

# an expanding catalogue of permanently tracking GNSS stations in Europe

## Introduction

The "Metadata Management and Distribution System for Multiple GNSS Networks" (M<sup>3</sup>G) has been developed to gather and distribute information about permanently tracking GNSS stations and apply the most recent standards. Originally created to serve the GNSS component of the European Plate Observing System (EPOS), M<sup>3</sup>G is now also used within the EUREF Permanent GNSS Network (EPN) and by local/national GNSS networks. In the past years, M<sup>3</sup>G has been adapted to comply with EU GDPR regulations, respond to the need for FAIR data, and lay the basis for applying Linked Data Principles.

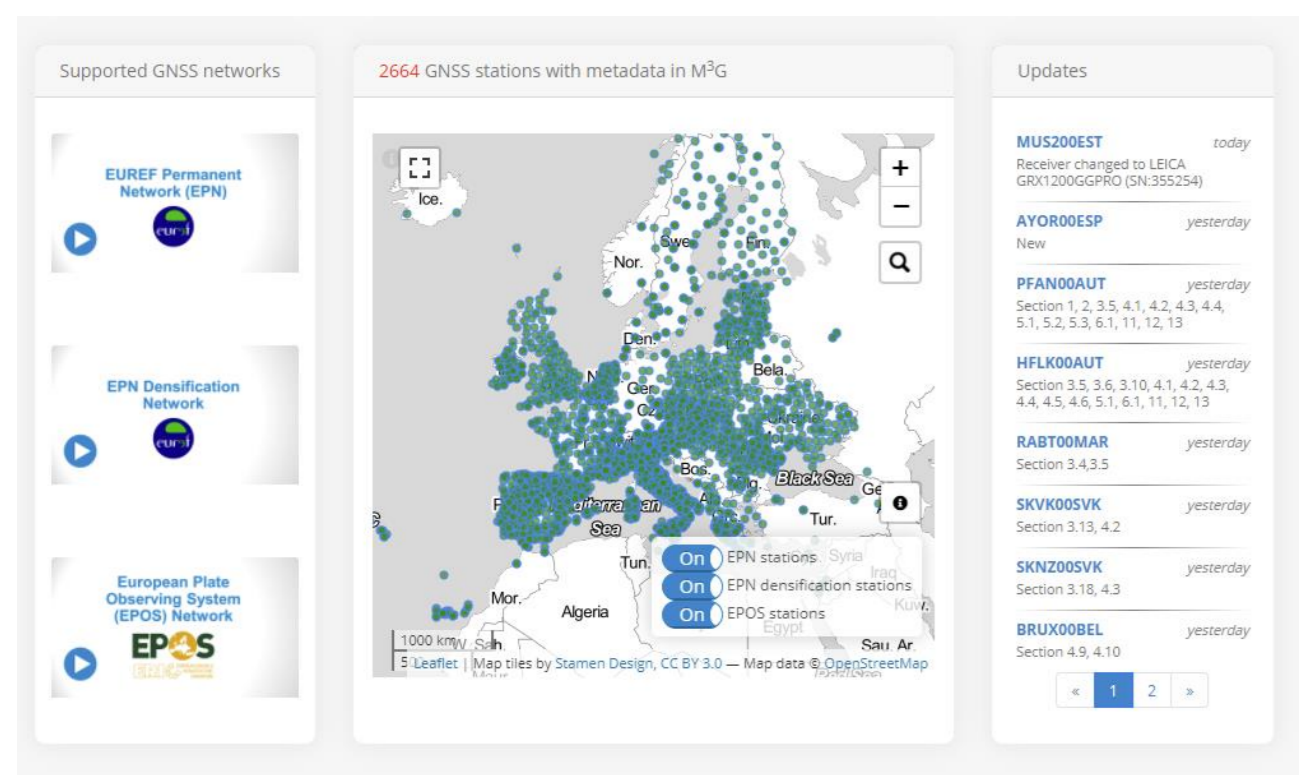


Figure 1 - M<sup>3</sup>G Web portal welcome page (<https://gnss-metadata.eu>)

## GNSS stations in M<sup>3</sup>G

In 2017, the Royal Observatory of Belgium (ROB) started to develop the M<sup>3</sup>G. The system was created to collect GNSS station metadata such as IGS site log, GeodesyML, network information with DOI (Digital Object Identifier), station pictures and GNSS data license information. M<sup>3</sup>G V1.0 was released in 2018 and since then, M<sup>3</sup>G has been used operationally in both the EPN and EPOS. Since its first release, M<sup>3</sup>G has been under continuous development in order to respond to additional requirements imposed by EPOS, the EU GDPR regulation, and the need to evolve towards FAIR and Linked Open Data.

Agencies (called Operational Centers in M<sup>3</sup>G) have an agency-specific login which can be used to upload/edit GNSS metadata. M<sup>3</sup>G validates the provided information using three sets of validation rules: i) general rules (minimal requirements), ii) network-dependent rules (specific rules for international GNSS networks), and iii) station-dependent rules (exceptions to the previous rules) [see Figure 2].

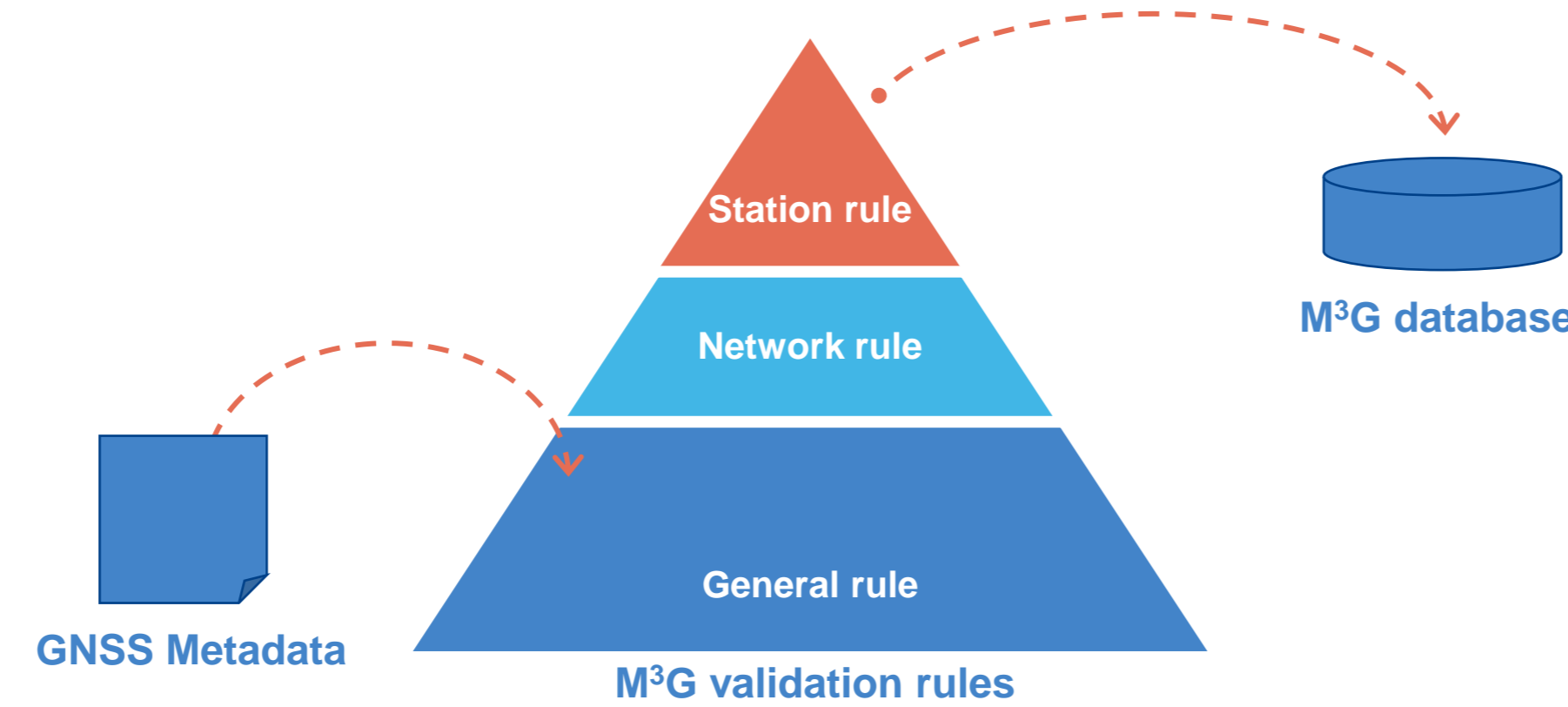


Figure 2 - M<sup>3</sup>G station metadata validation

Once M<sup>3</sup>G has validated the information, the Operational Center will be able to submit it so that it is included in the M<sup>3</sup>G database. This database was set up to be GeodesyML-compliant and enable export of GNSS station information in both the GeodesyML and classic IGS site log format on the M<sup>3</sup>G FTP server.

The use of M<sup>3</sup>G has increased significantly since its first version [see Table 1]. Currently more than 130 Operational Centers all over Europe use M<sup>3</sup>G to maintain their GNSS station metadata. To date, the system includes the metadata of 2664 GNSS stations.

Stations in M <sup>3</sup> G			
Year	Number of stations	Comment	M <sup>3</sup> G Version
2017	56	Developing and Testing phase	V1.0
2018	2026	Required to use for EPOS and EPN	V1.1
2019	2228		V3.0
2020	2585	Publicly open service for the GNSS community	V4.1
2021	2664		

Table 1 - Number of stations in M<sup>3</sup>G

The GNSS station metadata is openly available and M<sup>3</sup>G provides a wide range of services to download it:

- Metadata Catalog (<https://gnss-metadata.eu/site/metadata>)
- FTP (<ftp://gnss-metadata.eu>)
- REST API (<https://gnss-metadata.eu/site/api-docs>)

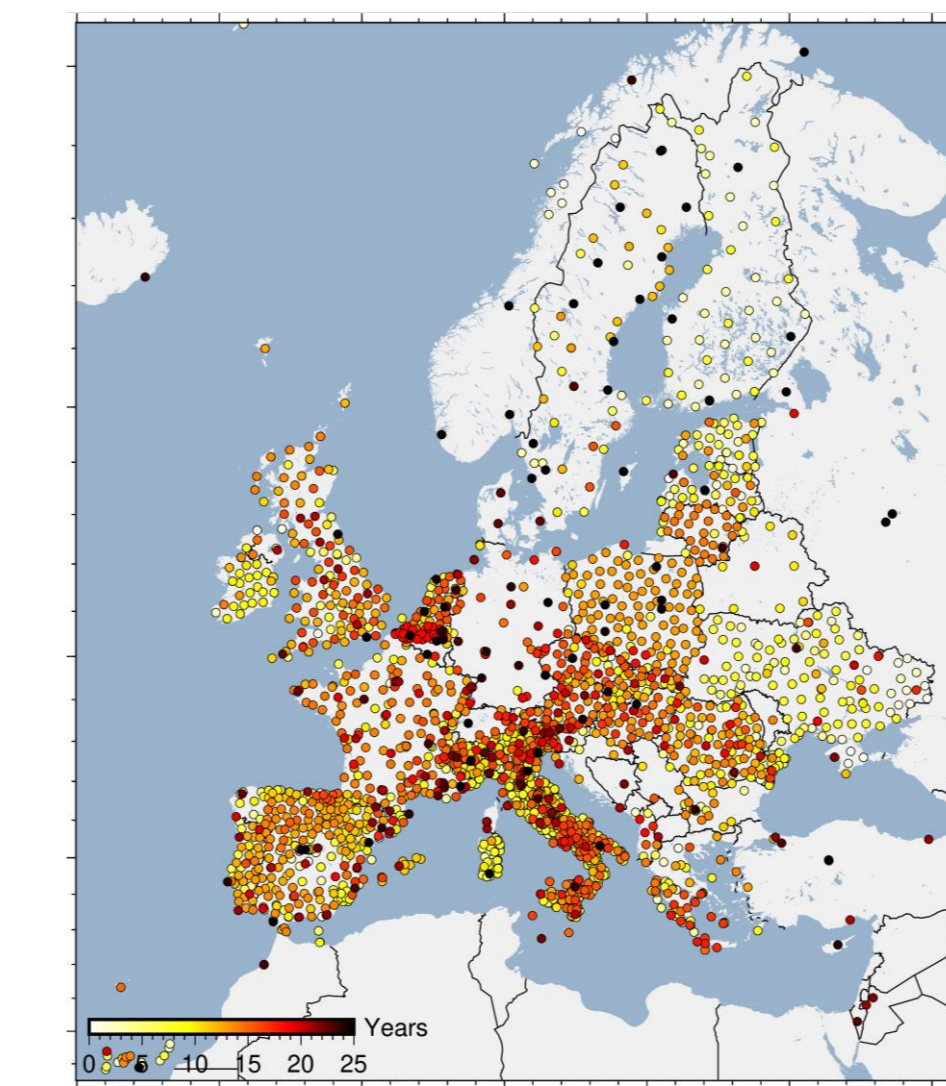


Figure 3 - 20 years of GNSS station history in M<sup>3</sup>G (2021)

## Towards an interoperable service

M<sup>3</sup>G is primarily designed to serve international GNSS networks. For stations belonging to the EPN or EPN densification network, M<sup>3</sup>G automatically sends the updated site log to the EPN Central Bureau. For stations belonging to the EPOS network, M<sup>3</sup>G sends the GeodesyML file to the EPOS-GNSS Data Gateway.

In 2020, ROB published and [documented](#) a new REST (Representational state transfer) API to POST, PUT and GET GNSS metadata.

The new service enables the users to:

- request network, data license and other metadata information, e.g. list all the stations from EPOS.
- find and filter GNSS metadata. The filters are flexible, customizable and allow the use of operators (=,<,!,=,>), e.g. list the stations from CZEPOS network whose metadata were updated after 10/03/2021.
- pass information to M<sup>3</sup>G using command-line instructions. For this purpose, each agency operating GNSS stations has a specific token permitting it to make changes to its metadata in M<sup>3</sup>G, e.g. upload a site log from local disk for a specific station.

```
> curl -X GET "https://gnss-metadata.eu/v1/network/view?id=EPOS" -H "accept: application/json"
> curl -X GET "https://gnss-metadata.eu/v1/sitelog?page=1&network=CZEPOS&filter[dateUpdate][gt]=2021-03-10T00:00Z" -H "accept: application/json"
> curl -X PUT "https://gnss-metadata.eu/v1/sitelog/upload-sitelog?id=AIT00FRA" -H "accept: application/json" -H "Authorization: Bearer <agency token>" -H "Content-Type: text/plain; charset=utf-8" --data-binary "@ait_20210415.log"
```

## Future concept

ROB is aiming to turn GNSS metadata into FAIR (Findable, Accessible, Interoperable and Reusable) Data Object. Checking the current status of M<sup>3</sup>G based on the FAIRsFAIR metrics [Figure 4]. There are several requirements that need to be implemented:

- PID (Persistent identification of the GNSS metadata) for the resources.
- Metadata description schema to ensure the interoperability of metadata.
- License of use information for GeodesyML and site log files.

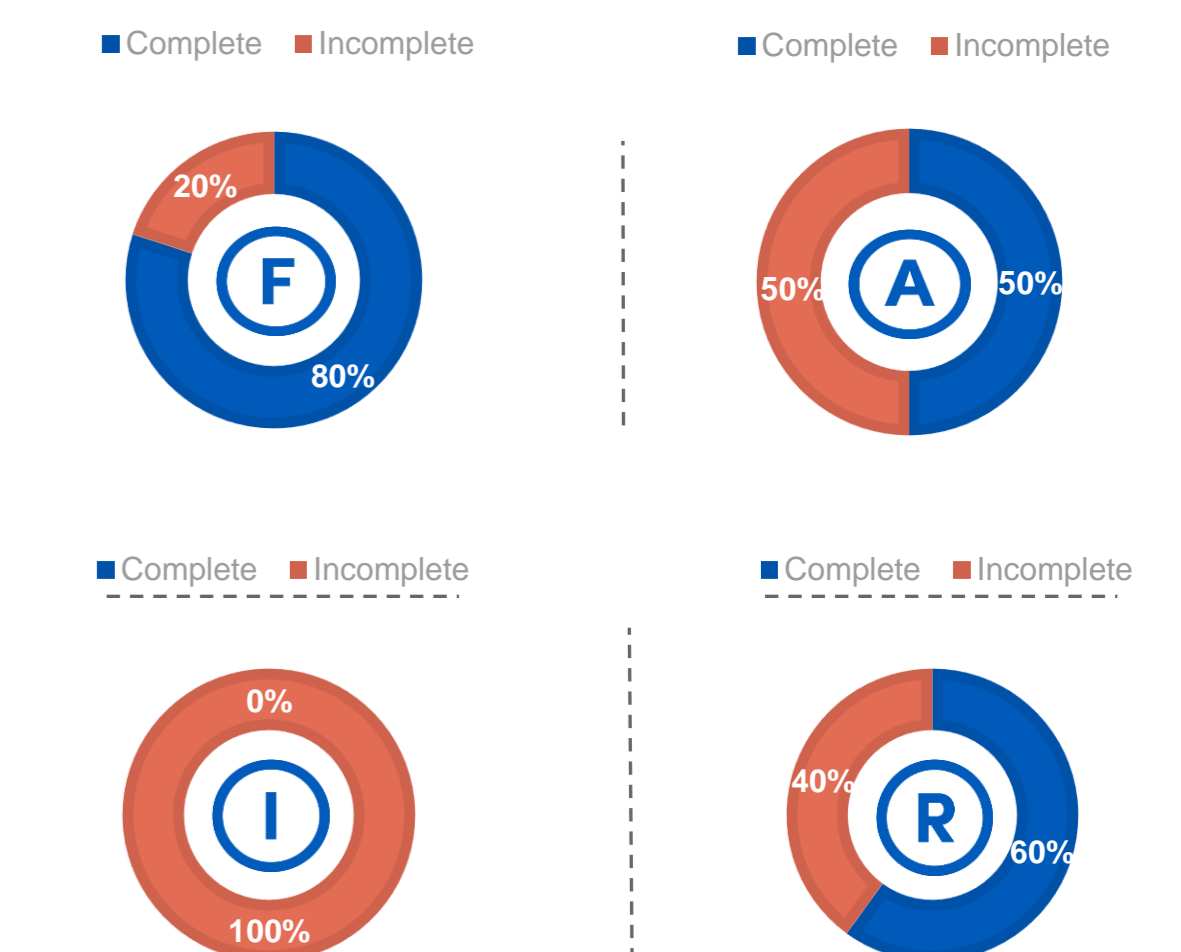


Figure 4 - Findability, Accessibility, Interoperability, and Reuse metrics score in M<sup>3</sup>G according to the FAIRsFAIR Data Object Assessment Metrics (<https://github.com/FAIRsFAIR/DataObjectMetrics>)

## References

1. Bruyninx, C., Fabian, A., Miglio, A., Legrand, J., "How to Integrate a GNSS Station in EPOS", EPOS-GNSS Webinar, 18-19 January 2021 DOI:10.24414/ROB-EPOS-GNSS.PR.01.2021
2. Bruyninx, C., Legrand, J., Fabian, A. and Pottiaux, E. "GNSS metadata and data validation in the EUREF Permanent Network", GPS Solutions. 23 (2019) DOI:10.1007/s10291-019-0880-9
3. Wilkinson, M.D., Dumontier, M., Aalbersberg, I.J.J., et al. 2016. The FAIR Guiding Principles for scientific data management and stewardship. Scientific Data, 3: 160018. DOI: <https://doi.org/10.1038/sdata.2016.18>

