the OIMS structure metadata section

Technical design and implementation: OIMS core attributes

The core attributes of OIMS base self-describing metadata are the attributes that one would expect to see in any OIMS-compatble metametadata file that describes the metadata of metadata. The core attriobutes consist of:

- Attribute name
- Attribute description
- Data type class

- Data type
- Requirement level
- Multiple



```
"attribute_name": "attribute_name",
"attribute_description": "name of the data dictionary metadata field",
"data_type": "string",
"requirement_level": "required",
"data_type_class": "primitive",
"multiple": false,
```

```
"attribute_name": "attribute_description",
"attribute_description": "description of the data dictionary metadata field",
"data_type": "text",
"requirement_level": "required",
"data_type_class": "primitive",
"multiple": false,
```

```
"attribute_name": "data_type",
"attribute_description": "datatypes used in the data dictionary metadata fields",
"data_type": "controlled_vocabulary",
"requirement_level": "required",
"data_type_class": "primitive",
"multiple": false,
```

```
"attribute_name": "requirement_level",
"attribute_description": "see OIMS self describing metadata schema",
"data_type": "controlled_vocabulary",
"requirement_level": "required",
"data_type_class": "primitive",
"multiple": false,
```

```
"attribute_name": "data_type_class",
"attribute_description": "if the attribute is compound or primitive",
"data_type": "controlled_vocabulary",
"requirement_level": "required",
"data_type_class": "primitive",
"multiple": false,
```

```
"attribute_name": "multiple",
"attribute_description": "can the attribute have multiple values",
"data_type": "boolean",
"requirement_level": "required",
"data_type_class": "primitive",
"multiple": false,
```

Fig 21` Excerpts from OIMS_base.json showing the core attributes in terms of themselves

Note that these core attributes are considered required so any metametadata file that uses the OIMS base metadata schema as part of its underlying schema will contain these elements. The data type ”controlled-vocabulary” refers to properties with values that are items in a controlled vocabulary, enumeration, factor (In R jargon) or list. The controlled vocabulary will be discussed in the next section. The attribute ”multiple” refers to the case where a property can have multiple values. A practical example is found in the next section regarding the attribute value elements.

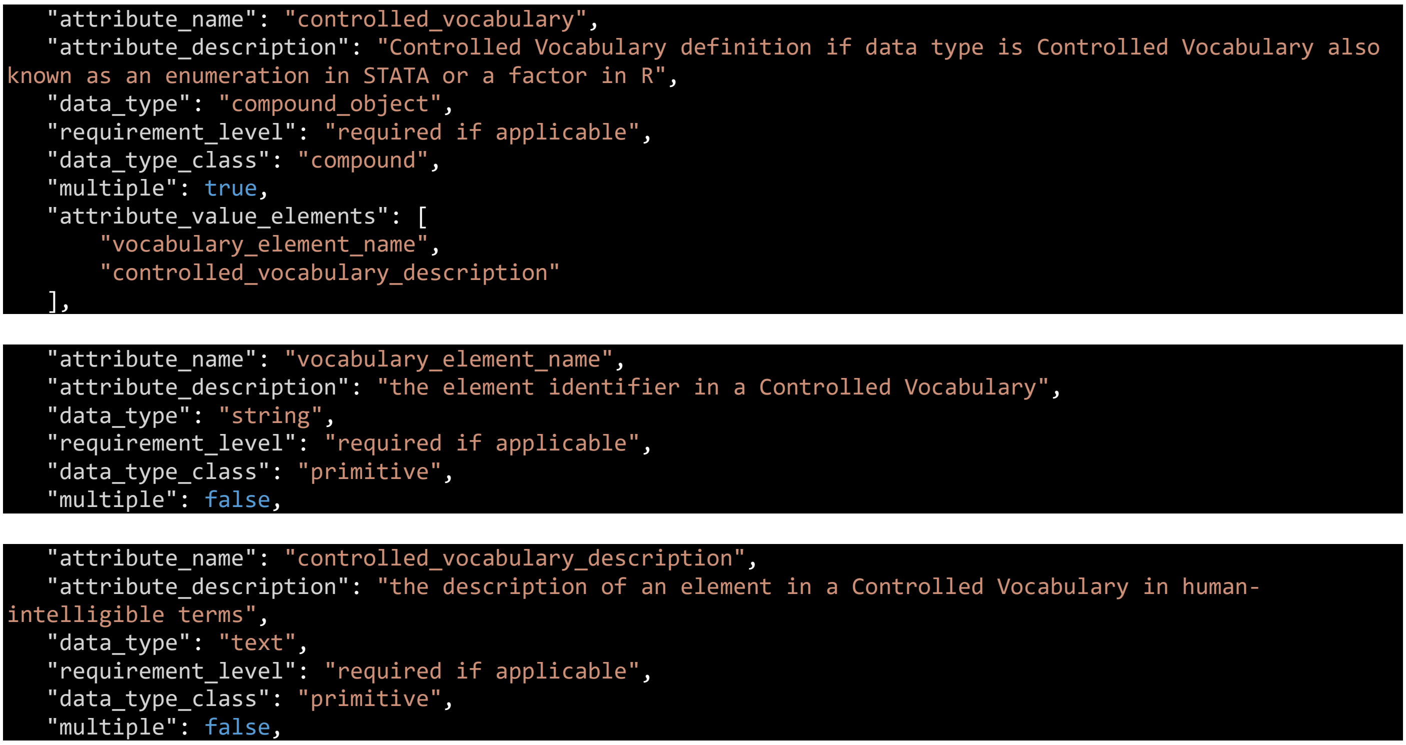
Technical design and implementation: OIMS context specific required attributes

There are some context specific attributes that are required if applicable. These are the following attributes:

- Controlled vocabulary term definitions if the data type is controlled vocabulary;
- Attribute value elements. This refers to a list of attributes that are expected to be found if an attribute is a compound object;
- Ontology

Controlled vocabulary

The attribute ”controlled_vocabulary” is a compound object that captures the controlled vocabulary elements and their descriptions. It is a required property when the data type of an attribute is a controlled vocabulary, factor or list. See also Fig. 22 below.



```
   "attribute_name": "controlled_vocabulary",
   "attribute_description": "Controlled Vocabulary definition if data type is Controlled Vocabulary also known as an enumeration in STATA or a factor in R",
   "data_type": "compound_object",
   "requirement_level": "required if applicable",
   "data_type_class": "compound",
   "multiple": true,
   "attribute_value_elements": [
       "vocabulary_element_name",
       "controlled_vocabulary_description"
   ],
```

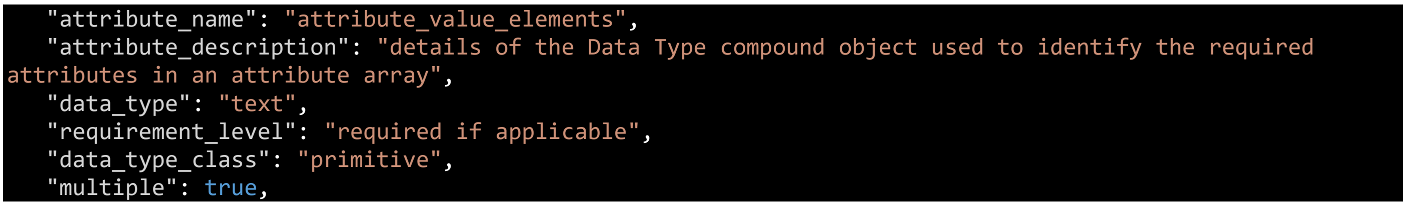
```
   "attribute_name": "vocabulary_element_name",
   "attribute_description": "the element identifier in a Controlled Vocabulary",
   "data_type": "string",
   "requirement_level": "required if applicable",
   "data_type_class": "primitive",
   "multiple": false,
```

```
   "attribute_name": "controlled_vocabulary_description",
   "attribute_description": "the description of an element in a Controlled Vocabulary in human-intelligible terms",
   "data_type": "text",
   "requirement_level": "required if applicable",
   "data_type_class": "primitive",
   "multiple": false,
```

Fig 22: Excerpts from OIMS_base.json showing the context specific required attribute controlled vocabulary in terms of the core metadata and the context specific required metadata

Attribute value elements

The attribute "attribute_value_elements" refers to a list of attributes that are expected to be found if an attribute is a compound object; An example was provided in Fig 22. The metadata of yje attribute can be found in Fig. 23.

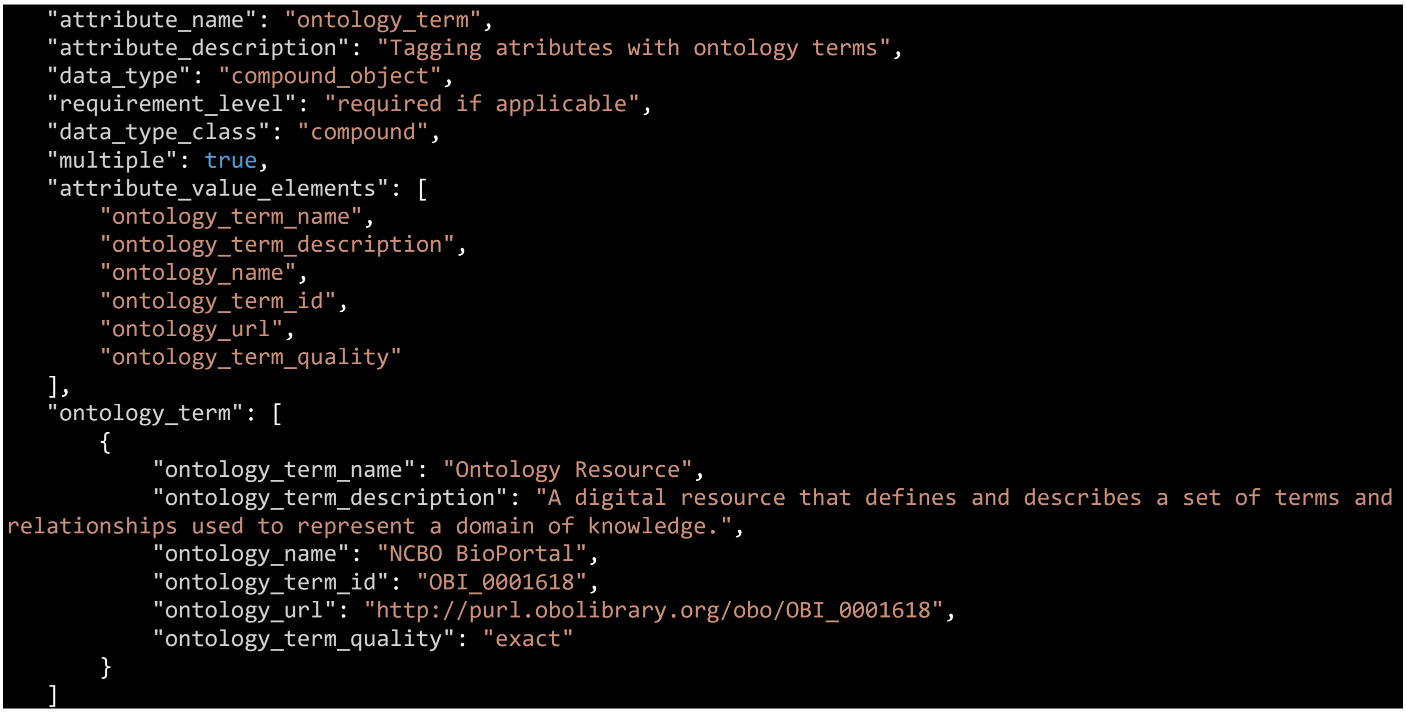


```
   "attribute_name": "attribute_value_elements",
   "attribute_description": "details of the Data Type compound object used to identify the required
attributes in an attribute array",
   "data_type": "text",
   "requirement_level": "required if applicable",
   "data_type_class": "primitive",
   "multiple": true,
```

Fig 23: Excerpts from OIMS_base.json showing the context specific required attribute attribute value elements in terms of the core metadata

Ontology terms

Ontology terms are an essential part of the ontology- ased nature of OIMS. However, OIMS is ontology agnostic so it is imperative to identify not only the ontology term but alsao the ontology of whuich it is a part. We will break down the term into its components. The atrribute "onology_term" is a compound object so it has a list of attribute value elements. It also has an ontology term attached to it, see Fig 24. The attribute value elements are an example of a poprty that can have multiple values. A compound object does not have a simple value, but consists of an array of properties. The properties are mentioned in the list of attribute value elements.



```
   "attribute_name": "ontology_term",
   "attribute_description": "Tagging atributes with ontology terms",
   "data_type": "compound_object",
   "requirement_level": "required if applicable",
   "data_type_class": "compound",
   "multiple": true,
   "attribute_value_elements": [
       "ontology_term_name",
       "ontology_term_description",
       "ontology_name",
       "ontology_term_id",
       "ontology_url",
       "ontology_term_quality"
   ],
   "ontology_term": [
       {
           "ontology_term_name": "Ontology Resource",
           "ontology_term_description": "A digital resource that defines and describes a set of terms and
relationships used to represent a domain of knowledge.",
           "ontology_name": "NCBO BioPortal",
           "ontology_term_id": "OBI_0001618",
           "ontology_url": "http://purl.obolibrary.org/obo/OBI_0001618",
           "ontology_term_quality": "exact"
       }
   ]
```

Fig 24: Excerpt from OIMS_base.json showing the context specific required attribute ontology term in terms of the core metadata and the context specific required metadata

Similarly for the context specific required attributes ontology term name, ontolgy term description, ontology name, ontology term identifier and the ontology term url, these can be described using the core metametadata attributes oj the self-describing metadata schemaand the context specific metadata element related to ontology terms. An excerpt from the self-describing metadata can be found in Fig 25.

```
    "attribute_name": "ontology_term_name",
    "attribute_description": "Term in an ontology that describes the relevant attribute value",
    "requirement_level": "recommended if applicable",
    "data_type_class": "primitive",
    "multiple": false,
    "data_type": "string",
    "ontology_term": [
        {
            "ontology_term_name": "Ontology Term",
            "ontology_term_description": "A term in an ontology that represents a concept or entity in a
particular domain.",
            "ontology_name": "NCBO BioPortal",
            "ontology_term_id": "OBI_0001616",
            "ontology_url": "http://purl.obolibrary.org/obo/OBI_0001616",
            "ontology_term_quality": "exact"
        }
    ]
```

```
    "attribute_name": "ontology_term_description",
    "attribute_description": "Description of the ontology term",
    "requirement_level": "recommended if applicable",
    "data_type_class": "primitive",
    "multiple": false,
    "data_type": "string"
```

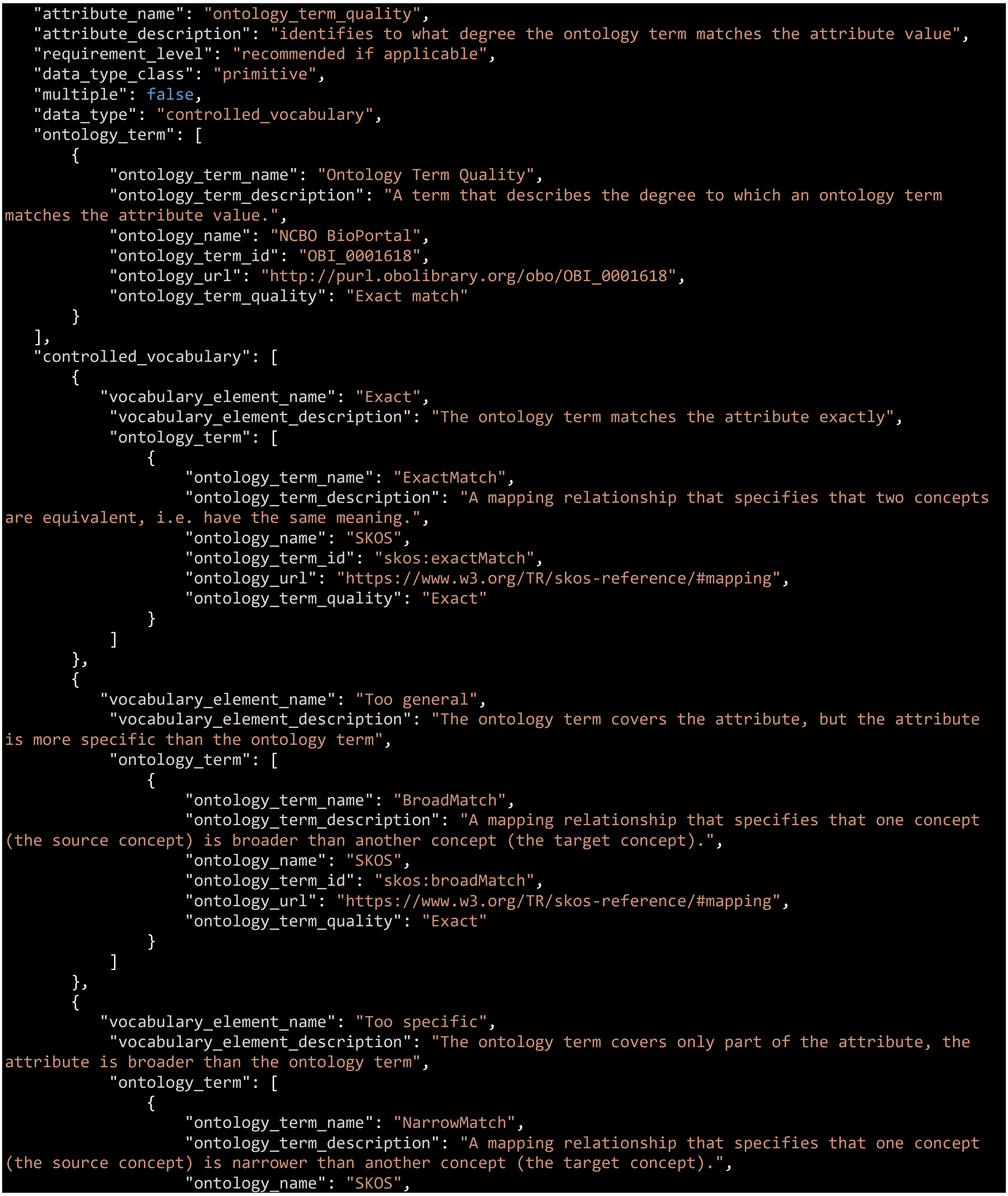
```
    "attribute_name": "ontology_name",
    "attribute_description": "The name of the ontology from which we take the ontology term",
    "requirement_level": "required if applicable",
    "data_type_class": "primitive",
    "multiple": false,
    "data_type": "string",
    "ontology_term": [
        {
            "ontology_term_name": "Ontology Name",
            "ontology_term_description": "The name of an ontology or controlled vocabulary that provides a
set of terms and relationships for describing entities in a specific domain.",
            "ontology_name": "NCBO BioPortal",
            "ontology_term_id": "OBI_0001614",
            "ontology_url": "http://purl.obolibrary.org/obo/OBI_0001614",
            "ontology_term_quality": "exact"
        }
    ]
```

```
    "attribute_name": "ontology_term_id",
    "attribute_description": "the identifier for the ontology term in the specified ontology",
    "requirement_level": "required if applicable",
    "data_type_class": "primitive",
    "multiple": false,
    "data_type": "string"
```

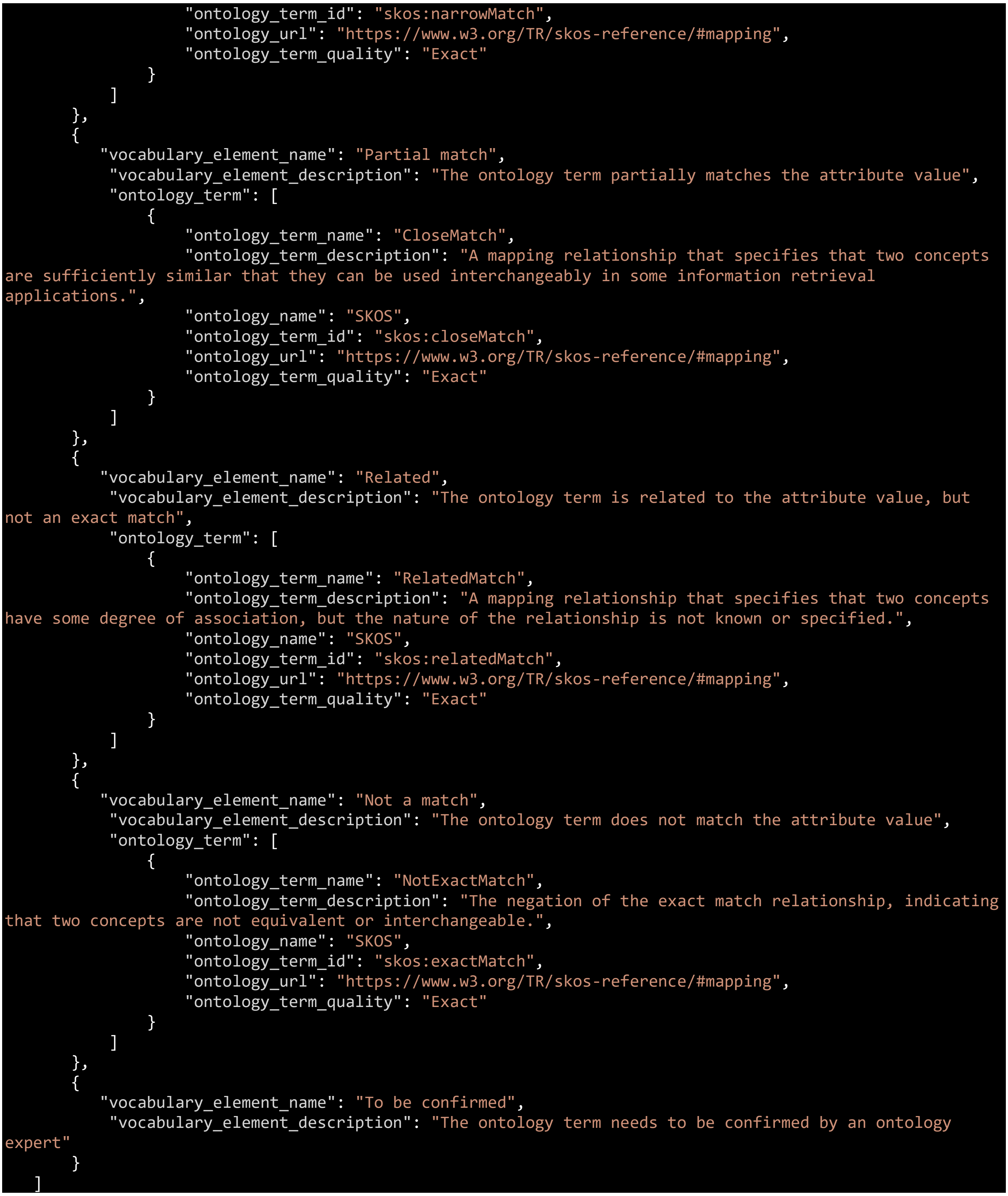
```
    "attribute_name": "ontology_url",
    "attribute_description": "persistent URL where the ontology term can be found",
    "requirement_level": "required if applicable",
    "data_type_class": "primitive",
    "multiple": false,
    "data_type": "uri"
```

Fig 25: Excerpts from OIMS_base.json showing the context specific required attributes ontology term name, ontolgy term description, ontology name, ontology term identifier and the ontology term url, in terms of the core metadata and the context specific required metadata

The last attribute that is part of the ontology term compound object is the ontology term quality property. This is a controlled vocabulary with controlled vocabulary terms as described earlier in this section. We reproduce the excerpt from the self-deswcribing metadata here because it demonstares that the concept of an ontology term applies not only to the metadata attributes, but also to the controlled vocabulary terms. Thsi can be o=bserved in Fig 26.



```
   "attribute_name": "ontology_term_quality",
   "attribute_description": "identifies to what degree the ontology term matches the attribute value",
   "requirement_level": "recommended if applicable",
   "data_type_class": "primitive",
   "multiple": false,
   "data_type": "controlled_vocabulary",
   "ontology_term": [
       {
           "ontology_term_name": "Ontology Term Quality",
           "ontology_term_description": "A term that describes the degree to which an ontology term
matches the attribute value.",
           "ontology_name": "NCBO BioPortal",
           "ontology_term_id": "OBI_0001618",
           "ontology_url": "http://purl.obolibrary.org/obo/OBI_0001618",
           "ontology_term_quality": "Exact match"
       }
   ],
   "controlled_vocabulary": [
       {
          "vocabulary_element_name": "Exact",
           "vocabulary_element_description": "The ontology term matches the attribute exactly",
           "ontology_term": [
               {
                   "ontology_term_name": "ExactMatch",
                   "ontology_term_description": "A mapping relationship that specifies that two concepts
are equivalent, i.e. have the same meaning.",
                   "ontology_name": "SKOS",
                   "ontology_term_id": "skos:exactMatch",
                   "ontology_url": "https://www.w3.org/TR/skos-reference/#mapping",
                   "ontology_term_quality": "Exact"
               }
           ]
       },
       {
          "vocabulary_element_name": "Too general",
           "vocabulary_element_description": "The ontology term covers the attribute, but the attribute
is more specific than the ontology term",
           "ontology_term": [
               {
                   "ontology_term_name": "BroadMatch",
                   "ontology_term_description": "A mapping relationship that specifies that one concept
(the source concept) is broader than another concept (the target concept).",
                   "ontology_name": "SKOS",
                   "ontology_term_id": "skos:broadMatch",
                   "ontology_url": "https://www.w3.org/TR/skos-reference/#mapping",
                   "ontology_term_quality": "Exact"
               }
           ]
       },
       {
          "vocabulary_element_name": "Too specific",
           "vocabulary_element_description": "The ontology term covers only part of the attribute, the
attribute is broader than the ontology term",
           "ontology_term": [
               {
                   "ontology_term_name": "NarrowMatch",
                   "ontology_term_description": "A mapping relationship that specifies that one concept
(the source concept) is narrower than another concept (the target concept).",
                   "ontology_name": "SKOS",
```



```
                   "ontology_term_id": "skos:narrowMatch",
                   "ontology_url": "https://www.w3.org/TR/skos-reference/#mapping",
                   "ontology_term_quality": "Exact"
               }
           ]
       },
       {
          "vocabulary_element_name": "Partial match",
           "vocabulary_element_description": "The ontology term partially matches the attribute value",
           "ontology_term": [
               {
                   "ontology_term_name": "CloseMatch",
                   "ontology_term_description": "A mapping relationship that specifies that two concepts
are sufficiently similar that they can be used interchangeably in some information retrieval
applications.",
                   "ontology_name": "SKOS",
                   "ontology_term_id": "skos:closeMatch",
                   "ontology_url": "https://www.w3.org/TR/skos-reference/#mapping",
                   "ontology_term_quality": "Exact"
               }
           ]
       },
       {
          "vocabulary_element_name": "Related",
           "vocabulary_element_description": "The ontology term is related to the attribute value, but
not an exact match",
           "ontology_term": [
               {
                   "ontology_term_name": "RelatedMatch",
                   "ontology_term_description": "A mapping relationship that specifies that two concepts
have some degree of association, but the nature of the relationship is not known or specified.",
                   "ontology_name": "SKOS",
                   "ontology_term_id": "skos:relatedMatch",
                   "ontology_url": "https://www.w3.org/TR/skos-reference/#mapping",
                   "ontology_term_quality": "Exact"
               }
           ]
       },
       {
          "vocabulary_element_name": "Not a match",
           "vocabulary_element_description": "The ontology term does not match the attribute value",
           "ontology_term": [
               {
                   "ontology_term_name": "NotExactMatch",
                   "ontology_term_description": "The negation of the exact match relationship, indicating
that two concepts are not equivalent or interchangeable.",
                   "ontology_name": "SKOS",
                   "ontology_term_id": "skos:exactMatch",
                   "ontology_url": "https://www.w3.org/TR/skos-reference/#mapping",
                   "ontology_term_quality": "Exact"
               }
           ]
       },
       {
          "vocabulary_element_name": "To be confirmed",
           "vocabulary_element_description": "The ontology term needs to be confirmed by an ontology
expert"
       }
   ]
```

Fig 26: Excerpts from OIMS_base.json showing the context specific required attribute ontology term quality, in terms of the core metadata and the context specific required metadata related to ontology terms and controlled vocabularies.

Technical design and implementation: OIMS transparency attributes

The optional attributes that are part of the base OIMS can be sub-divided into two categories. The first category are optional attributes that play a key role in enhancing the transparency of OIMS-compatible metadata schemas. The second are optional attributes that can enhance the usability of OIMS-compatible metadata schemas.

We first look at the key transparency attributes.

Comments

A key drawback of JSON is its lack of commenting capabilities. This has been solved in OIMS by introducing a comment attribute that can be used throughout OIMS-compatible metadata files in JSON format. It is an attribute ”\\” and consists of an array of strings. See Fig 27 for the formal derscription in the self-describing metadata. Note that we have included the GTREE tags in comments as an example of how tyhe comment capability of OIMS can be used.

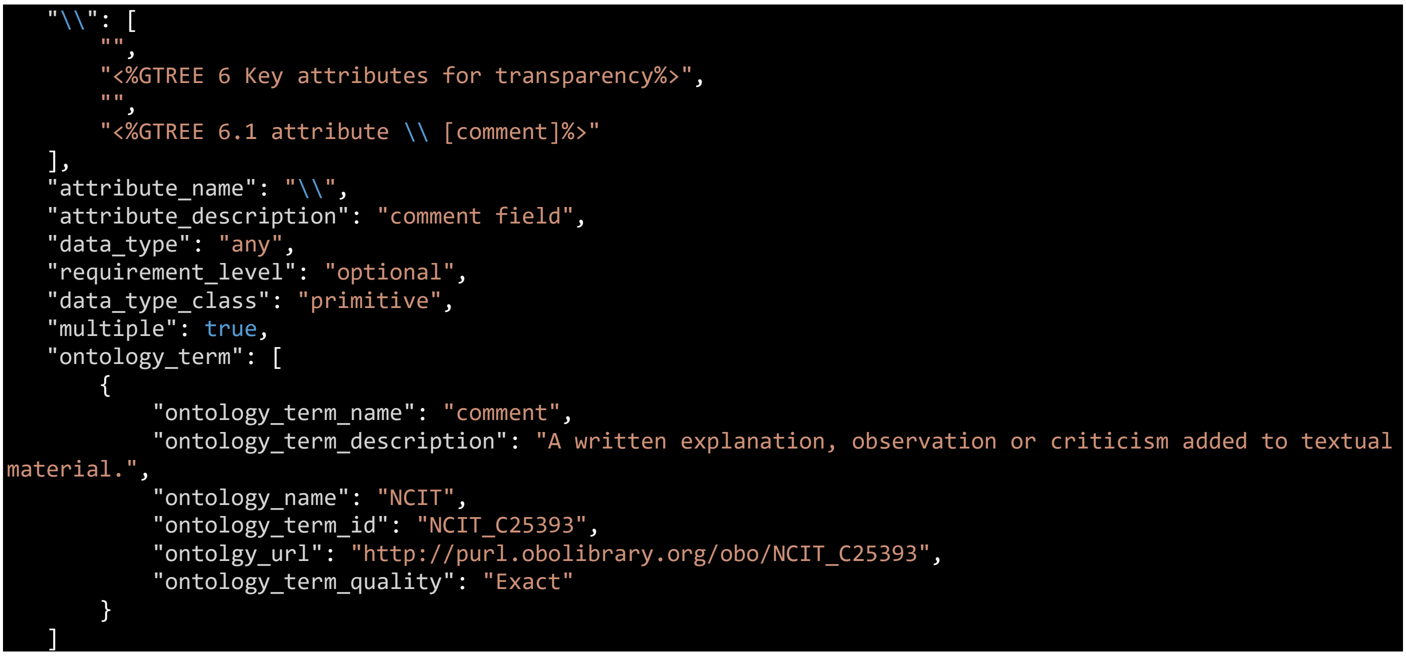
Gtree scans for Gtree scans for comments (called Gtree tags) that influence the tree content:

<%GTREE comment%>

This tag implies that the comment is shown in the tree as illustrated in Figs. 14 and 20. In Figure 14 the second item "[130] 2.1 OIMS" in the tree structure generated by GTREE, correponds tothe following line (line umber 130) in the JSON file The indentation is due to standard JSON indentation conventions:

"<%GTREE 2.1 OIMS%>"

By using numbering, which colors teal in the tree we can create a nested structure of comments and hence a nested structure of our JSON file. Creating Chapters, Sections, and Subsections etc. are now not only limited to integers but can be any word, though in OIMS we do use integers to structure our tags.



```
    "\\": [
        "",
        "<%GTREE 6 Key attributes for transparency%>",
        "",
        "<%GTREE 6.1 attribute \\ [comment]%>"
    ],
    "attribute_name": "\\",
    "attribute_description": "comment field",
    "data_type": "any",
    "requirement_level": "optional",
    "data_type_class": "primitive",
    "multiple": true,
    "ontology_term": [
        {
            "ontology_term_name": "comment",
            "ontology_term_description": "A written explanation, observation or criticism added to textual 
material.",
            "ontology_name": "NCIT",
            "ontology_term_id": "NCIT_C25393",
            "ontolgy_url": "http://purl.obolibrary.org/obo/NCIT_C25393",
            "ontology_term_quality": "Exact"
        }
    ]
```

Fig 27: Excerpt from OIMS_base.json of the formsal definition of an OIMS comment

The example of comments at the top of Fig. 27 maps to lines 1340 and 1342 as illustrated in Fig. 14. Note that GTREE tagging is optional and is not a feature that is specific to OIMS. It certainly is not JSON related, but rather is a useful way for creating transparency in any code.

Attribute status

We add attribute status as an optional attribute to indicate the life-cycle status of an attribute, whetehr or not it is deprecated, under review, or currently used or active. The basic assumption is that attributes in schemas are active. But they can be included when they are no longer active to allow for backward compatibility.

Attribute status is a property that has a controlled vocabulary

- Active
- Inactive
- Deprecated
- Under review

Technical design and implementation: OIMS optional attributes

Other optional attributes include default values, value reserved words and content objects.

Default values

Sometimes an attribute can have a default value, if that is the most common case of a value for a specific property. The attribute default values allws for this.

Value reserved words

Value reserved words are reserved words that have a special meaning in the context of the attribute and are not covered by a controlled vocabulary.

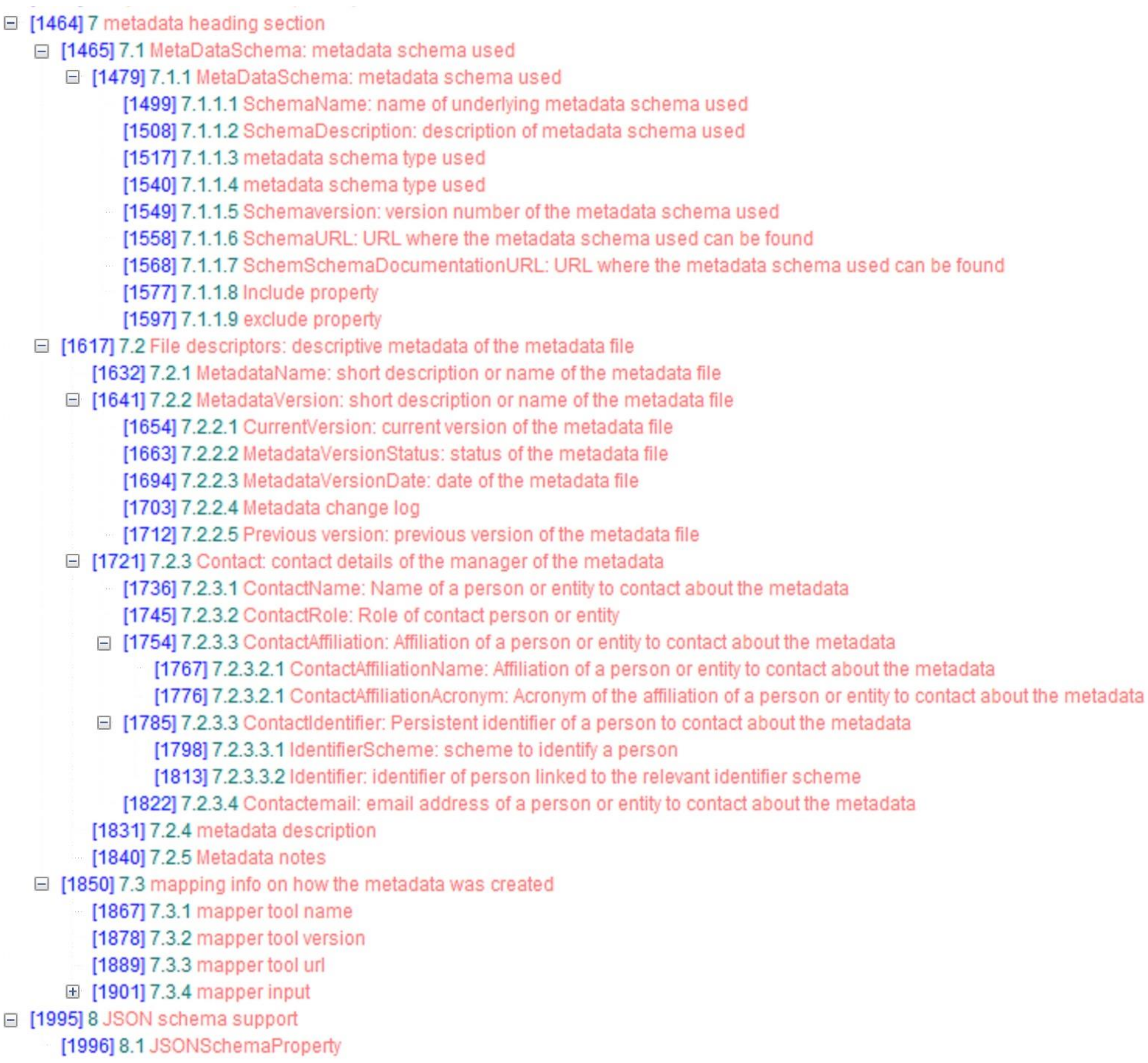
An example from the heading section is found in Fig. 29

Content objects

Content objects are a way of cimmunicating attribute value elements in a less restrictive way.

Technical design and implementation: OIMS header metadata attributes

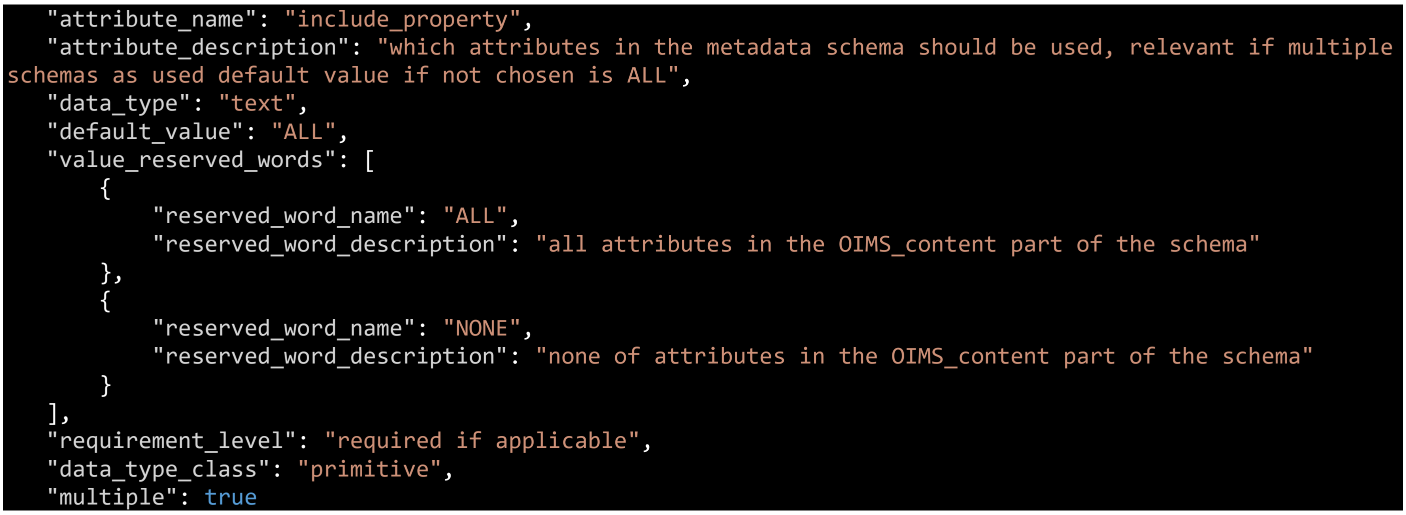
The header section was described in detail earlier in this Chapter as well as in the Chapter on the high-level OIMS structure. The section on the OIMS header metadata attributes, provides the formal description of all of the properties in terms of self describing metadata. If additional properties are needed they are formally described as well. The block falls into two sub-blocks. The first related to the typical OIMS header properties, the second to JSON Schema properties that are used in OIMS. The structure of the block is illustrated in Figure 28.



```
⊟ [1464] 7 metadata heading section
   ⊟ [1465] 7.1 MetaDataSchema: metadata schema used
      ⊟ [1479] 7.1.1 MetaDataSchema: metadata schema used
           [1499] 7.1.1.1 SchemaName: name of underlying metadata schema used
           [1508] 7.1.1.2 SchemaDescription: description of metadata schema used
           [1517] 7.1.1.3 metadata schema type used
           [1540] 7.1.1.4 metadata schema type used
           [1549] 7.1.1.5 Schemaversion: version number of the metadata schema used
           [1558] 7.1.1.6 SchemaURL: URL where the metadata schema used can be found
           [1568] 7.1.1.7 SchemSchemaDocumentationURL: URL where the metadata schema used can be found
           [1577] 7.1.1.8 Include property
           [1597] 7.1.1.9 exclude property
   ⊟ [1617] 7.2 File descriptors: descriptive metadata of the metadata file
        [1632] 7.2.1 MetadataName: short description or name of the metadata file
      ⊟ [1641] 7.2.2 MetadataVersion: short description or name of the metadata file
           [1654] 7.2.2.1 CurrentVersion: current version of the metadata file
           [1663] 7.2.2.2 MetadataVersionStatus: status of the metadata file
           [1694] 7.2.2.3 MetadataVersionDate: date of the metadata file
           [1703] 7.2.2.4 Metadata change log
           [1712] 7.2.2.5 Previous version: previous version of the metadata file
      ⊟ [1721] 7.2.3 Contact: contact details of the manager of the metadata
           [1736] 7.2.3.1 ContactName: Name of a person or entity to contact about the metadata
           [1745] 7.2.3.2 ContactRole: Role of contact person or entity
         ⊟ [1754] 7.2.3.3 ContactAffiliation: Affiliation of a person or entity to contact about the metadata
              [1767] 7.2.3.2.1 ContactAffiliationName: Affiliation of a person or entity to contact about the metadata
              [1776] 7.2.3.2.1 ContactAffiliationAcronym: Acronym of the affiliation of a person or entity to contact about the metadata
         ⊟ [1785] 7.2.3.3 ContactIdentifier: Persistent identifier of a person to contact about the metadata
              [1798] 7.2.3.3.1 IdentifierScheme: scheme to identify a person
              [1813] 7.2.3.3.2 Identifier: identifier of person linked to the relevant identifier scheme
           [1822] 7.2.3.4 Contactemail: email address of a person or entity to contact about the metadata
        [1831] 7.2.4 metadata description
        [1840] 7.2.5 Metadata notes
   ⊟ [1850] 7.3 mapping info on how the metadata was created
        [1867] 7.3.1 mapper tool name
        [1878] 7.3.2 mapper tool version
        [1889] 7.3.3 mapper tool url
      ⊞ [1901] 7.3.4 mapper input
⊟ [1995] 8 JSON schema support
     [1996] 8.1 JSONSchemaProperty
```

Fig 28: Structure of OIMS_base.json block dedicated toof the formal definition of the OIMS header

The elements of the header were discussed earlier as indocated. There are a few elements that were not discussed yet. They are all straight forward and can be deduced fom their formal description. Below we present one example, see Fig.29.



```
   "attribute_name": "include_property",
   "attribute_description": "which attributes in the metadata schema should be used, relevant if multiple
schemas as used default value if not chosen is ALL",
   "data_type": "text",
   "default_value": "ALL",
   "value_reserved_words": [
       {
           "reserved_word_name": "ALL",
           "reserved_word_description": "all attributes in the OIMS_content part of the schema"
       },
       {
           "reserved_word_name": "NONE",
           "reserved_word_description": "none of attributes in the OIMS_content part of the schema"
       }
   ],
   "requirement_level": "required if applicable",
   "data_type_class": "primitive",
   "multiple": true
```

Fig 29: Excerpt from OIMS_base.json of the formsal definition of an include property

The "include property" is used in the metadata schema section to indicate which properties described by the relevant underlying metametadata schema should be included. The default value is "ALL". As indicated in the formal description the list can contain the names of the proprties to be included or one of the reserved words "ALL" or "NONE".

Software and library requirements, and dependencies

The high-level OIMS structure is in JSON format(JSON.org n.d.). JSON (JavaScript Object Notation) is a lightweight data-interchange format. It is easy for humans to read and write. It is easy for machines to parse and generate. It is based on a subset of the JavaScript Programming Language(ECMA 1999). Many programming languages can handle JSON files.

The self-describing metadata schema uses GTREE tags to enhance readability (Dol 2010). [3]

Known issues and bugs

There are no known issues or bugs in the OIMS base self-describing metadata schema. We encourage users to report any issues they encounter to ensure continuous improvement.

Recommended improvements

Linking the concepts in OIMS to ontology terms is not complete. Adding more and better existing terms is important. In addition a full ontology of OIMS including some of the key applications of OIMS is expected in 2024.

The discussion on backward compatibility is important. We need to elaborate on how deprecated attributes are handled within OIMS and the implications for users who may be working with older datasets or schemas.

[3] GTREE can be downloaded free of charge from: https://www.medictcare.nl/gamstools/

Concluding remarks

The OIMS self-describing metadata schema is the foundation of the OIMS approach to tagging data and metrics, models and tools, and documents with rich findable, accessible, interoperable and reusable (FAIR) metadata, to ensure that the underlying assets are also FAIR.

We cannot over-emphasize the importance of community feedback, sharing experiences, and collaborative development in improving and expanding the framework. We encourage our readers, the architects and enthusiasts of data management, to engage with this evolving framework actively. Your insights, experiences, and contributions are invaluable in shaping the future of OIMS.

Further reading

Dol, Wietse. 2015. “GTREE: Version 4.11.” The Hague: LEI wageningen UR. https://www.medictcare.nl/gamstools/.

Kruseman, Gideon. 2022. “A Flexible, Extensible, Machine-Readable, Human-Intelligible, and Ontology-Agnostic Metadata Schema (OIMS).” *Frontiers in Sustainable Food Systems* 6. https://doi.org/10.3389/fsufs.2022.767863.

Installation instructions

No specific installation instructions exist.

The OIMS base self-describing metadata file structure in JSON format can be found here: https://raw.githubusercontent.com/ForesightInitiative/OIMS/main/BasicSchemas/OIMS_base.json

User guidelines

No specific user guidelines exist.

JSON schema for validating metadata schemas using the self-describing metadata

In the dynamic landscape of data management, ensuring the integrity and compliance of metadata is pivotal. Building on the foundational principles laid out in the OIMS self-describing metadata schema, this chapter introduces the OIMS_base.schema.json – a dedicated JSON Schema designed to validate OIMS-compatible metametadata files. This schema represents a critical tool in the OIMS ecosystem, bridging the gap between theoretical structuring and practical application, thereby ensuring that metadata files not only adhere to the OIMS standards but also maintain consistency and reliability across diverse implementations.

As data assets grow in complexity and scope, the need for robust validation mechanisms becomes increasingly essential. The OIMS_base.schema.json serves this need, offering a methodical approach to verify the structural integrity and compliance of metametadata files with the OIMS specifications. Its introduction marks a significant step in the advancement of metadata management, aligning with the overarching goal of making data Findable, Accessible, Interoperable, and Reusable (FAIR). The full schema can be found in Annex 5

Technical factsheet

Key	Value
General information	
Name	OIMS_base.schema.json
Version	2.3.3
Language	JSON Schema
Contact	Gideon Kruseman <g.kruseman@cgiar.org>
Status	Under review
Latest release date	December 7, 2023
System requirements	
Operating system	No specific requirement
Software requirements	Many programming languages including Python accommodate JSON Schema
General information	
Key features	Validator for OIMS compatible metametadata files
Key inputs	An OIMS-compatible metametadata file based on the OIMS base self-describing metadata schema
Key outputs	Validation information
License info and acknowledgements	
License	GPL-3.0 license
Acknowledgements	CGIAR Foresight Initiative

Functional design

This JSON schema serves as a tool to validate OIMS-compatible metadata files based on the OIMS self-describing metadata schema. It is designed to ensure that metametadata conforms to the established OIMS structure and data integrity requirements. The schema aids in identifying any deviations or errors in the metadata, thus ensuring consistent quality and structure across different assets.

The OIMS_base.schema.json is meticulously engineered to validate the structure and integrity of OIMS-compatible metametadata files. It checks for compliance with the OIMS standards in terms of attribute definitions, data types, controlled vocabularies, ontology terms, and overall file organization. The schema ensures that:

- Required and optional attributes are correctly implemented.
- Data types conform to the OIMS base schema standards.
- Controlled vocabularies and ontology terms are accurately represented.
- Structural hierarchy within the metadata files is maintained as per OIMS guidelines.

Key components of the schema

OIMS Object: The root object encapsulating the entire metadata structure.

Comments (\\): A unique implementation to include comments in JSON, enhancing readability and comprehension.

OIMS Header: Validates the structure and content of the header section, including mapping information and file descriptors.

OIMS Content: Ensures that the content section correctly represents the metadata, adhering to the OIMS standards.

Pattern definitions

The schema utilizes patternProperties and definitions to manage specific attributes such as comments, providing flexibility and enhancing the schema's capability to handle diverse metadata scenarios.

Validation mechanics

The schema uses conditional validation (if, then, else statements) to handle different scenarios based on the data types and class of the attributes.

It also incorporates enumeration (enum) for attributes where a limited set of values are permissible.

Technical design and implementation

The OIMS_base.schema.json is engineered to be a robust and versatile tool for validating OIMS-compatible metametadata files. It leverages the JSON Schema standard to enforce the structural and content-specific requirements of the OIMS framework. This section details the technical intricacies and functionalities of the schema.

Schema foundation

Root Object: The schema is anchored around the "OIMS" root object, reflecting the highest level of the metadata structure. This ensures that every validated file aligns with the OIMS base structure.

Schema Definitions: The $schema and $id attributes define the schema's identity and its compliance with the JSON Schema standard. This helps in maintaining interoperability and standardization across various applications and tools.

Property validation

OIMS Header: Within the "OIMS_header" object, the schema rigorously validates key sections like "mapping_info", "metadata_schema", and "file_descriptors". Each section is structured to validate specific attributes and their data types, ensuring adherence to the OIMS guidelines.

Conditional Checks: The schema employs conditional statements (if, then, else) to dynamically validate properties based on their data type. For instance, if a property is of type "controlled_vocabulary", the schema verifies the presence of an appropriate vocabulary list.

Data Type Enforcement

Enumerations: Attributes with a predefined set of permissible values use the enum keyword. This enforces consistency, especially in attributes related to data types, requirement levels, and ontology term quality.

Type Specifications: The schema rigorously defines the expected data types (string, object, array, etc.) for each attribute, ensuring that data entries conform to the intended format.

Handling Comments

Incorporation of Comments: The schema uniquely addresses JSON's lack of native commenting through the \\ property, structured as an array of strings. This allows for explanatory notes and annotations within the metadata file.

Metadata Content Validation:

Content Object Properties: The "OIMS_content" object is designed to validate the metadata content, ensuring that each "OIMS_content_object" adheres to the OIMS structure. This includes verifying metadata classes, controlled vocabulary details, and ontology-related attributes.

Flexibility in Content Validation: The use of patternProperties and definitions allows for adaptable validation strategies, especially for complex or nested metadata structures.

Error Reporting and Feedback:

The schema is structured to provide detailed error messages and feedback on non-conformities. This assists users in identifying and rectifying issues in their metadata files, ensuring they meet the OIMS standards.

Backward Compatibility and Extensions:

The schema is designed with backward compatibility in mind, allowing for the validation of older versions of metametadata files while being open to extensions and updates as the OIMS framework evolves.

Software and library requirements, and dependencies

By adopting JSON Schema we open the schema to an expansive range of community-driven tools, libraries, and frameworks across many programming languages. The schema can be integrated into various data management systems, programming environments, or used standalone in JSON validation tools.

It supports automated validation processes, enabling efficient quality control of metadata files.

Known issues and bugs

No known issues or bugs.

We are currently not aware of any performance considerations such as issues arising from processing large files.

Recommended improvements

User-Friendly Error Reporting:

Enhance error messages to be more descriptive and user-friendly. This can include suggestions for rectifying common issues and clear explanations of why a certain aspect of the metadata didn't validate.

Version Compatibility Checks:

Integrate checks for schema version compatibility. This ensures that users are aware if they are validating metadata against an outdated or mismatched schema version.

Extended Validation for Controlled Vocabularies and Ontologies:

Consider validating controlled vocabularies and ontology terms against external authoritative sources if feasible. This would further ensure the accuracy and relevance of these terms in the metadata.

Support for Internationalization:

Implement features to support internationalization, such as validating metadata content in multiple languages, which is critical for global data interoperability.

Testing and Quality Assurance:

Regularly test the schema with diverse metadata files to ensure robustness and adaptability. Include test cases that cover edge cases and unusual metadata structures.

Performance Optimization:

Optimize the schema for performance, especially for validating large or complex metadata files, to ensure a smooth and efficient validation process.

Concluding remarks

The OIMS_base.schema.json is an integral tool in the OIMS ecosystem, bridging theoretical structuring with practical application. It is pivotal in maintaining the consistency and reliability of metadata management, ensuring that metametadata files remain aligned with the FAIR principles and the evolving needs of data management.

The OIMS_base.schema.json represents a significant technical advancement in metadata validation. Its detailed and dynamic structure enables comprehensive and accurate validation of metametadata files, fostering consistency and reliability in data management practices aligned with the OIMS framework.

We encourage readers to contribute to the ongoing development and refinement of the JSON schema to validate metameta data files based on the OIMS base self-describing metadata schema. We cannot over-emphasize the importance of community feedback, sharing experiences, and collaborative development in improving and expanding the framework. We encourage our readers, the architects and enthusiasts of data management, to engage with this evolving framework actively. Your insights, experiences, and contributions are invaluable in shaping the future of OIMS.

We encourage users to share tools and schemas based on the OIMS base JSON schema file on our GitHub repository: https://github.com/ForesightInitiative/OIMS/tree/main by contacting the contact person mentioned.

Looking ahead, the OIMS holds immense potential for growth and adaptation. As technology evolves and data management practices advance, OIMS is poised to embrace these changes, continually enhancing its relevance and efficacy.

Further reading

More information on JSON schema at: https://json-schema.org/

User guidelines

User guidelines currently do not exist. Expanded documentation to include more real-world examples of both valid and invalid metadata files is foreseen. This can help users better understand how to format their metadata correctly.

It should include a detailed guide or a walkthrough of the validation process, particularly focusing on how to interpret and act on validation feedback.

Concluding remarks

The basic structure of an OIMS-compatible JSON metadata file consists of a header and the metadata content. The header provides some versioning information and information about the underlying metadata schema. OIMS also allows for metadata to be described with its own metadata, meaning that at a certain point, the metadata can be described with a self-describing metadata schema. This is the basis of OIMS, which is flexible, extensible, ontology-agnostic, machine-readable, and human-intelligible.

The metadata content is composed of a set of attributes and values that provide descriptive information about the resource being tagged. Each attribute is assigned a value that represents the value of the attribute for the resource being described. These attributes are defined in the metadata schema and can be either required or optional.

The metadata schema used in OIMS is designed to be flexible and extensible, allowing for new attributes to be added as needed. It is also ontology-agnostic, meaning that it does not rely on any particular ontology or vocabulary, making it more widely applicable to different domains and use cases.

In summary, OIMS provides a standardized way to describe metadata and metametadata using a JSON format, which allows for flexibility, extensibility, and ontology-agnosticism. Its use of self-describing metadata allows for rich interoperability and ensures that metadata can be easily understood by both machines and humans.

References

Arms, W.Y., C. Blanchi, and E.A Overly. 1997. “An Architecture for Information in Digital Libraries.” *D-Lib Magazine* 3 (2).

Dol, Wietse. ~~2015.~~2010. “GTREE: Version 4.11.” The Hague: LEI wageningen UR. https://www.medictcare.nl/gamstools/. Accessed November 11, 2023.

ECMA. 1999. “Standard ECMA-262 ECMAScript Language Specification.” *ECMA (European Association for Standardizing Information and Communication Systems)*. Geneva, Switzerland. https://ecma-international.org/wp-content/uploads/ECMA-262_3rd_edition_december_1999.pdf.

Jacobsen, Annika, Ricardo de Miranda Azevedo, Nick Juty, Dominique Batista, Simon Coles, Ronald Cornet, Mélanie Courtot, et al. 2020. “Fair Principles: Interpretations and Implementation Considerations.” *Data Intelligence*. https://doi.org/10.1162/dint_r_00024.

JSON.org. n.d. “Introducing JSON.” Accessed November 29, 2023. https://www.json.org/json-en.html.

Kruseman, Gideon. 2022. “A Flexible, Extensible, Machine-Readable, Human-Intelligible, and Ontology-Agnostic Metadata Schema (OIMS).” *Frontiers in Sustainable Food Systems* 6. https://doi.org/10.3389/fsufs.2022.767863.

Open Knowledge. n.d. “The Open Data Handbook.” Accessed November 29, 2023. https://opendatahandbook.org/.

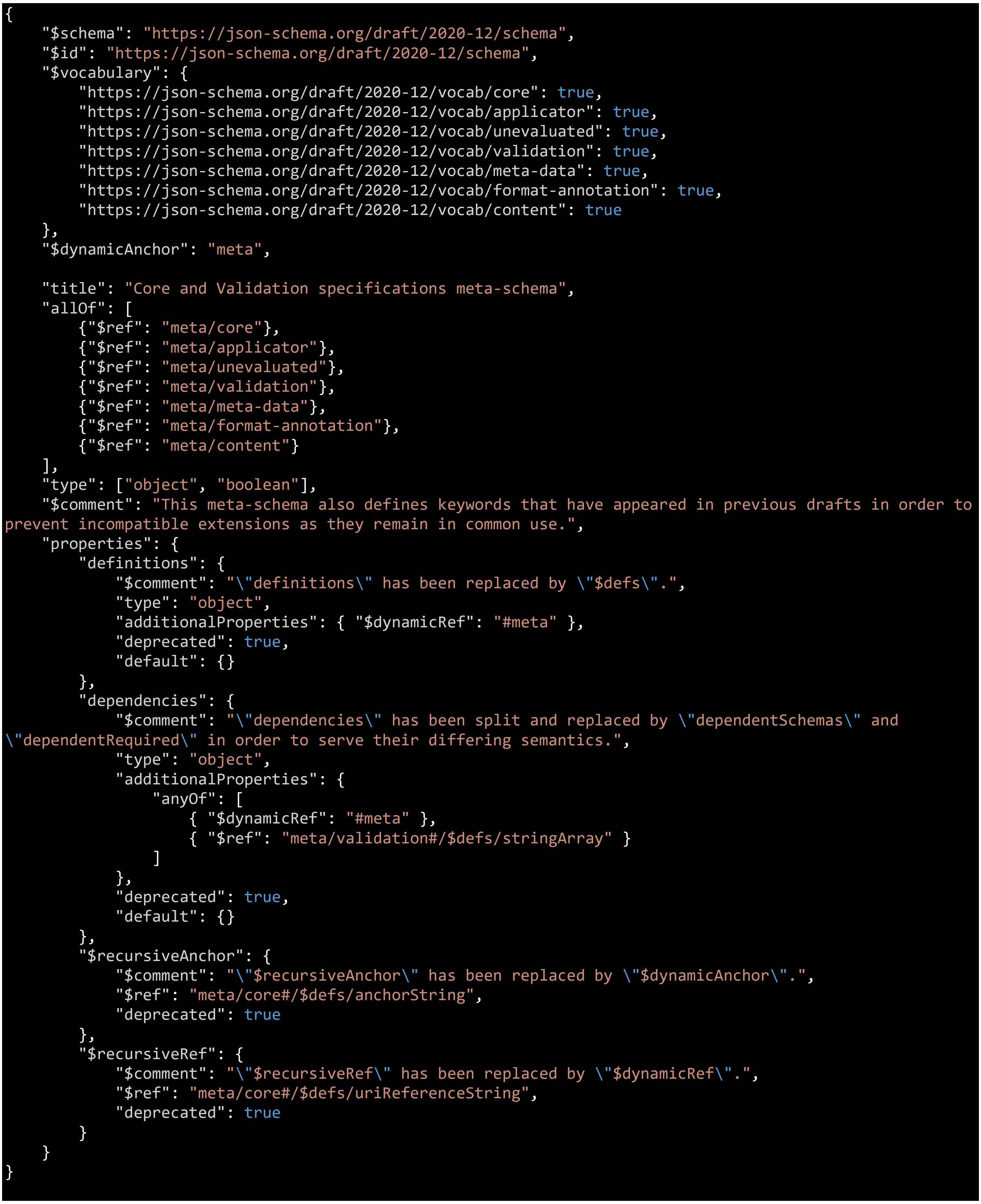
Visual Studio. 2023. “Documentation for Visual Studio Code.” 2023. https://code.visualstudio.com/docs#vscode.

Wilkinson, Mark D, Michel Dumontier, IJsbrand Jan Aalbersberg, Gabrielle Appleton, Myles Axton, Arie Baak, Niklas Blomberg, et al. 2016. “The FAIR Guiding Principles for Scientific Data Management and Stewardship.” *Scientific Data* 3 (March): 160018. http://dx.doi.org/10.1038/sdata.2016.18.

Annex 1: High-level OIMS structure

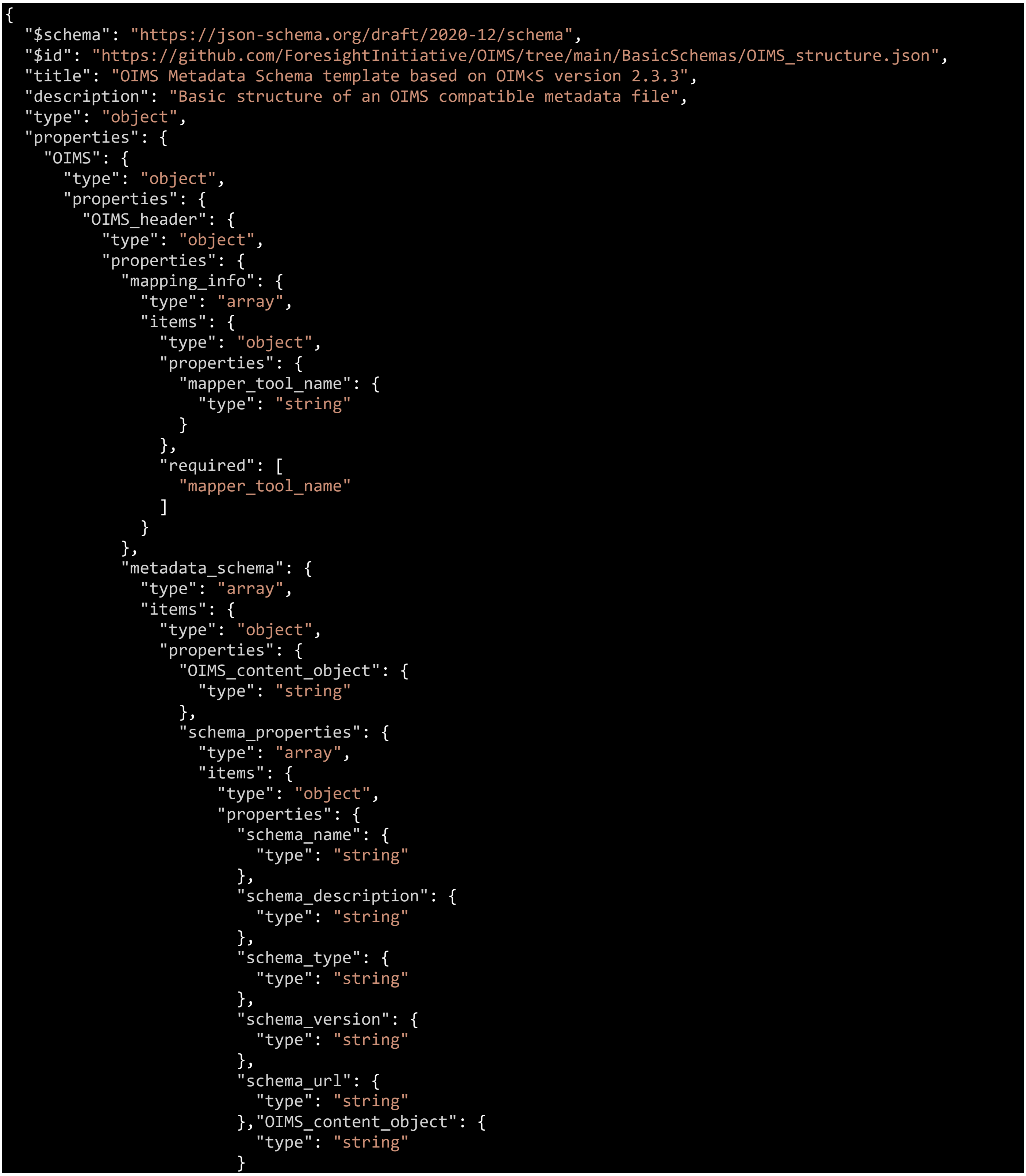
```
{
    "OIMS": {
        "\\": [
            "optimized for viewing in GTREE",
            "https://www.medictcare.nl/gamstools/",
            "GTREE requires GAMS for optimal viewing purposes",
            "this structure is based on OIMS version 2.3.3",
            "<%GTREE 1 heading section of the OIMS metadata schema%>"
        ],
        "OIMS_header": {
            "mapping_info": [{}],
            "metadata_schema": [
                {
                    "OIMS_content_object": "[required] <machine readable and human intelligible 
identifier> see OIMS_content below",
                    "schema_properties": [
                        {
                            "schema_name": "<Schema Name that describes the OIMS Content section below>",
                            "schema_description": "<short description of the meta-metadata>",
                            "schema_type": "<sub type of OIMS_Content_Object>",
                            "schema_subtype": "<subtype of the above schema_type>",
                            "schema_version": "<version of schema used>",
                            "schema_url": "[required] <e.g. schema on Foresight GitHub repository>",
                            "OIMS_content_object": "[required] <section of OIMS_Content in metametadata 
file containing relevant metadata>"
                        }
                    ]
                }
            ],
            "file_descriptors": {
                "metadata_name": "[required] <template for OIMS compatible metadata>",
                "meta_data_description": "<basic structure of OIMS compatible metadata schemas>",
                "metadata_version": {
                    "current_version": "[required] <version of this metadata>",
                    "metadata_version_status": "under review"
                },
                "contact": [
                    {
                        "contact_name": "<name>",
                        "contact_affiliation": {
                            "contact_affiliation_name": "<affiliation>",
                            "contact_affiliation_acronym": "<acronym>"
                        },
                        "contact_identifier": [
                            {
                                "identifier_scheme": "<e.g. ORCID>",
                                "identifier": "<actual ID>"
                            }
                        ],
                        "contact_email": [
                            "example@example.com"
                        ]
                    }
                ]
            }
        },
        "OIMS_content": [
            {
                "\\": [
                    "<%GTREE 2 Content section of the OIMS metadata schema%>"
                ],
                "OIMS_content_object": "[required]  <machine readable and human intelligible 
identifier>",
                "OIMS_content_object_properties": [
                    {
                        "metadata_class": [],
                        "metadata": [
                            {}
                        ]
                    }
                ]
            }
        ]
    }
}
```

Annex 2: JSON schema vers. 2020-12

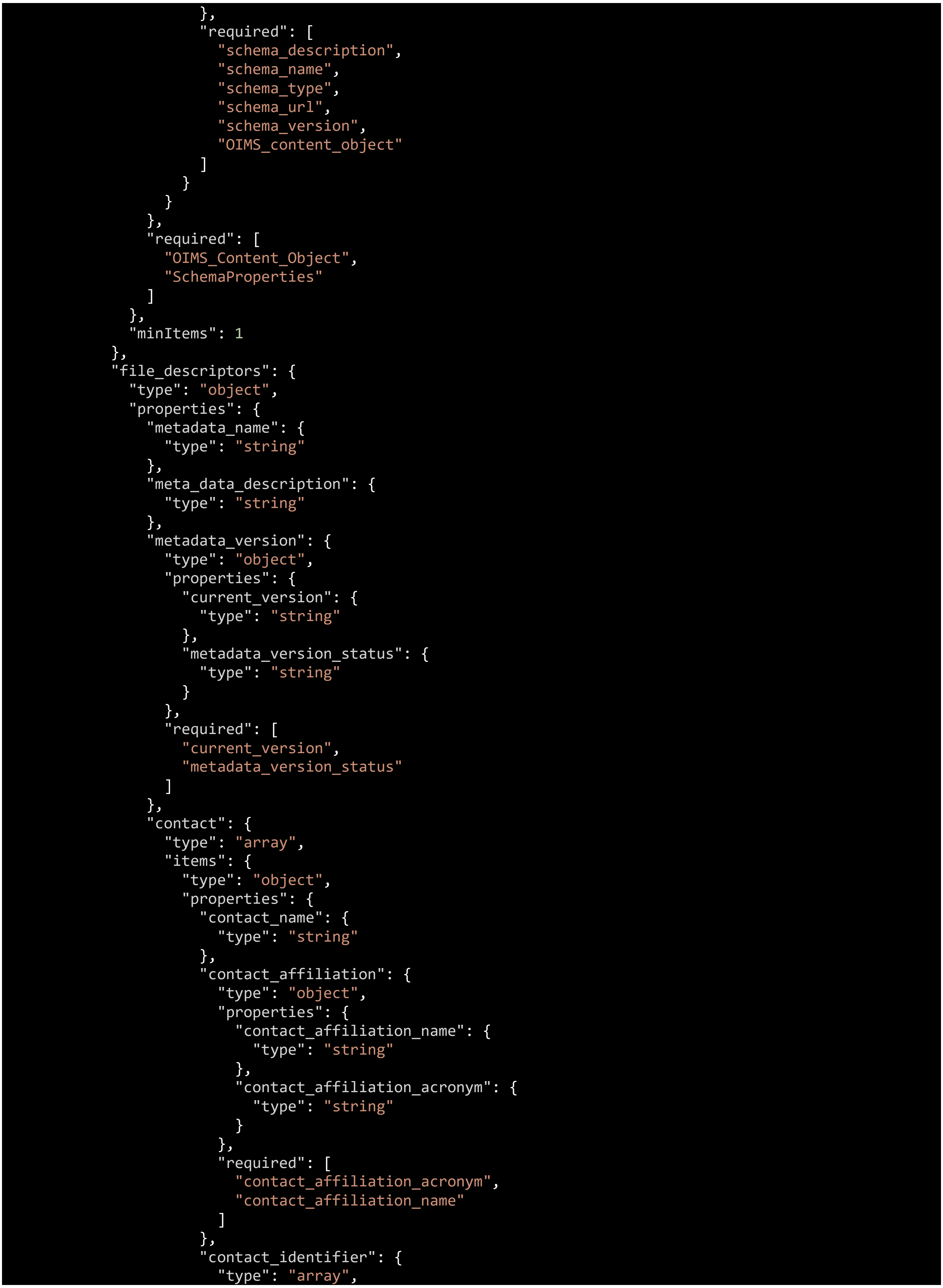


```
{
    "$schema": "https://json-schema.org/draft/2020-12/schema",
    "$id": "https://json-schema.org/draft/2020-12/schema",
    "$vocabulary": {
        "https://json-schema.org/draft/2020-12/vocab/core": true,
        "https://json-schema.org/draft/2020-12/vocab/applicator": true,
        "https://json-schema.org/draft/2020-12/vocab/unevaluated": true,
        "https://json-schema.org/draft/2020-12/vocab/validation": true,
        "https://json-schema.org/draft/2020-12/vocab/meta-data": true,
        "https://json-schema.org/draft/2020-12/vocab/format-annotation": true,
        "https://json-schema.org/draft/2020-12/vocab/content": true
    },
    "$dynamicAnchor": "meta",

    "title": "Core and Validation specifications meta-schema",
    "allOf": [
        {"$ref": "meta/core"},
        {"$ref": "meta/applicator"},
        {"$ref": "meta/unevaluated"},
        {"$ref": "meta/validation"},
        {"$ref": "meta/meta-data"},
        {"$ref": "meta/format-annotation"},
        {"$ref": "meta/content"}
    ],
    "type": ["object", "boolean"],
    "$comment": "This meta-schema also defines keywords that have appeared in previous drafts in order to
prevent incompatible extensions as they remain in common use.",
    "properties": {
        "definitions": {
            "$comment": "\"definitions\" has been replaced by \"$defs\".",
            "type": "object",
            "additionalProperties": { "$dynamicRef": "#meta" },
            "deprecated": true,
            "default": {}
        },
        "dependencies": {
            "$comment": "\"dependencies\" has been split and replaced by \"dependentSchemas\" and
\"dependentRequired\" in order to serve their differing semantics.",
            "type": "object",
            "additionalProperties": {
                "anyOf": [
                    { "$dynamicRef": "#meta" },
                    { "$ref": "meta/validation#/$defs/stringArray" }
                ]
            },
            "deprecated": true,
            "default": {}
        },
        "$recursiveAnchor": {
            "$comment": "\"$recursiveAnchor\" has been replaced by \"$dynamicAnchor\".",
            "$ref": "meta/core#/$defs/anchorString",
            "deprecated": true
        },
        "$recursiveRef": {
            "$comment": "\"$recursiveRef\" has been replaced by \"$dynamicRef\".",
            "$ref": "meta/core#/$defs/uriReferenceString",
            "deprecated": true
        }
    }
}
```

Annex 3: JSON schema for validating OIMS-compatible metadata files



```
{
  "$schema": "https://json-schema.org/draft/2020-12/schema",
  "$id": "https://github.com/ForesightInitiative/OIMS/tree/main/BasicSchemas/OIMS_structure.json",
  "title": "OIMS Metadata Schema template based on OIM<S version 2.3.3",
  "description": "Basic structure of an OIMS compatible metadata file",
  "type": "object",
  "properties": {
    "OIMS": {
      "type": "object",
      "properties": {
        "OIMS_header": {
          "type": "object",
          "properties": {
            "mapping_info": {
              "type": "array",
              "items": {
                "type": "object",
                "properties": {
                  "mapper_tool_name": {
                    "type": "string"
                  }
                },
                "required": [
                  "mapper_tool_name"
                ]
              }
            },
            "metadata_schema": {
              "type": "array",
              "items": {
                "type": "object",
                "properties": {
                  "OIMS_content_object": {
                    "type": "string"
                  },
                  "schema_properties": {
                    "type": "array",
                    "items": {
                      "type": "object",
                      "properties": {
                        "schema_name": {
                          "type": "string"
                        },
                        "schema_description": {
                          "type": "string"
                        },
                        "schema_type": {
                          "type": "string"
                        },
                        "schema_version": {
                          "type": "string"
                        },
                        "schema_url": {
                          "type": "string"
                        },"OIMS_content_object": {
                          "type": "string"
                        }
```



```
                    },
                    "required": [
                      "schema_description",
                      "schema_name",
                      "schema_type",
                      "schema_url",
                      "schema_version",
                      "OIMS_content_object"
                    ]
                  }
                }
              },
              "required": [
                "OIMS_Content_Object",
                "SchemaProperties"
              ]
            },
            "minItems": 1
          },
          "file_descriptors": {
            "type": "object",
            "properties": {
              "metadata_name": {
                "type": "string"
              },
              "meta_data_description": {
                "type": "string"
              },
              "metadata_version": {
                "type": "object",
                "properties": {
                  "current_version": {
                    "type": "string"
                  },
                  "metadata_version_status": {
                    "type": "string"
                  }
                },
                "required": [
                  "current_version",
                  "metadata_version_status"
                ]
              },
              "contact": {
                "type": "array",
                "items": {
                  "type": "object",
                  "properties": {
                    "contact_name": {
                      "type": "string"
                    },
                    "contact_affiliation": {
                      "type": "object",
                      "properties": {
                        "contact_affiliation_name": {
                          "type": "string"
                        },
                        "contact_affiliation_acronym": {
                          "type": "string"
                        }
                      },
                      "required": [
                        "contact_affiliation_acronym",
                        "contact_affiliation_name"
                      ]
                    },
                    "contact_identifier": {
                      "type": "array",
                      "items": {
                        "type": "object",
                        "properties": {
                          "identifier_scheme": {
                            "type": "string"
                          },
                          "identifier": {
                            "type": "string"
                          }
                        },
                        "required": [
                          "identifier",
                          "identifier_scheme"
                        ]
                      }
                    },
                    "contact_email": {
                      "type": "array",
                      "items": {
                        "type": "string"
                      }
                    }
                  },
                  "required": [
                    "contact_affiliation",
                    "contact_email",
                    "contact_identifier",
                    "contact_name"
                  ]
                }
              }
            },
            "required": [
              "contact",
              "meta_data_description",
              "metadata_name",
              "metadata_version"
            ]
          }
        },
        "required": [
          "file_descriptors",
          "metadata_schema",
          "mapping_info"
        ]
      },
      "OIMS_content": {
        "type": "array",
        "items": {
          "type": "object",
          "properties": {
            "OIMS_content_object":{
              "type": "string"
            },
            "OIMS_content_object_properties": {
              "type": "array",
              "items": {
                "type": "object",
                "properties": {
                  "metadata": {
                    "type":"array",
                    "items": {
                      "type": "object"
                    }
                  },
                  "metadata_class":{
                    "type":"string"
                  }
                },
                "required": [
                  "metadata"
                ]
              }
            }
          },
          "required": [
            "OIMS_content_object_properties",
            "OIMS_content_object"
          ]
        }
      }
    },
    "required": [
      "\\",
      "OIMS_header",
      "OIMS_content"
    ]
  }
},
"required": [
  "OIMS"
],
"patternProperties": {
  "^\\\\$": { "$ref": "#/definitions/comment" }
},
"definitions": {
  "comment": {
    "type": "array",
    "items": {
      "type": "string"
    },
    "description": "Array of comments"
  }
}
}
```

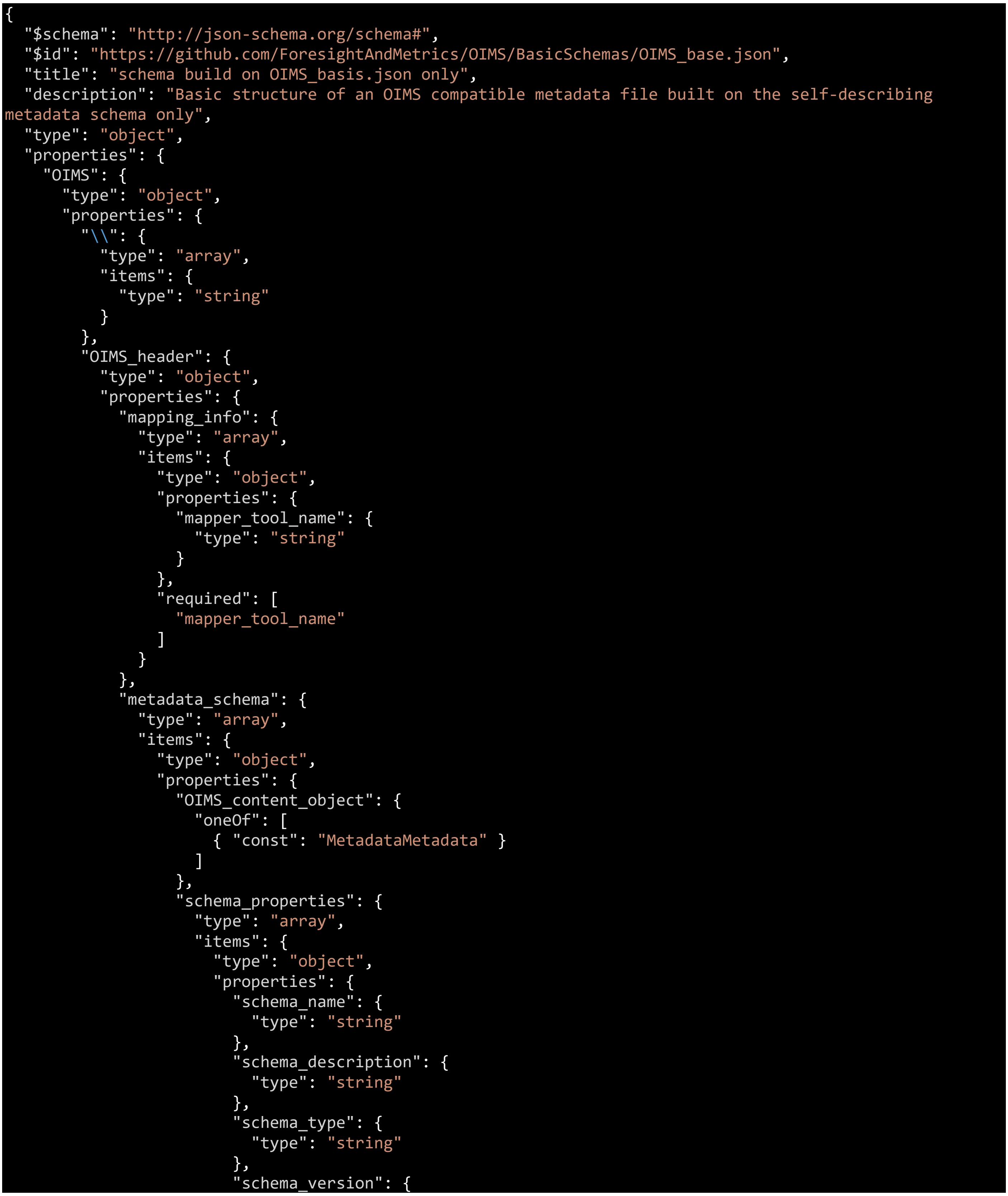
Annex 4: OIMS base self-describing metadata schema

```
{
    "OIMS": {
        "\\": [
            "<%GTREE 1 heading section of the OIMS selfdescribing metadata schema%>",
            "optimized for viewing in GTREE",
            "https://www.medictcare.nl/gamstools/",
            "GTREE requires GAMS and for viewing purposes"
        ],
        "OIMS_header": {
            "\\": [
                "<%GTREE 1.1 mapping information, this basic version was generated manually%>"
            ],
            "mapping_info": [
                {
                    "mapper_tool_name": "Manual"
                }
            ],
            "metadata_schema": [
                {
                    "\\": [
                        "<%GTREE 1.2 metadata schema information about which schemas describe which parts
of the OIMS content%>"
                    ],
                    "OIMS_content_object": "MetadataMetadata",
                    "schema_properties": [
                        {
                            "schema_name": "OIMS_base",
                            "schema_description": "OIMS selfdescribing metadata schema",
                            "schema_type": "self-describing metadata schema",
                            "schema_version": "2.3.3.0",
                            "schema_url":
"https://github.com/ForesightInitiative/OIMS/blob/main/BasicSchemas/OIMS_base.json",
                            "OIMS_content_object": "MetadataMetadata",
                            "include_property": [
                                "ALL"
                            ]
                        }
                    ]
                },
                {
                    "OIMS_content_object": "OIMS_Structure_Metadata",
                    "schema_properties": [
                        {
                            "schema_name": "OIMS_base",
                            "schema_description": "OIMS selfdescribing metadata schema",
                            "schema_type": "self-describing metadata schema",
                            "schema_version": "2.3.3.0",
                            "schema_url":
"https://github.com/ForesightInitiative/OIMS/blob/main/BasicSchemas/OIMS_base.json",
                            "OIMS_content_object": "MetadataMetadata"
                        },
                        {
                            "schema_name": "OIMS_base",
                            "schema_description": "OIMS selfdescribing metadata schema",
                            "schema_type": "self-describing metadata schema",
                            "schema_version": "2.3.3.0",
                            "schema_url":
"https://github.com/ForesightInitiative/OIMS/blob/main/BasicSchemas/OIMS_base.json",
                            "OIMS_content_object": "OIMS_Structure_Metadata",
                            "include_property": [
                                "ALL"
                            ]
                        }
                    ]
                },
                {
                    "OIMS_content_object": "OIMS_Header_Metadata",
                    "schema_properties": [
                        {
                            "schema_name": "OIMS_base",
                            "schema_description": "OIMS selfdescribing metadata schema",
                            "schema_type": "self-describing metadata schema",
                            "schema_version": "2.3.3.0",
                            "schema_url":
"https://github.com/ForesightInitiative/OIMS/blob/main/BasicSchemas/OIMS_base.json",
                            "OIMS_content_object": "MetadataMetadata"
                        },
                        {
                            "schema_name": "OIMS_base",
                            "schema_description": "OIMS selfdescribing metadata schema",
                            "schema_type": "self-describing metadata schema",
                            "schema_version": "2.3.3.0",
                            "schema_url":
"https://github.com/ForesightInitiative/OIMS/blob/main/BasicSchemas/OIMS_base.json",
                            "OIMS_content_object": "OIMS_Header_Metadata",
                            "include_property": [
                                "ALL"
                            ]
                        }
                    ]
                }
            ],
            "file_descriptors": {
                "\\": [
                     "<%GTREE 1.2 metadata file descriptors%>"
                ],
                "metadata_name": "OIMS_base",
                "meta_data_description": "OIMS self-describing metadata schema",
                "metadata_version": {
                    "current_version": "2.3.3.0",
                    "metadata_version_status": "released",
                    "version_date": "November 30, 2023"
                },
                "contact": [
                    {
                        "contact_name": "Kruseman, Gideon",
                        "contact_role": "metadata schema developer",
                        "contact_affiliation": {
                            "contact_affiliation_name": "Alliance of Bioversity International & CIAT",
                            "contact_affiliation_acronym": "Alliance"
                        },
                        "contact_identifier": [
                            {
                                "identifier_scheme": "ORCID",
                                "identifier": "0000-0002-3392-4176"
                            }
                        ],
                        "contact_email": [
                            "g.kruseman@cgiar.org",
                            "gkruseman@gmail.com"
                        ]
                    }
                ]
            }
        },
        "OIMS_content": [
            {
```

```
                "OIMS_content_object": "OIMS_Structure_Metadata",
                "OIMS_content_object_properties": [
                    {
                        "metadata_class": ["metametadata"],
                        "metadata": [
                            {
                                "\\": [
                                    "<%GTREE 2 major OIMS components metadata%>",
                                    "<%GTREE 2.1 OIMS%>"
                                ],
                                "attribute_name": "OIMS",
                                "attribute_description": "First element in any OIMS file that indicates 
that it is an OIMS file",
                                "data_type": "compound_object",
                                "requirement_level": "required",
                                "data_type_class": "compound",
                                "multiple": false,
                                "attribute_value_elements": [
                                    "OIMS_header",
                                    "OIMS_content"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 2.2 OIMS_Header%>"],
                                "attribute_name": "OIMS_header",
                                "attribute_description": "header section of an OIMS compatible metadata 
schema",
                                "data_type": "compound_object",
                                "requirement_level": "required",
                                "data_type_class": "compound",
                                "multiple": false,
                                "attribute_value_elements": [
                                    "mapping_info",
                                    "meta_data_schema",
                                    "file_descriptors"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 2.3 OIMS_Content%>"],
                                "attribute_name": "OIMS_content",
                                "attribute_description": "Description of the content of the metadata 
file",
                                "data_type": "compound_object",
                                "requirement_level": "required",
                                "data_type_class": "compound",
                                "multiple": true,
                                "attribute_value_elements": [
                                    "OIMS_content_object",
                                    "OIMS_content_object_properties"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 2.3.1 OIMS_Content_object %>"],
                                "attribute_name": "OIMS_content_object",
                                "attribute_description": "OIMS content object where in the header it has 
special meaning, namely  for which the metadata schemas are valid or OIMS content object to use as 
metadata schema",
                                "data_type": "text",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 2.3.2 OIMS_content_properties%>"],
                                "attribute_name": "OIMS_content_properties",
                                "attribute_description": "properties of the entity",
                                "data_type": "compound_object",
                                "requirement_level": "required",
                                "data_type_class": "compound",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.1 persistent_entity_id%>"],
                                "attribute_name": "persistent_entity_id",
                                "attribute_description": "an identifier for the entity being drescribed by the metadata of thius section",
                                "data_type": "compound_object",
                                "requirement_level": "required if applicable",
                                "data_type_class": "compound",
                                "multiple": true,
                                "attribute_value_elements": [
                                    "entity_label",
                                    "persistent_entity_id_schema_name",
                                    "persistent_entity_id_identifier"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.1.1 entity_label%>"],
                                "attribute_name": "entity_label",
                                "attribute_description": "short human intelligible description of the entity",

                                "data_type": "text",
                                "requirement_level": "optional",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.1.2 persistent_entity_id_schema_name%>"],
                                "attribute_name": "persistent_entity_id_schema_name",
                                "attribute_description": "persistent identifier for the entity, typically <DOI,Handle,FMI_ID,URI>",

                                "data_type": "text",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.1.3 persistent_entity_id_identifier%>"],
                                "attribute_name": "persistent_entity_id_identifier",
                                "attribute_description": "actual persistent identifier of the entity",
                                "data_type": "text",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.1.4 persistent_entity_url%>"],
                                "attribute_name": "persistent_entity_url",
                                "attribute_description": "url linking to the entity",
                                "data_type": "url",
                                "requirement_level": "recommended",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.2 entity_relationship%>"],
                                "attribute_name": "entity_relationship",
                                "attribute_description": "relationship between the current entity and other entities",

                                "data_type": "compound_object",
                                "requirement_level": "required if applicable",
                                "data_type_class": "compound",
                                "multiple": true,
                                "attribute_value_elements": [
                                    "entity_relationship_type",
                                    "entity_list"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.2.1 entity_relationship_type%>"],
                                "attribute_name": "entity_relationship_type",
                                "attribute_description": "relationship between the current entity and 
other entities",
                                "data_type": "controlled_vocabulary",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "controlled_vocabulary":  [
                                    {
                                        "\\": ["<%GTREE 2.3.2.2.1.1 parent of%>"],
                                        "vocabulary_element_name": "parent_of",
                                        "vocabulary_element_description": "the current entity is a parent 
of the listed entities"
                                    },
                                    {
                                        "\\": ["<%GTREE 2.3.2.2.1.2 child of%>"],
                                        "vocabulary_element_name": "child_of",
                                        "vocabulary_element_description": "the current entity is a child 
of the listed entities"
                                    },
                                    {
                                        "\\": ["<%GTREE 2.3.2.2.1.3 has_siblings%>"],
                                        "vocabulary_element_name": "has_siblings",
                                        "vocabulary_element_description": "the current entity has 
siblings namely the listed entities"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.2.2 entity_relationship_subtype%>"],
                                "attribute_name": "entity_relationship_subtype",
                                "attribute_description": "relationship between the current entity and 
other entities",
                                "data_type": "compound_object",
                                "requirement_level": "recommended if applicable",
                                "data_type_class": "compound",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.2.2.1 standard entity relationship subtype%>"],
                                "attribute_name": "standard_entity_relationship_type",
                                "attribute_description": "relationship between the current entity and 
other entities",
                                "data_type": "controlled_vocabulary",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "controlled_vocabulary":  [
                                    {
                                        "\\": ["<%GTREE 2.3.2.2.2.1.1 supplementary%>"],
                                        "vocabulary_element_name": "supplementary",
                                        "vocabulary_element_description": "supplementary information 
releted to current entity"
                                    },
                                    {
                                        "\\": ["<%GTREE 2.3.2.2.2.1.2 shared key%>"],
                                        "vocabulary_element_name": "shared_key",
                                        "vocabulary_element_description": "the current entity has shared 
keys with the listed entities"
                                    },
                                    {
                                        "\\": ["<%GTREE 2.3.2.2.1.2.3 segment%>"],
                                        "vocabulary_element_name": "segment",
                                        "vocabulary_element_description": "the current entity forms a 
whole with the listed entities"
                                    },
                                    {
                                        "\\": ["<%GTREE 2.3.2.2.1.2.3 other%>"],
                                        "vocabulary_element_name": "other_sibling",
                                        "vocabulary_element_description": "other type of sibling 
relationship with the listed entities"
                                    }
                                ]
                            },
                        {
                                "\\": ["<%GTREE 2.3.2.2.2.2 non-entity relationship subtype%>"],
                                "attribute_name": "non_standard_entity_relationship_type",
                                "attribute_description": "relationship between the current entity and 
other entities",
                                "data_type": "text",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.2.3 entity_relationship_order%>"],
                                "attribute_name": "entity_relationship_order",
                                "attribute_description": "if there is a specific order between siblings",
                                "data_type": "boolean",
                                "requirement_level": "required if applicable",
                                "data_type_class": "prinitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.2.4 entity_relationship_order_position%>"],
                                "attribute_name": "entity_relationship_order_position",
                                "attribute_description": "if there is a specific order between siblings 
what is the position of the current entity",
                                "data_type": "integer",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.2.5 entity_list%>"],
                                "attribute_name": "entity_list",
                                "attribute_description": "relationship between the current entity and 
other entities",
                                "data_type": "compound_object",
                                "requirement_level": "required if applicable",
                                "data_type_class": "compound",
                                "multiple": true,
                                "attribute_value_elements": [
                                    "persistent_entity_id",
                                    "entity_order_in_list"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.2.5.1 entity order in list%>"],
                                "attribute_name": "entity_order_in_list",
                                "attribute_description": "relationship order between the current entity 
and other entities",
                                "data_type": "integer",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.3 metadata_class%>"],
                                "attribute_name": "metadata_class",
                                "attribute_description": "class of the metadata",
                                "data_type": "controlled_vocabulary",
                                "requirement_level": "recommended",
                                "data_type_class": "primitive",
                                "multiple": true,
                                "controlled_vocabulary": [
                                    {
                                        "//": ["<%GTREE 2.3.2.4.1 Descriptive metadata %>"],
                                        "vocabulary_element_name": "descriptive_metadata",
                                        "vocabulary_element_description": "descriptive metadata "
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.4.2 Technical metadata %>"],
                                        "vocabulary_element_name": "technical_metadata",
                                        "vocabulary_element_description": "technical metadata "
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.4.3 Administrative metadata %>"],
                                        "vocabulary_element_name": "administrative_metadata",
                                        "vocabulary_element_description": "administrative metadata"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.4.4 Ethics metadata %>"],
                                        "vocabulary_element_name": "ethics_metadata",
                                        "vocabulary_element_description": "ethics metadata"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.4.5 Provenance metadata %>"],
                                        "vocabulary_element_name": "provenance_metadata",
                                        "vocabulary_element_description": "provenance metadata"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.4.6 preservation metadata %>"],
                                        "vocabulary_element_name": "preservation_metadata",
                                        "vocabulary_element_description": "preservation or life-cycle
metadata"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.4.7 Structural metadata %>"],
                                        "vocabulary_element_name": "structural_metadata_DataFile",
                                        "vocabulary_element_description": "information about data
entities and their relationships"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.4.8 Definition metadata%>"],
                                        "vocabulary_element_name": "definition_metadata",
                                        "vocabulary_element_description": "definition metadata of data
within files linked to data dictionaries"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.4.9 metadata metadata %>"],
                                        "vocabulary_element_name": "metametadata",
                                        "vocabulary_element_description": "metametadata or the metadata
of metadata attributes and properties"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.4.10 quality assurance metadata%>"],
                                        "vocabulary_element_name": "quality_assurance metadata",
                                        "vocabulary_element_description": "metadata of models tools and
ETL procedures"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.4.11 Rules governing metadata and their
relationships%>"],
                                        "vocabulary_element_name": "rules",
                                        "vocabulary_element_description": "Rules governing metadata and
their relationships"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.4.12 asset metadata%>"],
                                        "vocabulary_element_name": "asset_metadata",
                                        "vocabulary_element_description": "metadata of data, data files, datasets and collections, or publications and documents, or tools, models and ETL procedures"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.4 entity_class%>"],
                                "attribute_name": "entity_class",
                                "attribute_description": "class of the entity",
                                "data_type": "controlled_vocabulary",
                                "requirement_level": "recommended if applicable",
                                "data_type_class": "primitive",
                                "multiple": true,
                                "controlled_vocabulary": [
                                    {
                                        "//": ["<%GTREE 2.3.2.5.1  collection%>"],
                                        "vocabulary_element_name": "collectiont",
                                        "vocabulary_element_description": "collection of datasets or publications"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.5.2 dataset%>"],
                                        "vocabulary_element_name": "dataset",
                                        "vocabulary_element_description": "dataset"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.5.3 data file%>"],
                                        "vocabulary_element_name": "data_file",
                                        "vocabulary_element_description": "data file"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.5.4 aggregate_data_container%>"],
                                        "vocabulary_element_name": "aggregate_data_container",
                                        "vocabulary_element_description": "data container inside a file often a table or a sheet in an excel file"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.5.5 data_container%>"],
                                        "vocabulary_element_name": "data_container",
                                        "vocabulary_element_description": "what holds the actual data, often denoted as a variable or a column in tabular data"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.5.6 model framework%>"],
                                        "vocabulary_element_name": "model_framework",
                                        "vocabulary_element_description": "a framework that contains multiple models or tools"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.5.7 model, tool or etl procedure%>"],
                                        "vocabulary_element_name": "model_tool_etl",
                                        "vocabulary_element_description": "model, tool or etl procedure, something that takes input and transforms that into output"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.5.8 module%>"],
                                        "vocabulary_element_name": "module",
                                        "vocabulary_element_description": "a module within a model can be standalone but does not have to be"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.5.9 module section %>"],
                                        "vocabulary_element_name": "module_sectrion",
                                        "vocabulary_element_description": "lowest level of disaggregation of model, tool or etl procedure"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.5.10 document%>"],
                                        "vocabulary_element_name": "document",
                                        "vocabulary_element_description": "document, including web
material"
                                    },
                                    {
                                        "//": ["<%GTREE 2.3.2.5.11 rules%>"],
                                        "vocabulary_element_name": "rules",
                                        "vocabulary_element_description": "logical rules governing
assets"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 2.3.2.5 metadata%>"],
                                "attribute_name": "metadata",
                                "attribute_description": "actual metadata",
                                "data_type": "compound_object",
                                "requirement_level": "required",
                                "data_type_class": "compound",
                                "multiple": true
                            }
                        ]
                    }
                ]
            },
            {
                "OIMS_content_object": "MetadataMetadata",
                "OIMS_content_object_properties": [
                    {
                        "metadata_class": ["metametadata"],
                        "metadata": [
                            {
                                "\\": [
                                    "<%GTREE 3 Core self describing metadata attributes%>",
                                    "<%GTREE 3.1 attribute AttributeName %>"
                                ],
                                "attribute_name": "attribute_name",
                                "attribute_description": "name of the data dictionary metadata field",
                                "data_type": "string",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "Name",
                                        "ontology_term_description": "The words or language units by
which a thing is known.",
                                        "ontology_name": "NCIT",
                                        "ontology_term_id": "NCIT_C42614",
                                        "ontology_url": "http://purl.obolibrary.org/obo/NCIT_C42614",
                                        "ontology_term_quality": "to be confirmed"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 3.2 attribute AttributeDescription %>"],
                                "attribute_name": "attribute_description",
                                "attribute_description": "description of the data dictionary metadata
field",
                                "data_type": "text",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "Description",
                                        "ontology_term_description": "A written or verbal account, 
representation, statement, or explanation of something.",
                                        "ontology_name": "NCIT",
                                        "ontology_term_id": "C25365",
                                        "ontology_url": "http://purl.obolibrary.org/obo/NCIT_C25365",
                                        "ontology_term_quality": "to be confirmed"
                                    }
                                ]
                            },
                            {
                                "\\": [
                                    "<%GTREE 3.3 attribute DataType%>"
                                ],
                                "attribute_name": "data_type",
                                "attribute_description": "datatypes used in the data dictionary metadata 
fields",
                                "data_type": "controlled_vocabulary",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "controlled_vocabulary": [
                                    {
                                        "\\": ["<%GTREE 3.3.1 string%>"],
                                        "vocabulary_element_name": "string",
                                        "vocabulary_element_description": "For general textual data, 
including simple character strings.",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "Literal",
                                                "ontology_term_description": "A string of characters.",
                                                "ontology_name": "RDF",
                                                "ontology_term_id": "rdf:Literal",
                                                "ontology_url": "https://www.w3.org/TR/rdf11-
concepts/#dfn-literal",
                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "\\": ["<%GTREE 3.3.2 text%>"],
                                        "vocabulary_element_name": "text",
                                        "vocabulary_element_description": "For more substantial amounts 
of alphanumeric characters or longer text.",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "Text",
                                                "ontology_term_description": "Data that primarily 
includes sequences of characters.",
                                                "ontology_name": "Schema.org",
                                                "ontology_term_id": "schema:Text",
                                                "ontology_url": "https://schema.org/Text",
                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "\\": ["<%GTREE 3.3.3 compound%>"],
                                        "vocabulary_element_name": "compound_object",
                                        "vocabulary_element_description": "For properties with an array 
of properties as values.",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "CompoundObject",
                                                "ontology_term_description": "An object composed of 
multiple other objects.",
                                                "ontology_name": "CIDOC-CRM",
                                                "ontology_term_id": "E90_Substance",
                                                "ontology_url": "http://www.cidoc-
crm.org/Entity/E90_Substance/Version-6.2.1",
                                                "ontology_term_quality": "Related"
                                            }
                                        ]
                                    },
                                    {
                                        "\\": ["<%GTREE 3.3.4 date%>"],
                                        "vocabulary_element_name": "date",
                                        "vocabulary_element_description": "For date values used in
properties like version date.",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "Date",
                                                "ontology_term_description": "A particular day, month, or
year.",
                                                "ontology_name": "Schema.org",
                                                "ontology_term_id": "schema:Date",
                                                "ontology_url": "https://schema.org/Date",
                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "\\": ["<%GTREE 3.3.5 URI%>"],
                                        "vocabulary_element_name": "uri",
                                        "vocabulary_element_description": "For properties with URL or URI
values.",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "xsd:anyURI",
                                                "ontology_term_description": "A Uniform Resource
Identifier reference data type.",
                                                "ontology_name": "XML Schema",
                                                "ontology_term_id": "",
                                                "ontology_url": "https://www.w3.org/TR/xmlschema11-
2/#anyURI",
                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "\\": ["<%GTREE 3.3.6 Controlled vocabulary%>"],
                                        "vocabulary_element_name": "controlled_vocabulary",
                                        "vocabulary_element_description": "For properties with values
that are items in a controlled vocabulary, enumeration, or list.",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "ControlledVocabulary",
                                                "ontology_term_description": "A collection of
standardized terms and their meanings that are used to provide consistent labeling and descriptions of
concepts within a domain.",
                                                "ontology_name": "SKOS",
                                                "ontology_term_id": "skos:ConceptScheme",
                                                "ontology_url":
"http://www.w3.org/2004/02/skos/core#ConceptScheme",
                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "\\": ["<%GTREE 3.3.7 boolean%>"],
                                        "vocabulary_element_name": "boolean",
                                        "vocabulary_element_description": "a form of data with only two
possible values ( 'true' and 'false') ",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "boolean",
                                                "ontology_term_description": "A data type that has one of
two possible values (usually denoted true and false) which represent logic values.",
                                                "ontology_name": "NCIT",
                                                "ontology_term_id": "C65228",
                                                "ontology_url":
"http://purl.obolibrary.org/obo/NCIT_C65228",
                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "\\": ["<%GTREE 3.3.8 email%>"],
                                        "vocabulary_element_name": "email",
                                        "vocabulary_element_description": "For properties with email
address values.",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "EmailAddress",
                                                "ontology_term_description": "A string that represents
the email address of a person or organization.",
                                                "ontology_name": "Schema.org",
                                                "ontology_term_id": "schema:email",
                                                "ontology_url": "https://schema.org/email",
                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "\\": ["<%GTREE 3.3.9 integer%>"],
                                        "vocabulary_element_name": "integer",
                                        "vocabulary_element_description": "integer",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "xsd:integer",
                                                "ontology_term_description": "The datatype xsd:integer
represents an arbitrarily large mathematical integer. An xsd:integer is a sequence of decimal digits,
optionally preceded by a + or - sign. Leading zeros are permitted, but decimal points are not.",
                                                "ontology_name": "XML Schema",
                                                "ontology_term_id":
"http://www.w3.org/2001/XMLSchema#integer",
                                                "ontology_url": "http://www.w3.org/TR/xmlschema-
2/#integer",
                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "\\": ["<%GTREE 3.3.10 float%>"],
                                        "vocabulary_element_name": "float",
                                        "vocabulary_element_description": "number with decimal points",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "xsd:float",
                                                "ontology_term_description": "A built-in data type in the
XML Schema definition language used for defining simple type elements that represent single-precision 32-
bit floating point numbers.",
                                                "ontology_name": "XML Schema Definition Language",
                                                "ontology_term_id":
"http://www.w3.org/2001/XMLSchema#float",
                                                "ontology_url": "https://www.w3.org/TR/xmlschema-
2/#float",
                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "\\": ["<%GTREE 3.3.11 HTML%>"],
                                        "vocabulary_element_name": "html",
                                        "vocabulary_element_description": "specific text type, namely
hyper text markup language"
                                    },
                                    {
                                        "\\": ["<%GTREE 3.3.12 any%>"],
                                        "vocabulary_element_name": "any",
                                        "vocabulary_element_description": "any data type is acceptable"
                                    }
                                ],
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "data_type",
                                        "ontology_term_description": "An indication of the form that a
value will have.",
                                        "ontology_name": "NCIT",
                                        "ontology_term_id": "C42645",
                                        "ontology_url": "http://purl.obolibrary.org/obo/NCIT_C42645 ",
                                        "ontology_term_quality": "to be confirmed"
                                    },
                                    {
                                        "ontology_term_name": "data_type",
                                        "ontology_term_description": "A category of information,
indicating the nature or characteristics of the content of a resource.",
                                        "ontology_name": "DCMI",
                                        "ontology_term_id": "dcterms:type",
                                        "ontology_url": "http://purl.org/dc/terms/type",
                                        "ontology_term_quality": "Exact"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 3.4 attribute RequirementLevel %>"],
                                "attribute_name": "requirement_level",
                                "attribute_description": "see OIMS self describing metadata schema",
                                "data_type": "controlled_vocabulary",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "controlled_vocabulary": [
                                    {
                                        "//": ["<%GTREE 3.4.1 required%>"],
                                        "vocabulary_element_name": "required",
                                        "vocabulary_element_description": "If the metadata field is
required at all times",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "Required indicator",
                                                "ontology_term_description": "An indication as to whether
entity is mandatory",
                                                "ontology_name": "NCIT",
                                                "ontology_term_id": "C164599",
                                                "ontology_url":
"http://purl.obolibrary.org/obo/NCIT_C164599",
                                                "ontology_term_quality": "to be confirmed"
                                            }
                                        ]
                                    },
                                    {
                                        "//": ["<%GTREE 3.4.2 recommended%>"],
                                        "vocabulary_element_name": "recommended",
                                        "vocabulary_element_description": "If the metadata field is
recommended but not strictly required",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "Recommended",
                                                "ontology_term_description": "Suggested as appropriate or
suitable, but not strictly required",
                                                "ontology_name": "NCIT",
                                                "ontology_term_id": "NCIT_C25697",
                                                "ontology_url":
"http://purl.obolibrary.org/obo/NCIT_C25697",
                                                "ontology_term_quality": "to be confirmed"
                                            }
                                        ]
                                    },
                                {
                                        "//": ["<%GTREE 3.4.3 required if applicable%>"],
                                        "vocabulary_element_name": "required if applicable",
                                        "vocabulary_element_description": "required if applicable",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "Conditional Requirement",
                                                "ontology_term_description": "A requirement that is
mandatory only under certain conditions or circumstances",
                                                "ontology_name": "NCIT",
                                                "ontology_term_id": "NCIT_C25698",
                                                "ontology_url":
"http://purl.obolibrary.org/obo/NCIT_C25698",
                                                "ontology_term_quality": "to be confirmed"
                                            }
                                        ]
                                    },
                                    {
                                        "//": ["<%GTREE 3.4.4 recommended if applicable%>"],
                                        "vocabulary_element_name": "recommended if applicable",
                                        "vocabulary_element_description": "recommended if applicable",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "Conditional Recommendation",
                                                "ontology_term_description": "A recommendation that is
appropriate or suitable only under certain conditions or circumstances",
                                                "ontology_name": "NCIT",
                                                "ontology_term_id": "NCIT_C25699",
                                                "ontology_url":
"http://purl.obolibrary.org/obo/NCIT_C25699",
                                                "ontology_term_quality": "to be confirmed"
                                            }
                                        ]
                                    },
                                    {
                                        "//": ["<%GTREE 3.4.5 optional%>"],
                                        "vocabulary_element_name": "optional",
                                        "vocabulary_element_description": "metadata field can be used if
the information is available",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "Optional",
                                                "ontology_term_description": "possible but not necessary;
left to choice",
                                                "ontology_name": "NCIT",
                                                "ontology_term_id": "C25603",
                                                "ontology_url":
"http://purl.obolibrary.org/obo/NCIT_C25603",
                                                "ontology_term_quality": "to be confirmed"
                                            }
                                        ]
                                    }
                                ],
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "Requirement level",
                                        "ontology_term_description": "The degree to which a metadata
attribute is required or recommended.",
                                        "ontology_name": "EDAM",
                                        "ontology_term_id": "http://edamontology.org/data_3774",
                                        "ontology_url": "http://edamontology.org/data_3774",
                                        "ontology_term_quality": "to be confirmed"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 3.5 attribute Data Type Class %>"],
                                "attribute_name": "data_type_class",
                                "attribute_description": "if the attribute is compound or primitive",
                                "data_type": "controlled_vocabulary",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "controlled_vocabulary": [
                                    {
                                        "vocabulary_element_name": "primitive",
                                        "vocabulary_element_description": "the attribute does not have 
underlying attributes",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "primitive",
                                                "ontology_term_description": "A basic or simple type that 
does not have underlying attributes",
                                                "ontology_name": "SIO",
                                                "ontology_term_id": "SIO_000614",
                                                "ontology_url": 
"http://semanticscience.org/resource/SIO_000614",
                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "vocabulary_element_name": "compound",
                                        "vocabulary_element_description": "the attribute has underlying 
attributes",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "compound",
                                                "ontology_term_description": "A type that has underlying 
attributes",
                                                "ontology_name": "SIO",
                                                "ontology_term_id": "SIO_000615",
                                                "ontology_url": 
"http://semanticscience.org/resource/SIO_000615",
                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    }
                                ],
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "data item type",
                                        "ontology_term_description": "A class of data item that is 
intended to capture the general category of the data item",
                                        "ontology_name": "IAO",
                                        "ontology_term_id": "IAO_0000029",
                                        "ontology_url": "http://purl.obolibrary.org/obo/IAO_0000029",
                                        "ontology_term_quality": "To be coinfirmed"
                                    },
                                    {
                                        "ontology_term_name": "type",
                                        "ontology_term_description": "A class that characterizes a set of 
entities that have common properties",
                                        "ontology_name": "SIO",
                                        "ontology_term_id": "SIO_000097",
                                        "ontology_url": "http://semanticscience.org/resource/SIO_000097",
                                        "ontology_term_quality": "Exact"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 3.6 attribute multiple %>"],
                                "attribute_name": "multiple",
                                "attribute_description": "can the attribute have multiple values",
                                "data_type": "boolean",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "hasPart",
                                        "ontology_term_description": "A related resource that is included
either physically or logically in the described resource.",
                                        "ontology_name": "DCMI",
                                        "ontology_term_id": "http://purl.org/dc/terms/hasPart",
                                        "ontology_url": "http://purl.org/dc/terms/hasPart",
                                        "ontology_term_quality": "Related"
                                    }
                                ]
                            },
                            {
                                "\\": [
                                    "<%GTREE 4 Required if applicable attributes %>",
                                    "<%GTREE 4.1 attribute ControlledVocabulary %>"
                                ],
                                "attribute_name": "controlled_vocabulary",
                                "attribute_description": "Controlled Vocabulary definition if data type
is Controlled Vocabulary also known as an enumeration in STATA or a factor in R",
                                "data_type": "compound_object",
                                "requirement_level": "required if applicable",
                                "data_type_class": "compound",
                                "multiple": true,
                                "attribute_value_elements": [
                                    "vocabulary_element_name",
                                    "controlled_vocabulary_description"
                                ],
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "controlled_vocabulary",
                                        "ontology_term_description": "A set of terms that are selected
and defined based on the requirements set out by the user group, usually a set of vocabulary is chosen to
promote consistency across data collection projects.",
                                        "ontology_name": "NCIT",
                                        "ontology_term_id": "C25704",
                                        "ontology_url": "http://purl.obolibrary.org/obo/NCIT_C25704",
                                        "ontology_term_quality": "to be confirmed"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 4.1.1  Vocabulary element name%>"],
                                "attribute_name": "vocabulary_element_name",
                                "attribute_description": "the element identifier in a Controlled
Vocabulary",
                                "data_type": "string",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "Controlled Vocabulary Term",
                                        "ontology_term_description": "A term or label used in a
controlled vocabulary",
                                        "ontology_name": "NCIt",
                                        "ontology_term_id": "C400",
                                        "ontology_url": "http://purl.obolibrary.org/obo/NCIT_C400",
                                        "ontology_term_quality": "exact"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 4.1.2  Vocabulary element description%>"],
                                "attribute_name": "controlled_vocabulary_description",
                                "attribute_description": "the description of an element in a Controlled
Vocabulary in human-intelligible terms",
                                "data_type": "text",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "Term Definition",
                                        "ontology_term_description": "A definition of a term in a
controlled vocabulary",

                                        "ontology_name": "NCIt",
                                        "ontology_term_id": "C25567",
                                        "ontology_url": "http://purl.obolibrary.org/obo/NCIT_C25567",
                                        "ontology_term_quality": "exact"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 4.2 attribute AttributeValueElements %>"],
                                "attribute_name": "attribute_value_elements",
                                "attribute_description": "details of the DataType compound used to
identify the required attributes in an attribute array",
                                "data_type": "text",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": true,
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "Ontology Class",
                                        "ontology_term_description": "A group of related entities or
concepts, including lists of attributes that describe those entities or concepts.",
                                        "ontology_name": "OBO Foundry",
                                        "ontology_term_id": "IAO_0000030",
                                        "ontology_url": "http://purl.obolibrary.org/obo/IAO_0000030",
                                        "ontology_term_quality": "exact"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 4.3 attribute Ontology %>"],
                                "attribute_name": "ontology_term",
                                "attribute_description": "Tagging atributes with ontology terms",
                                "data_type": "compound_object",
                                "requirement_level": "required if applicable",
                                "data_type_class": "compound",
                                "multiple": true,
                                "attribute_value_elements": [
                                    "ontology_term_name",
                                    "ontology_term_description",
                                    "ontology_name",
                                    "ontology_term_id",
                                    "ontology_url",
                                    "ontology_term_quality"
                                ],
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "Ontology Resource",
                                        "ontology_term_description": "A digital resource that defines and
describes a set of terms and relationships used to represent a domain of knowledge.",
                                        "ontology_name": "NCBO BioPortal",
                                        "ontology_term_id": "OBI_0001618",
                                        "ontology_url": "http://purl.obolibrary.org/obo/OBI_0001618",
                                        "ontology_term_quality": "exact"
                                    }
                                ]
                            },
                            {
                                "//": ["<%GTREE 4.3.1 OntologyTermName%>"],
                                "attribute_name": "ontology_term_name",
                                "attribute_description": "Term in an ontology that describes the relevant
attribute value",
                                "requirement_level": "recommended if applicable",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "data_type": "string",
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "Ontology Term",
                                        "ontology_term_description": "A term in an ontology that
represents a concept or entity in a particular domain.",
                                        "ontology_name": "NCBO BioPortal",
                                        "ontology_term_id": "OBI_0001616",
                                        "ontology_url": "http://purl.obolibrary.org/obo/OBI_0001616",
                                        "ontology_term_quality": "exact"
                                    }
                                ]
                            },
                            {
                                "//": ["<%GTREE 4.3.2 OntologyTermDescription%>"],
                                "attribute_name": "ontology_term_description",
                                "attribute_description": "Description of the ontology term",
                                "requirement_level": "recommended if applicable",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "data_type": "string"
                            },
                            {
                                "//": ["<%GTREE 4.3.3 OntologyName%>"],
                                "attribute_name": "ontology_name",
                                "attribute_description": "The name of the ontology from which we take the
ontology term",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "data_type": "string",
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "Ontology Name",
                                        "ontology_term_description": "The name of an ontology or
controlled vocabulary that provides a set of terms and relationships for describing entities in a
specific domain.",
                                        "ontology_name": "NCBO BioPortal",
                                        "ontology_term_id": "OBI_0001614",
                                        "ontology_url": "http://purl.obolibrary.org/obo/OBI_0001614",
                                        "ontology_term_quality": "exact"
                                    }
                                ]
                            },
                            {
                                "//": ["<%GTREE 4.3.4 OntologyTermID%>"],
                                "attribute_name": "ontology_term_id",
                                "attribute_description": "the identifier for the ontology term in the
specified ontology",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "data_type": "string"
                            },
                            {
                                "//": ["<%GTREE 4.3.5 OntologyURL%>"],
                                "attribute_name": "ontology_url",
                                "attribute_description": "persistent URL where the ontology term can be
found",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "data_type": "uri"
                            },
                            {
                                "//": ["<%GTREE 4.3.6 ontology_term_quality%>"],
                                "attribute_name": "ontology_term_quality",
                                "attribute_description": "identifies to what degree the ontology term
matches the attribute value",
                                "requirement_level": "recommended if applicable",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "data_type": "controlled_vocabulary",
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "Ontology Term Quality",
                                        "ontology_term_description": "A term that describes the degree to
which an ontology term matches the attribute value.",
                                        "ontology_name": "NCBO BioPortal",
                                        "ontology_term_id": "OBI_0001618",
                                        "ontology_url": "http://purl.obolibrary.org/obo/OBI_0001618",
                                        "ontology_term_quality": "Exact match"
                                    }
                                ],
                                "controlled_vocabulary": [
                                    {
                                        "//": ["<%GTREE 4.3.6.1 Exact match%>"],
                                        "vocabulary_element_name": "Exact",
                                        "vocabulary_element_description": "The ontology term matches the
attribute exactly",

                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "ExactMatch",
                                                "ontology_term_description": "A mapping relationship that
specifies that two concepts are equivalent, i.e. have the same meaning.",
                                                "ontology_name": "SKOS",
                                                "ontology_term_id": "skos:exactMatch",
                                                "ontology_url": "https://www.w3.org/TR/skos-
reference/#mapping",

                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "//": ["<%GTREE 4.3.6.2 Too general%>"],
                                        "vocabulary_element_name": "Too general",
                                        "vocabulary_element_description": "The ontology term covers the
attribute, but the attribute is more specific than the ontology term",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "BroadMatch",
                                                "ontology_term_description": "A mapping relationship that
specifies that one concept (the source concept) is broader than another concept (the target concept).",
                                                "ontology_name": "SKOS",
                                                "ontology_term_id": "skos:broadMatch",
                                                "ontology_url": "https://www.w3.org/TR/skos-
reference/#mapping",

                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "//": ["<%GTREE 4.3.6.3 Too specific%>"],
                                        "vocabulary_element_name": "Too specific",
                                        "vocabulary_element_description": "The ontology term covers only 
part of the attribute, the attribute is broader than the ontology term",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "NarrowMatch",
                                                "ontology_term_description": "A mapping relationship that 
specifies that one concept (the source concept) is narrower than another concept (the target concept).",
                                                "ontology_name": "SKOS",
                                                "ontology_term_id": "skos:narrowMatch",
                                                "ontology_url": "https://www.w3.org/TR/skos-
reference/#mapping",
                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "//": ["<%GTREE 4.3.6.4 Partial match%>"],
                                        "vocabulary_element_name": "Partial match",
                                        "vocabulary_element_description": "The ontology term partially 
matches the attribute value",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "CloseMatch",
                                                "ontology_term_description": "A mapping relationship that 
specifies that two concepts are sufficiently similar that they can be used interchangeably in some 
information retrieval applications.",
                                                "ontology_name": "SKOS",
                                                "ontology_term_id": "skos:closeMatch",
                                                "ontology_url": "https://www.w3.org/TR/skos-
reference/#mapping",
                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "//": ["<%GTREE 4.3.6.5 Related%>"],
                                        "vocabulary_element_name": "Related",
                                        "vocabulary_element_description": "The ontology term is related 
to the attribute value, but not an exact match",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "RelatedMatch",
                                                "ontology_term_description": "A mapping relationship that 
specifies that two concepts have some degree of association, but the nature of the relationship is not 
known or specified.",
                                                "ontology_name": "SKOS",
                                                "ontology_term_id": "skos:relatedMatch",
                                                "ontology_url": "https://www.w3.org/TR/skos-
reference/#mapping",
                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "//": ["<%GTREE 4.3.6.6 Not a match%>"],
                                        "vocabulary_element_name": "Not a match",
                                        "vocabulary_element_description": "The ontology term does not 
match the attribute value",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "NotExactMatch",
                                                "ontology_term_description": "The negation of the exact 
match relationship, indicating that two concepts are not equivalent or interchangeable.",
                                                "ontology_name": "SKOS",
                                                "ontology_term_id": "skos:exactMatch",
                                                "ontology_url": "https://www.w3.org/TR/skos-
reference/#mapping",
                                                "ontology_term_quality": "Exact"
                                            }
                                        ]
                                    },
                                    {
                                        "//": ["<%GTREE 4.3.6.7 To be confirmed%>"],
                                        "vocabulary_element_name": "To be confirmed",
                                        "vocabulary_element_description": "The ontology term needs to be 
confirmed by an ontology expert"
                                    }
                                ]
                            },
                            {
                                "\\": [
                                    "<%GTREE 5 optional attributes %>",
                                    "<%GTREE 5.1 Default value %>"
                                ],
                                "attribute_name": "default_value",
                                "attribute_description": "default value of the attribute if not set in 
the metadata",
                                "data_type": "any",
                                "requirement_level": "recommended if applicable",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "Default Value",
                                        "ontology_term_description": "The value of a parameter that is 
used when no other value is specified.",
                                        "ontology_name": "QUDT",
                                        "ontology_term_id": "QUDT_DefaultValue",
                                        "ontology_url": 
"http://www.qudt.org/qudt/owl/1.0.0/datatype.owl#DefaultValue",
                                        "ontology_term_quality": "Exact"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 5.2 Value Reserved Words%>"],
                                "attribute_name": "value_reserved_words",
                                "attribute_description": "reserved words that have a special meaning in 
the contexr of the attribute and are not covered by Controlled Vocabulary",
                                "data_type": "compound_object",
                                "requirement_level": "recommended if applicable",
                                "data_type_class": "compound",
                                "multiple": true,
                                "attribute_value_elements": [
                                    "reserved_word_name",
                                    "reserved_word_description"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 5.2.1 Reserved Words name%>"],
                                "attribute_name": "reserved_word_name",
                                "attribute_description": "reserved words that have a special meaning in 
the context of the attribute and are not covered by Controlled Vocabulary",
                                "data_type": "text",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 5.2.2 Reserved Words description%>"],
                                "attribute_name": "reserved_word_description",
                                "attribute_description": "definition of reserved words that have a 
special meaning in the contexr of the attribute and are not covered by Controlled Vocabulary",
                                "data_type": "text",
                                "requirement_level": "recommended if applicable",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 5.3 Content objects%>"],
                                "attribute_name": "content_objects",
                                "attribute_description": "comparable to AttributeValueElements but less
restrictive",

                                "data_type": "compound_object",
                                "requirement_level": "recommended if applicable",
                                "data_type_class": "compound",
                                "multiple": false,
                                "attribute_value_elements": [
                                    "allowed_content_objects",
                                    "allowed_content_rule"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 5.3.1 Allowed Content objects%>"],
                                "attribute_name": "allowed_content_objects",
                                "attribute_description": "list of allowed content",
                                "data_type": "text",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": true
                            },
                            {
                                "\\": ["<%GTREE 5.3.2 Allowed Content Rule%>"],
                                "attribute_name": "allowed_content_rule",
                                "attribute_description": "rule how to manage the list of allowed
content",

                                "data_type": "compound_object",
                                "requirement_level": "required if applicable",
                                "data_type_class": "compound",
                                "multiple": false,
                                "attribute_value_elements": [
                                    "allowed_content_rule_type",
                                    "allowed_content_rule_number"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 5.3.2.1 Allowed Content Rule Type %>"],
                                "attribute_name": "allowed_content_rule_type",
                                "attribute_description": "specifics about rule how to manage the list of
allowed content",

                                "data_type": "controlled_vocabulary",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "controlled_vocabulary": [
                                    {
                                        "vocabulary_element_name": "AtLeast",
                                        "vocabulary_element_description": "at least"
                                    },
                                    {
                                        "vocabulary_element_name": "AtMost",
                                        "vocabulary_element_description": "at most"
                                    },
                                    {
                                        "vocabulary_element_name": "Exactly",
                                        "vocabulary_element_description": "exactly"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 5.3.2.2 Allowed Content Rule Number %>"],
                                "attribute_name": "allowed_content_rule_number",
                                "attribute_description": "",
                                "data_type": "integer",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": [
                                    "",
                                    "<%GTREE 6 Key attributes for transparency%>",
                                    "",
                                    "<%GTREE 6.1 attribute \\ [comment]%>"
                                ],
                                "attribute_name": "\\",
                                "attribute_description": "comment field",
                                "data_type": "any",
                                "requirement_level": "optional",
                                "data_type_class": "primitive",
                                "multiple": true,
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "comment",
                                        "ontology_term_description": "A written explanation, observation
or criticism added to textual material.",
                                        "ontology_name": "NCIT",
                                        "ontology_term_id": "NCIT_C25393",
                                        "ontolgy_url": "http://purl.obolibrary.org/obo/NCIT_C25393",
                                        "ontology_term_quality": "Exact"
                                    }
                                ]
                            },
                            {
                                "\\": [
                                    "<%GTREE 6.2 attribute Status [Statuscondition]%>"
                                ],
                                "attribute_name": "status_condition",
                                "attribute_description": "Status",
                                "data_type": "controlled_vocabulary",
                                "requirement_level": "optional",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "ontology_term": [
                                    {
                                        "ontology_term_name": "Status",
                                        "ontology_term_description": "A categorical descriptor of the
status of something, e.g., the status of an entity in a process, or the status of a process itself.",
                                        "ontology_name": "EDAM",
                                        "ontology_term_id": "http://edamontology.org/data_2332",
                                        "ontology_url": "http://edamontology.org/data_2332",
                                        "ontology_term_quality": "Exact"
                                    },
                                    {
                                        "ontology_term_name": "lifecycleStatus",
                                        "ontology_term_description": "The status of a resource in its
lifecycle.",
                                        "ontology_name": "DCMI",
                                        "ontology_term_id": "http://purl.org/dc/terms/lifecycleStatus",
                                        "ontology_url": "http://purl.org/dc/terms/lifecycleStatus",
                                        "ontology_term_quality": "Exact"
                                    }
                                ],
                                "controlled_vocabulary": [
                                    {
                                        "//": ["<%GTREE 6.2.1 Active%>"],
                                        "vocabulary_element_name": "Active",
                                        "vocabulary_element_description": "",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "Active",
                                                "ontology_term_description": "",
                                                "ontology_name": "",
                                                "ontology_term_id": "",
                                                "ontolgy_url": "",
                                                "ontology_term_quality": "exact"
                                            }
                                        ]
                                    },
                                    {
                                        "//": ["<%GTREE 6.2.2 inactive%>"],
                                        "vocabulary_element_name": "inactive",
                                        "vocabulary_element_description": "",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "inactive",
                                                "ontology_term_description": "",
                                                "ontology_name": "",
                                                "ontology_term_id": "",
                                                "ontolgy_url": "",
                                                "ontology_term_quality": "exact"
                                            }
                                        ]
                                    },
                                    {
                                        "//": ["<%GTREE 6.2.3 Depricated%>"],
                                        "vocabulary_element_name": "",
                                        "vocabulary_element_description": "required if applicable",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "depricated",
                                                "ontology_term_description": "",
                                                "ontology_name": "",
                                                "ontology_term_id": "",
                                                "ontolgy_url": "",
                                                "ontology_term_quality": "exact"
                                            }
                                        ]
                                    },
                                    {
                                        "//": ["<%GTREE 6.2.4 under review%>"],
                                        "vocabulary_element_name": "under review",
                                        "vocabulary_element_description": "",
                                        "ontology_term": [
                                            {
                                                "ontology_term_name": "under review",
                                                "ontology_term_description": "",
                                                "ontology_name": "",
                                                "ontology_term_id": "",
                                                "ontolgy_url": "",
                                                "ontology_term_quality": "exact"
                                            }
                                        ]
                                    }
                                ]
                            }
                        ]
                    }
                ]
            },
            {
                "OIMS_content_object": "OIMS_Header_Metadata",
                "OIMS_content_object_properties": [
                    {
                        "metadata_class": ["metametadata"],
                        "metadata": [
                            {
                                "\\": [
                                    "<%GTREE 7 metadata heading section %>",
                                    "<%GTREE 7.1 MetaDataSchema: metadata schema used %>"
                                ],
                                "attribute_name": "metadata_schema",
                                "attribute_description": "metadata schema(s) of this metadata schema",
                                "data_type": "compound_object",
                                "requirement_level": "required",
                                "data_type_class": "compound",
                                "multiple": true,
                                "attribute_value_elements": [
                                    "OIMS_content_object",
                                    "schema_properties"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 7.1.1 MetaDataSchema: metadata schema used %>"],
                                "attribute_name": "schema_properties",
                                "attribute_description": "metadata schema of this metadata schema",
                                "data_type": "compound_object",
                                "requirement_level": "required",
                                "data_type_class": "compound",
                                "multiple": true,
                                "attribute_value_elements": [
                                    "schema_name",
                                    "schema_description",
                                    "schema_type",
                                    "schema_version",
                                    "schema_url",
                                    "OIMS_content_object",
                                    "schema_documentation_url",
                                    "include_property",
                                    "exclude_property"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 7.1.1.1 SchemaName: name of underlying metadata schema
used %>"],
                                "attribute_name": "schema_name",
                                "attribute_description": "name of underlying metadata schema used",
                                "data_type": "text",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.1.1.2 SchemaDescription: description of metadata schema
used %>"],
                                "attribute_name": "schema_description",
                                "attribute_description": "description of metadata schema used",
                                "data_type": "text",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.1.1.3 metadata schema type used %>"],
                                "attribute_name": "schema_type",
                                "attribute_description": "metadata schema of this metadata schema",
                                "data_type": "controlled_vocabulary",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "controlled_vocabulary": [
                                    {
                                        "vocabulary_element_name": "self-describing metadata schema",
                                        "vocabulary_element_description": "basis of OIMS is a self-
describing metadata schema"
                                    },
                                    {
                                        "vocabulary_element_name": "primary metametadata",
                                        "vocabulary_element_description": "apex metadata schema 
description"
                                    },
                                    {
                                        "vocabulary_element_name": "intermediate metadata metadata",
                                        "vocabulary_element_description": "intermediate description 
between the apex metadata schema description and the self-describing metadata schema of OIMS"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 7.1.1.4 metadata schema type used %>"],
                                "attribute_name": "schema_subtype",
                                "attribute_description": "metadata schema of this metadata schema",
                                "data_type": "text",
                                "requirement_level": "recommended",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.1.1.5 Schemaversion: version number of the metadata 
schema used %>"],
                                "attribute_name": "schema_version",
                                "attribute_description": "version number of the metadata schema used",
                                "data_type": "text",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.1.1.6 SchemaURL: URL where the metadata schema used can 
be found%>"],
                                "attribute_name": "schema_url",
                                "json_schemaproperty": "$ref",
                                "attribute_description": "URL where the metadata schema used can be 
found",

                                "data_type": "uri",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.1.1.7 SchemSchemaDocumentationURL: URL where the 
metadata schema used can be found%>"],
                                "attribute_name": "schema_documentation_url",
                                "attribute_description": "URL where the documentation of metadata schema 
used can be found",
                                "data_type": "uri",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.1.1.8 Include property%>"],
                                "attribute_name": "include_property",
                                "attribute_description": "which attributes in the metadata schema should 
be used, relevant if multiple schemas as used default value if not chosen is ALL",
                                "data_type": "text",
                                "default_value": "ALL",
                                "value_reserved_words": [
                                    {
                                        "reserved_word_name": "ALL",
                                        "reserved_word_description": "all attributes in the OIMS_content 
part of the schema"
                                    },
                                    {
                                        "reserved_word_name": "NONE",
                                        "reserved_word_description": "none of attributes in the 
OIMS_content part of the schema"
                                    }
                                ],
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": true
                            },
                        {
                                "\\": ["<%GTREE 7.1.1.9 exclude property%>"],
                                "attribute_name": "exclude_property",
                                "attribute_description": "which attributes in the metadata schema should 
be not used, relevant if multiple schemas as used default value if not chosen is NONE",
                                "data_type": "text",
                                "default_value": "NONE",
                                "value_reserved_words": [
                                    {
                                        "reserved_word_name": "ALL",
                                        "reserved_word_description": "all attributes in the OIMS_content 
part of the schema"
                                    },
                                    {
                                        "reserved_word_name": "NONE",
                                        "reserved_word_description": "none of attributes in the 
OIMS_content part of the schema"
                                    }
                                ],
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": true
                            },
                            {
                                "\\": ["<%GTREE 7.2 File descriptors: descriptive metadata of the 
metadata file%>"],
                                "attribute_name": "file_descriptors",
                                "attribute_description": "descrptive metadata of the metadata file",
                                "data_type": "compound_object",
                                "requirement_level": "required",
                                "data_type_class": "compound",
                                "multiple": false,
                                "attribute_value_elements": [
                                    "metadata_name",
                                    "metadata_description",
                                    "metadata_version",
                                    "contact"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 7.2.1 MetadataName: short description or name of the 
metadata file%>"],
                                "attribute_name": "metadata_name",
                                "attribute_description": "short description or name of the metadata 
file",
                                "data_type": "text",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.2.2 MetadataVersion: short description or name of the 
metadata file%>"],
                                "attribute_name": "metadata_version",
                                "attribute_description": "short description or name of the metadata 
file",
                                "data_type": "compound_object",
                                "requirement_level": "required",
                                "data_type_class": "compound",
                                "multiple": false,
                                "attribute_value_elements": [
                                    "current_version",
                                    "metadata_version_status"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 7.2.2.1 CurrentVersion: current version of the metadata
file%>"],
                                "attribute_name": "current_version",
                                "attribute_description": "current version of the metadata file",
                                "data_type": "text",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.2.2.2 MetadataVersionStatus: status of the metadata
file%>"],
                                "attribute_name": "metadata_version_status",
                                "attribute_description": "short description or name of the metadata
file",
                                "data_type": "controlled_vocabulary",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "controlled_vocabulary": [
                                    {
                                        "vocabulary_element_name": "development",
                                        "vocabulary_element_description": "The metadata file is not
complete and cannot yet be used"
                                    },
                                    {
                                        "vocabulary_element_name": "testing",
                                        "vocabulary_element_description": "meta data file is being tested
for consistency"
                                    },
                                    {
                                        "vocabulary_element_name": "under review",
                                        "vocabulary_element_description": "meta data file is under
review"
                                    },
                                    {
                                        "vocabulary_element_name": "provisional publication",
                                        "vocabulary_element_description": "the metadata has been tested
and the file is OIMS compatible but still needs revisions"
                                    },
                                    {
                                        "vocabulary_element_name": "released",
                                        "vocabulary_element_description": "published metadata"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 7.2.2.3 MetadataVersionDate: date of the metadata
file%>"],
                                "attribute_name": "version_date",
                                "attribute_description": "Date of this version of the metadata",
                                "data_type": "date",
                                "requirement_level": "recommended",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.2.2.4 Metadata change log%>"],
                                "attribute_name": "metadata_change_log",
                                "attribute_description": "log of chnages to the metadata",
                                "data_type": "text",
                                "requirement_level": "recommended",
                                "data_type_class": "primitive",
                                "multiple": true
                            },
                            {
                                "\\": ["<%GTREE 7.2.2.5 Previous version: previous version of the
metadata file%>"],
                                "attribute_name": "previous_version",
                                "attribute_description": "previous version of the metadata file",
                                "data_type": "text",
                                "requirement_level": "optional",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.2.3 Contact: contact details of the manager of the
metadata%>"],
                                "attribute_name": "contact",
                                "attribute_description": "contact details of the manager of the
metadata",
                                "data_type": "compound_object",
                                "requirement_level": "required",
                                "data_type_class": "compound",
                                "multiple": false,
                                "attribute_value_elements": [
                                    "contact_name",
                                    "contact_affiliation",
                                    "contact_identifier",
                                    "contact_email"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 7.2.3.1 ContactName: Name of a person or entity to
contact about the metadata%>"],
                                "attribute_name": "contact_name",
                                "attribute_description": "Name of a person or entity to contact about the
metadata",
                                "data_type": "text",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.2.3.2 ContactRole: Role of contact person or
entity%>"],
                                "attribute_name": "contact_role",
                                "attribute_description": "Role of contact person or entity ",
                                "data_type": "text",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.2.3.3 ContactAffiliation: Affiliation of a person or
entity to contact about the metadata%>"],
                                "attribute_name": "contact_affiliation",
                                "attribute_description": "Affiliation of a person or entity to contact
about the metadata",
                                "data_type": "compound_object",
                                "requirement_level": "required",
                                "data_type_class": "compound",
                                "multiple": true,
                                "attribute_value_elements": [
                                    "contact_affiliation_name",
                                    "contact_affiliation_aconym"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 7.2.3.2.1 ContactAffiliationName: Affiliation of a person
or entity to contact about the metadata%>"],
                                "attribute_name": "contact_affiliation_name",
                                "attribute_description": "Affiliation of a person or entity to contact
about the metadata",
                                "data_type": "text",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.2.3.2.1 ContactAffiliationAcronym: Acronym of the
affiliation of a person or entity to contact about the metadata%>"],
                                "attribute_name": "contact_affiliation_acronym",
                                "attribute_description": "acronym of the affiliation of a person or
entity to contact about the metadata",
                                "data_type": "text",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.2.3.3 ContactIdentifier: Persistent identifier of a
person to contact about the metadata%>"],
                                "attribute_name": "contact_identifier",
                                "attribute_description": "Identifier of a person to contact about the
metadata",
                                "data_type": "compound_object",
                                "requirement_level": "recommended",
                                "data_type_class": "compound",
                                "multiple": true,
                                "attribute_value_elements": [
                                    "identifier_scheme",
                                    "identifier"
                                ]
                            },
                            {
                                "\\": ["<%GTREE 7.2.3.3.1 IdentifierScheme: scheme to identify a
person%>"],
                                "attribute_name": "identifier_scheme",
                                "attribute_description": "scheme to identify a person",
                                "data_type": "controlled_vocabulary",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "controlled_vocabulary": [
                                    {
                                        "vocabulary_element_name": "ORCID",
                                        "vocabulary_element_description": "ORCID: https://orcid.org/"
                                    }
                                ]
                            },
                            {
                                "\\": ["<%GTREE 7.2.3.3.2 Identifier: identifier of person linked to the
relevant identifier scheme%>"],
                                "attribute_name": "identifier",
                                "attribute_description": "identifier of person linked to the relevant
identifier scheme",
                                "data_type": "text",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.2.3.4 Contactemail: email address of a person or entity
to contact about the metadata%>"],
                                "attribute_name": "contact_email",
                                "attribute_description": "email address of a person or entity to contact
about the metadataa",
                                "data_type": "email",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": true
                            },
                            {
                                "\\": ["<%GTREE 7.2.4 metadata description%>"],
                                "attribute_name": "metadata_description",
                                "attribute_description": "short descroiption of the metadata file",
                                "data_type": "text",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": ["<%GTREE 7.2.5 Metadata notes%>"],
                                "attribute_name": "metadata_notes",
                                "attribute_description": "any notes about the metadata not caotured in
other attribute fields",
                                "data_type": "text",
                                "requirement_level": "optional",
                                "data_type_class": "primitive",
                                "multiple": true
                            },
                            {
                                "\\": [
                                    "<%GTREE 7.3 mapping info on how the metadata was created%>",
                                    "note that this is work in progress only Mapper_tool_Name identified
as compound element"
                                ],
                                "attribute_name": "mapping_info",
                                "attribute_description": "information on how the metadata was created",
                                "data_type": "compound_object",
                                "requirement_level": "optional",
                                "data_type_class": "compound",
                                "multiple": true,
                                "attribute_value_elements": [
                                    "mapper_tool_name",
                                    "mapper_tool_version",
                                    "mapper_tool_url"
                                ]
                            },
                            {
                                "\\": [
                                    "<%GTREE 7.3.1 mapper tool name%>"
                                ],
                                "attribute_name": "mapper_tool_name",
                                "attribute_description": "name of the tool used to map could be manual",
                                "data_type": "text",
                                "requirement_level": "optional",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": [
                                    "<%GTREE 7.3.2 mapper tool version%>"
                                ],
                                "attribute_name": "mapper_tool_version",
                                "attribute_description": "version of the tool used if not manual",
                                "data_type": "text",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": [
                                    "<%GTREE 7.3.3 mapper tool url%>"
                                ],
                                "attribute_name": "mapper_tool_url",
                                "attribute_description": "persistent url of the mapper tool",
                                "json_schemaproperty": "$ref",
                                "data_type": "url",
                                "requirement_level": "recommended",
                                "data_type_class": "primitive",
                                "multiple": false
                            },
                            {
                                "\\": [
                                    "<%GTREE 7.3.4 mapper input%>",
                                    "note that this is work in progress and not fully developed"
                                ],
                                "attribute_name": "mapper_input",
                                "attribute_description": "input into the mapper tool provided for
transparency purposes",
                                "data_type": "compound_object",
                                "requirement_level": "recommended",
                                "data_type_class": "compound",
                                "multiple": true,
                                "attribute_value_elements":[
                                    "mapper_input_type",
                                    "mapper_input_values"
                                ]
                            },
                            {
                                "\\": [
                                    "<%GTREE 7.3.4.1 mapper input type%>",
                                    "note that this is work in progress and not fully developed"
                                ],
                                "attribute_name": "mapper_input_type",
                                "attribute_description": "type of information into on input into the
mapper tool provided for transparency purposes",
                                "data_type": "controlled_vocabulary",
                                "requirement_level": "required",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "controlled_vocabulary":[
                                    {
                                        "vocabulary_element_name": "command line paremeter",
                                        "vocabulary_element_description": "command line parameter"
                                    },
                                    {
                                        "vocabulary_element_name": "transparency report",
                                        "vocabulary_element_description": "report containing all the
relevant settings, user input and other information for understanding how metadata was generated"
                                    }
                                ]
                            },
                            {
                                "\\": [
                                    "<%GTREE 7.3.4.2 mapper input values%>",
                                    "note that this is work in progress and not fully developed"
                                ],
                                "attribute_name": "mapper_input_values",
                                "attribute_description": "values linked to the type of information into
on input into the mapper tool provided for transparency purposes",
                                "data_type": "compound object",
                                "requirement_level": "required",
                                "data_type_class": "compound",
                                "multiple": true
                            },
                            {
                                "\\": [
                                    "<%GTREE 7.3.4.2.1 mapper input values if command line parameter:
parameter name%>",
                                    "note that this is work in progress and not fully developed"
                                ],
                                "attribute_name": "parameter_name",
                                "attribute_description": "name of the command line parameter",
                                "data_type": "text",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive"
                            },
                            {
                                "\\": [
                                    "<%GTREE 7.3.4.2.2 mapper input values if command line parameter: 
parameter value%>",
                                    "note that this is work in progress and not fully developed"
                                ],
                                "attribute_name": "parameter_value",
                                "attribute_description": "value of the command line parameter",
                                "data_type": "any",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive"
                            },
                            {
                                "\\": [
                                    "<%GTREE 7.3.4.2.3 mapper input values if transparency report: report 
name%>",
                                    "note that this is work in progress and not fully developed"
                                ],
                                "attribute_name": "report_name",
                                "attribute_description": "name of the report",
                                "data_type": "text",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive"
                            },
                            {
                                "\\": [
                                    "<%GTREE 7.3.4.2.4 mapper input values if transparency report: report 
url%>",
                                    "note that this is work in progress and not fully developed"
                                ],
                                "attribute_name": "report_url",
                                "attribute_description": "persistent url of the transparency repport 
containing mapper input information",
                                "data_type": "url",
                                "requirement_level": "required if applicable",
                                "data_type_class": "primitive"
                            },
                            {
                                "\\": [
                                    "<%GTREE 8 JSON schema support%>",
                                    "<%GTREE 8.1 JSONSchemaProperty%>"
                                ],
                                "attribute_name": "json_schema_property",
                                "attribute_description": "specific property that is a reserved word in 
JSON Schema",
                                "data_type": "controlled_vocabulary",
                                "requirement_level": "optional",
                                "data_type_class": "primitive",
                                "multiple": false,
                                "controlled_vocabulary": [
                                    {
                                        "vocabulary_element_name": "$ref",
                                        "vocabulary_element_description": "In a JSON schema, a $ref 
keyword is a JSON Pointer to a schema, or a type or property in a schema. A JSON pointer takes the form 
of A # B in which: A is the relative path from the current schema to a target schema. If A is empty, the 
reference is to a type or property in the same schema, an in-schema reference."
                                    }
                                ]
                            }
                        ]
```

```
                    }
                ]
            }
        ]
    }
```

Annex 5: JSON schema for validating OIMS-compatible metametadata files



```
{
  "$schema": "http://json-schema.org/schema#",
  "$id": "https://github.com/ForesightAndMetrics/OIMS/BasicSchemas/OIMS_base.json",
  "title": "schema build on OIMS_basis.json only",
  "description": "Basic structure of an OIMS compatible metadata file built on the self-describing
metadata schema only",
  "type": "object",
  "properties": {
    "OIMS": {
      "type": "object",
      "properties": {
        "\\": {
          "type": "array",
          "items": {
            "type": "string"
          }
        },
        "OIMS_header": {
          "type": "object",
          "properties": {
            "mapping_info": {
              "type": "array",
              "items": {
                "type": "object",
                "properties": {
                  "mapper_tool_name": {
                    "type": "string"
                  }
                },
                "required": [
                  "mapper_tool_name"
                ]
              }
            },
            "metadata_schema": {
              "type": "array",
              "items": {
                "type": "object",
                "properties": {
                  "OIMS_content_object": {
                    "oneOf": [
                      { "const": "MetadataMetadata" }
                    ]
                  },
                  "schema_properties": {
                    "type": "array",
                    "items": {
                      "type": "object",
                      "properties": {
                        "schema_name": {
                          "type": "string"
                        },
                        "schema_description": {
                          "type": "string"
                        },
                        "schema_type": {
                          "type": "string"
                        },
                        "schema_version": {
```

```
                        "type": "string"
                      },
                      "schema_url": {
                        "type": "string"
                      },
                      "OIMS_content_object": {
                        "oneOf": [
                          { "const": "MetadataMetadata" }
                        ]
                      }
                    },
                    "required": [
                      "schema_description",
                      "schema_name",
                      "schema_type",
                      "schema_url",
                      "schema_version",
                      "OIMS_content_object"
                    ]
                  }
                }
              },
              "required": [
                "OIMS_content_object",
                "schema_properties"
              ]
            },
            "minItems": 1
          },
          "file_descriptors": {
            "type": "object",
            "properties": {
              "metadata_name": {
                "type": "string"
              },
              "meta_data_description": {
                "type": "string"
              },
              "metadata_version": {
                "type": "object",
                "properties": {
                  "current_version": {
                    "type": "string"
                  },
                  "metadata_version_status": {
                    "type": "string"
                  },
                  "version_date": {
                    "type": "string"
                  }
                },
                "required": [
                  "current_version",
                  "metadata_version_status",
                  "version_date"
                ]
              },
              "contact": {
                "type": "array",
                "items": {
                  "type": "object",
                  "properties": {
                    "contact_name": {
                      "type": "string"
                    },
                    "contact_role": {
                      "type": "string"
                    },
                    "contact_affiliation": {
                      "type": "object",
                      "properties": {
                        "contact_affiliation_name": {
                          "type": "string"
                        },
                        "contact_affiliation_acronym": {
                          "type": "string"
                        }
                      },
                      "required": [
                        "contact_affiliation_acronym",
                        "contact_affiliation_name"
                      ]
                    },
                    "contact_identifier": {
                      "type": "array",
                      "items": {
                        "type": "object",
                        "properties": {
                          "identifier_scheme": {
                            "type": "string"
                          },
                          "identifier": {
                            "type": "string"
                          }
                        },
                        "required": [
                          "identifier",
                          "identifier_scheme"
                        ]
                      }
                    },
                    "contact_email": {
                      "type": "array",
                      "items": {
                        "type": "string"
                      }
                    }
                  },
                  "required": [
                    "contact_affiliation",
                    "contact_email",
                    "contact_identifier",
                    "contact_name"
                  ]
                }
              }
            },
            "required": [
              "contact",
              "meta_data_description",
              "metadata_name",
              "metadata_version"
            ]
          }
        },
        "required": [
          "mapping_info",
          "metadata_schema",
          "file_descriptors"
        ]
      },
      "OIMS_content": {
        "type": "array",
        "items": {
          "type": "object",
          "properties": {
```

```
            "\\": {
              "type": "array",
              "items": {
                "type": "string"
              }
            },
            "OIMS_content_object": {
              "oneOf": [
                { "const": "MetadataMetadata" }
              ]
            },
            "OIMS_content_object_properties": {
              "type": "array",
              "items": {
                "type": "object",
                "properties": {
                  "metadata": {
                    "type": "array",
                    "items": {
                      "type": "object",
                      "properties": {
                        "attribute_name": {
                          "description": "name of the data dictionary metadata field",
                          "type": "string"
                        },
                        "attribute_description": {
                          "description": "description of the data dictionary metadata field",
                          "type": "string"
                        },
                        "data_type": {
                          "description": "datatypes used in the data dictionary metadata fields",
                          "type": "string",
                          "enum": [
                            "string",
                            "text",
                            "compound_object",
                            "date",
                            "uri",
                            "controlled_vocabulary",
                            "boolean",
                            "email",
                            "integer",
                            "float",
                            "html",
                            "any"
                          ]
                        },
                        "requirement_level": {
                          "description": "see OIMS self describing metadata schema",
                          "type": "string",
                          "enum": [
                            "required",
                            "recommended",
                            "required if applicable",
                            "recommended if applicable",
                            "optional"
                          ]
                        },
                        "data_type_class": {
                          "description": "if the attribute is compound or primitive",
                          "type": "string",
                          "enum": [
                            "primitive",
                            "compound"
                          ]
                        },
                        "multiple": {
                          "description": "can the attribute have multiple values",
                            "type": "boolean"
                          },
                          "controlled_vocabulary": {
                            "description": "Controlled Vocabulary definition if data type is Controlled
Vocabulary also known as an enumeration in STATA or a factor in R",
                            "type": "array",
                            "items": {
                              "type": "object",
                              "properties": {
                                "vocabulary_element_name": {
                                  "type": "string"
                                },
                                "controlled_vocabulary_description": {
                                  "type": "string"
                                }
                              }
                            }
                          },
                          "vocabulary_element_name": {
                            "description": "the element identifier in a Controlled Vocabulary",
                            "type": "string"
                          },
                          "controlled_vocabulary_description": {
                            "description": "the description of an element in a Controlled Vocabulary in
human-intelligible terms",
                            "type": "string"
                          },
                          "attribute_value_elements": {
                            "description": "details of the DataType compound used to identify the
required attributes in an attribute array",
                            "type": "array",
                            "items": {
                              "type": "string"
                            }
                          },
                          "ontology": {
                            "description": "Tagging atributes with ontology terms",
                            "type": "array",
                            "items": {
                              "type": "object",
                              "properties": {
                                "ontology_term_name": {
                                  "type": "string"
                                },
                                "ontology_term_description": {
                                  "type": "string"
                                },
                                "ontology_name": {
                                  "type": "string"
                                },
                                "ontology_term_id": {
                                  "type": "string"
                                },
                                "ontology_url": {
                                  "type": "string"
                                },
                                "ontology_term_quality": {
                                  "type": "string"
                                }
                              }
                            }
                          },
                          "ontology_term_name": {
                            "description": "Term in an ontology that describes the relevant attribute
value",
                            "type": "string"
                          },
                          "ontology_term_description": {
                            "description": "Description of the ontology term",
                            "type": "string"
                          },
                          "ontology_name": {
                            "description": "The name of the ontology from which we take the ontology 
term",
                            "type": "string"
                          },
                          "ontology_term_id": {
                            "description": "the identifier for the ontology term in the specified 
ontology",
                            "type": "string"
                          },
                          "ontology_url": {
                            "description": "persistent URL where the ontology term can be found",
                            "type": "string"
                          },
                          "ontology_term_quality": {
                            "description": "identifies to what degree the ontology term matches the 
attribute value",
                            "type": "string",
                            "enum": [
                              "Exact",
                              "Too general",
                              "Too specific",
                              "Partial match",
                              "Related",
                              "Not a match",
                              "To be confirmed"
                            ]
                          },
                          "default_value": {
                            "description": "default value of the attribute if not set in the metadata",
                            "type": "string"
                          },
                          "value_reserved_words": {
                            "description": "reserved words that have a special meaning in the contexr of 
the attribute and are not covered by Controlled Vocabulary",
                            "type": "array",
                            "items": {
                              "type": "object",
                              "properties": {
                                "reserved_word_name": {
                                  "type": "string"
                                },
                                "reserved_word_description": {
                                  "type": "string"
                                }
                              }
                            }
                          },
                          "reserved_word_name": {
                            "description": "reserved words that have a special meaning in the context of 
the attribute and are not covered by Controlled Vocabulary",
                            "type": "string"
                          },
                          "reserved_word_description": {
                            "description": "definition of reserved words that have a special meaning in 
the contexr of the attribute and are not covered by Controlled Vocabulary",
                            "type": "string"
                          },
                          "content_objects": {
                            "description": "comparable to AttributeValueElements but less restrictive",
                            "type": "object",
                            "properties": {
                              "allowed_content_objects": {
                                "type": "string"
                              },
                              "allowed_content_rule": {
                                "type": "string"
                              }
                            }
                          },
                          "allowed_content_objects": {
                            "description": "list of allowed content",
                            "type": "array",
                            "items": {
                              "type": "string"
                            }
                          },
                          "allowed_content_rule": {
                            "description": "rule how to manage the list of allowed content",
                            "type": "object",
                            "properties": {
                              "allowed_content_rule_type": {
                                "type": "string"
                              },
                              "allowed_content_rule_number": {
                                "type": "string"
                              }
                            }
                          },
                          "allowed_content_rule_type": {
                            "description": "specifics about rule how to manage the list of allowed
content",

                            "type": "string",
                            "enum": [
                              "AtLeast",
                              "AtMost",
                              "Exactly"
                            ]
                          },
                          "allowed_content_rule_number": {
                            "description": "",
                            "type": "number"
                          },
                          "\\": {
                            "description": "comment field",
                            "type": "array",
                            "items": {
                              "type": "string"
                            }
                          },
                          "status_condition": {
                            "description": "Status",
                            "type": "string"
                          }
                        },
                        "required": [
                          "attribute_name",
                          "attribute_description",
                          "data_type",
                          "requirement_level",
                          "data_type_class",
                          "multiple"
                        ],
                        "if": {
                          "properties": {
                            "data_type": {"const": "controlled_vocabulary"}
                        },
                        "then": {
                          "properties": {
                            "controlled_vocabulary": {
                              "type": "array",
                              "minItems": 1
                            }
                          }
                        },
                        "else": {
                          "if": {
                            "properties": {
                              "data_type": {"const": "compound_object"}
                            }
                          },
                          "then": {
                            "properties": {
                              "data_type_class": {"const": "compound"},
                              "attribute_value_elements": {
                                "type": "array",
                                "minItems": 1
                              }
                            }
                          },
                          "else": {
                            "if": {
                              "properties": {}
                            },
                            "then": {
                              "properties": {}
                            }
                          }
                        }
                      }
                    }
                  },
                  "required": [
                    "metadata"
                  ]
                }
              }
            },
            "required": [
              "OIMS_content_object_properties",
              "OIMS_content_object"
            ]
          }
        }
      },
      "required": [
        "\\",
        "OIMS_header",
        "OIMS_content"
      ]
    }
  },
  "required": [
    "OIMS"
  ],
  "patternProperties": {
    "^\\\\$": { "$ref": "#/definitions/comment" }
  },
  "definitions": {
    "comment": {
      "type": "array",
      "items": {
        "type": "string"
      },
      "description": "Array of comments"
    }
  }
}
}
```

[LOGO]
[LOGO]
[LOGO]
[LOGO]
[LOGO]

Gideon Kruseman, Foresight Initiative WP3 leader, g.kruseman@cgiar.org

Name, Title, emailaddress@cgiar.org

CGIAR is a global research partnership for a food-secure future. CGIAR science is dedicated to transforming food, land, and water systems in a climate crisis. Its research is carried out by 13 CGIAR Centers/Alliances in close collaboration with hundreds of partners, including national and regional research institutes, civil society organizations, academia, development organizations and the private sector. www.cgiar.org

We would like to thank all funders who support this research through their contributions to the CGIAR Trust Fund: www.cgiar.org/funders.

To learn more about this Initiative, please visit this webpage.

To learn more about this and other Initiatives in the CGIAR Research Portfolio, please visit www.cgiar.org/cgiar-portfolio

© 2023 CGIAR System Organization. Some rights reserved.

This work is licensed under a Creative Commons Attribution-Noncommercial 4.0 International Licence (CC BYNC 4.0).

CGIAR

INITIATIVE ON
Foresight