Space Vocabularies:
Research, Development, Alignment, and Formalization in Astronomy and Astronautics

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Presented 15 November 2023 at Australian Vocabulary Symposium

Brief Bio

- Masters via Philosophy Dept.
- Actively serve in (inter)national space groups: standards, research, …
- PhD student, UNSW
- Web:
  - https://ontospace.wordpress.com
  - https://github.com/rrovetto
- Open to opportunities

Acknowledgement of land & indigenous peoples.

Note

- Has been mostly independent and unfunded personal project to date. Need formal support & partnerships to realize vision.
- *Wearing 2-hats*: independent available for hire, and current PhD student available for collaborations & misc. University PPT template for the latter is used in what follows.

In a nutshell

WHAT:

- R&D into collecting, analyzing, attempts-to-harmonize, develop & formalize concepts, terms, knowledge models on selected astro- topics.
- *Min. Viable Products (sample goals)*: conceptual models providing coherent terminology and (actual or potential) knowledge representation models.
- *History*:
  - https://ontospace.wordpress.com/presentations-posters/
    - *Example* Workshop Presentation: “A Framework for Knowledge Organization & Modeling of Space Data from Astronomy to near-Earth Space Activities” (2022)
  - https://ontospace.wordpress.com/publications
    - *Example Paper*: “Research & development in Astronautical Terminology – A project summary and call for support” (2022)

WHY you should care:

- mutual interest in vocab., clarity, improving current systems, knowledge management, innovation, …

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Scope: Topics & Systems

- **Topics**: astronomy & astronautics (spaceflight) but selected focus areas to start

- **Systems**: from vocabs to knowledge representation models
  - controlled vocabs., conceptual (data) models, semantic models, ontologies / knowledge graphs, … *
  - variable complexity, applicability & capabilities of knowledge organization systems

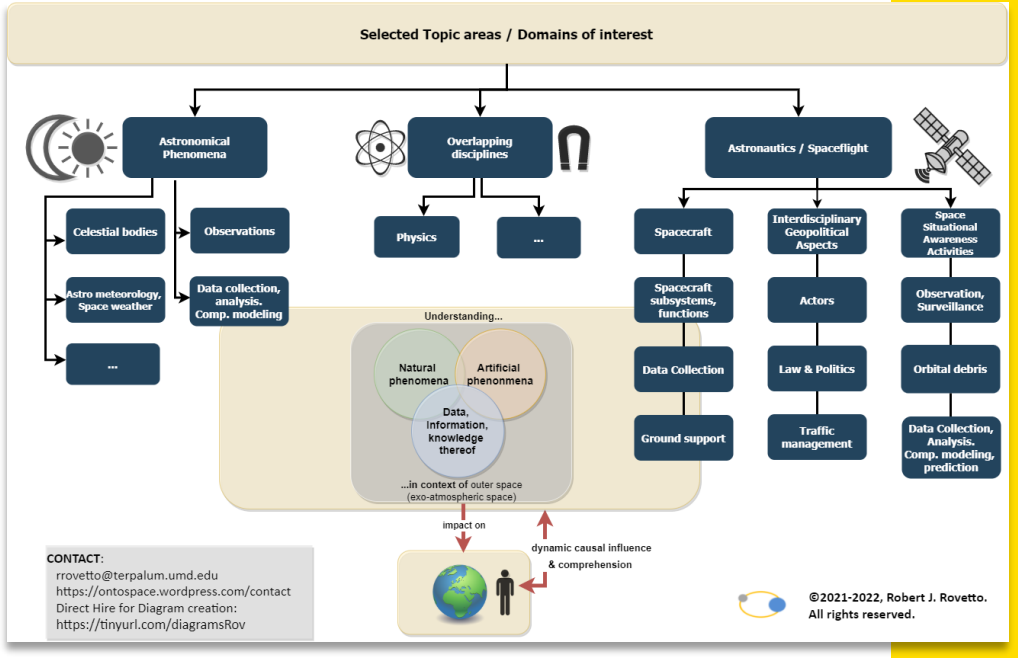

Diagram used from past presentation by R.Rovetto

*KOS (knowledge organization system) for short, a.k.a 'semantic artifacts' in some EU circles

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Collecting & Analyzing

- Collecting (& creating) space vocabularies
  - Living Catalog of Vocabularies: https://tinyurl.com/SpaceVocabulariesCatalog
  - Living Catalog of selected terms: https://tinyurl.com/SpaceflightTerminologyCatalog
  - Beginning with high-level (broad) terms* → some relevant to policy
  - Degrees of specificity. Open to variable grouping, demarcation, scoping

- Analyzing space vocabularies
  - Terminology & individual terms, definitions, documentation, …
  - Compare & contrast
  - Applying terminological principles
  - Philosophical analysis & theorizing
  - *Method*: manual approach

**Sample terms*: spaceflight, spacecraft, space situational awareness, … celestial body, stellar object, space object, orbit, space traffic management, …

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Developing space vocabularies

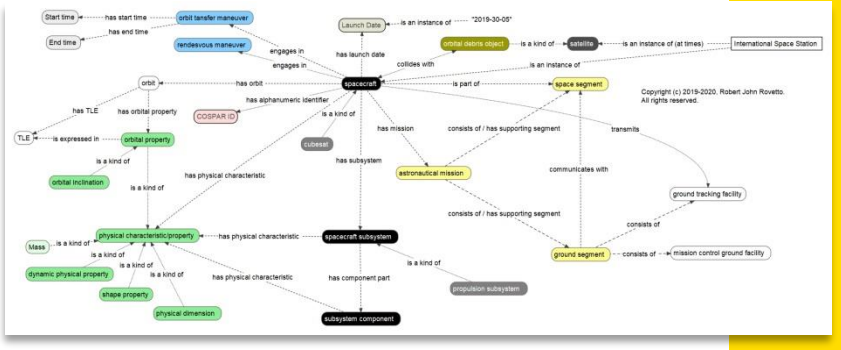

Diagram used from past presentation by R.Rovetto. Sample of authors conceptual models with terms.

- Lexicons, conceptual models, taxonomies, ontologies, …
- *Method*: manual dev. open to support for (semi)auto methods
- Examples:
  - The Orbital Debris Ontology (concept expressed in (Rovetto, 2015))
  - Classification of Orbits & The Orbit Ontology (Rovetto, misc.)
  - Astronomical Environment Ontology
  - Spacecraft / Space System taxonomy & ontologies
  - Others mentioned on https://ontospace.wordpress.com and https://github.com/rrovetto
  - *Collaborative*: activities in space orgs. such as IAF
  - *Future*: developing, improving, and completing the above
- Applications / Beneficiaries:
  - policy stakeholders, (inter)national standards, non-profit orgs. (e.g., business glossary, lexicons, …), space agencies, academic research (interdisciplinary), industry product dev. & knowledge management, …

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Terminology Harmonization
Semantic Synchronization

- (analysis) examination of selected vocabularies & other KOS

- R&D / Attempts at harmonizing & synchronizing terminology & semantics
  - Recommendations to the respective orgs.
    - Example (future): ISO Space Systems, open to improving that of other orgs., …
  - Mapping between vocabularies & individual terms
    - *Product(s):* crosswalk documents
  - *Method*: Manual-approach. Open to partnership/support for (semi)automated
  - *Note*: harmonization of any 2 (or n #) of systems may not be possible due to inherent structural, semantic, or ideological aspects → General principle: Do not force it.

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From Formalization to Advanced Applications

- (development) formalization of conceptual models and the vocabularies into symbolic logic and computational form
  - Knowledge representation languages
  - *Method*: manual. Open to other approaches.

- Limitations / Cautions
  - Constraints imposed by all formalisms
    - Develop a new formalism (computable language)?
  - Available tools
  - Computational burden
  - Manual approach is time-consuming, but desired for some tasks

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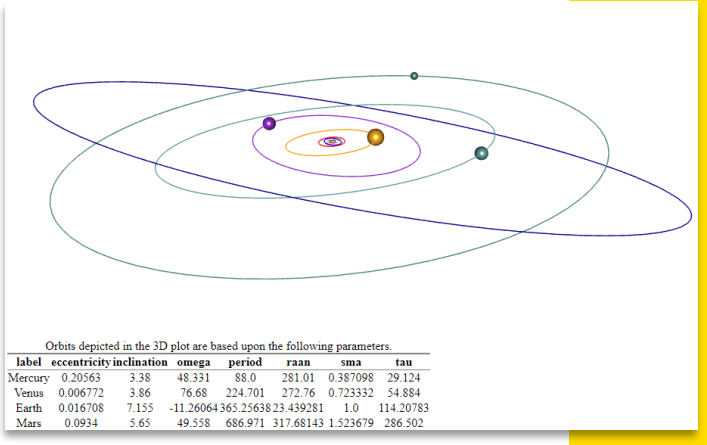
Example applications & goals

- Space (flight & science) → (future) library of models
- Astronomy → (future) developing a vocabulary repository
  - Recent presentation about my 2021 paper (PDF) proposing the use or dev. of software/tools (e.g., as OntoPortal or OntoHub) for space vocabs/KOS.
- Space visualizations (missions, space science) → (past) Using coding, ontology & tools for web-displaying space data & interactive solar system

  An Ontology-Based Virtual Orrery, NASA TM, D.A.O'Neil, R.J.Rovetto



Orbits depicted in the 3D plot are based upon the following parameters.

label	eccentricity	inclination	omega	period	raan	sma	tau
Mercury	0.20563	3.38	48.331	88.0	281.01	0.387098	29.124
Venus	0.006772	3.86	76.68	224.701	272.76	0.723332	54.884
Earth	0.016708	7.155	-11.26064	365.25638	23.439281	1.0	114.20783
Mars	0.0934	5.65	49.558	686.971	317.68143	1.523679	286.502

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Topical & Trending Relevance

- FAIR guidelines
  - My vocabularies/KOSs being/to-be developed are consistent with FAIR guidelines
    - Example: ontologies
    - Interoperable, Reusable, …
- Knowledge management / networks / commons
  - *Project Vision*: knowledge organization & modeling forming one or more networks with modular-capabilities for space data, documents, science, exploration & flight operations
- AI → knowledge representation & reasoning (KRR), ML, LLM, …
  - KRR involves dev. of computational ontologies
  - AI toward efficient, accurate, safe, actionable knowledge-discovery, decision-support, and actions

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Thank you

Questions?

Constructive comments?

Useful links

- **Project description**: https://ontospace.wordpress.com
- **Direct hire & Schedule meetings:**
  https://knowledgemodeling.setmore.com/
  ontologos@protonmail.com OR rrovetto@terpalum.umd.edu
- **Direct Ontology Consulting**: https://tinyurl.com/34u9w6wx
- **Direct Diagram Creation**: https://tinyurl.com/diagramsRov
- **Contact for university collaboration:** r.rovetto@unsw.edu.au
- **FYI**: sister project on maritime safety & ops - https://ontowaves.wordpress.com/