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Seafloor Geodesy Data Standardization Task Force **within the Inter-Commission Committee on** **Marine Geodesy (ICCM)**

report for the International Association of Geodesy (IAG)

July 2023, updated in November 2023

Pierre Sakic & David Schmidt on behalf of the Task Force

With the contribution of Valérie Ballu, Jesse Hutchinson, Martin Heesemann, Kaifei He, Motoyuki Kido, Yuto Nakamura, John DeSanto, Keiichi Tadokoro, Surui Xie, Yusuke Yokota, Shun-ichi Watanabe

Since the 19th of October 2022, representatives of the seafloor geodesy community meet on a regular basis within an ad hoc working group called the *Seafloor Geodesy Data Standardization Task Force* (SFGDSTF). This task force has been placed under the umbrella of the IAG's Inter-Commission Committee on Marine Geodesy (ICCM).

Goals

During the kickoff meeting, the goals of the task force were defined as follows:

- Enable the shareability of the seafloor geodesy data collected by the different working groups around the world
- Give better visibility to these data
- Respect the FAIR data principles (Findable, Accessible, Interoperable, Reusable)
- A special emphasis has to be given to the interoperability of seafloor geodetic data, i.e., the possibility to easily use data of one working group with the software of another one for instance.
- Identify how data can be easily stored in existing repositories or establish expectations for new repositories.
- Establish community-supported data standards that can be adopted by the repositories/data centers

More generally, this exercise has provided a venue for international colleagues to share technical details on differing approaches and find common issues of concern.

Considered techniques

The task force initially discussed a range of seafloor geodetic techniques. Given the considerable interest in GNSS-Acoustic by those who participated in the initial discussion, it was agreed to start discussions with this technique. Nevertheless, the task force is interested in a wide range of techniques, and will likely revisit other techniques in the future. Techniques of future interest may include:

- Acoustic ranging
- Ocean bottom pressure sensors (OBP)
- Tiltmeters
- Optical Fiber Strainmeter
- Seafloor gravimetry
- Mast Seafloor <> Surface combining GNSS+attitude measurement
- Multi-beam Bathymetry

It would be highly valuable if other working groups similar to the current one could emerge within the task force to consider the other techniques mentioned above, like the OBP for instance. An initial discussion towards this goal was carried out during the Seafloor Pressure Geodesy workshop held in Rhode Island, April 2023 (conveners: Matt Wei, Randy Watts and William Wilcock, funded by NSF).

Involved research teams/personals

The task force tries to meet virtually on a monthly basis. Usually, it gathers the following representatives from a broad panel of research groups across the globe:

- Valérie Ballu (CNRS/La Rochelle University, France)
- Jesse Hutchinson (Ocean Networks Canada, Canada)
- Martin Heesemann (Ocean Networks Canada, Canada)
- Kaifei He (China University of Petroleum, China)
- Motoyuki Kido (Tohoku University, Japan)
- Yuto Nakamura (Japan Coast Guard, Japan)
- Pierre Sakic (Institut de Physique du Globe de Paris, France), animator
- David Schmidt (University of Washington, USA)
- John DeSanto (University of Washington, USA)
- Keiichi Tadokoro (Nagoya University, Japan)
- Surui Xie (University of Houston, USA)
- Yusuke Yokota (University of Tokyo, Japan)
- Shun-ichi Watanabe (Japan Coast Guard, Japan)

The list above includes those who have regularly attended the discussion. Nevertheless, others have participated for one or two sessions, and participation remains open to anyone..

An original invitation to join the task force was sent through the seafloor-geodesy-community@earthscope.org listserv (facilitated by Earthscope/ex-UNAVCO). Since then, The seafloor geodesy community is informed

about the task force's progress through a dedicated mailing list:
seafloor-geodesy-data-standardization@groupe.renater.fr

it is possible to register for the mailing list via the following link:
<https://groupe.renater.fr/sympa/subscribe/seafloor-geodesy-data-standardization>

As of July 2023, the mailing list has 32 subscribers.

A public workspace has been set up for collaborative work; the link is available upon request.

Summary of work and exchanges

As mentioned above, it was decided to focus first on the GNSS/A acoustics data. Since it regroups different observables of different natures, the reflections can be a basis for the other technique's data standardization.

The members of the working group initially completed standardized description sheets of their own data formats. The description sheets are available in the shared workspace.

The task force members also introduced and detailed their data format during a dedicated session. There are many similarities between the 5 formats presented. And all user group utilize ASCII data tables as their primary file type.

The main technical points which have been discussed

Should we continue with such an ASCII/CSV style for GNSS-A data?

⇒ **Yes**

This decision has been justified by the fact that it is a data representation style that is more or less "universal" since all the members of the Task Force are use to it. To quote David Schmidt "such representation format must remain community-driven".

*The necessity to explicitly include both the send and receive ping epochs?
If not, which one is the best?*

⇒ **We include both**

What data level (raw versus initially processed) is appropriate for broad dissemination of GNSS-A data, and ingestion by processing codes?

⇒ **Level 1:** raw observation i.e. RINEXs, lever arms, waveforms...

⇒ **Level 2:** a "master/main" file with preprocessed data

Question of the time scale/representation of the recorded epochs?

⇒ **UTC scale**, a reference epoch in the header, and the seconds w.r.t. the reference for each event

Question of the Surface platform position representation? Which coordinates representation?

⇒ **ECEF representation**. A sufficient level of detail must be provided regarding the reference frame in the metadata/header

Definition of a level 2 file prototype

The task force has used several meetings to identify standardized column headings and flags for a universal GNSS-A Level-2 data file. This file would contain all the preprocessed GNSS/A data (two-way travel time, the position of the surface ship/platform, INS attitude if any...). It is expected that this file format would allow groups to easily share data, and that these data could be ingested into any GNSS-A data processing package.

The Japan Coast Guard format developed for the software GARPOS, has been retained as the basis for the definition of a common exchange file. It takes the form of a CSV file. The preliminary version of this prototype definition is given as an appendix.

Future points of discussions

(prospective and non-exhaustive)

For the next work sessions of the task force, the emphasis should be given to:

- Data to be included as Level 1 data (GNSS record as RINEX, raw waveforms...)
- The definition of the best relevant Data Quality indicators for a GNSS/A acquisition
- The improvement of metadata records.
- In the medium term, the possibility of archiving data in a binary format such as NetCDF.

Appendix

Draft of GNSS-A data format standardization

Pages hereafter

Draft of GNSS-A data format standardization

Version 0.231129 before discussion of the standardization
Taskforce meeting of the 29th November 2023

Definitions of column in GNSS-A standard CSV format

Table 1. Definitions of column in GNSS-A standard CSV format

Index	Necessity	Description
MT_ID	Essential	ID of mirror transponder
TravelTime	Essential	Observed travel time (net value) [sec.]
T_transmit	Essential	Transmission time of acoustic signal [sec. from origin]
X_transmit	Essential	Transducer position at T_transmit <i>in ECEF</i> [m]
Y_transmit	Essential	Transducer position at T_transmit <i>in ECEF</i> [m]
Z_transmit	Essential	Transducer position at T_transmit <i>in ECEF</i> [m]
T_receive	Essential	Reception time of acoustic signal [sec. from origin]
X_receive	Essential	Transducer position at T_receive <i>in ECEF</i> [m]
Y_receive	Essential	Transducer position at T_receive <i>in ECEF</i> [m]
Z_receive	Essential	Transducer position at T_receive <i>in ECEF</i> [m]
ant_X0	Optional	GNSS position at T_transmit <i>in ECEF</i> [m]
ant_Y0	Optional	GNSS position at T_transmit <i>in ECEF</i> [m]
ant_Z0	Optional	GNSS position at T_transmit <i>in ECEF</i> [m]
roll0	Optional	Roll at T_transmit (in degree) *rotation around "forward" axis in ATD offset
pitch0	Optional	Pitch at T_transmit (in degree) *rotation around "rightward" axis in ATD offset
heading0	Optional	Heading at T_transmit (in degree from north) *rotation around "downward" axis in ATD offset
ant_X1	Optional	GNSS position at T_receive <i>in ECEF</i> [m]
ant_Y1	Optional	GNSS position at T_receive <i>in ECEF</i> [m]
ant_Z1	Optional	GNSS position at T_receive <i>in ECEF</i> [m]
roll1	Optional	Roll at T_receive (in degree)
pitch1	Optional	Pitch at T_receive (in degree)
heading1	Optional	Heading at T_receive (in degree from north)
[other]	Optional	Any other optional indices * should be defined in the header or other documents

Definitions of site information file in GNSS-A standard format

Separate the field with “=” such as: “[variable name] = [value]”

- List of value should be separated with space.
- Other format such as YAML would also be acceptable but should clearly be determined in the WG.

Contains the following essential information:

Variable	Format	Description
Site_name	character	GNSS-A site name or code
Campaign	character	Observation campaign name
TimeOrigin	YYYY-MM-DD hh:mm:ss.s	Origin of time used in the file [UTC]
RefFrame	character	Reference frame used in the file
MTlist	list of character	List of ID of mirror transponders
[*]_appPos	list of float	Approximate positions of transponder in ECEF [m] [*] should be replaced with MT's ID.
ATDoffset (optional)	list of float	ATD offset (or local-tie/ lever-arm) defined as the vector of GNSS to transducer with [forward, rightward, downward] in [m]
[other] (optional)	N/A	Any other optional values * should be clearly defined in comments or other documents
Comments (optional)	character	Any other optional comments

<Example of Site Information file (*in ini file format but it should be discussed)>

```
Site_name = CHOS
Campaign = 1204.meiyo_m4
TimeOrigin = 2012-04-19 00:00:00.000
RefFrame = ITRF2008
MTlist = M01 M02 M03 M04
M01_appPos = xxxxxxx.xxx yyyyyyyy.yyy zzzzzzz.zzz
M02_appPos = xxxxxxx.xxx yyyyyyyy.yyy zzzzzzz.zzz
M03_appPos = xxxxxxx.xxx yyyyyyyy.yyy zzzzzzz.zzz
M04_appPos = xxxxxxx.xxx yyyyyyyy.yyy zzzzzzz.zzz
```

Draft of GNSS-A data format standardization

Version 0.230629 after discussion of the standardization
Taskforce meeting of the 27th June 2023

Definitions of column in GNSS-A standard CSV format

Table 1. Definitions of column in GNSS-A standard CSV format

Index	Necessity	Description
MT_ID	Essential	ID of mirror transponder
TDC_ID	Optional	ID of the reception transducer
TravelTime	Essential	Observed travel time (net value) [sec.]
aSNR	Optional	Signal/Noise Ratio of the acoustic ping
acc	Optional	acoustic_Cross_Correlation of the acoustic ping
dbV	Optional	acoustic Decibel Volt voltage of the acoustic ping
quality_flag	Optional	String defining the quality of the record
T_transmit	Essential	Transmission time of acoustic signal [sec. from origin]
X_transmit	Essential	Transducer position at T_transmit <i>in ECEF</i> [m]
Y_transmit	Essential	Transducer position at T_transmit <i>in ECEF</i> [m]
Z_transmit	Essential	Transducer position at T_transmit <i>in ECEF</i> [m]
trans_sigX0	Optional	Transducer position std at transmit
trans_sigY0	Optional	Transducer position std at transmit
trans_sigZ0	Optional	Transducer position std at transmit
T_receive	Essential	Reception time of acoustic signal [sec. from origin]
X_receive	Essential	Transducer position at T_receive <i>in ECEF</i> [m]
Y_receive	Essential	Transducer position at T_receive <i>in ECEF</i> [m]
Z_receive	Essential	Transducer position at T_receive <i>in ECEF</i> [m]
trans_sigX1	Optional	Transducer position std at receive
trans_sigY1	Optional	Transducer position std at receive
trans_sigZ1	Optional	Transducer position std at receive
ant_X0	Optional	GNSS position at T_transmit <i>in ECEF</i> [m]
ant_Y0	Optional	GNSS position at T_transmit <i>in ECEF</i> [m]
ant_Z0	Optional	GNSS position at T_transmit <i>in ECEF</i> [m]
ant_sigX0	Optional	GNSS antenna std at transmit
ant_sigY0	Optional	GNSS antenna std at transmit
ant_sigZ0	Optional	GNSS antenna std at transmit
ant_cov_XY0	Covariance matrix
heading0	Optional	Heading at T_transmit (in degree from north)
pitch0	Optional	Pitch at T_transmit (in degree)
roll0	Optional	Roll at T_transmit (in degree)
ant_X1	Optional	GNSS position at T_receive <i>in ECEF</i> [m]
ant_Y1	Optional	GNSS position at T_receive <i>in ECEF</i> [m]
ant_Z1	Optional	GNSS position at T_receive <i>in ECEF</i> [m]
ant_sigX1	Optional	GNSS antenna std at transmit
ant_sigY1	Optional	GNSS antenna std at transmit
ant_sigZ1	Optional	GNSS antenna std at transmit
roll1	Optional	Roll at T_receive (in degree)
[other]	Optional	Any other optional indices * should be defined in the header or other documents
doa_R	Optional	direction of arrival vector wrt Roll vector direction
doa_P	Optional	direction of arrival vector wrt Pitch vector direction
doa_H	Optional	direction of arrival vector wrt Heading vector direction

*ECEF or local ENU or Lat-Lon-Height should be discussed in the WG.

Definitions of header in GNSS-A standard CSV format

- Line should start with “#”
- Separate the field with “=” such as: “[variable name] = [value]”
 - List of value should be separated with space.
- Contains the following essential information:

Variable	Format	Description
Site_name	character	GNSS-A site name or code
Campaign	character	Observation campaign name
UTCdate	YYYY-MM-DD	Origin of time used in the file
RefFrame	character	Reference frame used in the file and reference epoch of the reference frame. e.g. ITRF20XX@YYYY.YY
MTlist	list of character	List of ID of mirror transponders
[*]_appPos	list of float	Approximate positions of transponder <i>in ECEF</i> [m] [*] should be replaced with MT's ID.
ATDoffset (optional)	list of float	ATD offset (or local-tie/ lever-arm) defined as the vector of GNSS to transducer with [forward, rightward, downward] in [m]
[other] (optional)	N/A	Any other optional values * should be clearly defined in comments or other documents
Comments (optional)	character	Any other optional comments
<MT TDC>_ [*]_Delay	float	Turn-Around-Time implemented in transponder or transducer [*] should be replaced with MT's ID or TDC's ID.

Example of header

```
# Site_name = CHOS
# Campaign = 1204.meiyo_m4
# UTCdate = 2012-04-19
# RefFrame = ITRF2008
# MTlist = M01 M02 M03 M04
# M01_appPos = -36.5030 698.5700 -1509.5790
# M02_appPos = 750.0060 -9.6570 -1548.1650
# M03_appPos = 9.6750 -781.3210 -1556.1690
# M04_appPos = -768.0610 -32.3080 -1519.3960
```

