Developing metrics and instruments to evaluate citizen science impacts on the environment and society

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Abstract (for dissemination)	The MICS repository is a storage facility for the data and documents collected, produced and managed by the project, featuring a metadata scheme for common and interoperable data documentation and processing.
Keywords	Storage facility, Data, Metadata scheme, Interoperable data

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Version as date	**Author**	**Partner**	**Change**
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Contents

1 Executive Summary

The MICS repository is a storage facility for the data and documents collected, produced and managed by the project, featuring a metadata scheme for common and interoperable data documentation and processing.

2 Introduction

2.1 Context within the MICS project

MICS investigates and optimises how citizen science can add value to research and innovation. To this end, it develops methods and instruments to measure the impact of citizen science. The change in the efficiency and the outcomes compared with "traditional" projects is measured with existing indicators (such as MoRRI, the IRIS catalogue of generally-accepted performance metrics that leading impact investors use to measure the social, environmental, and financial performance of their investments,

and the guidelines produced by the Global Reporting Initiative), modified to be fit for purpose, and with completely new **indicators and methodologies**.

These indicators and methodologies need **data** to be tested, and these data are stored in a **repository**, which is the object of this deliverable. The project acquires qualitative and quantitative data for impact analysis using instruments based on results from previous and ongoing European projects, as well as new approaches specifically linked to citizen science (e.g., stakeholder feedback questionnaires, field reports, local-context analysis, retrospective pre-post questionnaires, and case studies). Specific measurements focus on each of the following **domains** at the intersection of citizen science and research: (1) society, (2) governance, (3) the economy, (4) the environment, and (5) science.

- **Society**. Effective actions require mobilisation and serious commitment at every level, from international co-operation to individual choices. Citizen science can have an impact on participants' perception of themselves and of science. Participation in citizen science allows for an increased understanding of the environment or citizens' health. Citizen scientists report an increased self-confidence, social responsibility, citizenship and commitment to action (Jordan et al., 2011). Citizen-science projects can induce a behaviour change for participants, but a clear approach to optimise the scientist-public collaboration and determine the impacts of citizen science on different aspects of participant behaviour is lacking. Citizen science also provides individuals with an improved capacity to engage in public discourse as a result of their improved understanding and their increased confidence as part of a wider network supported by scientists (Cooper, 2012). Experiential learning plays a key role in this new understanding and favours a more active involvement in the local community (Schultz, 2011). This has effects in the wider community, which, while not directly involved in the citizen science activities, is aware that such programmes exist and receives indirect benefits of learning and engagement by acknowledging the participation of other members of the community. Additionally, MICS defines methods to assess the impact of citizen science on the following conditions of citizen scientists:
    - well-being;
    - empowerment (e.g., ability to provide suggestions about the design of NBSs or to influence areas of uncertainty);
    - education (e.g., scientific familiarity at personal level); and
    - engagement with societal problems.

- **Governance**. When people participate in citizen-science associations/activities/projects, their actions and democratic sensibilities are affected by the ways in which civic educators describe the future uses of the data they are collecting/analysing. MICS studies the impact of citizen science on:
    - this democratic sensibility;
    - the democratisation of environmental governance;
    - the participation in politics; and
    - environmental justice.

  The project also defines methods to measure if citizen science has a role, in different contexts, in changing decision-makers attitude from

channelling public concern about something toward future action

to

policy action in the present to prevent future problems.

- **The economy**. MICS defines methods to study the impact of citizen science on:
  - cooperation for exploitation, e.g. with social entrepreneurs;
  - cost reduction;
  - new job creation;
  - generation of new business models;
  - the extension of studies beyond the time frames of funding.

- **The environment**. Citizen science can, sometimes, provide a huge amount of data at low cost, and has the potential to provide information at spatial and temporal scales otherwise unavailable. In certain fields of science, such as environmental sciences, quantity can, often, be more important than accuracy: citizen-science methods (when associated to more data) may produce better results to characterise environment patterns than those based on professional research (usually associated to more accuracy). Simple protocols lower barriers for data collection, empowering a wider community to participate in monitoring environmental data.

- **Science**. MICS defines methods to assess the impact of citizen science on:
  - science results;
  - data standards;
  - best-practice documents; and
  - educational materials.

MICS explores different approaches to impact assessment of existing citizen-science projects and evaluates the applicability/adaptability of relevant concepts and methodologies. Likewise, relevant indicators are identified and adapted to citizen science, and benchmarks are determined using previous projects.

All these methods are not defined from scratch, but, in WP2, a critically reviewed evidence of all available research results about citizen-science impact assessment is established. Defining the assessment indicators to measure the impact of citizen science includes identifying and collecting relevant available scientific and non-scientific publications (digital scientific publications as well as newspaper and journal articles, policy papers, legal instruments, data from existing surveys, summaries of political discussions) produced on the impact of citizen science. This is supported by a formal methodology and related tools and technologies, as well as several sources of open-access data, including CORDIS, the EU Open Data Portal and OpenAIRE. Sensitive data are treated with the utmost care and prudence. The collected data are stored in a dedicated and secure storage facility (the MICS repository), together with deliverables, including applications, which can be published as open source, and linked to equivalent established open-source repositories, such as Zenodo, and, in general, together with the consolidated corpus of knowledge created within MICS.

Finally, the MICS project might involve, at some point in the future, personal-data collection and processing, and therefore an ethics self-assessment will be carried out before storing them in the MICS repository. And the MICS's case-study sites collect environmental data brought by individual citizens'

observations and will make them also available to the public through the open access to the MICS repository. Therefore, two types of data will be potentially collected: personal and environmental data. These two sets of data will be stored and processed in the MICS repository.

2.2 Context within WP3

WP3 identifies, adapts and develops (as appropriate) tools for impact assessment, based on input from WP2 with respect to relevant concepts and methodologies. This input aids the implementation of the tools and their initial running. To incorporate all this information, WP3 works in short and focused iterations. WP3 also delivers the MICS platform, i.e., its technical specifications, interoperability specifications and implementation, including its functionalities and back-end services. The MICS platform includes the incremental versions of the project's services, when adapted and enhanced from existing services used by the communities (social networking and notification services), and additional services (which focus on the measurement of citizen science's impact). Results from this work package are the MICS platform specification and integration, with:

- the **MICS repository** linked with other data services; and
- the user management associated with the distributed social networking and notification services.

It is also an objective of WP3 to impact the relevant standards (e.g., of an ontology of citizen science) through active contribution and participation. WP3 is responsible for helping to raise the impact of the project outputs via powerful, personalised and highly usable information visualisation and delivery. Configurable user interfaces (a project's dashboard with web interface, including a mobile-friendly interface) will include visualisations of the data adapted to the user profile.

Specifically, in Task 3.2, the tools to be adapted/developed implement the methods to measure the impact of citizen science defined in WP2. Existing tools are reviewed for applicability and accordingly adapted and fine-tuned to the specific tasks' needs. If needed, new tools are developed. As already mentioned, the collected data are stored in a dedicated, secure storage facility (the MICS repository). The metadata model is the outcome of close collaboration with citizen-science experts, who are active in the COST Action on citizen science; adherence to this model ensures discoverability of the resources stored, extensibility of the catalogue of resources according to common collection criteria, maintenance of the MICS repository and sustainability beyond the end of the project. The MICS repository will host the impact-related data and make them accessible and searchable, enabling users to retrieve comparisons of specific aspects in different regions, and also to look for a specific region and receive a list with all relevant topics for that region.

3 MICS's storage facility

MICS's data and technical documents are stored in four classes of repositories:

- personal computers and personal cloud systems (out of the scope of this document);
- partner organisations' servers and cloud systems (out of the scope of this document);
- MICS's OneDrive cloud system (also accessible via the MICS shared workspace SharePoint): this is the "**MICS repository**";
- other storage systems (e.g., paper) (out of the scope of this document).

3.1.1 OneDrive and SharePoint

The MICS repository is based on OneDrive for Business, which is a system where files from a computer can be stored into the cloud, and be accessed from any device, or shared with others. As part of Office

365 (or SharePoint Server), OneDrive for Business lets update and share files from anywhere and work on Office documents with others at the same time.

The MICS repository is a place where users can collaborate on files, documents, and ideas. It is set up to facilitate two-way communication between team members. The MICS repository offers a full range of document libraries, task lists, calendars, workflows, wikis, and other features to help a team communicate and collaborate.

With OneDrive for Business, the MICS repository's files are stored in the cloud. The members of the Consortium can sync either OneDrive for Business or SharePoint to their computer[1] (for offline working).

MICS's OneDrive cloud system and SharePoint site are a private repository accessible only by projects participants and managed by Earthwatch. MICS's OneDrive can be directly accessed at:

[https://earthwatch611.sharepoint.com/sites/mics-group/Shared%20Documents/Forms/AllItems.aspx].

It can be accessed also from the corresponding SharePoint page:

[https://earthwatch611.sharepoint.com/sites/mics-group].

Any format can be used for documents, but, because of market dominance and because of the chosen repository system, most documents will be using Microsoft Office formats. In these cases, OneDrive documents can be edited collaboratively online in real time by various users with Office 365. (The collaborative editing environment is more powerful than Google Drive.) This makes versioning and change-tracking management somehow different from systems that are more traditional.

For example, in Word Online, changes can be tracked, but there are a couple of important things to keep in mind:

- You cannot see tracked changes in Word Online but they are still there. When you open a document in Word Online that has tracked changes, they are preserved and any changes you make will also be tracked. You just will not see them until you open the document in the Word desktop application.
- You cannot turn "Track Changes" on or off in Word Online; you can only do that in the Word desktop application.
- You will know "Track Changes" is on when you see it in the status bar at the bottom of Word Online.

Word Online also lets you add, view, and delete comments, as well as reply to comments from other reviewers.

[1] https://support.office.com/en-us/article/should-i-save-my-documents-to-onedrive-for-business-or-a-team-site-d18d21a0-1f9f-4f6c-ac45-d52afa0a4a2e

If you have the Word desktop application, use the "**Open in Word**" command to open the document and turn on track changes. When you are done and you save the document, it will continue to be stored where you opened it in Word Online. Tracked changes will be preserved and—if you turned on "Track Changes" before you opened the document in Word Online—any changes you make in Word Online will also be tracked.

3.1.2 Nomenclature

For the naming and versioning of MICS datasets and technical documents (if not otherwise specified) the following guidelines apply:

MICS_DocumentTitleNoSpaces_yyyy_mm_dd.doc / pdf / xls...

(Note that the version is the date of editing of the document.)

Example of document name:

MICS_ Project_impact_dataset_2019_01_28.xls

Sometimes, more details are needed to specify a version. In this case, the following guidelines apply:

MICS_DocumentTitleNoSpaces_yyyy_mm_dd.doc XXh Author

(Note that the use of spaces is fine.)

Examples of document names:

MICS_Project_impact_dataset_2019_01_28 09h.xls

MICS_Project_impact_dataset_2019_01_28 Luigi.xls

MICS_Project_impact_dataset_2019_01_28 09h Luigi.xls

4 MICS's metadata scheme for interoperable data

4.1 Scope of the metadata scheme

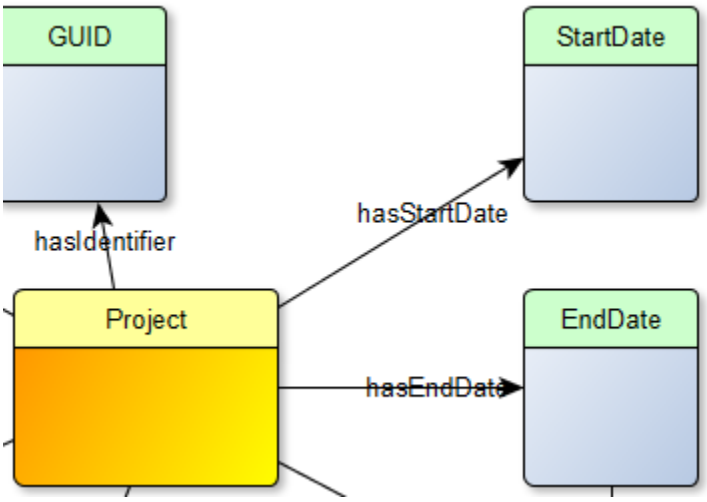
MICS's metadata scheme follows the Geneva Declaration on Citizen Science Data and Metadata Standards that emerged from the COST Action WG5 workshop in Geneva (Switzerland), 6th of June 2018 and subsequent work from that WG5, which proposes an **ontology of citizen science** in the form of changes and extensions to the PPSR Core model (Version 1) as presented in the Citizen Science Association Data & Metadata Working Group: Report from CSA 2017 and Future Outlook.

In its current form, MICS's metadata scheme adopts a proposal related only to central elements of the model, i.e. it contains important parts but not all of the elements envisaged by the COST Action on Citizen Science. A more complete version of the metadata scheme will be presented in deliverable 2.5 "A multilingual ontology".

4.2 Notes on terminology: classes and properties

In this document, we use a terminology typical of the ontology domain/community, which can be easily replaced (if needed) by another terminology, more typical of another domain/community. We use "class" or "concept" to refer to what can be otherwise described as "entity", and "property" to refer to what can be otherwise described as "relationship". As in an ontology-oriented language, such as OWL 2, a property usually originates from a "domain class" and points to a "range class" (i.e., a

property connects a “domain class” to a “range class”), and a class can be specialised into “subclasses”. Thus, in the diagram below, "Project" is a domain class for the property "hasStartDate", and "StartDate" is a range class for this property. (Database terms and data types will only be specified at a later stage.)



The concepts of MICS’s metadata scheme are inspired by but not formally connected to other ontologies. Therefore, MICS’s metadata scheme does not commit to other ontologies’ semantics and does not inherit anything from other ontologies. For explicit connections with other ontologies, we recommend using *simple knowledge organization system* (SKOS) matches.

4.3 Rationale

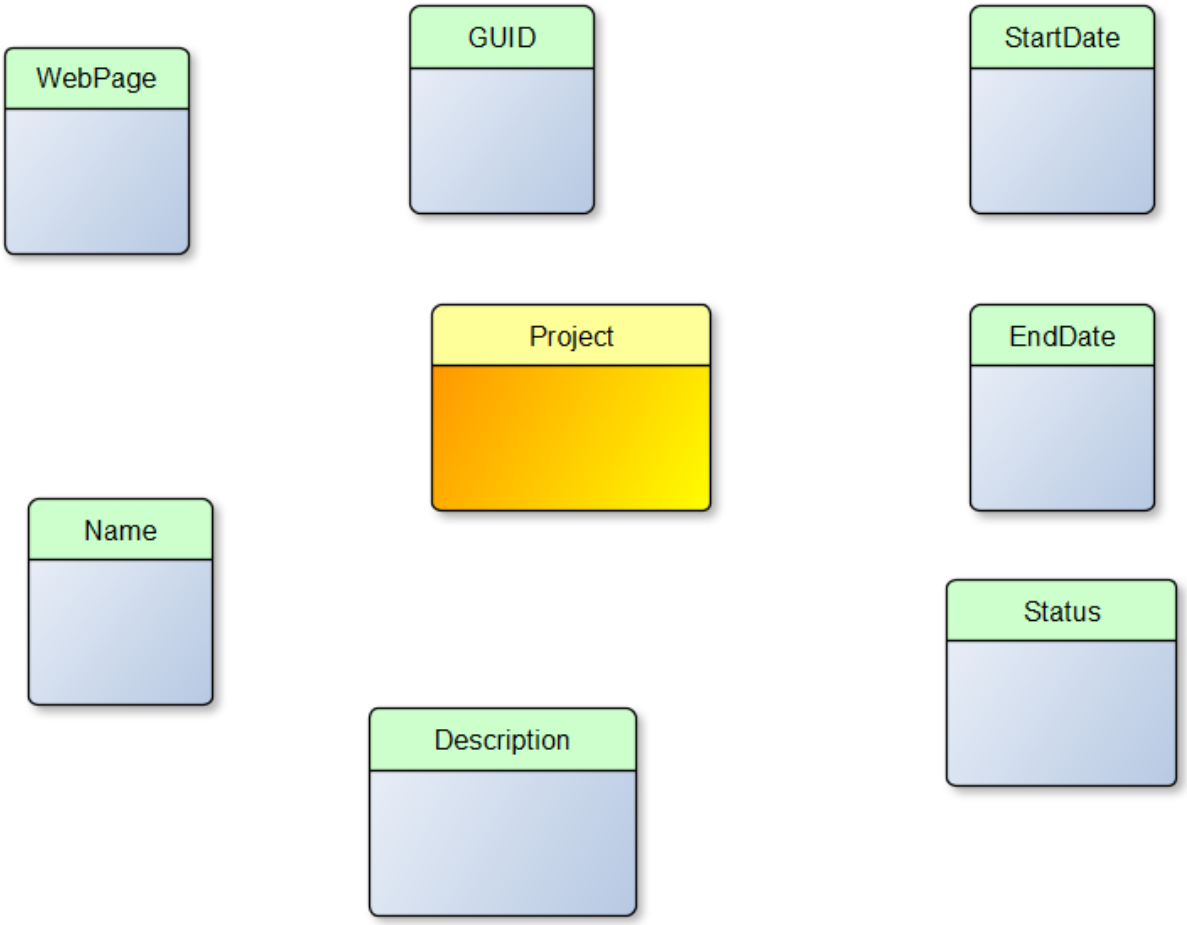
The 2017 version of PPSR-Core includes a set of fields (see the figures below for a partial list).

PPSR-Core field name	PPSR-Core database term	Required	Data type	Multiplicity	Related standard/ term mapping	Description/ comments
Database information						
GUID	projectId	Y	text	1		Globally unique identifier (GUID) for the project; system generated.
External Id	projectExternalId	N	text	0:1		The identifier of the project in an external database or repository.
Origin	project OriginalRepository	Y	text	1		The name of the project database where a project was first registered. Allows traceability of a project in multiple databases to its original registration.
Date Created	projectDateCreated	Y	dateTime	1	dcterms:created ISO 8601:2004 (E)	The date and time that the record was created in the database.
Date Updated	project Last UpdatedDate	Y	dateTime	1	dcterms:modified ISO 8601:2004 (E)	The date and time that the record was last updated in the database.

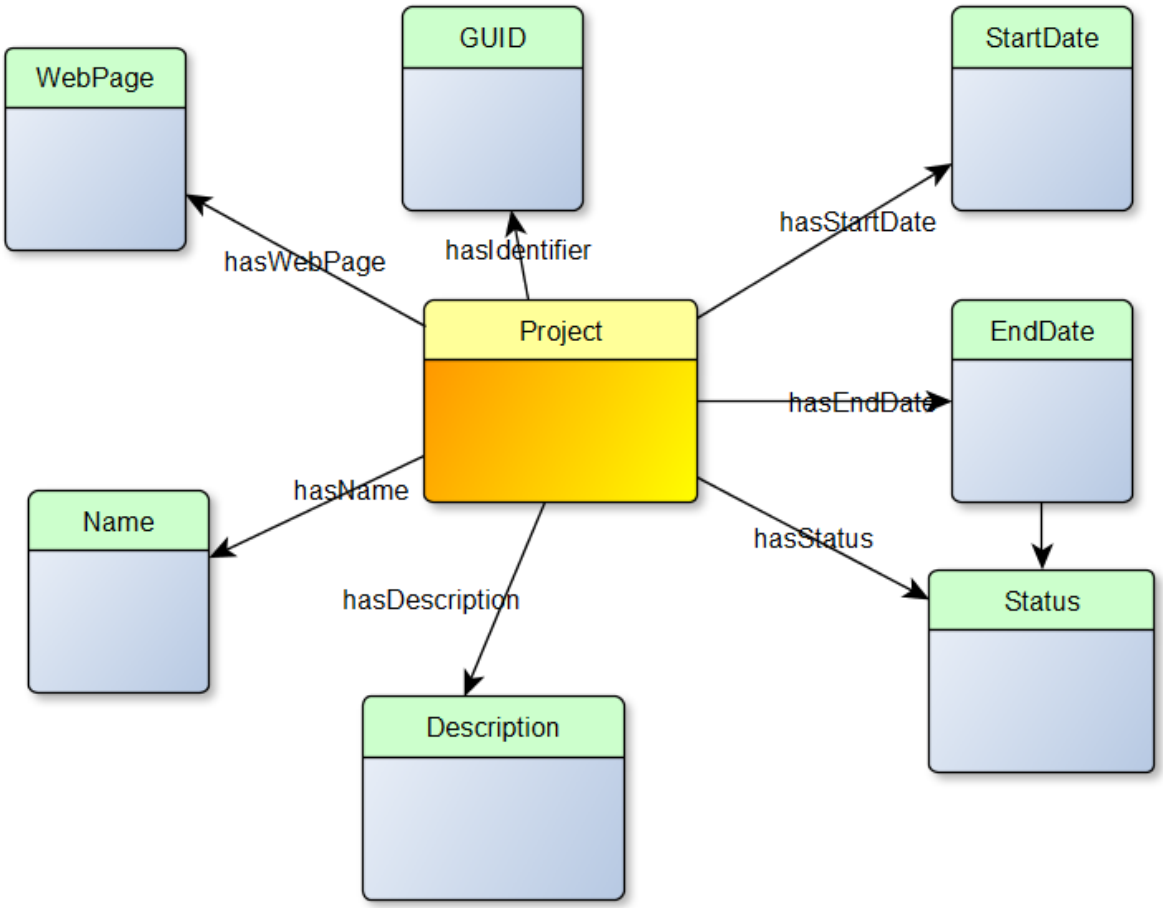
Basic Project Information						
Name	projectName	Y	text	1	proj:name	Short name or title of the project.
Aim	projectAim	Y	text	1	proj:objective	Primary aim, goal, or objective.
Description	projectDescription	Y	text	1	rdfs:comment	Abstract or description of the project.
Tags	projectTags	N	vocabulary	0:many		Controlled vocabulary terms, supplied by the person who entered the project, to assist with search and filtering.
Keywords	dcat:keyword	N	text	0:many	dcat:keyword	Keywords (comma separated) which are indexed and aid in searching for and finding projects. Data Catalogue Vocabulary (DCAT)
Status	projectStatus	Y	vocabulary	1		The activity status of the project.
State date	projectStartDate	Y	dateTime	1	prov:startedAtTime ISO 8601:2004 (E)	The actual date that a project began.
End date	projectEndDate	N	dateTime	0:1	prov:endedAtTime ISO 8601:2004(E)	The actual date that a project ended.
Project topic	projectScienceType	N	vocabulary	0:many	proj: hasFieldOfResearch	The project topic or field of science.
Intended outcomes	project IntendedOutcomes	N	vocabulary	0:many	proj:objective	A project's goals, or intended outcomes of participation.
Images and communications						
Image	projectImage	N	image	0:1	foaf:img	An image to represent a project
Image credit	projectImage Credit	N	text	0:1		A credit for the image used to represent a project.
URL	projectUrl	N	http uri	0:1		URL to an external web site for the project.

These fields include properties such as "projectDateCreated". Those properties refer to concepts, which are not explicitly represented (yet), i.e. they do not appear in the field list. For example, in the tables above, "projectURL" represents a property of a project, but the concept "Project" is not explicitly represented in the model. Likewise, "projectDateCreated" is a property of a project record, but the concept "Project Record" is not explicitly represented in the model.

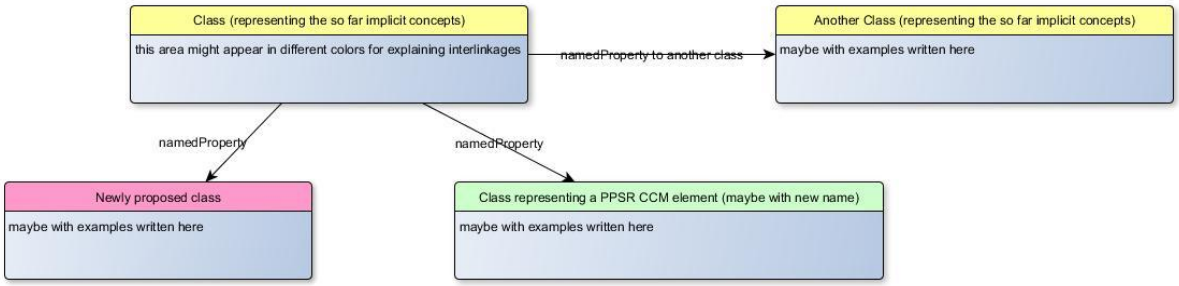
These concepts are therefore not explicitly related to each other in the original model (see figure below).



MICS's metadata scheme (1) adds these implicit concepts as classes to the model, which in effect equate to the domain classes of the properties of the 2017 model; and (2) adds a formal representation of all corresponding properties (see an example in the figure below).



We use the following colour coding of graphical elements:



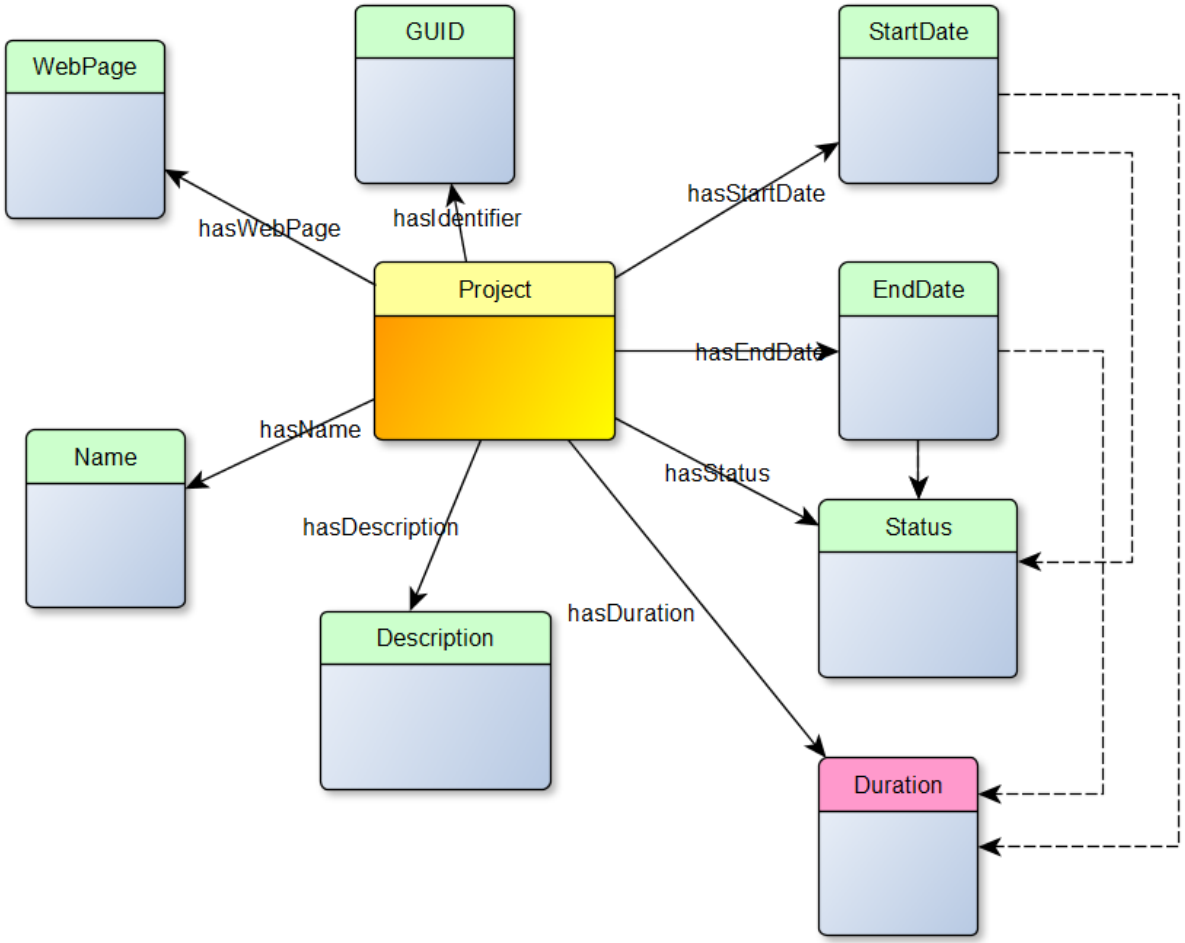
Additionally, MICS's metadata scheme connects the various classes and adds new classes and properties, which are necessary to represent a basic description of projects and datasets (see examples in the figures below). In the rest of the document, a formal description of MICS's metadata scheme is provided.

4.4 Description of MICS's metadata scheme

The object of this document is **one single** ontology, whose classes are all (directly or indirectly) connected. For clarity, its description is presented in the form of modules. Each module contains concepts that are grouped because of their close logical relationships. (This grouping is also referred to as "profiles".) At the end of each module, a table with the included properties is presented.

4.4.1 Project core

The following figure represents the central class Project and its properties.

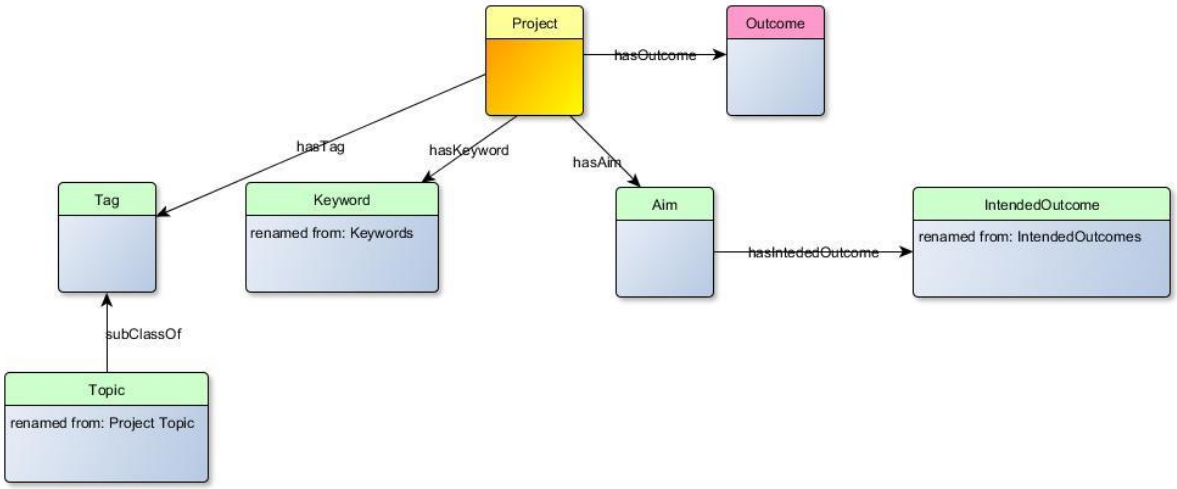


Comments: "Duration" has been added to PPSR-Core scheme because sometimes we only know the duration of a project but not the end date or the start date, so we need this option. For example, a project can have a duration of 36 months, but its starting date has not been defined yet. A web page is an essential part of most projects, so it is part of the core. The edges between Duration, StartDate and EndDate show that the duration of a project can be computed from its start and end dates (if they are known). The status of a project is influenced by the start and end dates (in the sense that, depending on the start and end dates, the project status can be set to "non-active" or "active"). For example, if we are in August 2018, the start date is January 2019 and the end date is December 2021, the status is "non-active".

Property	Description/comments
hasDescription	It associates a project to its textual description.
hasDuration	It associates a project to its duration.
hasEndDate	It associates a project to its end date.
hasIdentifier	It associates a project to its *Globally Unique IDentifier* (GUID).
hasName	It associates a project to its name.
hasStartDate	It associates a project to its start date.
hasStatus	It associates a project to its activity status.
hasWebPage	It associates a project to its web page or URL.

4.4.2 Project detailed information

The following figure represents the central class Project and its properties related to the representation of the detailed information about the project.

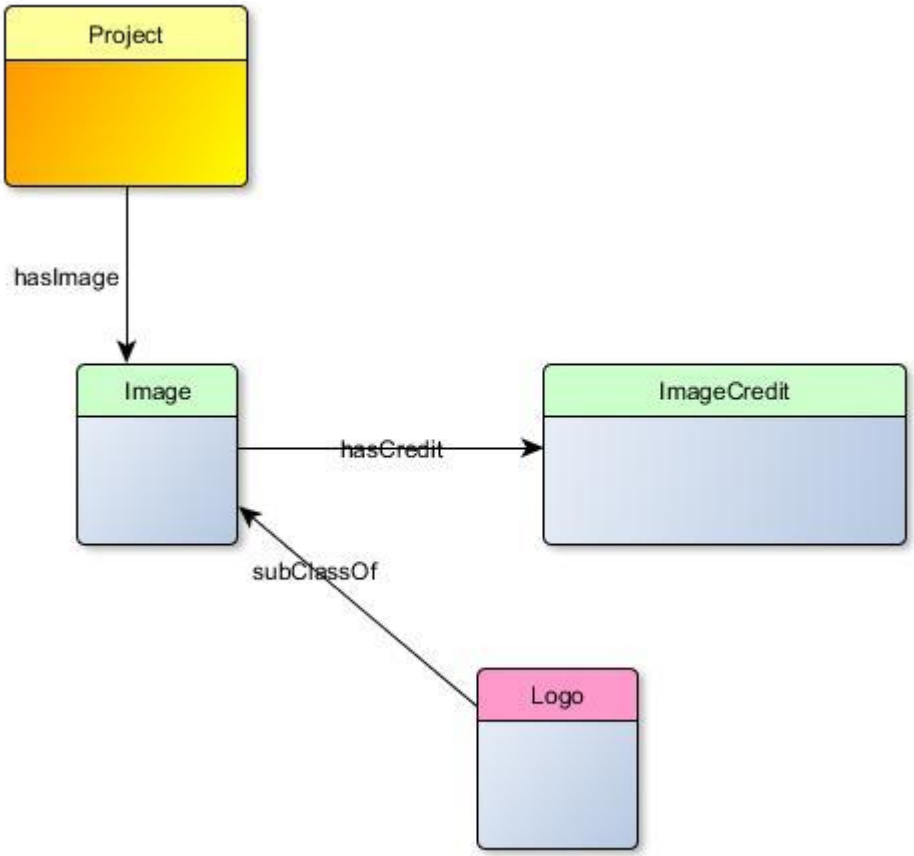


Comments: “Outcome” has been added to PPSR-Core scheme to allow representing the actual outcomes of a project, which are not necessarily the “intended outcomes”. The multiplicity of the properties related to “Outcome”, “Aim”, “IntendedOutcome” and, basically, to all classes of the model is “0..*”. Therefore, a project can have multiple outcomes, multiple keywords, multiple web pages and multiple names. In few occasions, such as “GUID”, multiplicity is better limited to “1”.

Property	Description/comments
hasAim	It associates a project to its aims.
hasKeyword	It associates a project to its keywords. Keywords are chosen from a predefined set of text expressions.
hasIntendedOutcome	It associates the intended outcomes of a project to its aims. For example, a project can have, as aim, “to evaluate impacts of citizen science” and, as intended outcome, “metrics and instruments to evaluate citizen science impacts”. As another example, a project can have, as aim, “to increase the impact of citizen science” and, as intended outcome, “an increase of the awareness of the citizens”.
hasOutcome	It associates a project to its outcomes.
has Tag	It associates a project to its tags. Tags are free text expressions. The keyword vocabulary can be used for tags.

4.4.3 Project image

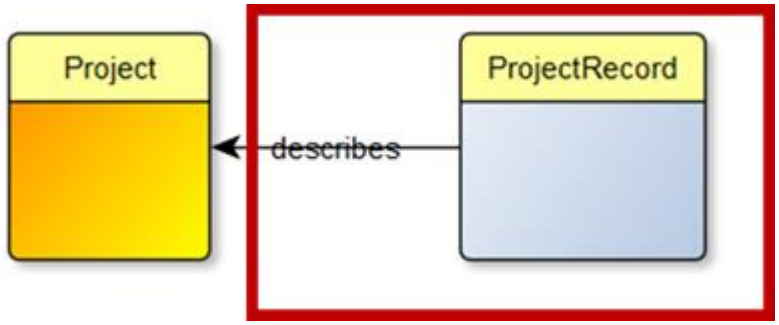
The following figure represents the central class Project and its properties to represent the images about the project and related to the project.

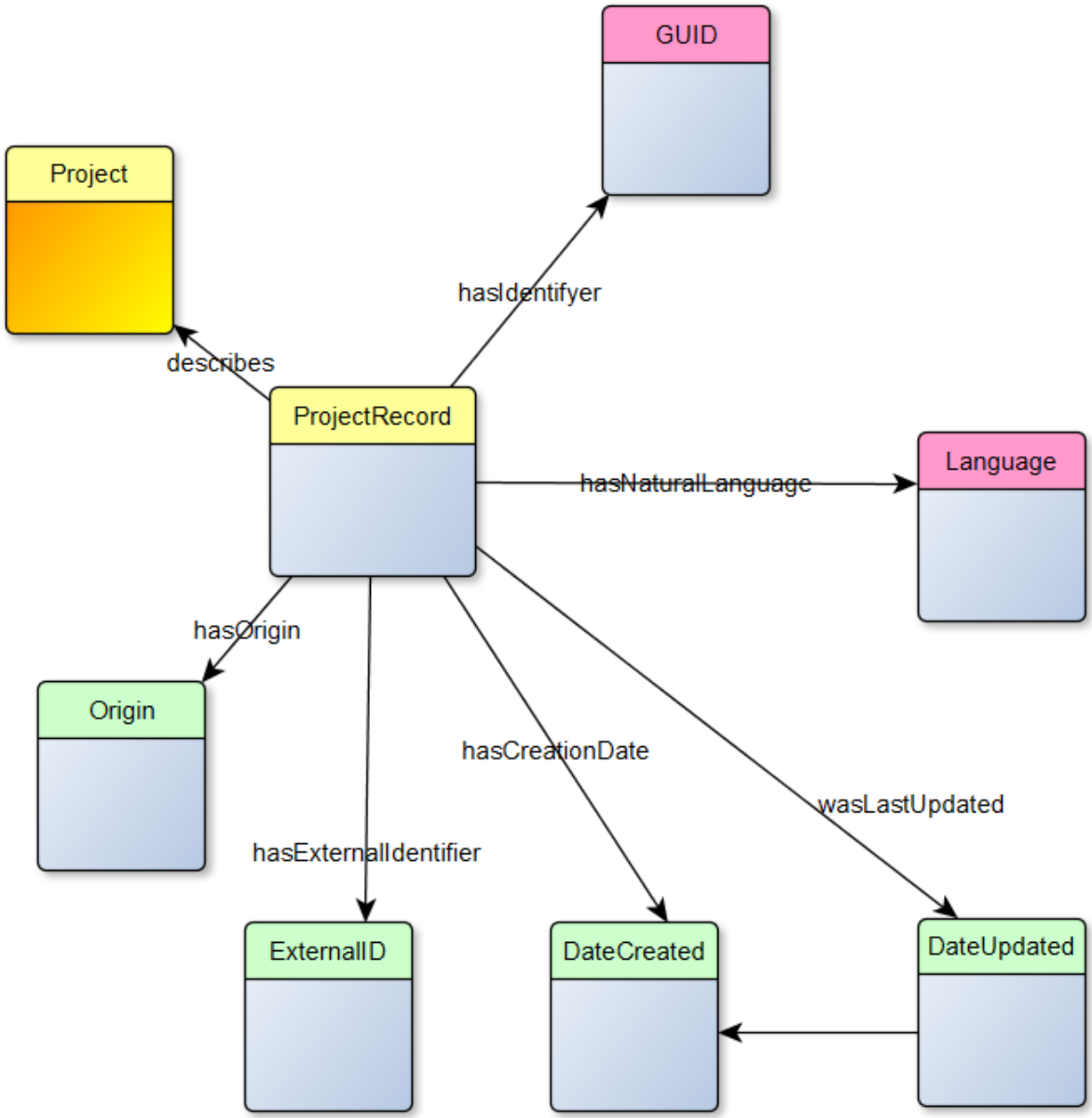


Property	Description/comments
hasCredit	It associates an image to its credits.
hasImage	It associates a project to images about the project and related to the project.

4.4.4 Project record

A "ProjectRecord" class has been added to PPSR-Core scheme to make the underlying structure explicit and to specify the semantics more formally. This concept does not refer to observations or to the dataset holding the project observations, but to a part of a database or spreadsheet that contains a complete set of information about the project. This is a concept that was implicit in the 2017 model, with a variety of characteristics that were well-defined, necessary and easily reusable. The project record, which is not essential to the representation of a project, given that all project metadata are defined and linked directly to the Project class, is basically used in catalogues and repositories of projects, such as Scistarter or BioCollect. Therefore, multiple project records can exist in different catalogues/repositories, which refer to the same project, and the "ProjectRecord" class helps the linkage among them. This class can also represent a snapshot of project information, which is used to make search and reasoning more efficient.



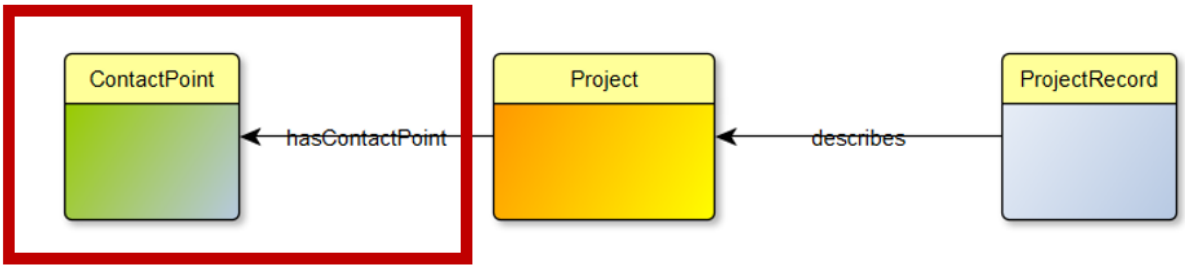


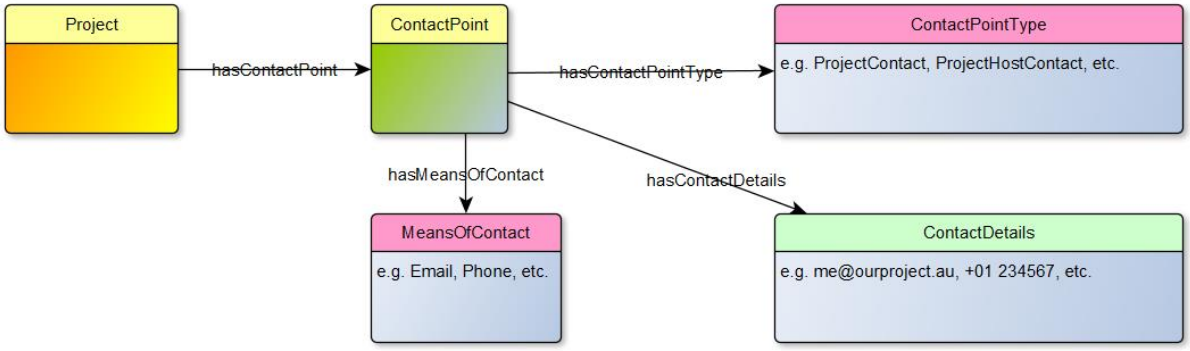
Comments: The natural language of the project record is important because it can affect reuse and sharing. A GUID for the project record helps referencing the project through catalogues and repositories (good data-management practice).

Property	Description/comments
describes	It associates the record with the project it refers to. In a concrete implementation, the link could be through the identifier "Project.GUID".
hasCreationDate	It associates the record with the date it was created.
hasExternalIdentifier	It associates the record with the identifier of a harvested or linked Project Record in another repository (see above). It promotes traceability.
hasIdentifier	It associates the record with its GUID (for example, identifier of a database record).
hasOrigin	It associates the record with an external source (if applicable) from which the record is derived - e.g. external catalogue from which it was harvested.
hasNaturalLanguage	It associates the record with a human-readable natural language in which it is written.
wasLastUpdated	It associates the record with the date it was last updated.

4.4.5 Project contact point

This concept is addressed in more detail as it is of importance for data management.

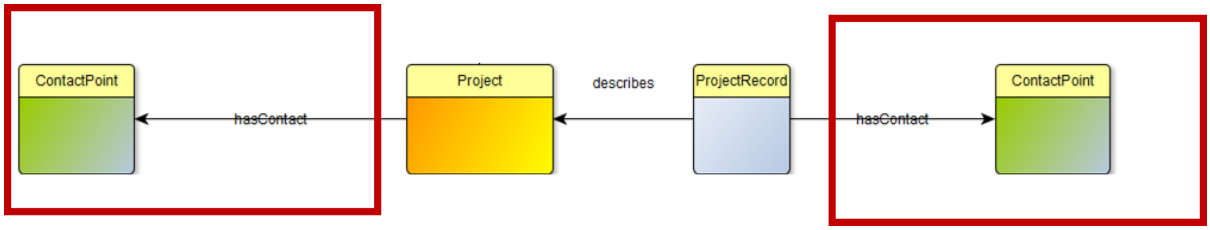




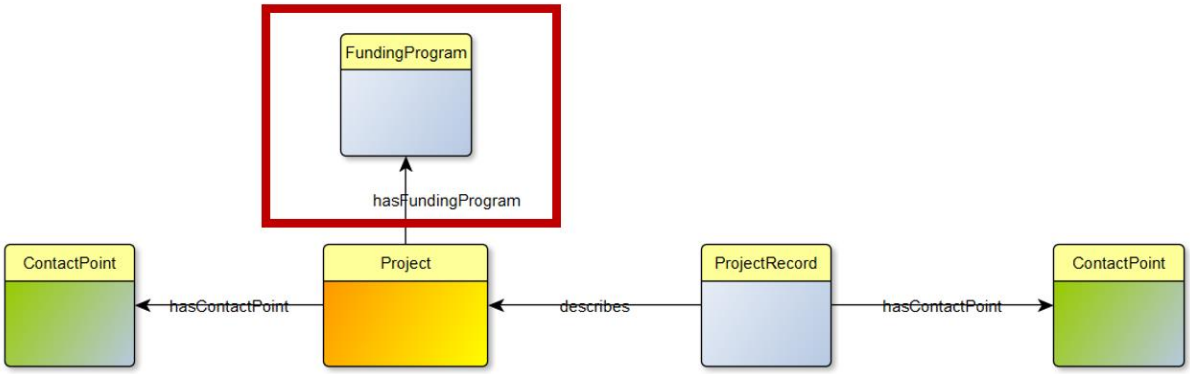
Comments: ContactPointType is a simple way of separating contacts that serve different purposes. This modelling approach, borrowed from schema.org, avoids unnecessary sub-classing. Specific contact types can be specified using controlled vocabularies (see examples in the diagram). We use "MeansOfContact" to be able to specify email, phone, etc.

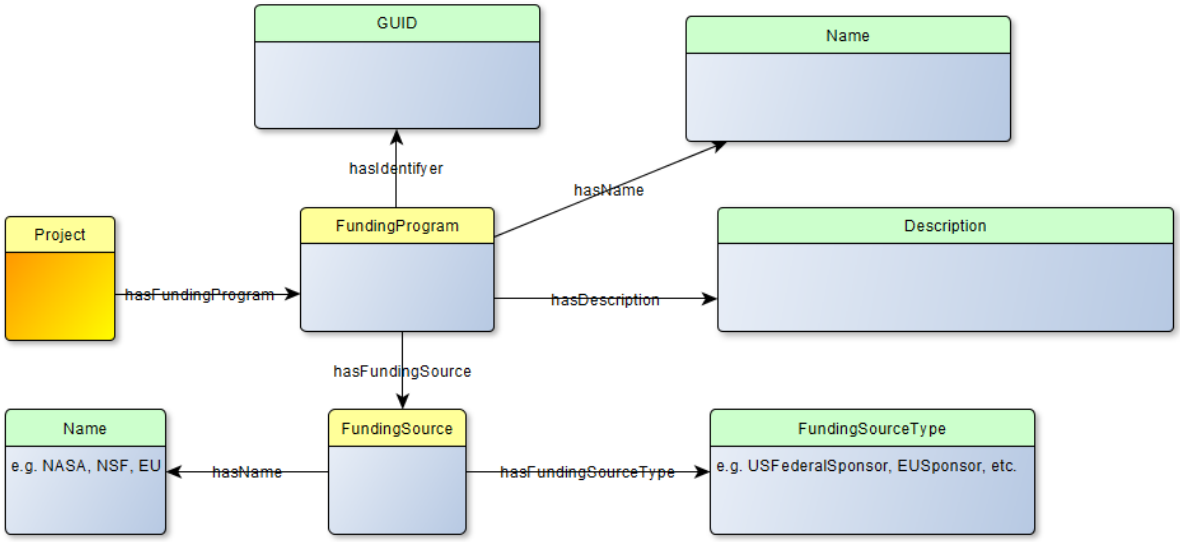
Property	**Description/comments**
hasContactPoint	It associates a project with an agent that acts as contact point for it.
hasContactDetails	It associates a contact point with its contact details.
hasMeansofContact	It associates a contact point with the applicable means of contact.
hasContactPointType	It associates a contact point with its type.

The concept "ContactPoint" could be used more widely, i.e. not only for Project contact points. It could, for example, also be re-used for a "ProjectRecord" (as suggested in the figure below), data sets and organisations.



4.4.6 Project funding



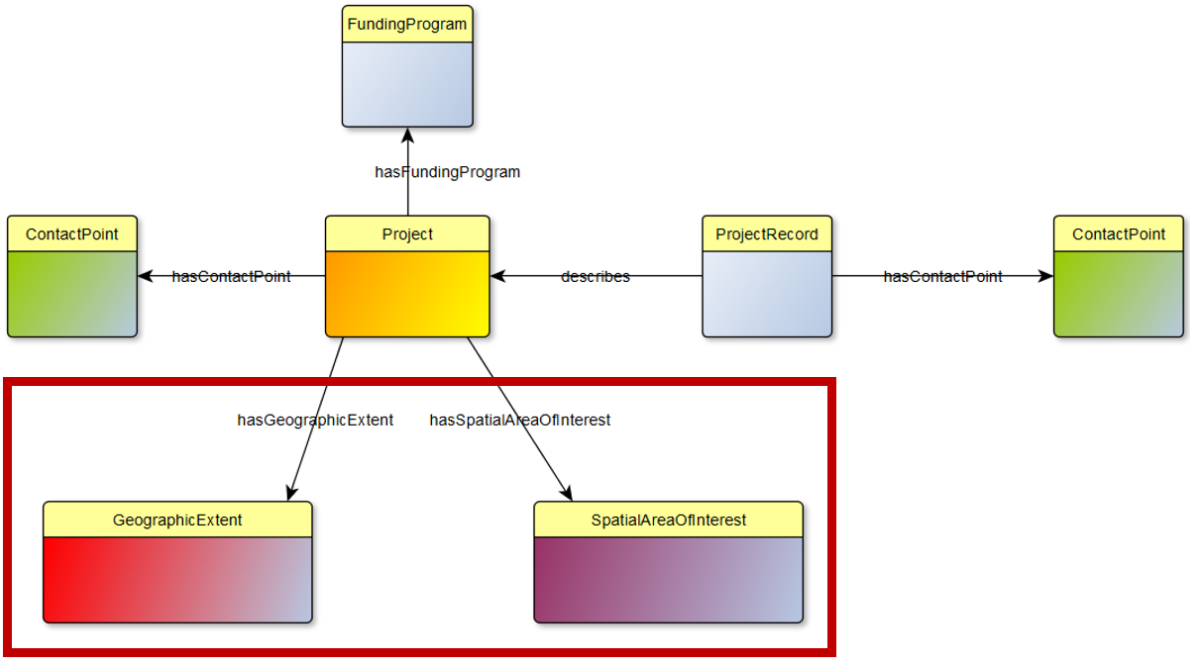


Property	Description/comments
hasDescription	It associates a funding program to its textual description.
hasFundingProgram	It associates a project to its funding program.
hasFundingSource	It associates a funding program to its funding source(s).
hasIdentifier	It associates a funding program to its GUID.
hasName	It associates a funding program / funding source to its name.
hasFundingSourceType	It associates a funding source with its type.

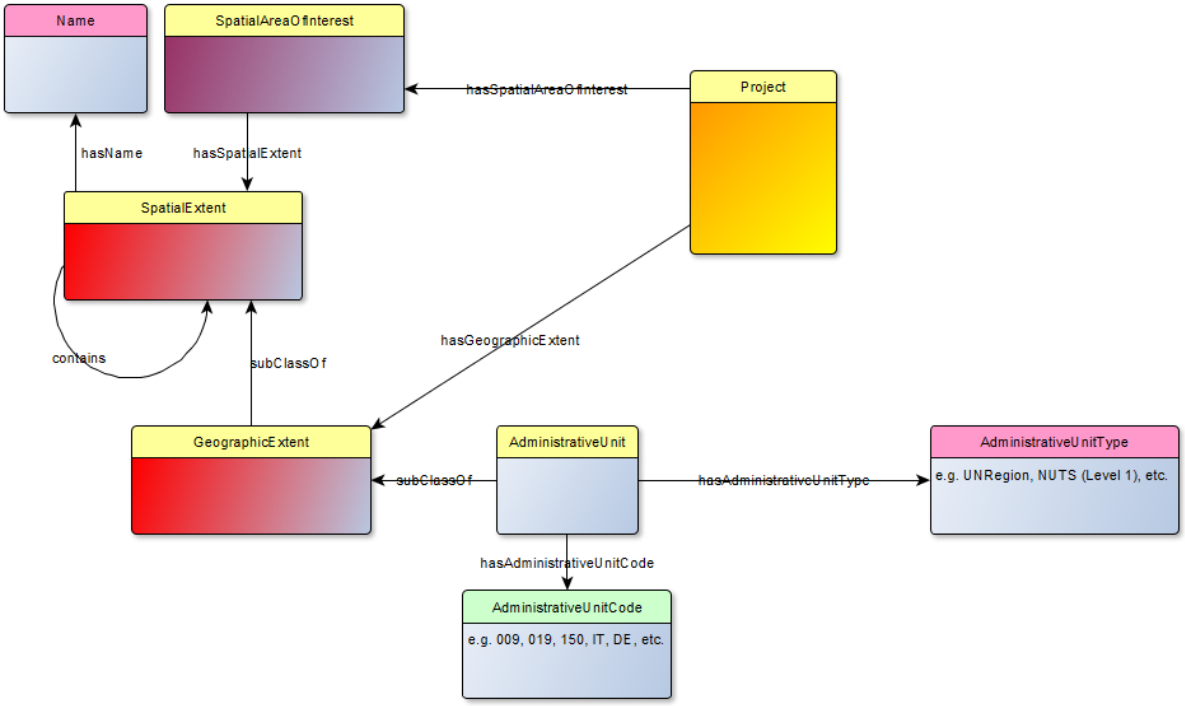
4.4.7 Project geography

Location and place information can be highly ambiguous. A rich, formal specification of the semantics of the terms used is defined in order to avoid misinterpretations. Project's "GeographicExtent" is separated from its "SpatialAreaOfInterest". The former can be used to represent the partners or participants locations, whereas the latter is the area on which the project operates. As this might be out in space, "SpatialAreaOfInterest" is used (i.e., not necessarily geography). This is not necessarily an "area"; it could be a "volume" (e.g. some part of our galaxy) and might be revised in the future. A "temporal extent of interest" could also be added (e.g. the 16th century) for historical projects.

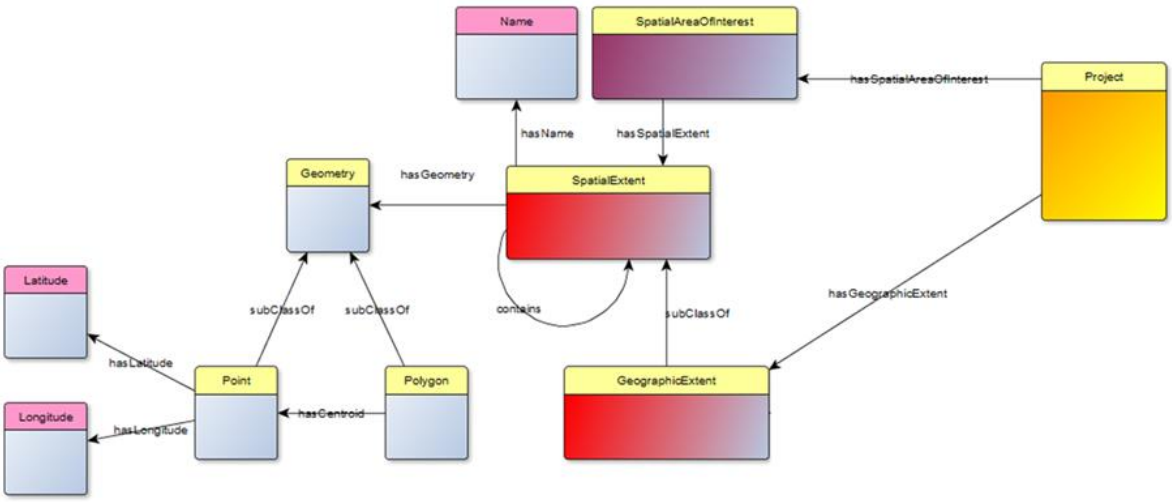
The suggested structure might later also be re-used in other parts of the model.



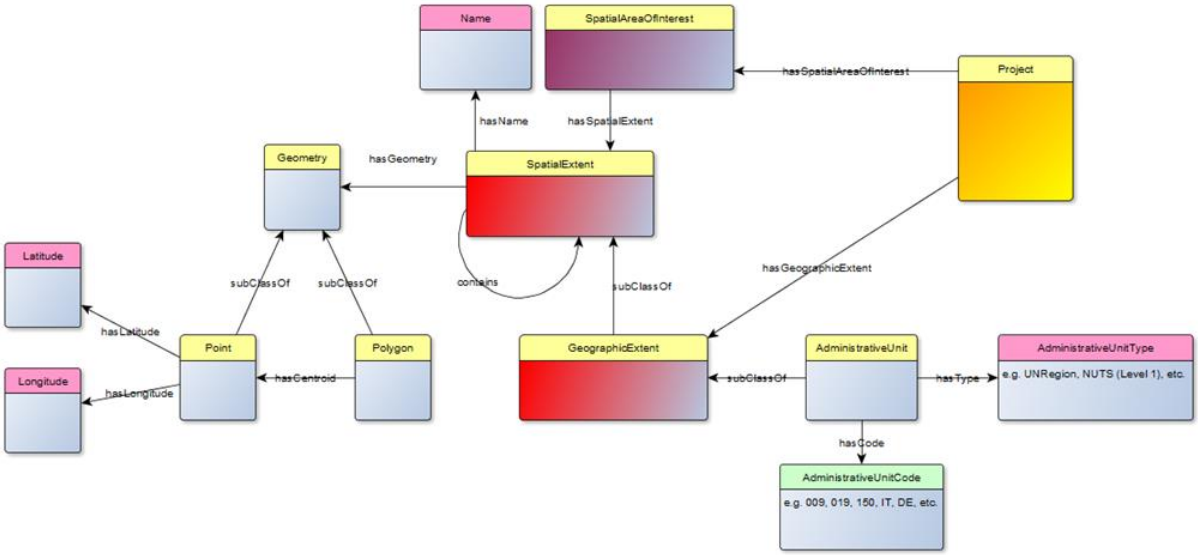
Following the same principle as before (for contact point), possible separations of different types of administrative units are introduced. Each "AdministrativeUnit" can then have a name, a type and a code.



A common way of modelling geometric representations of spatial objects is used. Point geometries (for the time being with two standard coordinates) and polygon geometries, which have a point in their centre, are considered.



Following this approach, spatial representations of multiple aspects of projects are structured. This provides a considerably more precise extension to the 2017 PPSR model and opens the possibilities for more detailed extension in the future - if required by the community.



Property	Description/comments
contains	It associates a spatial extent with its sub-extents.
hasCentroid	It associates a polygon with its centroid.
hasCode	It associates an administrative unit with its code.
hasGeographicExtent	It associates a project with its geographic extent.
hasGeometry	It associates a spatial extent with its geometry.
hasLatitude	It associates a point with its latitude.
hasLongitude	It associates a point with its longitude.
hasName	It associates a spatial extent with its name.
hasSpatialAreaofInterest	It associates a project with its spatial area of interest.
hasSpatialExtent	It associates a spatial area of interest with its spatial extent.
hasAdministrativeUnitType	It associates an administrative unit with its type.

5 References

- Cooper, C. B. (2012). Links and Distinctions among Citizenship, Science, and Citizen Science. A Response to "The Future of Citizen Science". *Democracy and Education*, *20*(2), 13.
- Jordan, R. C., Gray, S. A., Howe, D. V., Brooks, W. R., & Ehrenfeld, J. G. (2011). Knowledge gain and behavioral change in citizen-science programs. *Conservation Biology*, *25*(6), 1148-1154.
- Schultz, P. W. (2011). Conservation means behavior. *Conservation biology*, *25*(6), 1080-1083.