PITHIA-NRF

Plasmasphere Ionosphere Thermosphere Integrated Research
Environment and Access services:
a Network of Research Facilities

PITHIA Space Physics Ontology

for content-aware data collection registration at PITHIA e-Science Centre

User Guide

Version 1.4

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Release History

Version	Date	Writer	Description
IR	23-Dec-2022	Ivan Galkin	The first draft released
1.0	30-Dec-2022	Ivan Galkin	Wave phenomenon attributes added
1.1	24-Jan-2023	Ivan Galkin	Photon phenomenon is made a new PhotonType attribute of the Wave phenomenon.
1.2	18-Jul-2023	Ivan Galkin	The initial release to the PITHIA team for review
1.3	26-Jul-2023	Jurgen Watermann, Dalia Burešová	Team review results (multiple changes)
1.4	1-Sep-2023	Ivan Galkin	Added Activity Indicator and updated Computation Type

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1. Synopsis

The PITHIA-NRF e-Science Centre (eSC) manages the vocabulary of Space Physics keywords that can be used to narrow down data searches to acquired or computed observations of specific physical content. Such *content-aware* search is provided by eSC in addition to the commonly practiced selection by resource name (e.g., looking up "Cluster" in the list of space missions) and a simple free-text search for keywords. The **content**-aware search differs from the **context**-aware search that subsets resources by their availability during specific periods of time or locations defined *externally*; for example, during an elevated geospace activity event or a conjunction of the observation platforms.

This document is a user guide to the PITHIA-NRF content-aware search based on standard vocabularies of the Space Physics domain.

2. Preamble: The joys and woes of ISO terminology

The underlying foundation of the PITHIA-NRF data collection registration is the International Standard Organization (ISO) standards for metadata, most importantly, ISO 19156:2011 Observations and Measurements (O&M) schemas. ISO O&M prescribes specific, domain-neutral language to describe measurements and model computations. By design, it supports a fine detail of metadata descriptions down to the founding physical phenomena and particular capabilities of the sensor instrumentation to observe their properties. However, certain parts of the O&M terminology may appear unconventional, albeit standard, to the experts across numerous science domains who are accustomed to their established terminology and everyday jargon.

This User's Guide introduces the basic principles of ISO O&M organization and clarifies the meaning of each key term used for designing the standard-compliant ontology vocabularies.

3. Terminology and Abbreviations

Terminology and abbreviations are alphabetically sorted and provided for reference. An uninitiated reader may prefer to skip this section and proceed further into the text where these concepts are introduced logically.

Acquisition	[standard ISO vocabulary]: Interaction of the *Instrument* with the *Feature of Interest* to obtain its *Observed Properties*. [Step 8 of the data registration procedure].
Catalogue	[standard PITHIA vocabulary]: A listing of events or investigations assembled to aid users in locating data of interest. Each *Entry* in a Catalogue has distinct begin and end times and a list of registered *Data Subsets* with optional DOIs for their persistent storage.
Computation	[standard ISO vocabulary]: Numerical calculations without interacting with the *Feature of Interest*; characterised by numerical input and output. [Step 10 of the registration procedure].

Data Collection	[standard PITHIA vocabulary]: top-level metadata document for registration of provided measurements and model computations [The final Step 12 of the registration procedure].
Data Level	Level of information processing ranging from L0 (unprocessed) to L4 (derived by secondary analysis of lower-level data or by modelling computation).
Data Resource	Single data service item and its associated metadata, accessible through the PITHIA-NRF system using registered method(s) of interacting with the service.
Dataset	Pre-computed or pre-processed data resource available for download.
Data Subset	A portion of a *Data Collection* for registration in a *Catalogue* of particular events or targeted investigations
eSC	e-Science Center
Feature of Interest	[standard ISO vocabulary]: Real-world object that carries the property which is observed or modelled to produce a *Data Collection*. Subject to dictionary control using PITHIA Ontology.
GUID	Global Unique Identifier, generated on demand using an algorithm that does not have to consult with a centralised authority to issue the identifier.
ISO	International Standards Organisation
Metadata Model	[science-neutral]: Specification of different documents and their contents that are required for registration of data resources
Ontology	[science-specific]: A set of standard vocabularies for the selected domain of science
Observed Property	[standard ISO vocabulary]: description of a physical *Phenomenon*. *Observed Property* is obtained by means of observation or modelling that generates an estimate of the *Phenomenon*'s *Measurand* value. Technical details of generating *Observed Property* values are described by *Process*. The *Observed Property* descriptions are dictionary-controlled using PITHIA Onology.
O&M	Observations and Measurements
Phenomenon	[standard ISO vocabulary]: A physical observable (a.k.a. “Mother Nature”). This term is not to be confused with Event: *Phenomenon* does not admit a specific description in time or space. The top-level phenomenon categories are *Field*, *Particle*, and *Wave*.

PITHIA	Plasmasphere Ionosphere Thermosphere Integrated research environment and Access services
PITHIA-NRF	PITHIA Network of Research Facilities
Process	[standard ISO vocabulary]: A designated procedure used by the action of observation to assign a number, term, or other symbols to a *Phenomenon* generating the observation result. (Step #11 of the registration).
Registration	A three-phase operation of adding science metadata to the PITHIA e-Science Centre data search engine. Phase 1: building XML files describing the data collection ("12 steps"). Phase 2: ingesting the XML files in the e-Science Centre system using its online web submission page, Phase 3: Registering Interaction Methods for accessing the data resource by means of (a) local access/execution using the provider's interaction capability, (b) registered standardised application protocol interface (API) to the data provider access portal, (c) models deployed to EGI cloud for execution, and (d) model executable provided by PITHIA for download and execution on local computers.
XML	eXtensible Markup Language

4. Introduction: Metadata Model versus Domain Ontology

Concepts of "Data Model", "Metadata Model" and "Ontology" are used interchangeably in the e-Science community. In PITHIA-NRF, we draw a distinction between:

- **Metadata Model**: ISO-controlled organisation of the metadata components and their relationships in a generic, science-neutral manner;
- **Domain Ontology**: a vocabulary of physical concepts pertaining to a particular domain of science; usually structured and provided with wider-narrower relationships.

Figuratively speaking, Metadata Model is a *cathedral schematic* designed in accordance with the stated principles of its architecture, while Domain Ontology provides standard *building blocks* for the cathedral construction.

5. Key Elements of the PITHIA Metadata Model

5.1. Phenomenon versus Observation versus Event

In the architectural metadata layout of ISO 19156:2011, one of the less intuitive principles is the distinction that ISO draws between three founding concepts of O&M:

- **Phenomenon**: an observable physical constituent of Mother Nature; falls into three broad categories: Particle, Field, and Wave.
- **Observation**: a process of collecting information about a Phenomenon by means of Acquisition(s) and Computation(s).
- **Event**: a specific occurrence happening in a particular region of space and within a specific time interval.

The following additional arguments may help to appreciate the distinction further:

- Phenomena are not attributed to specific time or space (Observations and Events are).
- An Observation is merely an acquisition of information about a Phenomenon, *per se*.
  - Observations are generated by Process, a specific sequence of Acquisition(s) and Computation(s), used repeatedly.
- An Event is a specific occurrence happening at a particular time and location (and then discoverable in collected Observations).

The PITHIA eSC portal services reflect this Phenomenon-Observation-Event difference:

- **Data Collections** are built using a 12-step metadata registration procedure and provided with a query-by-content search engine for Collections;
- **Catalogues** are built using a 3-step metadata registration procedure and provided with a query-by-category search engine for Events.

Scientists who wish to locate, for example, Solar radio bursts records, would use the eSC Collection portal to find Data Collections by those instruments that observe the radiowaves originating on the Sun – but not the actual radio burst event listings that would be kept in a relevant Catalogue.

5.2. PITHIA Metadata Model extensions to ISO O&M standard

5.2.1. Background: ISO O&M quintessence

The PITHIA metadata model is based on the ISO O&M standard, whose quintessence can be compressed into the following single sentence:

Observed Property of a Feature of Interest describes the Phenomenon for which the Observation Result provides an estimate of its Measurand value, using a Process

This definition includes the following core O&M concepts as illustrated in Figure 1:

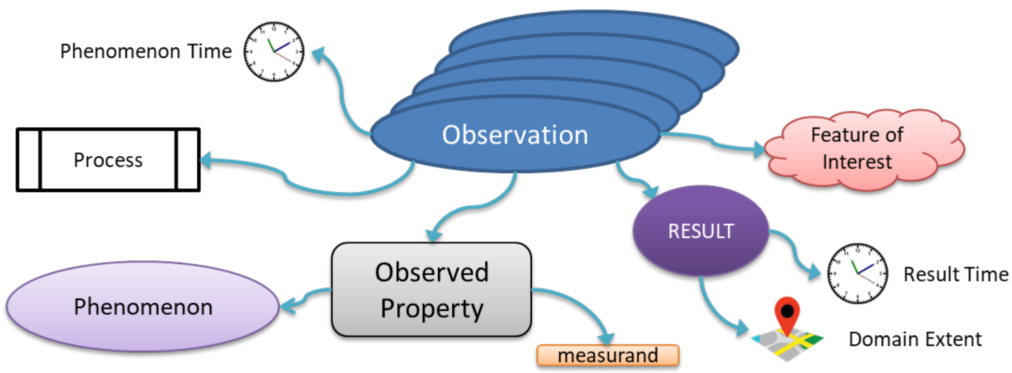


Figure 1: Standard components of the ISO 19156:2011 “O&M” Observation

- **Feature of Interest** = a real-world object (e.g., the Earth’s ionosphere) that carries the *Observed Property*
- **Observed Property** = a description of the underlying physical *Phenomenon* in the *Feature of Interest*
- **Measurand** = Measurable quantity of the *Observed Property*, whose value is estimated in the *Observation*
- **Result** = the outcome of the Observation act that produces a numerical value of particular temporal and spatial coverage (as defined in ISO 19123 Coverage standard)
- **Process** = a designated procedure used by the action of *Observation* to assign a numerical value to the *Phenomenon* that generates the *Observation*’s *Result*

5.2.2. PITHIA Extension: Observed Property

Many Observed Properties are defined in the Space Physics vocabulary, ranging from particle fluxes to critical frequencies. Given the variety of observations managed by PITHIA-NRF, presenting scientists with an alphabetically sorted list of all registered Observed Properties would be overwhelming.

For a more structured approach to the Observed Property organization (and content-targeted data searches), the Observed Property vocabulary is built as a set of **hierarchies** describing various aspects of the properties. While some of the resulting definitions are elaborate, especially in Wave phenomena (see Section 6 for a detailed description), all Observed Properties have two defined components: Phenomenon and Measurand.

- *def.* **Phenomenon**: **(not to confuse with Event): underlying physical phenomenon for which the Observation estimates its value.**

- *def.* **Measurand**: **measurable quantity of the Observed Property, whose value is estimated in Observation.**

PITHIA provides hierarchical lists of Observed Properties sorted by their Phenomenon and Measurand aspects to allow rapid access to the search criteria. The top-level hierarchy of the **Phenomenon** includes three sub-elements: Particle, Field, and Wave (Table 1).

Table 1: Top-level Hierarchy of Phenomenon

PHENOMENON		
Particle: a small, localized object that can be ascribed to several physical properties such as volume, mass, and charge.	**Field:** the space around a radiating body within which its electromagnetic attributes can exert force on another similar body that is not in direct contact	**Wave:** periodic or quasi-periodic (AC) variations of physical quantities in time and space, capable of propagating or being trapped within particular regimes

The top **Measurand** hierarchy includes several groups and individual items, arranged in a simple list with only a minor structurization (Figure 2).

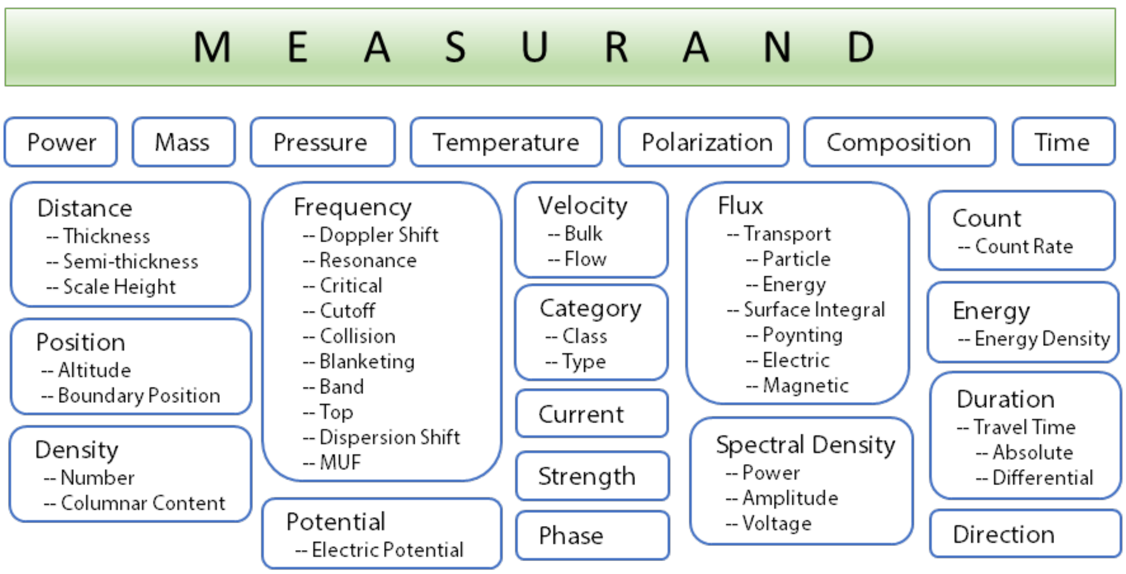


Figure 2: Ontology of Measurand

5.2.3. Observations can be Acquired and/or Computed

The ISO O&M standard prescribes a very specific metadata organisation using the concept of Observation. Intuitively, the *Observation* term is not quite applicable to the modelling data collections that are not based on actual sensor measurements. In order to relax this presumed restriction, Observations are allowed to be *purely computed,* per their Process description, without involving sensor instrumentation.

Each Observation is provided with a detailed description of the Acquisition and Computation components of the observation's Process. Both Acquisition and Computation, as parts of the Observation, provide values of the relevant observed property, but Computation does not involve physical interaction with the *Feature of Interest* using a sensor Instrument. To further help distinguish data collections arising from measurements versus models, Computation is provided with a searchable Computation Type dictionary (e.g., "Theoretical Model"), and Acquisition is provided with a searchable Instrument Type dictionary (e.g., "Energetic Particle Detector")[1].

The PITHIA metadata model extends ISO O&M accordingly by (a) adding *Composite Process* and then (b) attributing *Observed Properties* to various components of the *Process* (Figure 3) instead of the original Observation itself as in ISO O&M (Figure 1).

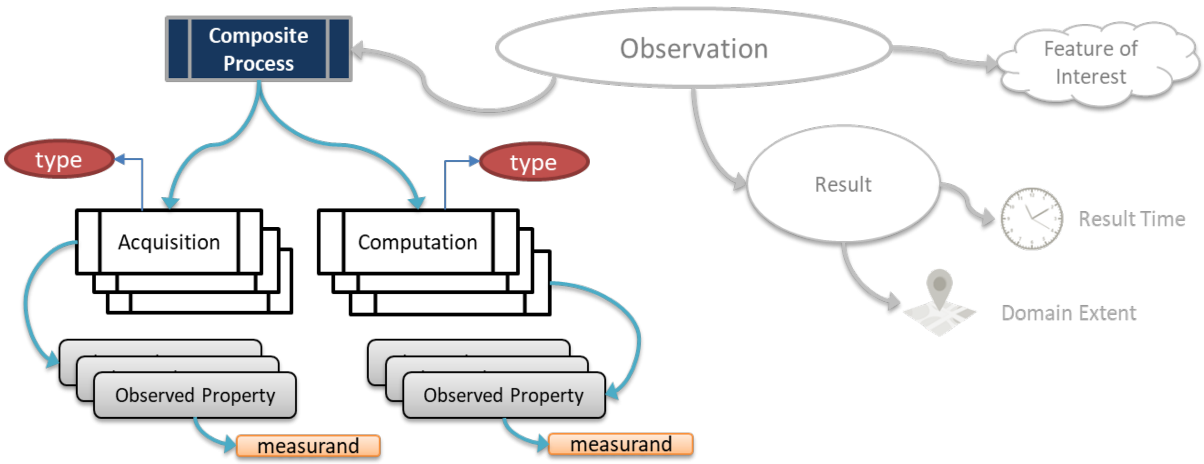


Figure 3: PITHIA metadata model distinguishes the Acquisition and Computation components of the Composite Process

5.2.4. PITHIA Extension: Data Collection, Collection Results, Catalogue

For practical considerations, the PITHIA metadata model does not include individual Observation registrations, because that would trigger an enormous effort to register a prohibitively large number of individual acts of observation, each with its own document. Instead, PITHIA suggests a composite observation entity called *Data Collection* that points to a composite result entity called Collection Results (Figure 4).

[1] Organisation of Process into Acquisition and Computation components allows those assimilative models designed to fill gaps in the fragmentary input measurements to report both Computation Type and Instrument Type attributes and then respond to queries of either one.

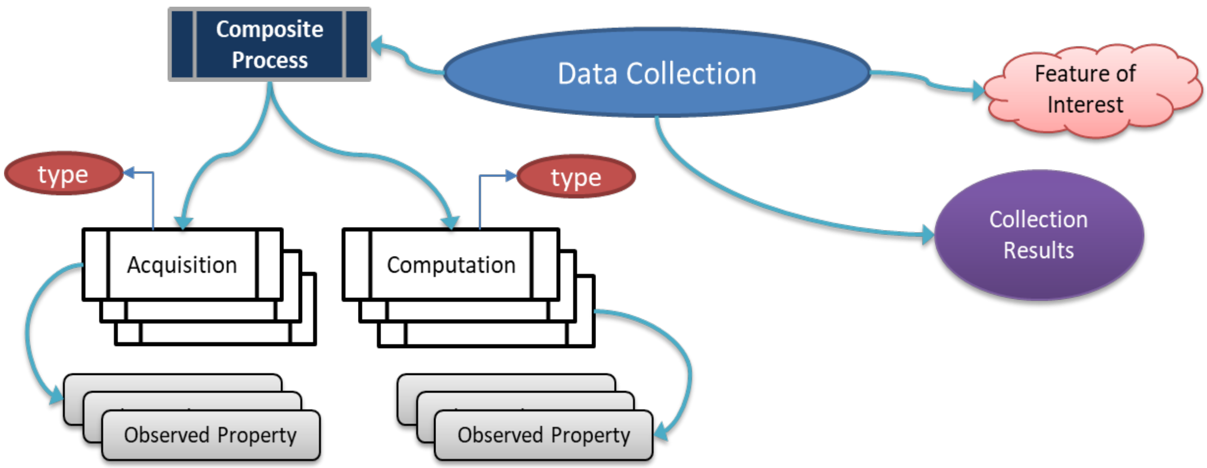


Figure 4: PITHIA metadata model uses Data Collection and Collection Results

In this design, the Collection Results element is no longer a particular numerical value/label/artefact; it is rather a **data access link**: a landing webpage, a description of the application protocol interface (API) for data retrieval, or a central service at PITHIA-NRF e-Science Centre for interaction with the data. This significant simplification of the original ISO O&M schema removes the Phenomenon Time, Result Time, and Domain Extent attributes of the Observation registration (as shown in Figure 1). Then, PITHIA introduces a new Catalogue metadata element (Figure 5) to describe specific data *subsets* relevant to a particular event, research project, or journal publication with DOI requirements.

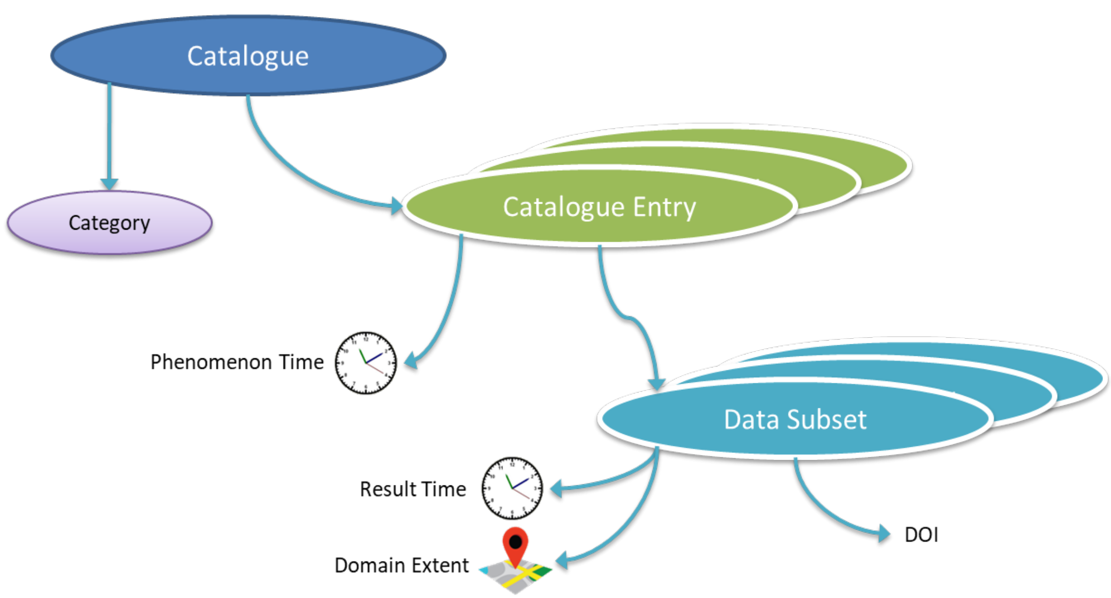


Figure 5. PITHIA adds Catalogues to its metadata model

For example, a Catalogue of type “Volcano Eruption” may include a Catalogue Entry for the 2022 Hunga-Tonga event that references, among others, a data subset from DIDBase Data Collection that holds manually validated ionograms from participating GIRO sites for the event day and a quiet-time reference days before and after the event.

5.2.5. PITHIA Extension: Platforms and Instruments (Acquisition)

An important design requirement for the PITHIA metadata model and ontology vocabulary has been their capability to describe sensor networks of varying membership and history of hardware upgrades (and therefore sets of available Observed Properties). To satisfy the requirement, the PITHIA metadata model includes two extensions to the GMD ISO/TS 19139:2007 standard:

- **Instrument** (based on DS_Sensor standard): Designation for the measuring instruments/sensors that interact with the *Feature of Interest* in order to obtain an estimate of the *Observed Property*; and
- **Platform** (based on DS_Platform standard): An identifiable object that brings the *Acquisition*’s *Instrument* to the appropriate environment (commonly an observatory facility or a satellite).

Furthermore, provision is made to assign different Acquisition Capabilities, depending on the Instrument design, to each Platform listed in the Acquisition document. The assignment is made by **linking <platform> and <acquisitionCapabilities>** using a special <capabilityLink>. For example, the tristatic UHF configuration of the EISCAT incoherent scatter radar that was operational from 1981 to 2012 is described in the following <capabilityLink> section of its “EISCAT Remote UHF” Acquisition document:

```
<capabilityLink>
    <platform xlink:href="https://metadata.pithia.eu/resources/2.2/platform/eiscat/Platform_EISCAT_Mainland"/>
    <acquisitionCapabilities xlink:href="https://metadata.pithia.eu/resources/2.2/acquisitionCapabilities/eiscat/AcquisitionCapabilities_EISCAT_RemoteUHF"/>
    <timeSpan>
        <gml:beginPosition>1981-08-26</gml:beginPosition>
        <gml:endPosition>2012-09-01</gml:endPosition>
    </timeSpan>
</capabilityLink>
```

Here the <acquisitionCapabilities> enlists all available Observed Property items, depending on the Instrument brand/manufacturer and the specific mode/configuration of its operation.

5.2.6. PITHIA Extension: Acquisition Capabilities and Computation Capabilities

We usually have limited means of observing the *Feature of Interest* (“Mother Nature”) in its entirety; our sensors present only fragmentary and/or sporadic information about the full domain extent of the feature. For example, one of the Observed Properties of the ionospheric plasma is its drift velocity that naturally exists as a vector quantity everywhere in the 3D volume of the Earth’s ionosphere. However, this naturally occurring property can be observed with various spatial coverages, completeness of the vector representation, choices of coordinate system and units, and background assumptions and approximations. Certain high-frequency (HF) sounders can detect the velocity of the drifting ionospheric plasma under the assumption that it moves across the sky over the observatory location as a single "frozen" entity. In this case, the Observed Property "drift velocity of electrons" is defined at one point in space.

To reflect the variety of our capabilities to observe Mother Nature, **Acquisition Capabilities** and **Computation Capabilities** include a suitable <processCapability> element for each Observed Property to describe the specific [and usually limited] characterization that our sensing instrumentation or models can offer. The <processCapability> element adds the following attributes to the Observed Property:

- **Dimensionality** = domain of the measured Observed Property spanned by its independent variables. Two Dimensionality attributes are defined:
  - **Dimensionality Instance** at one moment of time (e.g. 0D.Point, 1D.Profile, 2D.Map, 2D.Image, 3D); and
  - **Dimensionality Timeline** as presented in time progression (e.g., 1D.Timeseries, 2D.Spectrogram, 2D.Keogram, 2D.Animation).
- **Cadence** = Temporal resolution of the observations if they are repetitive at regular intervals.
- **Units** = Units of the observation result.
- **Vector Representation** = For those capabilities that are limited in their representation of the vector quantities, this defines projections or components of the acquired or computed values.
- **Coordinate Registration System (crs)** = For the selected presentation of the vector quantities.

In the example of HF ionosonde observing the bulk plasma drift over the observatory location, Dimensionality Instance is 0D.Point (rather than the naturally occurring 3D.Volume) and Dimensionality Timeline is 3D.TimeseriesStacked for 3 components of the drift vector. Additional examples of Dimensionality and Vector Representation used in describing particular Process Capabilities are given in Appendix A.

5.2.7. PITHIA Extension: Summary

SUMMARY of Section 5.2:

Content-targeted search across Observation Collections registered in PITHIA eSC can be made using Observed Property information provided for each data collection.
The complete list of available Observed Property definitions is large, but its structured organization allows rapid selection using Phenomenon and Measurand hierarchies.

A summary of the key PITHIA metadata model definitions is given in Table 3.

Table 3: Key metadata model definitions for PITHIA-NRF

KEY PITHIA METADATA MODEL DEFINITIONS		
Component	Sub-component	Description
Feature of Interest		A real-world object that carries the property which is observed
Observed Property	Phenomenon	Underlying physical phenomenon for which the Observation provides an estimate of its observed property value
	Measurand	Measurable quantity of the Observed Property, whose value is estimated in Observation.
Composite Process	Acquisition	Interaction of the Instrument with the Feature of Interest to obtain its Observed Properties.
	Computation	Numerical calculations without interacting with the Feature of Interest, characterised by numerical input and output.
	Process Capability	A description of one specific process capability to generate the Observation Result (applies to both Acquisitions and Computations). Includes: Observed Property, Dimensionality, Cadence, Units, Vector Representation, and CRS (coordinate registration system)
Acquisition	Capability Links	A list of links between Platform and Acquisition Capabilities to reflect the history of instrument upgrades at different nodes of a sensor network
	Platform	An identifiable object which brings the acquisition instrument(s) to the appropriate environment
	Acquisition Capabilities	List of Process Capability descriptions for a particular Instrument in its particular mode of operation.
	Instrument	Designations for the measuring instruments/sensors which interact with the feature of interest in order to obtain an estimate of the observed property.

Computation	Capability Links	A list of links between Platform and Computation Capabilities to reflect the history of software upgrades at different nodes of a sensor network
	Computation Capabilities	List of Process Capability descriptions for a particular Computation component.
Data Collection	Collection Results	A list of URLs to the data provider to retrieve the data product

6. PITHIA Space Physics Ontology

“Ontology” refers to a vocabulary of physical concepts pertaining to a particular domain of science. To simplify navigation through the wealth of Space Physics vocabulary terms, the PITHIA ontology is organized in several hierarchies of *keywords* connected to each other via a “broader-narrower” (parent-child) relationship. Understanding the ontology hierarchies is critical for efficient data search and discovery in PITHIA.

6.1 “Forest of Trees” Approach to Ontology

The science of building domain ontologies can be elaborate, involving various types of relationships between domain concepts and intricate inheritance rules for multiple aspects of the ontology constituents. For the PITHIA-NRF project, the academic exercise of building the Space Physics Ontology has been simplified to present an easier concept to the domain scientist. The ontology is formulated using two basic tools:

- **Hierarchical Tree**, built using one type of the Broader-Narrower (a.k.a. “parent-child”, “general-specific”) relationship.
- **Forest of Trees** architecture in which each domain concept is viewed as a set of independent aspects of its definition.

6.2. Observed Property as a Forest of Trees

6.2.1. Phenomenon and its attributes

The key component of the Observed Property vocabulary is *Phenomenon*, the physical constituent of Mother Nature, falling into three broad categories: Particle, Field, and Wave (see Table 1 above for their definitions). The domain of Space Physics supports multiple different ways of further classifying these 3 categories into subgroups using different independent criteria. The Wave phenomenon is particularly complex in its categorisation, allowing independent aspects of the wave generation, propagation, and interaction with the underlying medium to serve as classification criteria for building the ontology. While suitable multiple-inheritance techniques may be applied to architect a comprehensive Phenomenon classification, the resulting design would be unnecessarily complex. Instead, the decision is made to pick one primary aspect for building the Phenomenon classification tree (Figure 5):

- Particles are sorted by the **particle kind**
- Fields are sorted by **field type**
- Waves are sorted by the **oscillating agent(s)** and provided by the **PhotonType** attribute sorted by frequency band

All additional classification criteria are moved outside of the Phenomenon ontology tree for representation as separate and optional elements of the Observed Property. Special attention is given to the ontology of Wave phenomena (Figure 6) that are defined by their three aspects: *Generation* (by a source), *Propagation* (in a medium), and *Interaction* (with the medium).

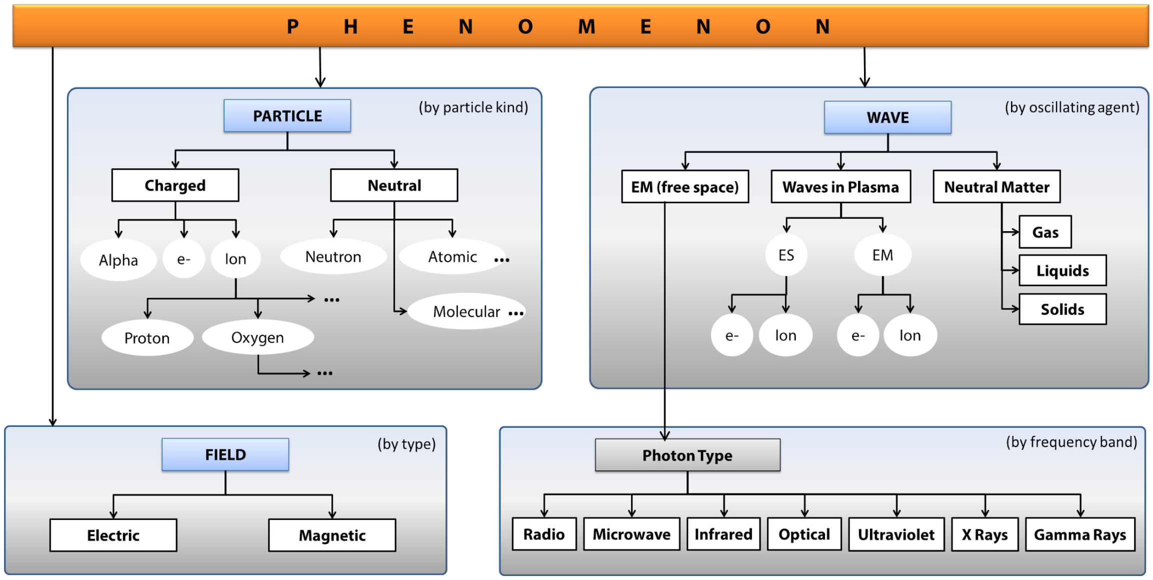


Figure 6: Ontology of Phenomenon

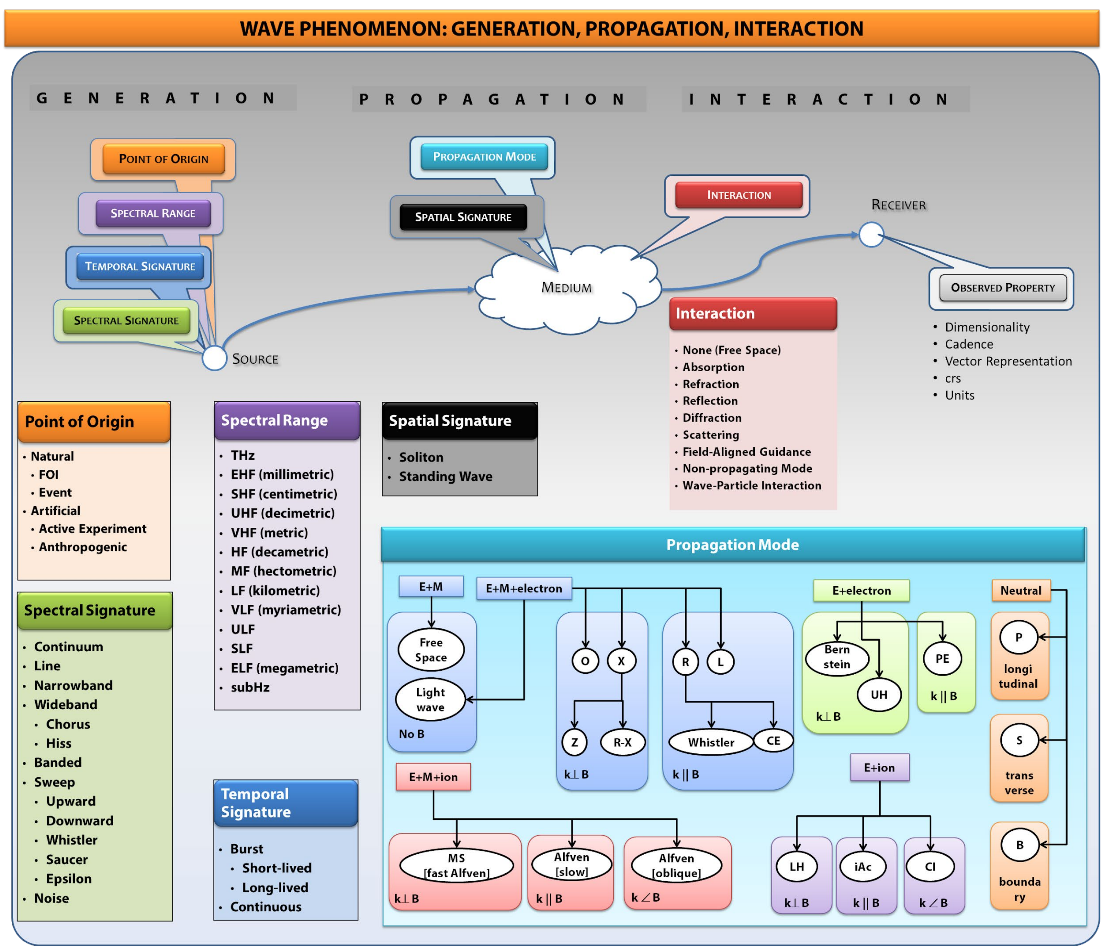


Figure 7: Ontology of Wave Phenomenon: Generation, Propagation, Interaction

6.2.2. Feature of Interest

The *Feature of Interest* (FOI) is organized by regions of space, which is straightforward. For illustration, here's the Earth Ionosphere subtree:

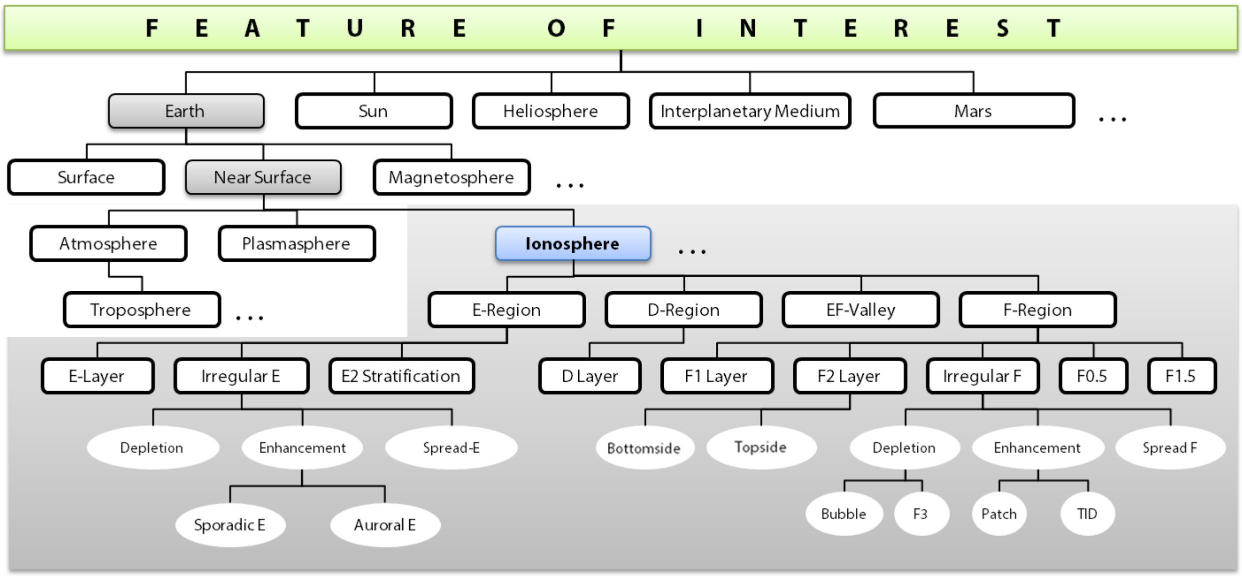


Figure 8: Ontology of Feature of Interest

6.2.3. Qualifier

Qualifier is used to refine the Observed Property definitions with generic attributes not otherwise captured by the other trees, such as Minimum, Maximum, Vertical, Parallel, Vector, or Scalar.

6.2.4. Example definition: foF2

As an example, an Observed Property of the Ionosphere, "Ordinary-wave critical frequency of F2 layer in the ionosphere", foF2, is defined using the six trees of the Observed Property in the following manner:

Definition of the O-wave Critical Frequency of the F2 layer in the ionosphere			
Tree #	Tree Name	Value	Reference
1	Phenomenon	Wave.Plasma.Electromagnetic	Figure 6
2	Measurand	Frequency.Critical	Figure 2
3	Feature of Interest	Plasma.Layer.Regular.F2	Figure 8
4	Propagation Mode	O	Figure 7

5	Interaction	Reflection, Refraction	Figure 7
6	Qualifier	Derived	Section 6.2.3

SUMMARY of Section 6:

Space Physics Ontology is built as a "Forest of Trees," in which multiple aspects of the Observed Property and Process Capability definitions are described using vocabulary terms arranged as a collection of hierarchical trees.

7. Other Ontology Vocabularies

7.1. Ontology of Activity Indicators

Space physics data collections commonly include indicators of the helio- and geo-space *activity* as indices and measures computed from the observed properties. The indicator variety may include measured quantities in physical units (such as for example, a sunspot count or a component of the interplanetary magnetic field) or numerical computations that map the *Observed Property* to a representative indicator value without a physical unit (such as Kp), often requiring comparison of the observation to statistical quiet-time and/or disturbed-time references and thresholds. Some indicator computations involve more than one observed property, such as for example, the magnetosonic Mach number. These activity indicators do not necessarily fit the ISO 19156:2011 O&M schema definitions directly.

Yet, search by content is a desirable capability for the activity indicators as well. This means that all data collections of the activity indicators have to follow the standard 12-step registration process and inform the PITHIA search engine about their content accordingly.

To identify activity indicator data collections, PITHIA ontology defines a special *Computation Type* "Activity Indicator" with its own dictionary. The *Observed Property* and *Feature of Interest* for the activity indicators are defined based on the sensor measurements that contributed to the computation. Then, just like searching measurement data collections would need a query with the *Instrument Type* checkbox selected or model data collection would require *Model* checked off under *Computation Type*, users looking for activity indicator datasets would select a suitable *Activity Indicator* checkbox in the search engine window.

7.2. Computation Type

A few PITHIA-specific entries were required for the *Computation Type* dictionary for the Computation element of the Process (Figure 9). At the time of this document preparation, the Activity Indicator sub-tree of the *Computation Type* remains incomplete in anticipation of the upcoming data registrations at PITHIA-NRF eSC.

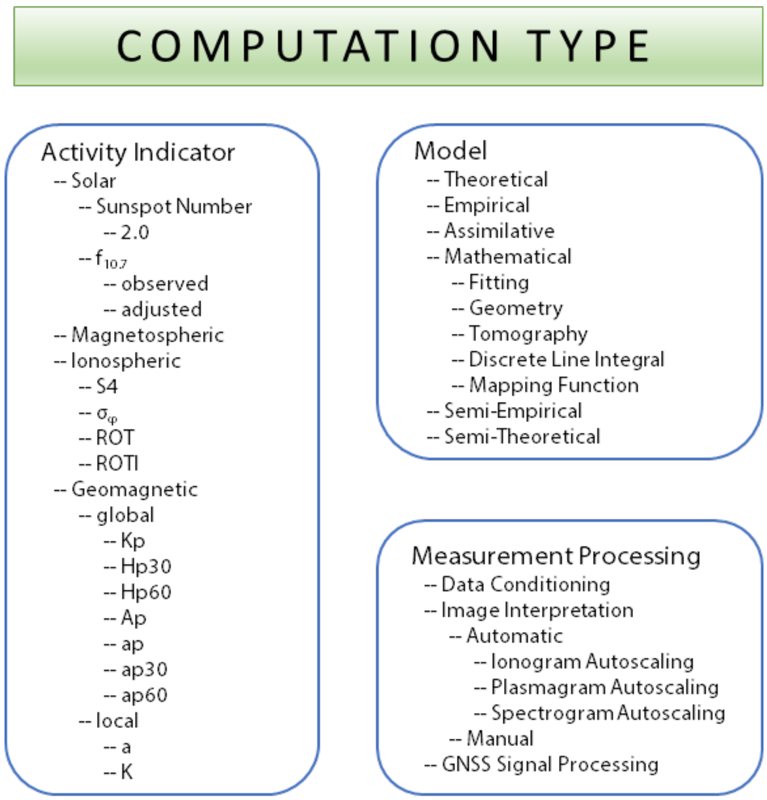


Figure 9: Ontology of Computation Type

7.3. Instrument Type

The instrument types used for Space Physics observations are specific to the domain and therefore, included in the ontology definitions. The tree of the instrument types for PITHIA is

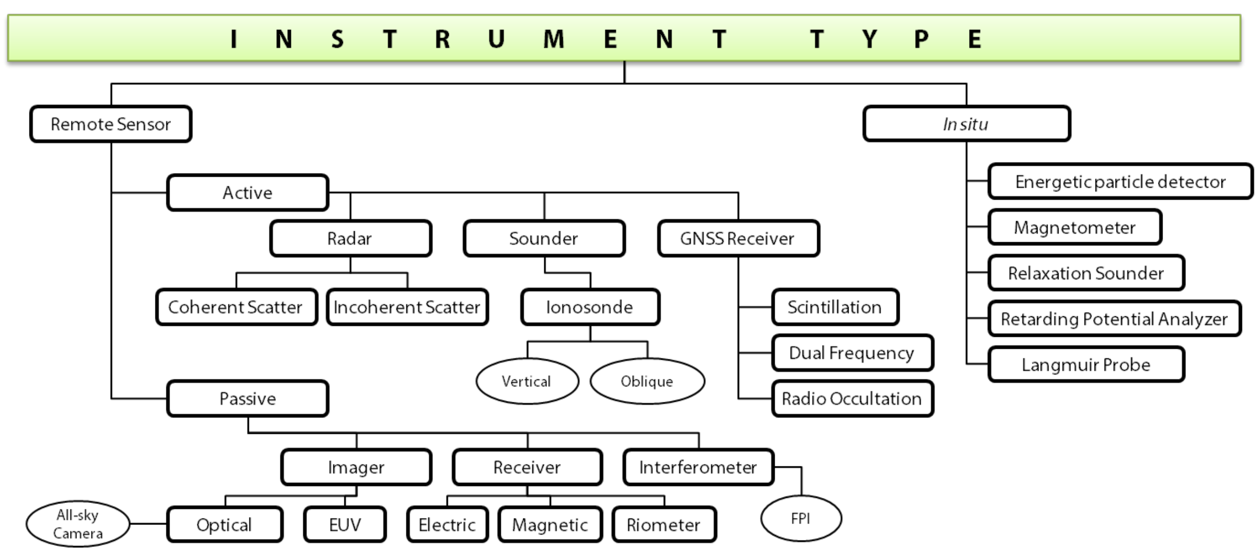
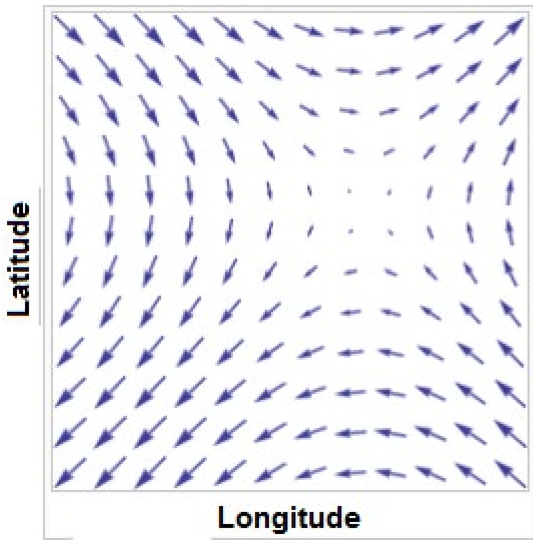


Figure 10: Ontology of Instrument Type

Appendix A. Use of Vector Representation and Dimensionality

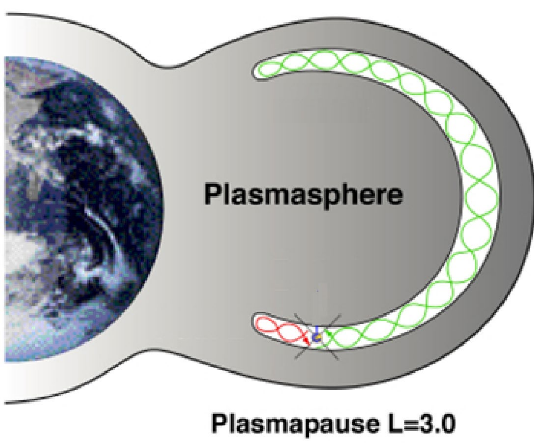
An example of using a Vector Representation and Dimensionality to describe a wind velocity observed as a 2D vector field:



Observed Property: Neutral Wind Velocity
Phenomenon: Particle.Neutral.Air
Measurand: Velocity.Flow
Feature of Interest: Earth.NearSurface.Atmosphere

Dimensionality: 2D.Map
Vector Representation: Projection.Horizontal
crs: GEOSpherical

Another example of using Dimensionality to describe the remote-sensing capability of the radio plasma imager on IMAGE satellite to observe electron densities along a B-field aligned plasma duct in 3D space:



Observed Property: Electron Density
Phenomenon: Particle.Charged.Electron
Measurand: Density.Number
Feature of Interest: Earth.NearSurface.Plasmasphere

Dimensionality: 1D.Profile.Field-Aligned
crs: GSM