ISO 19100 series compliant GNSS Metadata Profile

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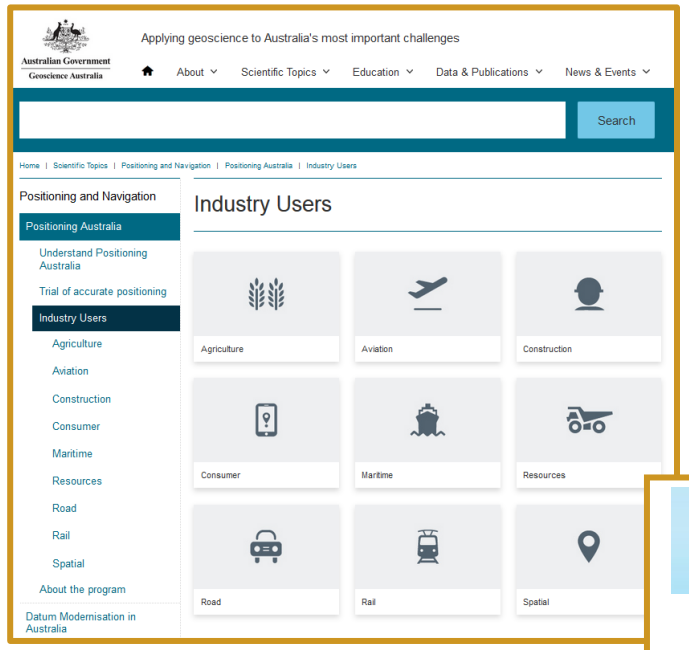
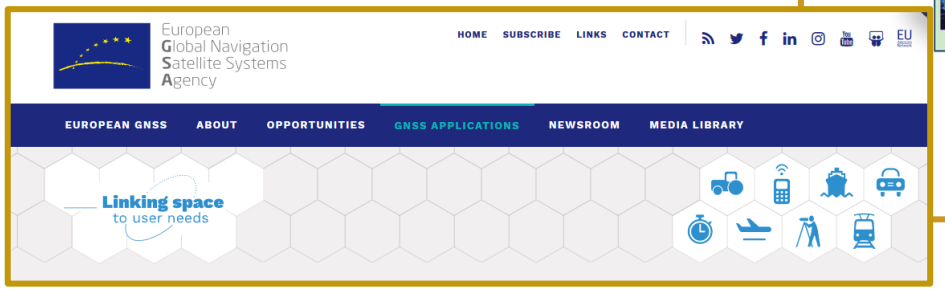
Who are the end-users of GNSS data?

- Users (machines or human) know that there we have SDIs and those curate metadata catalogues.
- Users still want to determine whether data fits their purpose.
- Users aren't native geodesists but have expectations on the quality of geodetic data and they learned use standard geodetic language for that.





Results in detail: here

What kind of information users want to see?

- Information about:

	Agriculture	Rail	Road	Maritime	Aviation	Location-Based Services	Time & Synchronisation	Surveying
Metadata	Accuracy Availability Integrity Coverage Reliability	Accuracy Availability Integrity Coverage Reliability Robustness Continuity Authentication	Accuracy Availability Integrity Continuity Reliability Authentication Interoperability	Accuracy Availability Integrity Coverage Reliability Coverage	Accuracy Availability Integrity Continuity	Accuracy Availability Integrity Authentication	Accuracy Authentication	Accuracy Availability

Results in detail: here

Gaps in standards to support FAIR data and services for current GNSS users

- Focus on subset of ISO 19100 suite relevant to GNSS data and services

Support for users reqs: POOR!

Standard	Supports for metadata elements (✓= support explicit, blank = support not explicit)							
	Accuracy	Availability	Integrity	Coverage	Reliability	Robustness	Continuity	Authentication
ISO 6709	✓							
ISO 19111	✓							
ISO 19115	✓			✓				
ISO 19116	✓		✓	✓				
ISO 19118								
ISO 19119		✓		✓	✓			
ISO 19127	✓							
ISO 19132	✓							
ISO 19133	✓	✓		✓				
ISO 19134								
ISO 19145								
ISO 19148								
ISO 19155				✓				
ISO 19156	✓			✓				
ISO 19157	✓			✓				
ISO 19161				✓				
ISO 19162	✓			✓				
ISO 19165-1								
ISO 19168--1								
ISO/NP 24245								
ISO/NP 24246	✓		✓					
ISO 18197	✓							
STAC								
ICSM Survey control standards	✓							
ICSM Metadata profile	✓			✓				
W3C DCAT								
INSPIRE(/OGC) GeoDCAT-AP				✓				
OGC TimeSeriesML								

Standard	Supports elements for FAIR (✓= support explicit, blank = support not explicit)			
	Findable	Accessible	Interoperable	Reusable
ISO 6709: 2008 Standard representation of geographic point location by coordinates ISO 6709:2008/COR 1: 2009			✓	✓
ISO 19111: 2019 Geographic information – Spatial referencing by geographic identifiers			✓	✓
ISO 19115-1: 2014 Geographic information – Metadata – Part 1: Fundamentals ISO 19115-1: 2014/AMD 1:2018 Geographic information – Metadata – Part 1: Fundamentals, Amendment 1 ISO 19115-2:2019 Geographic information – Metadata – Part 2: Extension for acquisition and processing ISO 19115-3: 2016 Geographic information – Metadata – Part 3: XML schema implementation for fundamental concepts ISO 19139-2: 2012 Geographic information – Metadata XML schema implementation – Part 2: Extension for imagery and gridded data	✓	✓	✓	✓
ISO 19116: 2019 Geographic information – Positioning services	✓	✓	✓	✓
ISO 19118: 2011 Geographic information – Encoding			✓	
ISO 19119: 2016 Geographic information – Services	✓	✓	✓	
ISO 19127: 2019 Geographic information – Geodetic register		✓	✓	
ISO 19132: 2007 Geographic information – Location-based services – Reference model		✓	✓	✓
ISO 19133: 2005 Geographic information – Location-based services – Tracking and navigation			✓	✓
ISO 19134: 2007 Geographic information – Location-based services – Multimodal routing and navigation			✓	✓
ISO 19145: 2013 Geographic information – Registry of representations of geographic point location		✓	✓	
ISO 19148: 2012 Geographic information – Linear referencing			✓	✓
ISO 19155: 2012 Geographic information – Place Identifier (PI) architecture ISO 19155-2: 2017 Geographic information – Place Identifier (PI) architecture – Part 2: Place Identifier (PI) linking	✓	✓	✓	
ISO 19156: 2011 Geographic information – Observations and Measurements			✓	✓
ISO 19157: 2013 Geographic information – Data Quality ISO 19157:2013/AMD 1: 2018 Geographic information – Describing data quality using coverages ISO 19157-2: 2016 Geographic information – Data Quality – Part 2: XML schema implementation	✓	✓	✓	✓
ISO 19161:2020 Geographic information – Geodetic references – Part 1: The international terrestrial reference system (ITRS)		✓	✓	
ISO 19162: 2019 Geographic information – Well-known text representation for coordinate reference systems			✓	✓
ISO 19165-1: 2018 Geographic information – Preservation of digital data and metadata – Part 1: fundamentals ISO 19165-2 (under development) Geographic information – Preservation of digital data and metadata – Part 2: Content specification for earth observation data and derived digital products	✓	✓	✓	✓
ISO 19168-1 (under development) Geographic information – Geospatial API for Features – Part 1: Core	✓	✓	✓	
ISO/NP 24245 Space systems – GNSS device codes			✓	
ISO/NP 24246 Space systems – Requirements for GNSS positioning augmentation centers			✓	
ISO 18197: 2015 Space systems — Space based services requirements for centimetre class positioning				✓
SpatioTemporal Asset Catalogue (STAC)[1]	✓	✓	✓	✓
ICSM Survey control standards				✓
ICSM Metadata profile	✓	✓	✓	✓
W3C DCAT	✓	✓	✓	✓
INSPIRE(/OGC) GeoDCAT-AP	✓	✓	✓	✓

Support for FAIR: GOOD!

Results in detail: here

What needs to be improved?

	Requirements		Supporting standards			Gaps in standards			Necessary improvement
	Element	**Value**	**Data**	**Quality**	**Metadata**	**Data**	**Quality**	**Metadata**	
Agriculture (Ag)	Accuracy	• 2.5-30cm; • sub-metre to metre level	• ISO 19133 • ISO 19148 • ISO 19156 • GeodesyML • OGC TimeSeriesML	• ISO 19157	• ISO 19115 • GeodesyML	• none	• insufficient data quality definition – missing: • quality elements • quality measures	• none	Expand ISO 19157 DQ model: • Add **Ag** DQ elements; • Specify measures for these new elements; and • Specify quality evaluation procedures for these elements. • Report metadata at end-user level – i.e. show **Ag** end-users **Ag** metadata – this requires update to the metadata catalogue interface; • Specify the data delivery format (GeodesyML, ISO 19156, TimeSeriesML, or raw data) of **Ag** data; • Include **Ag** metadata to the data delivered.
	Availability	• high • medium high							
	Integrity	• low • medium • high							
	Coverage	• national							
	Reliability	• low • medium • high							

Results in detail: here

GNSS Value chain

- Composed of various actors

- All have requirements on:
  - Standards
  - Protocols
  - FAIR

Results in detail: here

GNSS Value chain – Survey

2.5.3) **Accessible – Once the user finds the required data, they need to know how they can be accessed, possibly including authentication and authorisation.***

If you have experienced challenges accessing precise positioning information for your industry, please share details below. Describe the main challenges, how they impacted your positioning needs, and if relevant, how they were overcome.

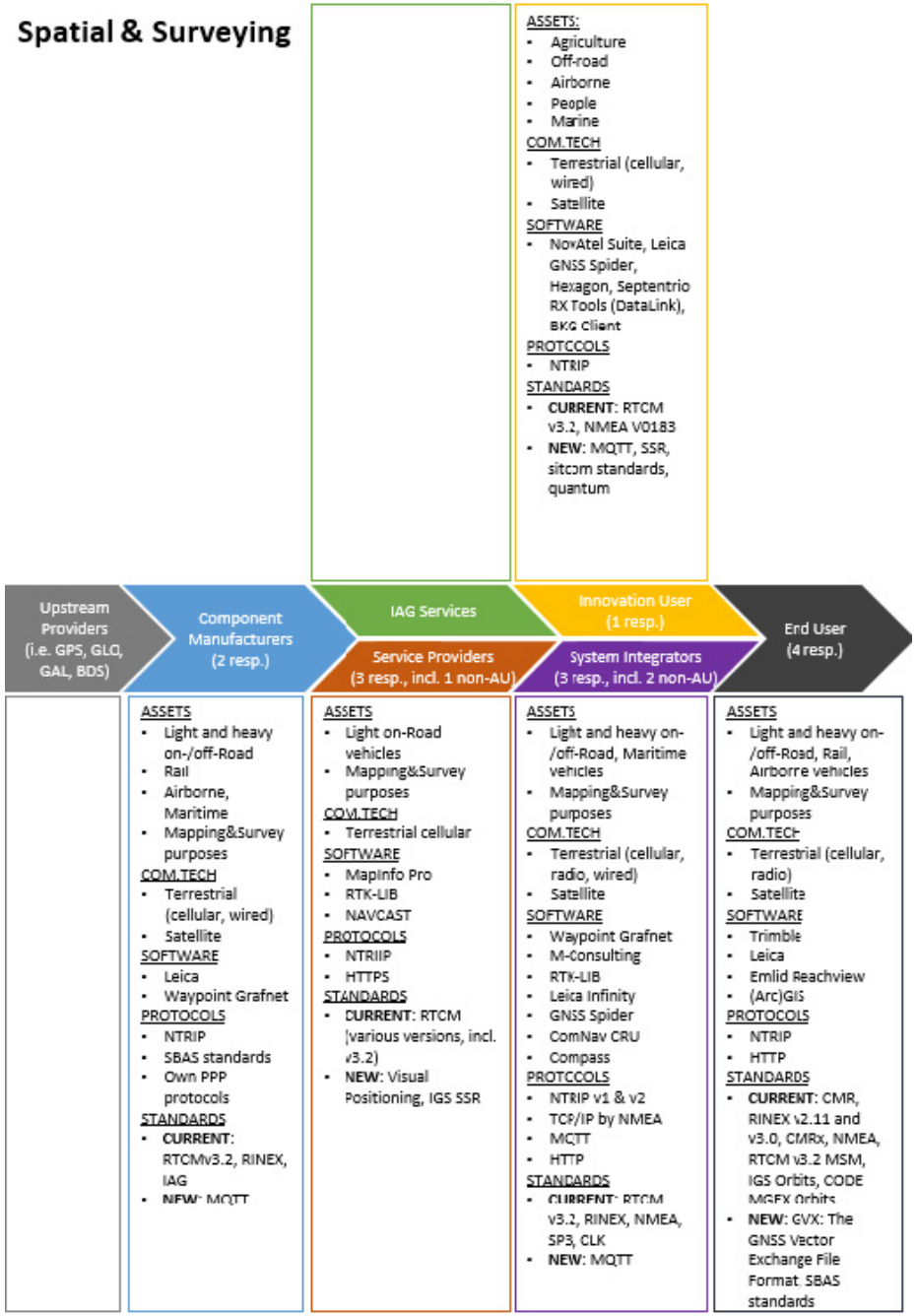
Type your answer here...

2.5.4) Which of the following data policies, if implemented, would improve the **accessibility** of the data you need?*

Description (optional)

Choose as many as you like

- A Access to data for precise positioning is open, free, and universally implementable e.g. through HTTP, JSON-RCP, XML-RCP protocols)
- B Common authentication and authorisation procedures where necessary (e.g. NTRIP, MQTT, PAP, EAP, EAP-TLS, EAP-PEAP, SRP)
- C Information about the publisher and distributor of the data are made readily available
- D It is clearly communicated whether data is available to the public, or if it requires user authentication
- E No Answer / Not Applicable



Results in detail: here

GNSS Value chain – survey

SPATIAL											
	METADATA Requirements										
Spatial Application	Accuracy (Horizontal, Vertical)	Coverage	Integrity Risk	TTA	Robustness			Availability	Fix Update Type	TTFF	Power Consumption
					Environmental conditions	Interference	Spoofing				
Mapping & GIS	**H:** < 1m **V:** < 1m	Global	Yes	?	Medium	High	N/A	High	Continuous	> 30s	< 2mA
Smart Cities	**H:** 1m – 5m **V:** 1m – 5m	Local	?	?	?	?	?	?	?	?	N/A
Digital Twins	**H:** 0.1m – 0.7m **V:** 0.1m – 0.5m	Depends on the spatial extent of the Digital Twin	?	?	?	?	?	?	?	?	N/A

- Missing elements and/or units:
  - Update rate, format type, constellations used/provided, reference datum
  - Blunders
  - Latency, Continuity, Availability (time period), Robustness (level), Position Fix Rate, Accuracy (cm), Coverage(KM2)
  - Receiver Autonomous Integrity Monitoring (RAIM)
  - Downtime on GNSS CORS site, i.e. why data may not be available in certain time periods.
- For identified application – Digital Twin or other:
  - Accuracy same as in surveying
  - Accuracy needs to be quantified and not classified
  - Robustness is important
  - Receiver Autonomous Integrity Monitoring (RAIM) and Ambiguity Resolution

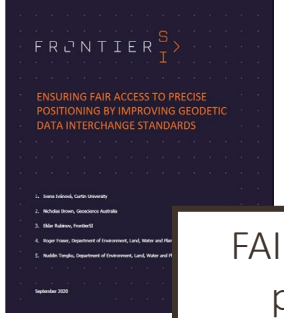
- Missing elements and/or units:
  - *None provided, noted that all is good as listed*
- Missing elements as identified for control traffic farming application:
  - GNSS Sensitivity
  - Power consumption

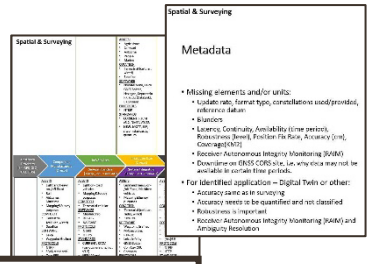
AGRICULTURE (1 = Controlled Traffic Farming (CTF) | 2 = Precision Livestock Tracking (PLT))						
	METADATA Requirements					
PAg Application	Accuracy	Availability	Integrity and Reliability	Robustness	Authentication	TTFF
Farm Machinery Guidance	10-30cm	High	High	Low	Low	a few min
Automatic Steering	2.5cm	High	High	Medium	Low	a few min
Spraying, Spreading, Harvesting, Bulk Crops (VRA*-Low)	10-30cm	High	High	Low	Low	a few min
Seeding, Planting (VRA*-High)	2.5-10cm	High	High	Low	Low	a few min
Harvest/Yield Monitoring	sub-metre	Medium	Medium	Low	Low	a few seconds
Biomass Monitoring	sub-metre	Medium	Medium	Low	Low	a few seconds
Soil Sampling	m-level/sub-metre	Medium	Low	Low	Low	a few min
Precision Viticulture	sub-metre	Medium	Medium	Low	Low	a few seconds
Precision Forestry	sub-metre	Medium	Low	Low	Low	a few seconds
Livestock tracking and Virtual Fencing	m-level	High	Medium	Low	Low	a few seconds

Results in detail: here

GNSS Metadata Profile

- Based on:
  - ISO 19100 series of standards
  - The FAIR principles
  - Result of GNSS user engagement
- Built following:
  - ICSM's Metadata Best Practice
  - GA Metadata Profile of ISO 19115-1:2014

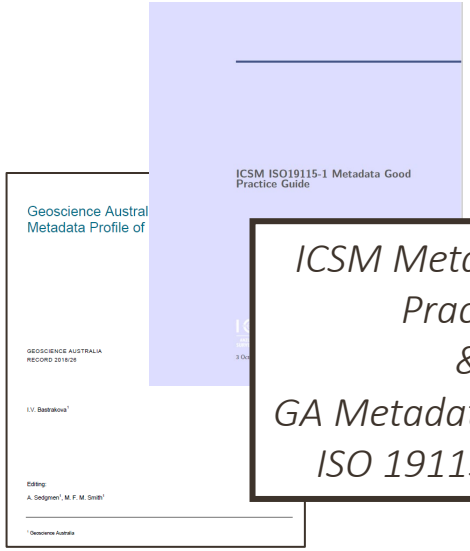




FAIR geodetic & positioning standards (P1003)

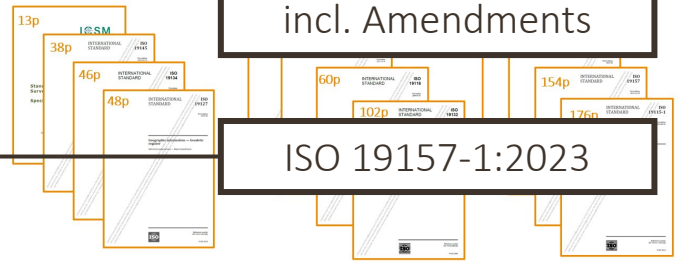
User requirements from RP 1.1

Metadata elements



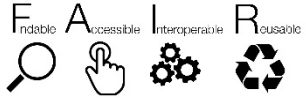
ICSM Metadata Best Practice
&
GA Metadata Profile of ISO 19115-1:2014

ISO 19115-1:2014
ISO 19115-2:2019
incl. Amendments



ISO 19157-1:2023

The FAIR principles



GNSS Metadata Profile

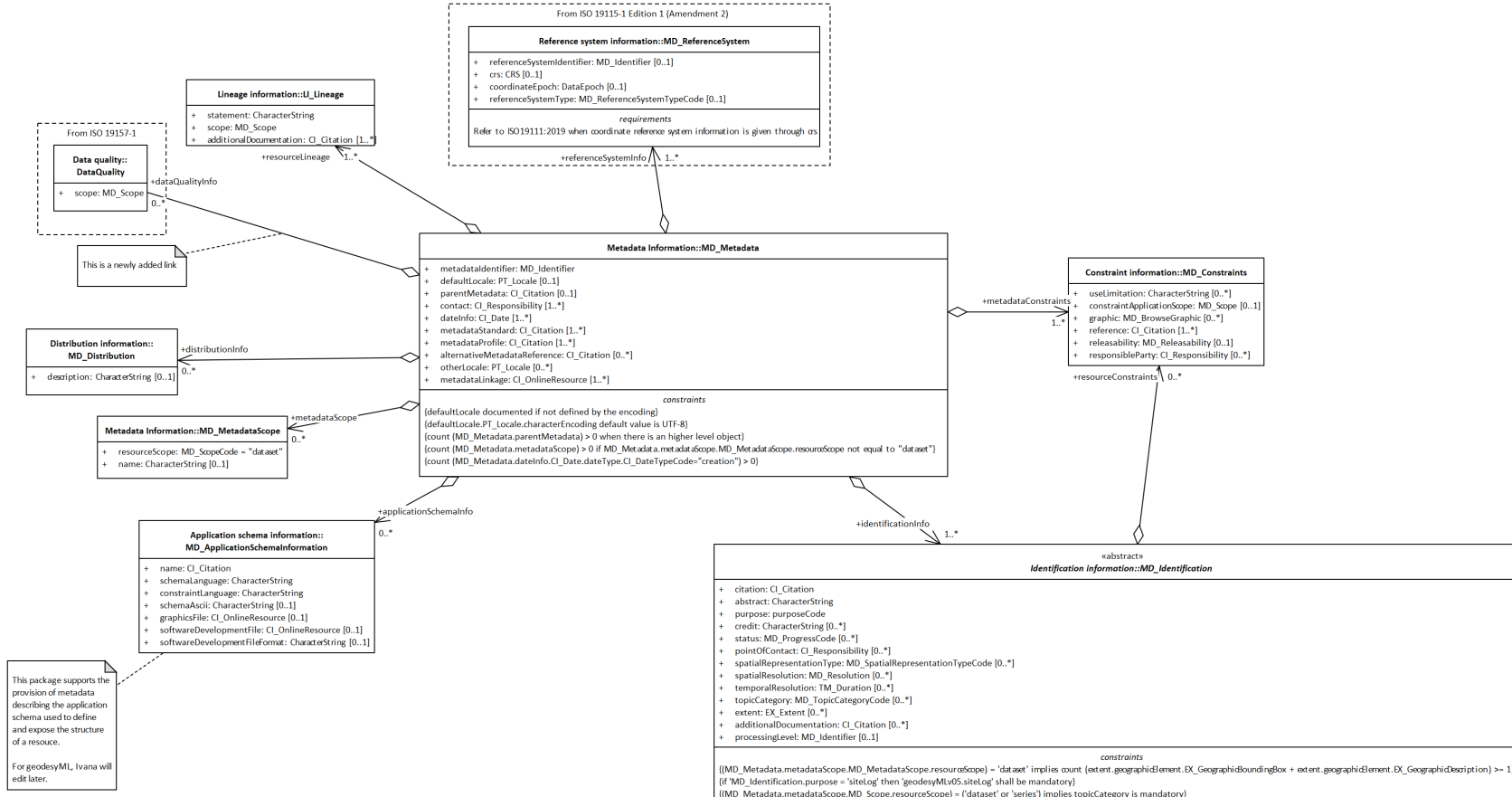
GNSS Metadata Profile is FAIR

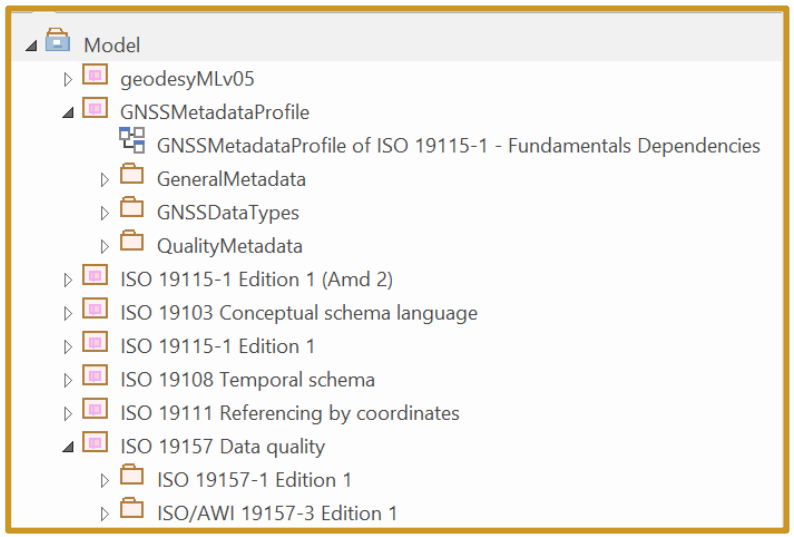
- Model revised to comply with the FAIR principles
- Several elements modified from optional to mandatory

FAIR principles		Entity	Name	Change from ISO 19115-1
F	F1	CI_Citation	identifier	Optional->Mandatory
F	F1	CI_Citation	onlineResource	Optional->Mandatory
F	F1	MD_Metadata	metadataIdentifier	Optional->Mandatory
F	F1	MD_Metadata	metadataLinkage	Optional->Mandatory
F	F4	MD_Identification	descriptiveKeywords	Optional->Mandatory
A	-	-	-	-
I	I3	MD_Metadata	metadataStandard	Optional->Mandatory
I	I3	MD_Metadata	metadataProfile	Optional->Mandatory
R	R1	MD_Metadata	metadataConstraints	Optional->Mandatory
R	R1.1	MD_Constraints	reference	Optional->Mandatory
R	R1.1	MD_LegalConstraints	useConstraints	Optional->Mandatory
R	R1.2	MD_Metadata	resourceLineage	Optional->Mandatory
R	R1.2	LI_Lineage	additionalDocumentation	Optional->Mandatory
R	R1.2	LI_Lineage	scope	Optional->Mandatory
R	R1.2	LI_Lineage	statement	Optional->Mandatory

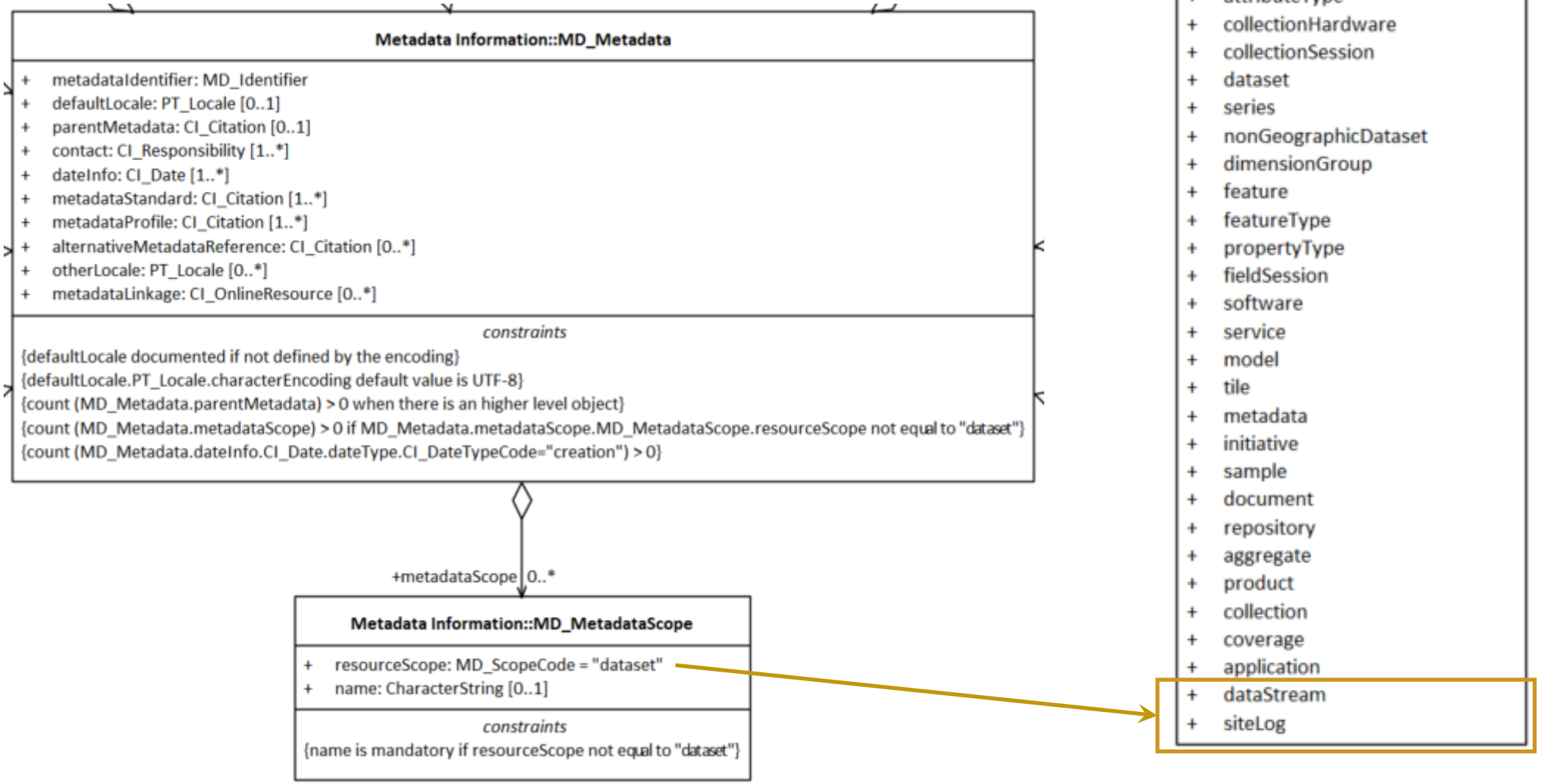
GNSS Metadata

- Conceptual model based on ISO/TC211 HM version Feb’23
- Uses GeodesyML v0.5

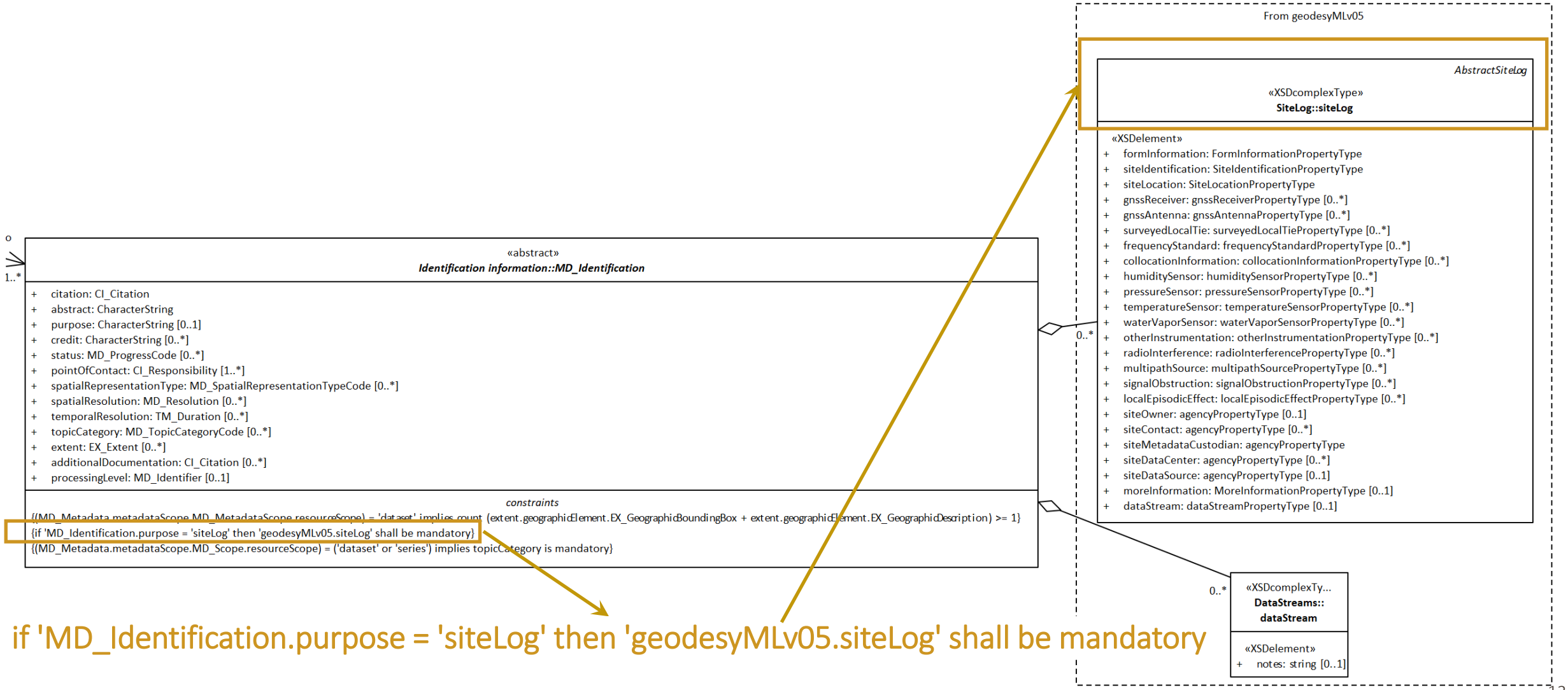




GNSS Product Identification



GNSS Product Identification

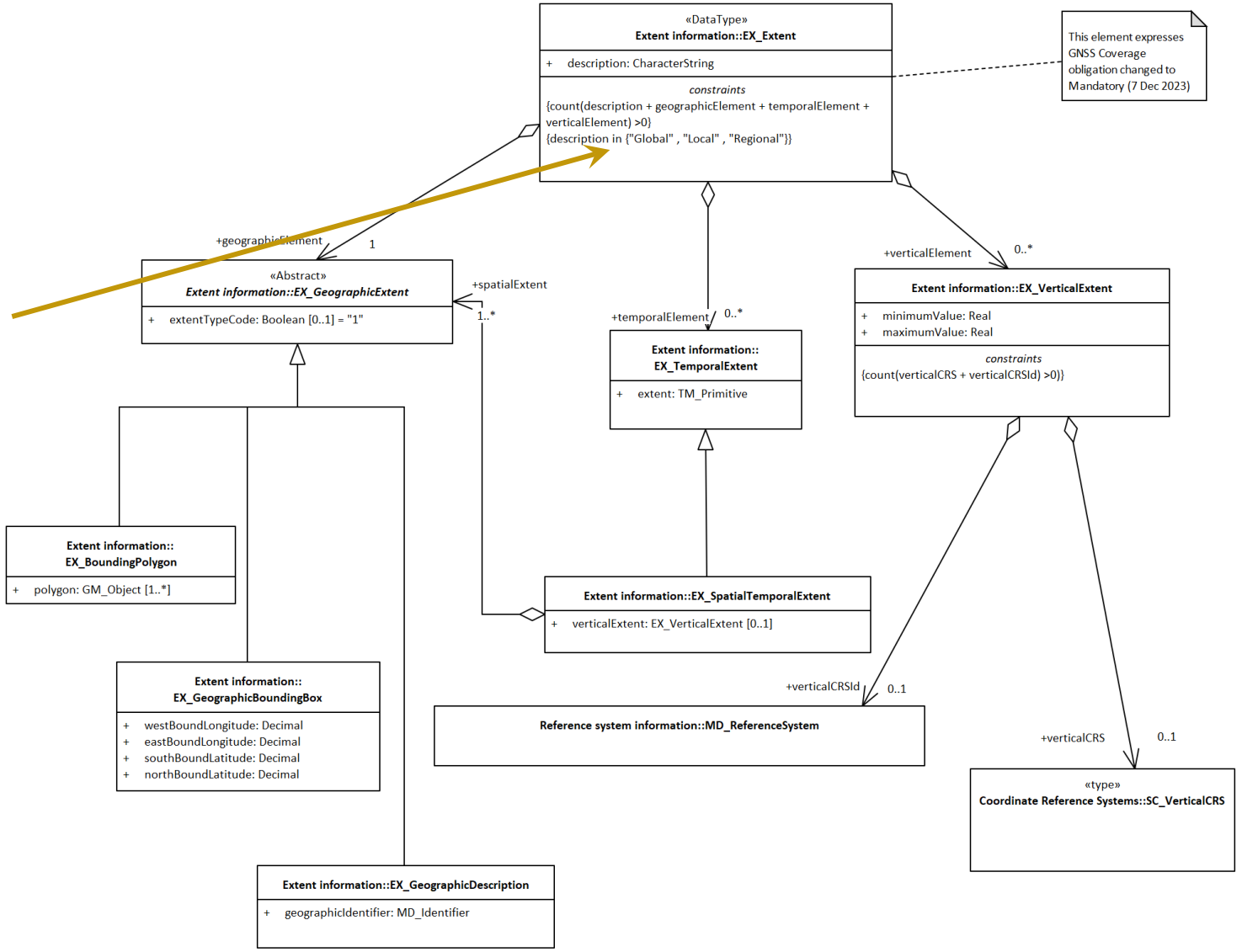


if 'MD_Identification.purpose = 'siteLog' then 'geodesyMLv05.siteLog' shall be mandatory

GNSS Extent adapted to community

Extent Information:

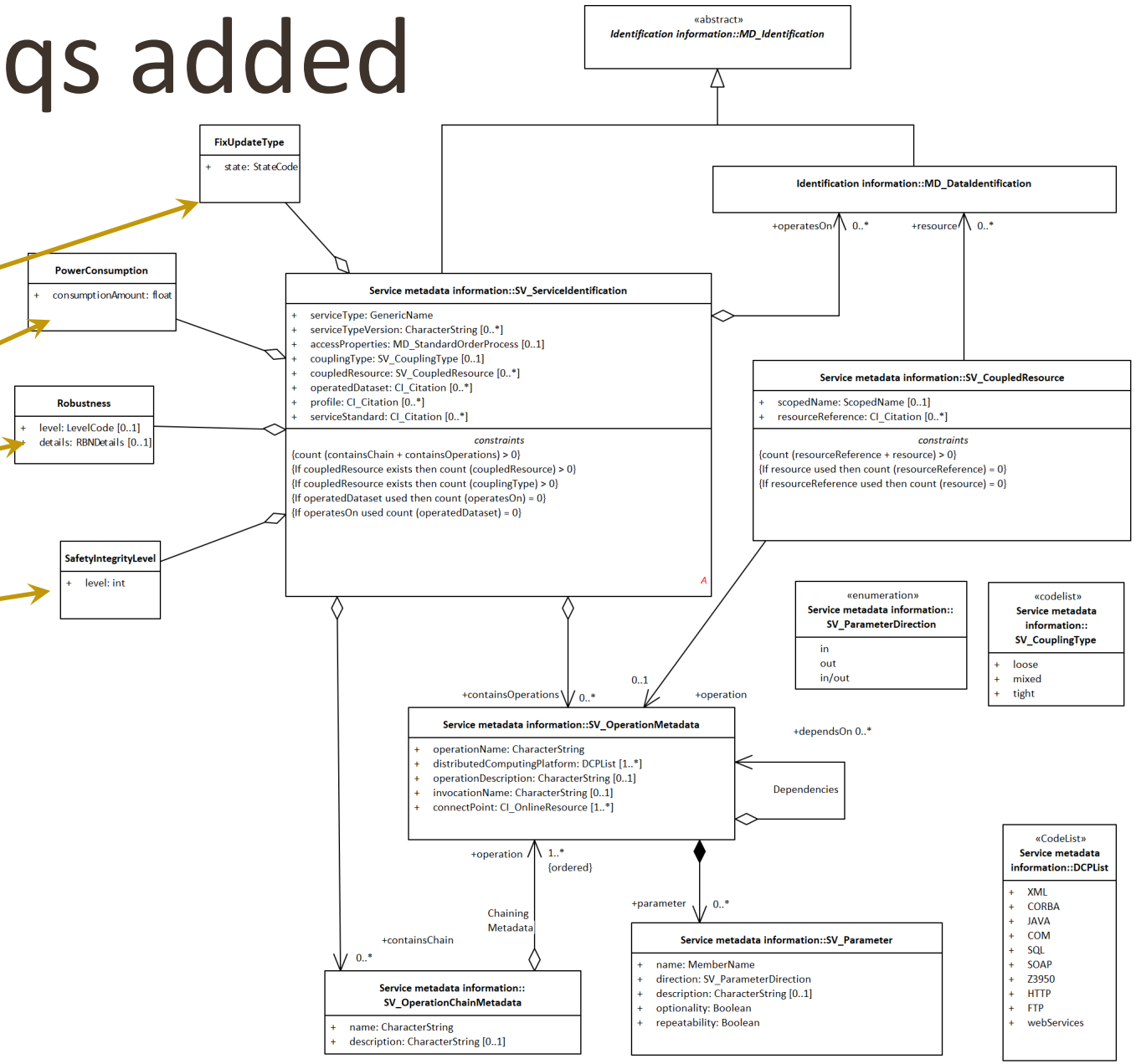
- Extended to comply with GNSS community semantics



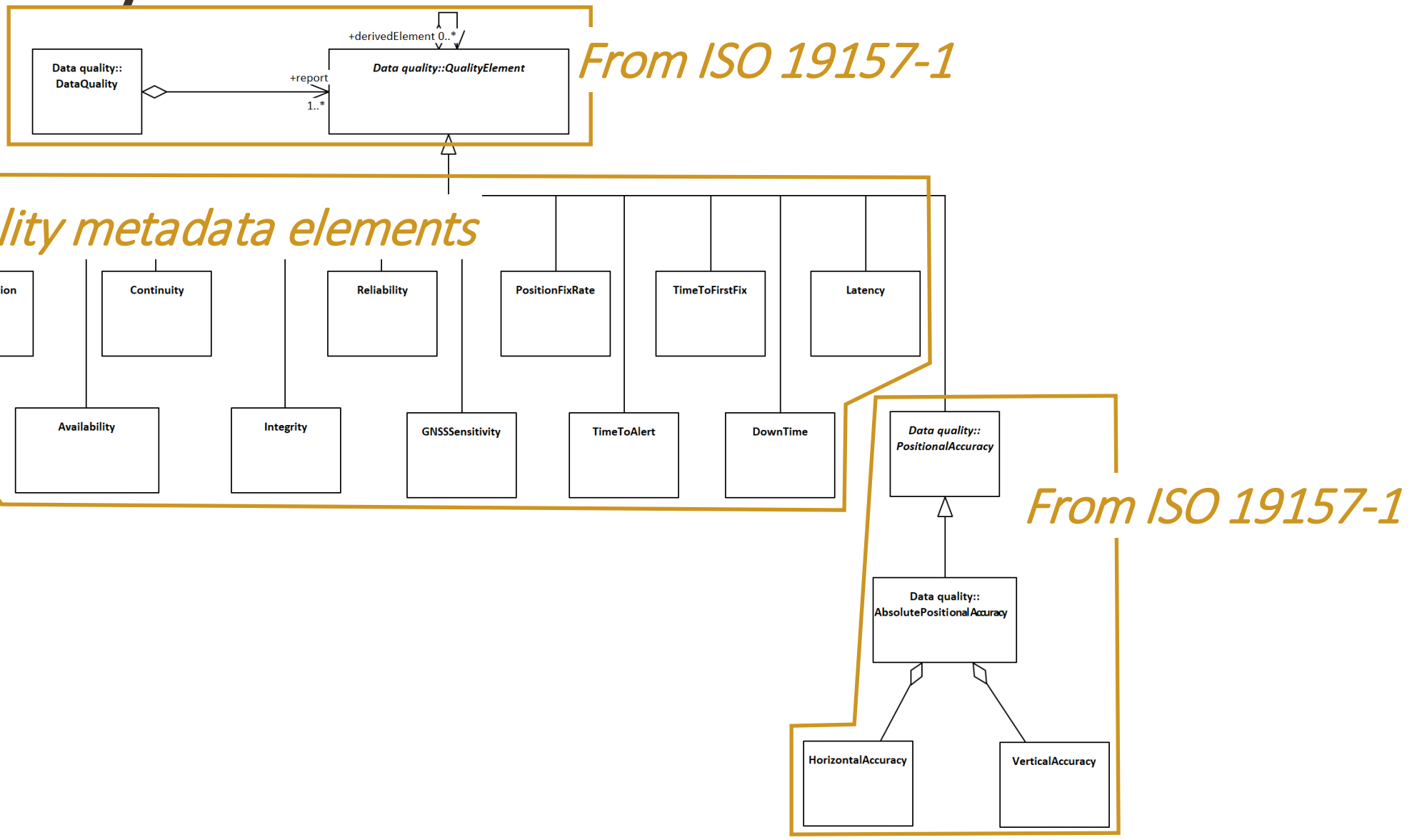
GNSS user-sector reqs added

Service metadata:

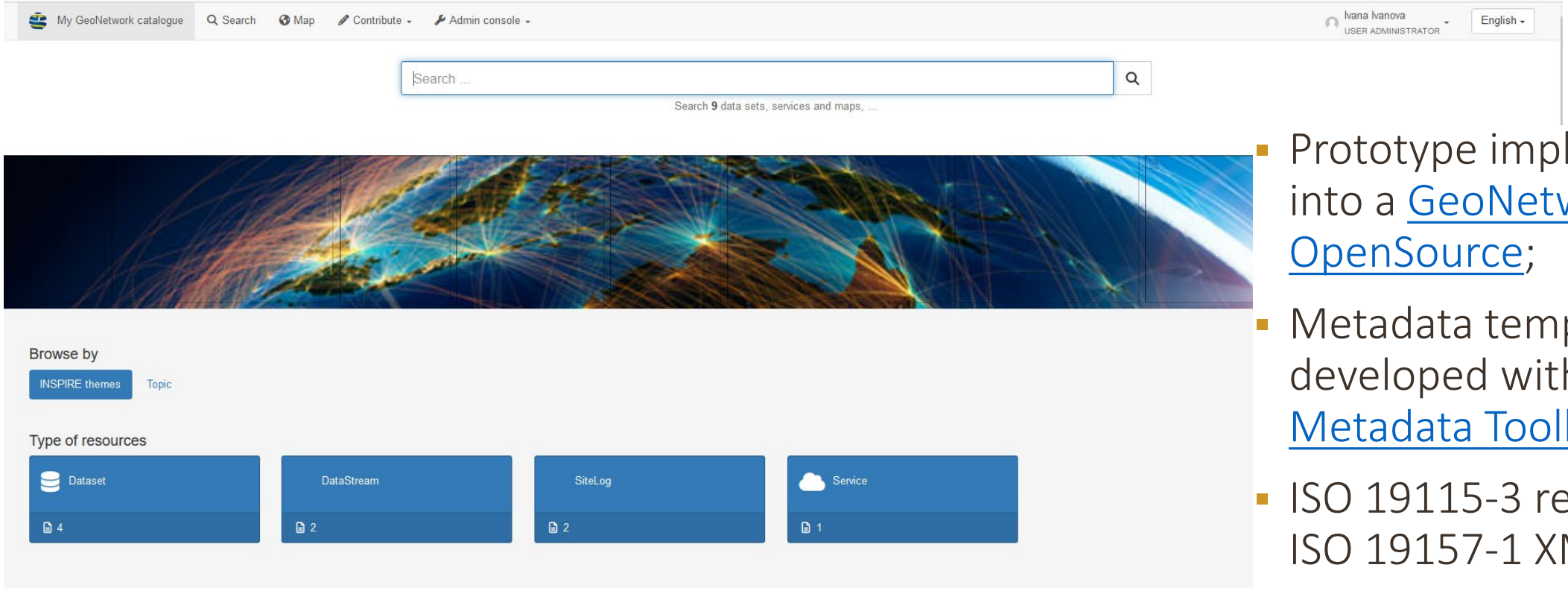
- Extended to add:
  - FixUpdateType
  - Power Consumption
  - Robustness
  - Safety Integrity Level



GNSS quality metadata added

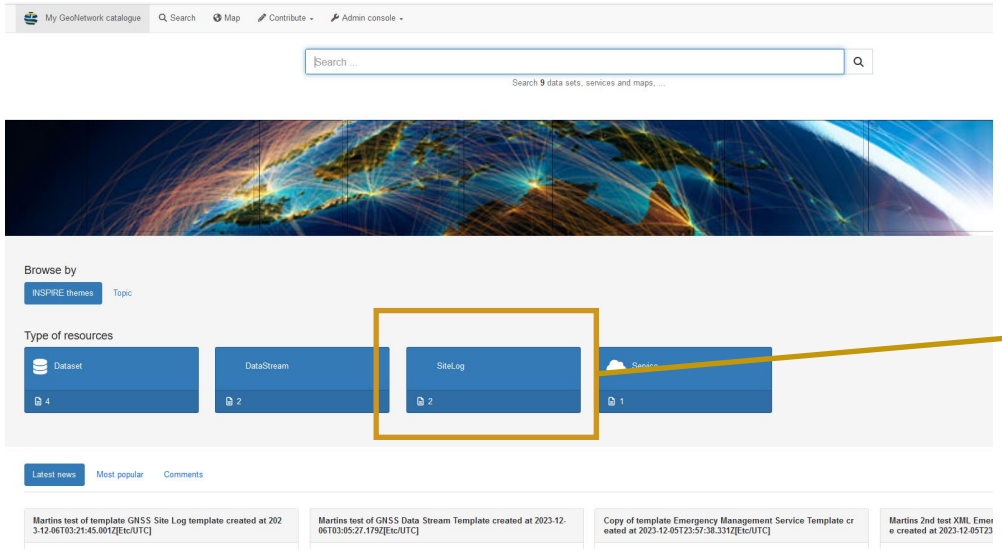


GNSS Metadata Profile – implementation @Geoscience Australia



- Prototype implementation into a GeoNetwork OpenSource;
- Metadata template developed with ANZLIC Metadata Toolkit
- ISO 19115-3 revised with ISO 19157-1 XML

GNSS Metadata Profile – implementation @




```
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  −<mcc:MD_Identifier>
   −<mcc:code>
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  </mcc:MD_Identifier>
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+<mdb:defaultLocale></mdb:defaultLocale>
−<mdb:metadataScope>
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   −<mdb:resourceScope>
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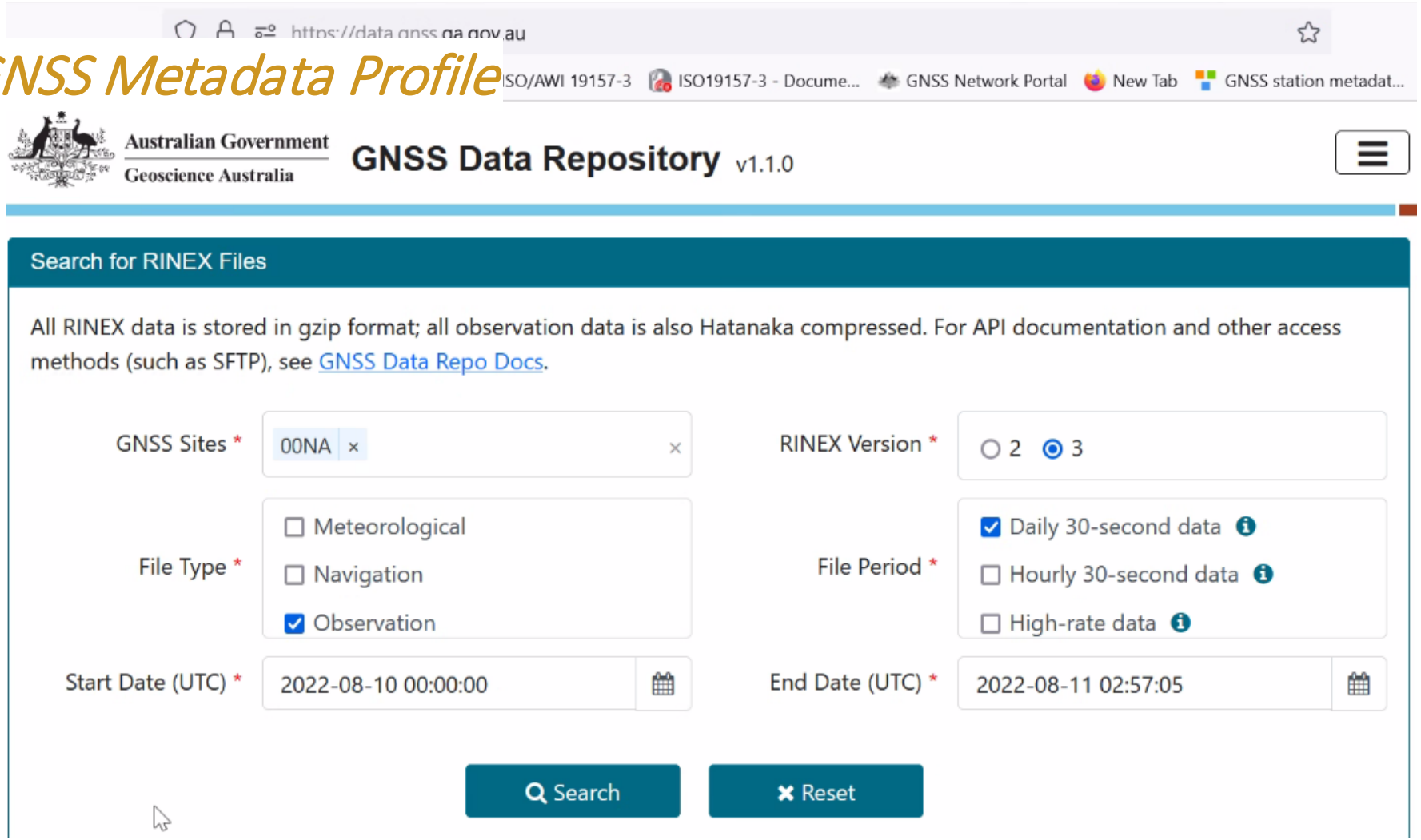
GNSS Metadata Profile in action @Positioning Australia

Without GNSS Metadata Profile



Australian Government
Geoscience Australia | Positioning Australia **GNSS Data Repository** v1.3.0

Search for RINEX Files

All RINEX data is stored in gzip format; all observation data is also Hatanaka compressed. For API documentation and other access Repo Docs.

With GNSS Metadata Profile

GNSS Sites * ALBY ×

RINEX Version * ○ 2 ◉ 3

File Type * ☐ Meteorological ☐ Navigation ☑ Observation

File Period * ☑ Daily 30-second data ☐ Hourly 30-second data ☐ High-rate data

Start Date (UTC) * 2023-12-04 00:00:00

End Date (UTC) * 2023-12-08 01:22:45

Sector: Agriculture

Application: Farm Machinery Guidance

Accuracy (Min): 10

Accuracy (Max): 30

Availability: Medium

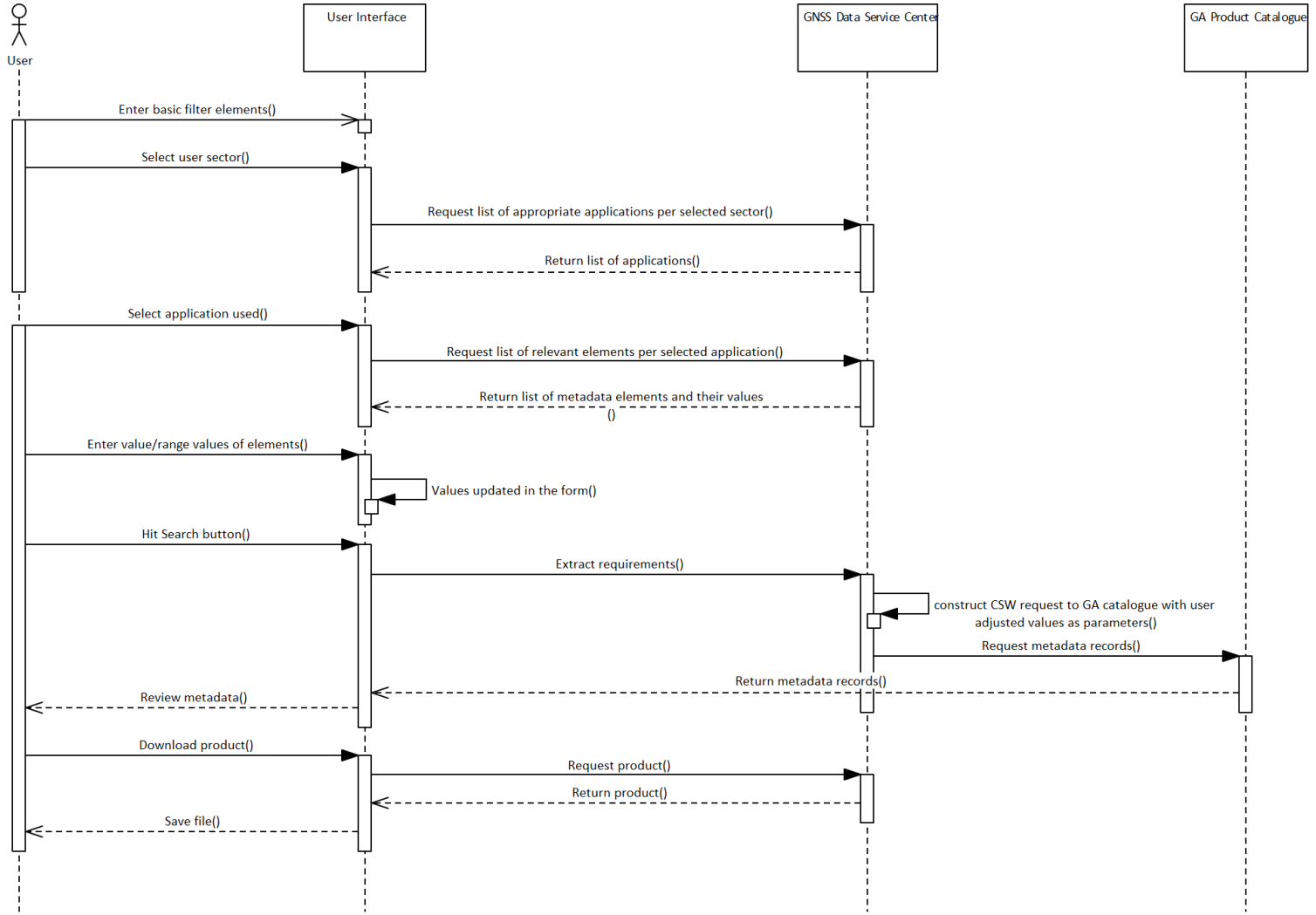
Integrity & Reliability: High

Robustness: High

Authentication: High

Search | Reset

GNSS Metadata Profile in action @Positioning Australia



Next steps

- Continue testing the current version – enhancement expected
- Mapping to other schemas – e.g. DataCite (e.g. used by UNAVCO, GGOS), (Geo)DCAT (e.g. used by INSPIRE, ROB)

- Related activity:
  - Recommendations to improve GeodesyML
  - Explored IoT protocols including MQTT for GNSS data delivery to mass market

THANK YOU!

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