*Proceedings of the International Conference on Industrial Engineering and Operations Management*
*Manila, Philippines, March 7-9, 2023*

# Capabilities Management for Project-Based Organizations: An Ontological Model Proposal

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## Abstract

In Project-Based Organizations (PBOs), projects, programs and portfolios are developed by professionals with different profiles and capabilities. These capabilities are composed of knowledge, skills, tools, and techniques for management, such as influencing, motivating, listening and enabling. Properly allocating these capabilities in projects allows for achieving objectives, removing obstacles, better decision-making, increasing productivity and team focusing. In a complex project environment, for instance, megaprojects, understanding and managing these capabilities could be difficult. This research proposes a tool for managing individual project management capabilities and facilitating their availability and correct allocation. This tool is developed through ontologies which are high-abstraction models composed of classes and relations and computer-processable. IPMA Individual Competence Baseline for Project Management is a reference framework for capabilities extraction, description, standardization and mapping.

## Keywords

Project-Based Organizations (PBO), Ontologies, Organizational Capabilities, Organizational design, Project Management.

## 1. Introduction

Project management (PM) is a temporary, multidisciplinary effort to achieve agreed deliverables within pre-defined requirements and constraints. Personnel involved in project management can range from project management associates to senior project managers (PMan). The endeavour is unique to the specific project and its goals (IPMA 2016).

To conduct a project, organizations and people must have a range of capabilities to complete projects as planned. Managing project capabilities can be challenging due to limited resources, competing priorities, project complexity, project stage, and organizational structure (Bredin 2008; Too et al. 2014). Organizations need to develop a project portfolio management process that aligns project management capabilities with organizational objectives, assesses the availability of project management resources, and prioritizes projects based on their importance and resource requirements (Bredin 2008; Too et al. 2014). Additionally, investing in developing and training project management

professionals is critical to ensure a steady supply of skilled project managers to meet the organization's needs (Hornstein 2015).

Capabilities (alternatively referred to as *competence* in this article) in the PM context may be structured in three groups: For (i) organizations, (ii) project teams and (iii) individuals (Gareis et al. 2000). The International Project Management Association (IPMA) proposes three standards for competencies in project domains. For (i) organizations, the Organizational Competence Baseline (IPMA OCB©) has been developed (D. Bushuyev et al. 2014). This guideline is structured by 18 organizational competence elements divided into five groups: governance, management, organizational alignment, resources and people competencies. These competencies are crucial in bridging the gap between mission, vision, strategy and tangible results. For (ii) project teams, the Project Excellence Baseline (PEB©) has been proposed (International Project Management Association 2016). This baseline is structured in three areas: people & purpose, processes & resources and project results. The PEB is designed to support organizations and project managers improve their PM practices by identifying strengths and weaknesses and providing a roadmap for improvement (International Project Management Association 2016). For (iii) individuals, the IPMA Individual Competence Baseline (IPMA ICB© or ICB4) has been presented (IPMA 2016). This framework defines a set of knowledge, skills and abilities structured in three competence areas: people, practices and perspective.

All these guidelines are available in a text form and the application in a PM context could be hard work if their application is developed manually. First, this application could be considered developing the catalogue of capabilities aligned regarding individuals, project teams and organizations. Other applications may consider assigning the difference to each individual, team, project and organization. To overcome this challenge, the use of ontologies may be an alternative. An ontology is a structured representation of knowledge within a particular domain, encompassing essential concepts and their relationships (Atencio et al. 2022). By utilizing metadata and conforming to a common standardized schema, ontologies facilitate converting information into knowledge. They have been successfully employed in various areas of project management, including human resources and risk management, and addressing practical challenges such as complexity in project controlling (Xing et al. 2008; Hai et al. 2011; Tereso et al. 2019; Zaouga et al. 2019).

This article develops an ontology for individual competencies to support the PM activities developed in an organization. This ontology is based on the IPMA ICB4© and is publicly available in .rdf for future studies. The rest of the paper is structured as follows: Section two includes this research's background, describing the uses of ontologies in the PM context and a summary of the ICB4©. The third section encompasses the steps followed to develop the proposed ontology. Section four shows the results obtained and the conclusions are presented in section five.

## 2. Background

### 2.1 Ontologies in project management

Ontologies are a formal and explicit specification of shared conceptualizations within computer science, consisting of classes and relationships (Noy et al. 2017). In business analysis, ontologies promote mutual understanding between individuals and companies, facilitate communication between people and applications, and enable computerized analysis and abstraction of models (Martin et al. 2013).

The construction of ontologies involves several steps, such as specification, conceptualization, formalization, integration, implementation, evaluation, and documentation, outlined in METHONTOLOGY (Fernández-López et al. 1997). Ontologies have been applied in the PM field, where specific applications have been developed to describe PM knowledge and domains. For example, the Project Management Ontology (PROMONT) was constructed based on the German PM standard DIN69901 and PMBOK (Abels S.2006 ; ,Ahlemann F. et al. 2006).

Ontologies are also useful for specific PM human resources. For instance, ontologies can describe knowledge, competencies, and software skills to allocate people effectively in projects (Filippetto et al. 2016). They can also be used to manage the location of project participants in a geographically dispersed environment (Hai et al. 2007).
Finally, ontologies are useful in other PM areas, such as procurement, project monitoring, scheduling, and risk management. Overall, ontologies are a powerful tool in computer science and business analysis, facilitating communication and abstraction and promoting shared understanding across diverse domains. (Hughes 2010; Hai et al. 2011; Srisungnoen et al. 2018; Tereso et al. 2019)

## 2.2 IPMA Individual Competence Baseline

The IPMA Individual Competence Baseline (ICB4©) is a framework that outlines the competencies required for successful project management. It was first introduced by the International Project Management Association (IPMA) in 1999 and has since been revised several times, with the latest version being ICB4, released in 2015 (IPMA 2016).

The ICB4 framework comprises three areas of competence: (i) people, referred to the interactions with the people around the project and the professional (subject of the training process by the ICB4). (ii) Practice competence encompasses a set of capabilities related to directly developing a project, program and portfolio. (iii) Perspective competence area considers a set of elements needed for understanding and managing the project and its relationship with external drivers.

Overall, PMan and organizations looking to improve their project management capabilities have adopted the IPMA Individual Competence Baseline framework. By outlining the competencies required for successful project management and providing a self-assessment tool, the ICB4 framework helps project managers to develop their skills and knowledge and organizations to recruit and develop their project management talent.

# 3. Research Method

This research was developed using the METHONTOLOGY (Fernández-López et al. 1997) guideline for creating ontologies with the following activities:

Table 1. METHONTOLOGY steps for developing ontologies.

| Step N° | Activity | Output |
|---|---|---|
| 1 | Specification | • The purpose of the ontology, e.g. intended users and scenarios<br>• Level of formality: highly formal, semi-informal, semi-formal or rigorously formal.<br>• Scope, with the terms represented and granularity. |
| 2 | Knowledge acquisition | • The data extraction uses, for instance, experts and books. |
| 3 | Conceptualization | • Structure of the domain knowledge.<br>• Glossary of terms. |
| 4 | Integration | • Definitions aligned with other ontologies. |
| 5 | Implementation | • The ontology model developed in a software tool. |
| 6 | Evaluation | • Validation of correctly language modelling<br>• Validation of domain modelled |
| 7 | Documentation | • The code of the ontology. |

The process of creating an ontology involves seven essential steps. In Step 1, the objective is to create a document that outlines the ontology's purpose, level of formality, and granularity, which refers to the level of detail represented within the domain. Step 2 involves extracting knowledge, which can be achieved through various activities such as expert interviews, text analysis, and model-based approaches. Step 3 focuses on organizing the extracted domain knowledge into a model and summarizing a glossary of terms, which may be presented in tables. In Step 4, existing ontologies are reviewed to identify terms that can be reused, thereby accelerating and enhancing the desired ontology. It is important to note that this process requires a thorough understanding of the concepts in the ontology to ensure proper adaptation or translation of reused terms. Step 5 involves codifying the ontology using a software tool, and in Step 6, the ontology is evaluated by reviewing the correct modelling language and the domain concepts being modelled. Finally, all outputs produced in the previous steps are summarized in Step 7. This final step allows for a comprehensive overview of the ontology creation process, ensuring that the result is accurate and aligns with the desired outcomes.

# 4. Results and Discussion

This section presents the results and discussion of the seven-step structure described in Section 3, which outlines the process for developing ontologies using METHONTOLOGY.

## 4.1 Specification

This ontology aims to describe the ICB4 framework for facilitating the competencies needed for a PMan. Facilitating competence management for different PM professionals and analysis is expected.

Regarding the models' granularity, all competence areas were opened regarding their knowledge, skills and abilities. Moreover, the Key Competences Indicators (KCI) were modelled without opening their indicators.

## 4.2 Knowledge Acquisition

The data extraction for constructing the ontology was obtained from the ICB4 baseline (IPMA 2016) and mapped directly in the Protégé[1] ontology editor.

## 4.3 Conceptualization

The domain knowledge structure and its terms' glossary was implemented in the Protégé ontology editor. Some terms description were described as a comment, as shown in Figure 1.

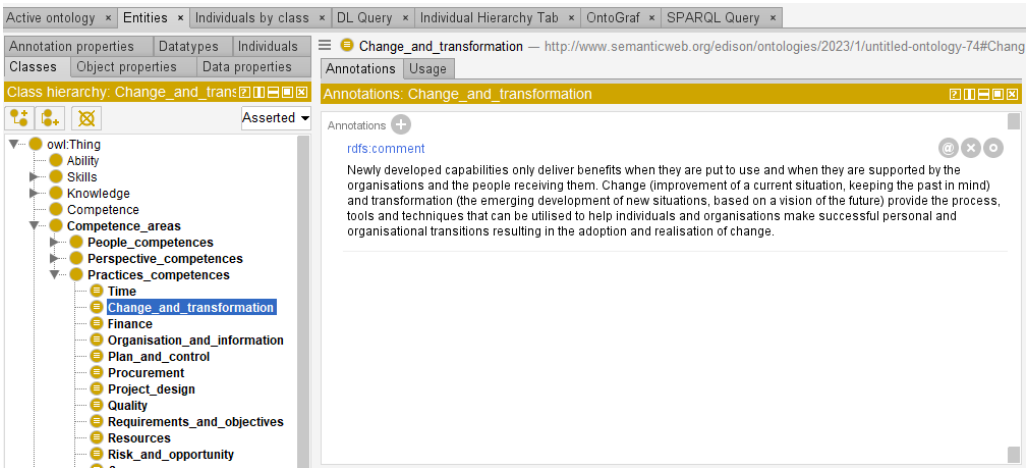


Figure 1. Example of terms' description glossary

## 4.4 Integration

The ontology that has been developed relies on the IPMA ICB4 framework as its foundation. However, it is important to note that its scope is limited to the concepts and terms contained within the framework, and it does not encompass any additional terms or concepts beyond the scope of this text.

## 4.5 Implementation

Protégé ontology editor was used for developing the IPMA ICB ontology. This tool allows the automatic analysis of the model. The metrics of the obtained model are shown in Figure 2.

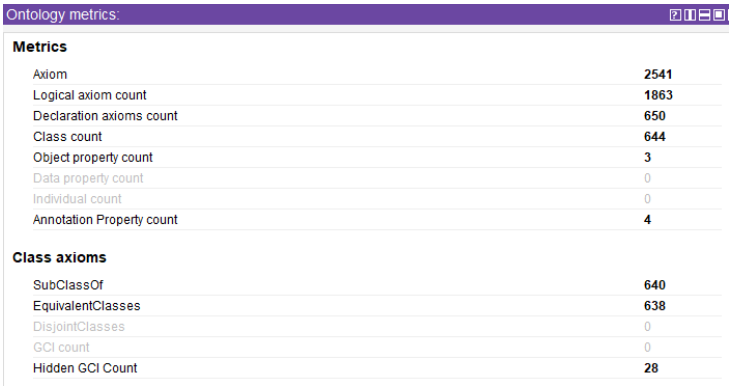


Figure 2. Ontology metrics

[1] https://protege.stanford.edu/

The class count corresponds to the 650 concepts modelled. The object property count equal to three corresponds to three different relationships: (i) *Applies*, when the competence area uses some knowledge, skill or ability. (ii) *Have relation with*, when a competence area is related to another. (iii) *Is measured by*. This relationship connects the competence area with the key competence indicator that measures it. These type of relationships generates 2442 connections between the 650 classes of ontology.

## 4.6 Evaluation

The evaluation of ontologies considers the technical judgment of the ontologies, their software environment, and documentation regarding the frame of reference (Fernández-López et al. 1997). The evaluation was conducted regarding the consistency with the selected modelled domain. In this line, the developed ontology will evaluate a set of structures and statements taken from ICB4.

**Statement 1:** *The IPMA ICB contains three areas of competence that form the IPMA Eye of Competence:*

Figure 3 shows the decomposition in sub-classes in practices, perspective and people regarding the competencies areas.

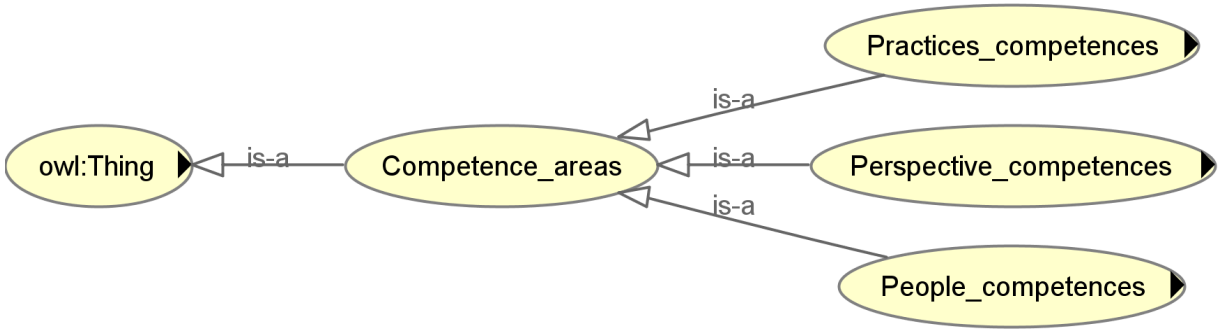


Figure 3. Competence areas descomposition

**Statement 2:** Table 3: The Perspectives of Contractors Regarding Selected Factors Contributing to the Generation of Waste in Abuja, Nigeria

*Competence in the project domain is broken down into 28 competence elements with one too many key competence indicators (KCI) each (I )Perspective competencies (5 elements); (ii) people competencies (10 elements) and (iii) Practice competences (13 elements).*

Figure 4 shows the decomposition of the (i) perspective competencies: power and interest; strategy; governance, structures and processes; compliance, standards and regulations and culture and values.

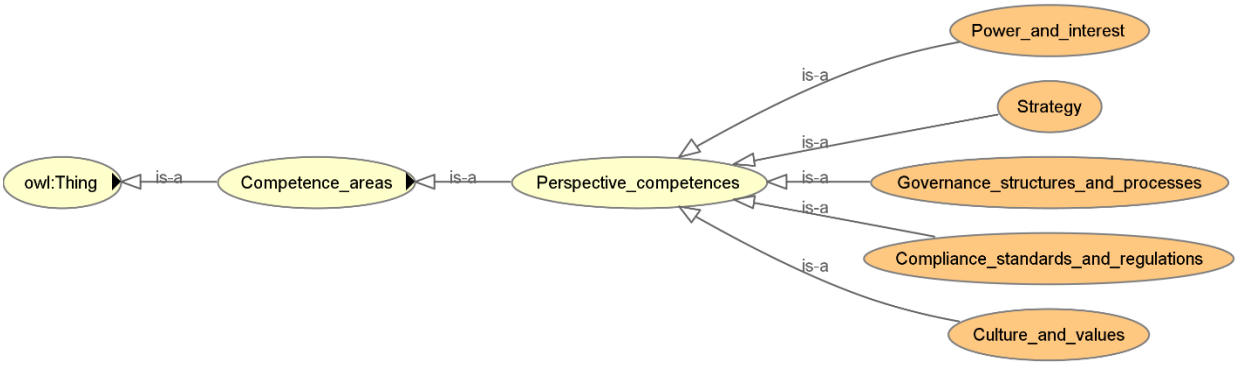


Figure 4. Perspective competences decomposition

Figure 5 shows the decomposition of the (ii) people competence area in ten elements: conflict and crisis; relations and engagement; personal communication; results orientation; negotiation; leadership; self-reflection and self-management; resourcefulness; teamwork and personal integrity and reliability.

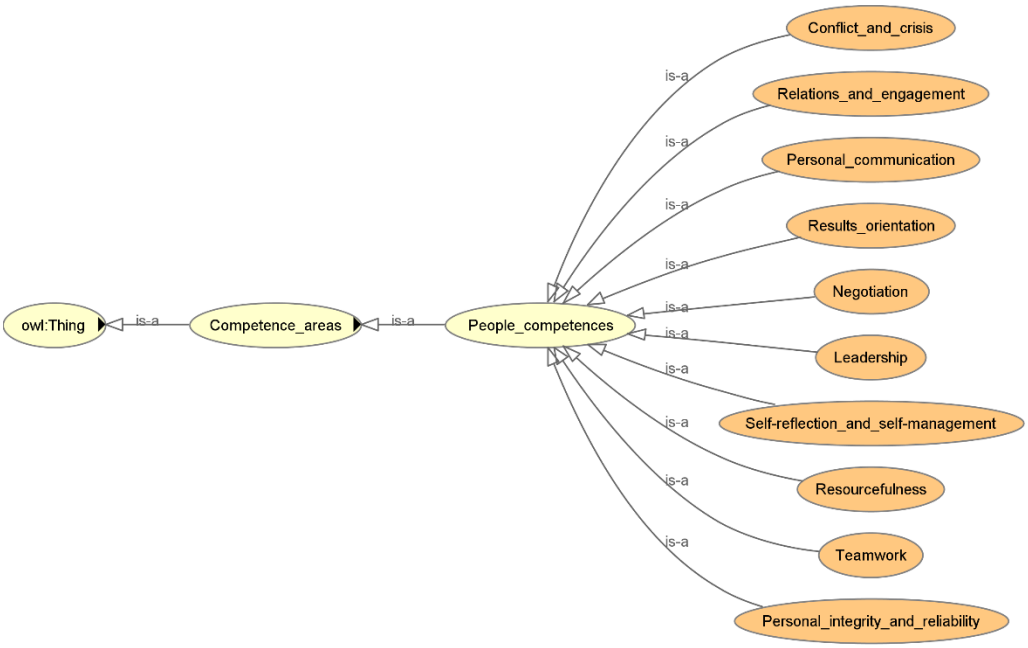


Figure 5. People compentences descomposition

Finally, verifying statement 2, the (iii) practices competencies are displayed in Figure 6, which encompasses time; procurement; organization and information; project design; stakeholders; scope; resources; plan and control; finance; change and transformation; quality; requirements and objectives and risk and opportunity.

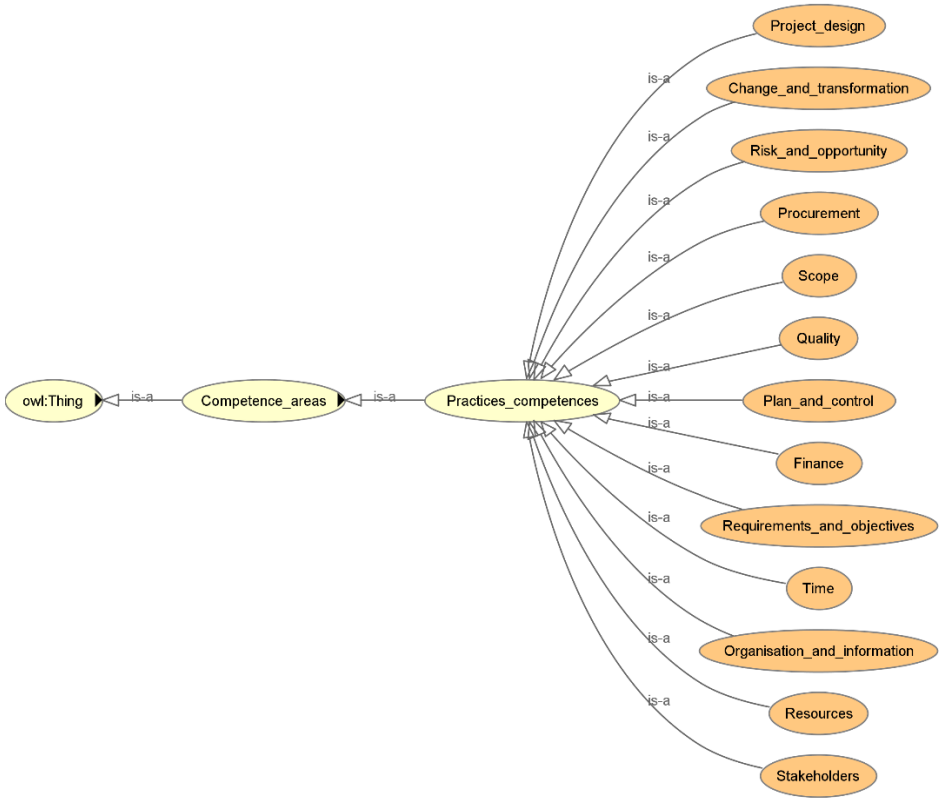


Figure 6. Practices competences descomposition

**Statement 4:** An inventory of competences is proposed. *"The IPMA Individual Competence Baseline (IPMA ICB®) is a comprehensive inventory of competencies that an individual needs to have or to develop to successfully realize projects.*

This statement considers the opening of each competence (of each area) in different knowleges, skills and abilities. This structure can be verified in Figure 7.

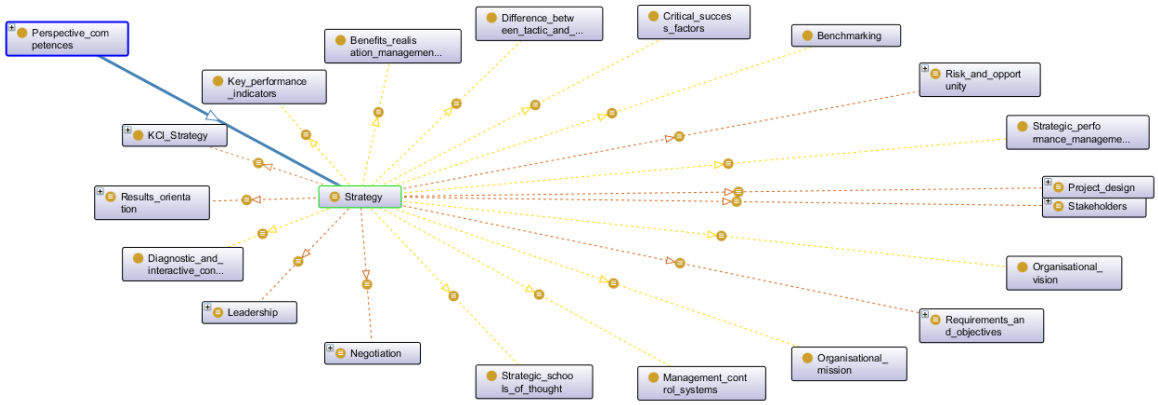


Figure 7. Strategy competencies and knowledge, skills and abilities applied and related

Figure 7 shows three types of relationships. First, the blue arrow represents the relation class-sub class between the *perspective and strategy competence areas*. Secondly, the yellow arrow represents the relationship called *applies,* which means what elements (knowledge, skills and abilities) use this competence. Finally, the orange arrow represents the *have relation with* the connection mentioned in section 4.5. This connection means the relationship between this competence with others. In this case, Figure 7 shows the relationship, for example, with the *project design* competence from the practices' competence area.

Statement 2 mentions the KCI elements applicable to each competence of each area. These KCIs are displayed in a homologous class called *KCIs and measurements*, with each competence through the link *is measured by*. An example of this relationship is shown in Figure 8.

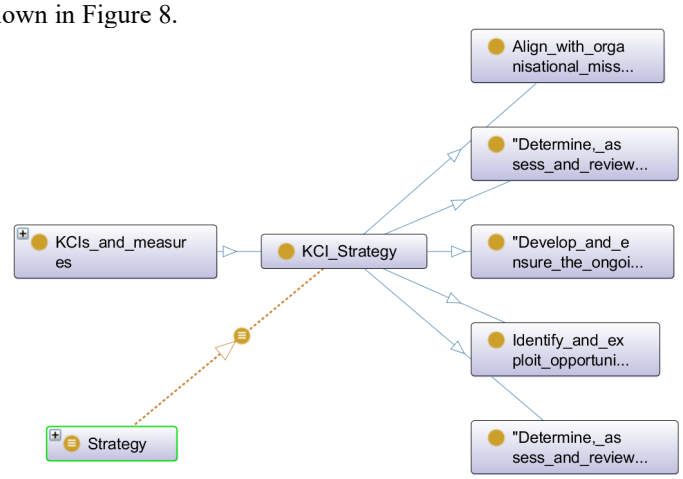


Figure 8. KCI for Strategy competence

In Figure 8 the KCI strategy class is a subclass of the KCIs and measurement class that encompasses all the KCIs for all competence. Moreover, the KCI class is opened in subclasses with specific KCIs. The orange arrow corresponds to the relationship "is measured by", which means "the strategy competence is measured by the strategy KCIs"

## 4.7 Documentation

After the METHONTOLOGY procedure application, the outputs are stored in Protégé. The ontology obtained is available in the Appendix section.

## 5. Conclusion

The IPMA ICB4 framework was modelled as an ontology in this paper. The analysis of the obtained model shows consistency in terms of the domain modelled (in this case, the guideline selected). The model is composed of 650 classes, which may mean a challenge in terms of how to apply all these concepts in a project and for each individual. The availability of this ontology – and the automatic possibilities of analysis using it – represents a building block to digitalize the allocation process of these competencies. However, a set of activities can be developed to improve this model as a future study. First, a language evaluation may be developed to verify the correct ontology language usage (OWL) usage. For this purpose, the OOPS! Ontology scanner is proposed (Poveda-Villalón et al. 2014). A second activity relates to creating the individuals and their properties in the ontology for assigning competencies. This development may be addressed through a case study and based on a real project environment. Finally, the developed ontology is publicly available for use and improvement and it is hoped that this work will promote the adoption of digital tools to facilitate project management.

## Appendix

Link to the developed ontology in .RDF format.
https://docs.google.com/document/d/e/2PACX-1vQrFo9DFCNUU1w2Au-jwd5SQjewcu892eK1Y7FUx0EV8eaLIaI9mEmLYUR4nt8F4dOmVO-DSHFhz1RV/pub

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