**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 other ontological views. This will assist in addressing sustainability consistently across communities and approaches. No matter which ontological view has been chosen in design ontologies, a representation of sustainability theoretical challenges according to such a view will be available to ontology developers for usage. Further, this will support alignments across SCO-compliant sustainability ontologies endorsing different ontological views on reality. Despite the differences deriving from the different ontological views chosen, those ontologies will all account for the sustainability challenges, having a common converging point for integration. 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**

SCO V1.0.0. covers two segments, CO-B and SCO-U. We constructed these two segments as follows, using [Protégé](https://protege.stanford.edu/). See also the related [slide deck.](https://github.com/gioUbbiali/Sustainability-Core-Ontology/tree/SCO-Alignment-to-UFO/SCO/working%20materials)

*SCO-B*

SCO-B aligns with BFO. Thus, it corresponds to SCO V11.0.0. In protégé, we imported in a new OWL file the previous version of SCO to construct this segment.

*SCO-U*

SCO-B aligns with UFO. In constructing this segment, we follow a *translation process*. We employed the existent BFO-compliant representation of the sustainability challenges as an initial guiding reference point, which we then converted into a UFO-compliant representation. We consider it noteworthy to clarify this point as the result may have been slightly different if starting from scratch. We performed the following passages.

1) in protégé, we imported [gUFO.ttl](https://nemo-ufes.github.io/gufo/gufo.ttl) file and SCO V1.0.0 in a new OWL file. This file contains both gUFO and BFO classes. SCO classes extend BFO classes.

2) We construct SCO hierarchy specializing and instantiating the gUFO “individual” and “type” class hierarchies as follows. We refer to [the gUFO documentation webpage](https://nemo-ufes.github.io/gufo/) and related UFO literature, such as Guizzardi (2005) and Guizzardi et al. (2022), for details regarding individual-type distinction, class specialization and instantiation, and more generally about UFO ontology theory. Here, we use the [SCO “complex system” class](http://gioUbbiali.github.io/sco/SCO_0000015) as an illustrative example.

1. Background assessment

We Evaluated the position of [the SCO “complex system” class](http://gioUbbiali.github.io/sco/SCO_0000015) in the BFO hierarchy, using the materials documented in the “references” slide of the [slide deck](https://github.com/gioUbbiali/Sustainability-Core-Ontology/tree/SCO-Alignment-to-UFO/SCO/working%20materials) as a reference point.

[The SCO “complex system” class](http://gioubbiali.github.io/sco/SCO_0000015) is a subclass of the [RO “system” class](http://purl.obolibrary.org/obo/RO_0002577) (subclass of [the BFO“material entity” class](http://purl.obolibrary.org/obo/BFO_0000040)).

1. Exploration of correspondences and construction of SCO-gUFO “individual” class hierarchy

We identified the rough corresponding class position into the gUFO “individual” class hierarchy, using the materials documented in the “references” slide of the [slide deck](https://github.com/gioUbbiali/Sustainability-Core-Ontology/tree/SCO-Alignment-to-UFO/SCO/working%20materials) as a reference point.

The [SCO “complex system” class](http://gioUbbiali.github.io/sco/SCO_0000015) specializes the ([RO “system” class](http://purl.obolibrary.org/obo/RO_0002577) that specializes the) [gUFO “object” class](http://purl.org/nemo/gufo#Object). In protégé we asserted the [RO “system” class](http://purl.obolibrary.org/obo/RO_0002577) as a subclass of the [gUFO “object” class](http://purl.org/nemo/gufo#Object).

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

We identified the “type” class that [the SCO “complex system” class](http://gioUbbiali.github.io/sco/SCO_0000015) instantiates into the gUFO “type” class hierarchy, using the materials documented in the “references” slide of the [slide deck](https://github.com/gioUbbiali/Sustainability-Core-Ontology/tree/SCO-Alignment-to-UFO/SCO/working%20materials) as a reference point.

The [SCO “complex system” class](http://gioUbbiali.github.io/sco/SCO_0000015) instantiates the [gUFO “subkind” class](http://purl.org/nemo/gufo#SubKind). In Protégé, we instantiated the [gUFO “subkind” class](http://purl.org/nemo/gufo#SubKind) with a [SCO “complex system” individual](http://gioUbbiali.github.io/sco/SCO_0000015) presenting the same URI of the [SCO “complex system” class](http://gioUbbiali.github.io/sco/SCO_0000015) ([Punning](https://nemo-ufes.github.io/gufo/)).

To deepen the representation of perspective, we imported classes and individuals used to represent tropes, modes, and dispositions, from the [Common Ontology of Value and Risk (COVER)](https://github.com/unibz-core/value-and-risk-ontology), as not presented in gUFO. See the [COVER imports](https://github.com/gioUbbiali/Sustainability-Core-Ontology/blob/SCO-Alignment-to-UFO/SCO/src/ontology/imports/SCO-U%20imports/COVER%20imports.owl) file.

To do

Axiomatization

Removal of BFO-compliant structure

Validation

All through the process of construction of SCO-U segment, we carried out discussions with subject matter experts.

The final release of SCO V1.1.0 can be found here: SCO-B, SCO-U.

**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.

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