**Protocol for aligning SCO V1.0.0 to UFO**

**Aim**

To align the [Sustainability Core Ontology (SCO)](https://github.com/gioUbbiali/Sustainability-Core-Ontology) to the [Unified Foundational Ontology (UFO)](https://ontouml.readthedocs.io/en/latest/intro/ufo.html).

**SCO Description**

Sustainability is characterized by three major theoretical challenges (Ubbiali et al., 2024):

1. The polysemy of the term sustainability.
2. The relationship between sustainability and sustainable development.
3. The complexity underlying sustainability.

The Sustainability Core Ontology (SCO) is a middle-level ontology modeling those challenges with the purpose of establishing a core central hub to harmonize ontologies regarding sustainability.

Currently, SCO reuses [Basic Formal Ontology (BFO)](https://basic-formal-ontology.org/), one of the existing Top-level ontologies (TLOs), as the upper-level ontology, aligning with the ontological realism view – see Arp et al. (2015) and Smith & Ceusters (2010) for details – according to which BFO has been designed. Nevertheless, we consider it essential to commit SCO representation to also other ontological views. This will assist in addressing sustainability consistently across communities and approaches. No matter which ontological view has been chosen, a representation of sustainability theoretical challenges according to such a view will be available to ontology developers for usage. Further, this will support integration and alignment across ontologies addressing sustainability that may endorse different ontological views on reality. Despite the ontological view chosen, those ontologies will commonly account for the sustainability challenges. Thus, SCO should align with alternative TLOs other than BFO, to consistently access and leverage the different ontological views proposed by such ontologies. This seems the most coherent way to establish a core hub that can effectively support the integration and interconnection of new and existing ontologies on sustainability.

This document describes the process of alignment of the Sustainability Core Ontology (SCO) to the [Unified Foundational Ontology (UFO)](https://ontouml.readthedocs.io/en/latest/intro/ufo.html), another existent TLO. UFO counts among the major internationally recognized TLOs. In addition, several ontologies that address domains of primary relevance to sustainability such as resilience (Barcelos et al., 2025) and risk and value (Sales et al., 2018), employ UFO as upper-level ontology.

The current working-in-progress version of SCO is SCO V1.1.0. SCO V1.1.0. is comprised of two segments: SCO-B (B for BFO) and SCO-U (U for UFO). SCO-B aligns the SCO vocabulary with BFO (as SCO V1.0.0.). SCO-U aligns the SCO vocabulary with gUFO ([UFO implementation in the Web Ontology Language (OWL)](https://nemo-ufes.github.io/gufo/)). SCO V1.1.0. is formalized in [OWL](https://www.w3.org/TR/owl2-overview/) and covers three natural languages, English, French, and Italian. SCO V1.1.0. conforms to [OBO-Foundry principles](https://obofoundry.org/principles/fp-000-summary.html).

The most recent version of SCO is available on GitHub at the following link: <https://github.com/gioUbbiali/Sustainability-Core-Ontology.git>. The person responsible for SCO is [Giorgio A. Ubbiali.](mailto:Giorgio.Ubbiali@unimi.it)

**Methods and Materials**

Work in progress

We construct SCO V1.0.0. in the following

See also the related [slide deck.](https://github.com/gioUbbiali/Sustainability-Core-Ontology/tree/SCO-Alignment-to-UFO/SCO/working%20materials)

Sustainability

* The Sustainability Core Ontology (SCO) currently employs [Basic Formal Ontology (BFO)](https://basic-formal-ontology.org/) as the upper-level ontology.
* This work explores and sets directions for aligning SCO to other Top-Level Ontologies (TLOs), specifically the [Unified Foundational Ontology (UFO)](https://ontouml.readthedocs.io/en/latest/intro/ufo.html).
  + UFO OWL version: [gUFO](https://nemo-ufes.github.io/gufo/).
* Towards SCO V1.1.0.
  + SCO-B (B for BFO): alignment to BFO.
  + SCO-U (U for UFO): alignment to UFO.
* Goal: to ensure SCO leverages and incorporates different ontological perspectives to establish a common reference hub for sustainability.

SCO-B

SCO-U

*SCO-U Alignment protocol*

Hierarchization

Example: [SCO “complex system” class](http://gioUbbiali.github.io/sco/SCO_0000015).

1. Background assessment

* Evaluating the position of [SCO “complex system” class](http://gioUbbiali.github.io/sco/SCO_0000015) in the BFO hierarchy.

(to use the materials documented in the “references” slide as a reference point.)

*Subclass of the system class (subclass of “material entity” BFO class).*

1. Exploration of correspondences

* Identification of the rough corresponding class position into the gUFO “individual” class hierarchy.

(to use the materials documented in the “references” slide as a reference point.)

*To position under the “endurant” -> “object” branch of the “individual” gUFO class hierarchy.*

1. Construction of SCO-gUFO “individual” class hierarchy

* Identification of adequate upper-level class(es) into the gUFO “individual” class hierarchy.

(to use the materials documented in the “references” slide as a reference point.)

*Subclass of: “object” gUFO class.*

* In Protégé: to add the [SCO “complex system” class](http://gioUbbiali.github.io/sco/SCO_0000015) *is\_a* (*subclassOf*) gUFO “object” class assertion.

1. Construction of SCO-gUFO “type” class hierarchy

* Identification of the “type” class that [the SCO “complex system” class](http://gioUbbiali.github.io/sco/SCO_0000015) instantiates into the gUFO “type” class hierarchy.

(to use the materials documented in the “references” slide as a reference point.)

*gUFO “phase”.*

* In Protégé: to create a corresponding individual (same class URI, *Punning*).
* In Protégé: to add the [SCO “complex system” individual](http://gioubbiali.github.io/sco/SCO_0000015) rdf:type gUFO “phase” class assertion.

Axiomatization

Removal of BFO-compliant structure

Validation

All through the process of translation, we carried out discussions with subject matter experts.

**Future Implementations**

To do

**Get In Touch**

Please contact Giorgio A. Ubbiali in case you wish to get involved and participate in the development of SCO.

**Bibliography**

* Arp, R., Smith, B., & Spear, A. D. (2015). *Building ontologies with Basic Formal Ontology*. Massachusetts Institute of Technology.
* F. Barcelos, P. P., Calhau, R. F., Oliveira, Í., Prince Sales, T., Gailly, F., Poels, G., & Guizzardi, G. (2025). Ontological Foundations of Resilience. In W. Maass, H. Han, H. Yasar, & N. Multari (A c. Di), *Conceptual Modeling* (Vol. 15238, pp. 396–416). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-75872-0\_21
* Sales, T. P., Baião, F., Guizzardi, G., Almeida, J. P. A., Guarino, N., & Mylopoulos, J. (2018). The Common Ontology of Value and Risk. In J. C. Trujillo, K. C. Davis, X. Du, Z. Li, T. W. Ling, G. Li, & M. L. Lee (A c. Di), *Conceptual Modeling* (Vol. 11157, pp. 121–135). Springer International Publishing. https://doi.org/10.1007/978-3-030-00847-5\_11
* Smith, B., & Ceusters, W. (2010). Ontological realism: A methodology for coordinated evolution of scientific ontologies. *Appl. Ontol.*, *5*(3–4), 139–188.
* Ubbiali, G. A., Borghini, A., & Lange, M. C. (2024). *Ontologies for Sustainability: Theoretical Challenges*.