DATA PRODUCT SPECIFICATION FOR BROADBAND GROUND ACCELERATION

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This document has been reviewed and approved for release to Configuration Management.

OOI Senior Systems Engineer: ______________________________

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This document has been reviewed and meets the needs of the OOI Cyberinfrastructure for the purpose of coding and implementation.

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1 Abstract

This document describes the computation used to calculate the OOI Level 1 Broadband Ground Acceleration (GRNDACC) core data product, which is the time-series seismic signal sensed from the strong motion accelerometer onboard the broadband seismometer (OBSBB and OBSBK) instruments. This document is intended to be used by OOI programmers to construct appropriate processes to create the L1 GRNDACC core data product.

2 Introduction

2.1 Author Contact Information

Please contact the Data Product Specification lead (DPS@lists.oceanobservatories.org) for more information concerning the computation and other items in this document.

2.2 Metadata Information

2.2.1 Data Product Name

The OOI Core Data Product Names for these products are

- GRNDACC

The OOI Core Data Product Descriptive Names for these products are

- Broadband Ground Acceleration

2.2.2 Data Product Abstract (for Metadata)

The OOI Level 1 Broadband Ground Acceleration core data product, GRNDACC, is the time-series seismic signal sensed by a strong motion accelerometer and digitized by a channel of the seismometer digitization system onboard the broadband (OBSBB and OBSBK) instruments. The seismic signal is obtained in conjunction with the broadband ground velocity (GRNDVEL) and the low frequency acoustic pressure waves (HYDAPLF) data products. The strong motion signal is digitized at the same rate(s), and with the same time-stamp, as the seismic signal and acoustic signals for greater correlation. The transformation of the L0 strong motion signal to L1 will consist of converting digital counts into physical units and correction for the applied gain.

2.2.3 Computation Name

N/A

2.2.4 Computation Abstract (for Metadata)

The OOI Level 1 Broadband Ground Acceleration core data product is computed by decoding binary format data, sensed and digitized by the seismometer digitization system onboard the broadband seismometer instruments After the data is parsed and decoded, a linear calibration factor (Gain), will be applied to transform the L0 digital counts into the L1 core data product GRNDACC.

2.2.5 Instrument-Specific Metadata

- See Section 4.4 for instrument-specific metadata fields that must be part of the output data.

2.2.6 Data Product Synonyms

Synonyms for this data product are

- Ground Acceleration Seismic Time Series

2.2.7 Similar Data Products

Broadband Ground Velocity (GRNDVEL)
Short Period Ground Velocity (SGRDVEL)

Additional information regarding the similar products can be found in OOI Data Product Specifications for GRNDVEL (DCN 1341-00090) and SGRDVEL (DCN 1341-00110).

2.3 Instruments

For information on the instruments from which the L1 Broadband Ground Acceleration (GRNDACC) core data product inputs are obtained, see the OBSBB (DCN 1342-00090) and OBSBK (DCN 1342-00100) Processing Flow documents. These documents contain information on the instrument class and make/models; they also describe the flow of data from these instruments through all of the relevant QC, calibration, and data product computations and procedures.

OBSBB and OBSBK instruments are deployed at multiple locations on the RSN system. Please see the Instrument Application in the SAF for specifics of instrument locations and platforms.

2.4 Literature and Reference Documents

The electronic files of the reference documents are stored on Alfresco under REFERENCE>Data Product Specification Artifacts (1341-00100_GRNDACC).

http://www.fdsn.org/seed_manual/SEEDManual_V2.4.pdf	SEED format manual.
http://www.seiscomp3.org/wiki/doc/applications/seedlink	Seedlink Manual
slink2orb.1.pdf	slink2orb man page
orbserver.5.pdf	orbserver interface man page
dbbuild.5.pdf	Antelope dbbuild parameter file description
packets.5.pdf	Antelope packet description
dm24_mk3.pf.pdf	Datalogger configuration description
css30.pdf	css3.0 schema description
tar_data	tar file of test data

http://www.guralp.com/fir-filter-configuration-of-the-cmg-dm24-mk3/ Guralp fir filters (This file is not stored in Alfresco. Please consult the website directly.)

Of Poles and Zeros: Fundamentals of Digital Seismology (Modern Approaches in Geophysics) by F. Scherbaum. Publisher: Springer; 2nd edition (January 19, 2007). Language: English. ISBN-10: 0792368355 ISBN-13: 978-0792368359

2.5 Terminology

2.5.1 Definitions

Definitions of general OOI terminology are contained in the Level 2 Reference Module in the OOI requirements database (DOORS). The following terms are defined here for use throughout this document.

Transfer Function - A transfer function is a mathematical representation, in terms of temporal frequency, of the relation between the input and output of a linear time-invariant system with zero initial conditions and zero-point equilibrium.

Poles and Zeros – solutions for Laplace's transform in a linear time-invariant system.

FIR Filter - a finite impulse response (FIR) filter is a filter whose impulse response (or response to any finite length input) is of finite duration, because it settles to zero in finite time.

Sensor Sensitivity – Nominal conversion factor from ground velocity in the middle of the seismometer passband to Volts.

ADC – Analog to Digital Converter, hardware that provides a conversion at a specified rate and bit-depth. For example in this case, the analog signal will be digitized by the Guralp DM24S3EAM at 24-bit resolution at 1000 samples per second.

2.5.2 Acronyms, Abbreviations and Notations

General OOI acronyms, abbreviations and notations are contained in the Level 2 Reference Module in the OOI requirements database (DOORS).

3 Theory

3.1 Description

The sensitivity of an accelerometer, is provided by the manufacturer. The complete transfer function of the seismometer is specified by a set of poles and zeros.

The seismometer output is digitized by an ADC. An example of a seismometer transfer function is shown in Figure 1. Please refer to Scherbaum (2007) if more details are needed.

The ADC converts the analog voltage output from the seismometer into a digital stream at a maximum rate of 1000 Samples per second with a resolution of 24-bits. This digital binary stream will represent the time-series seismic acceleration at the accelerometer. The output of the ADC will be passed through a cascade of FIR filters to achieve the desired sample rate. In the case of the GRNDACC sensor, it will produce data streams at 200 sps, and 1 sps. Please refer to Scherbaum (2007) if more details are needed.

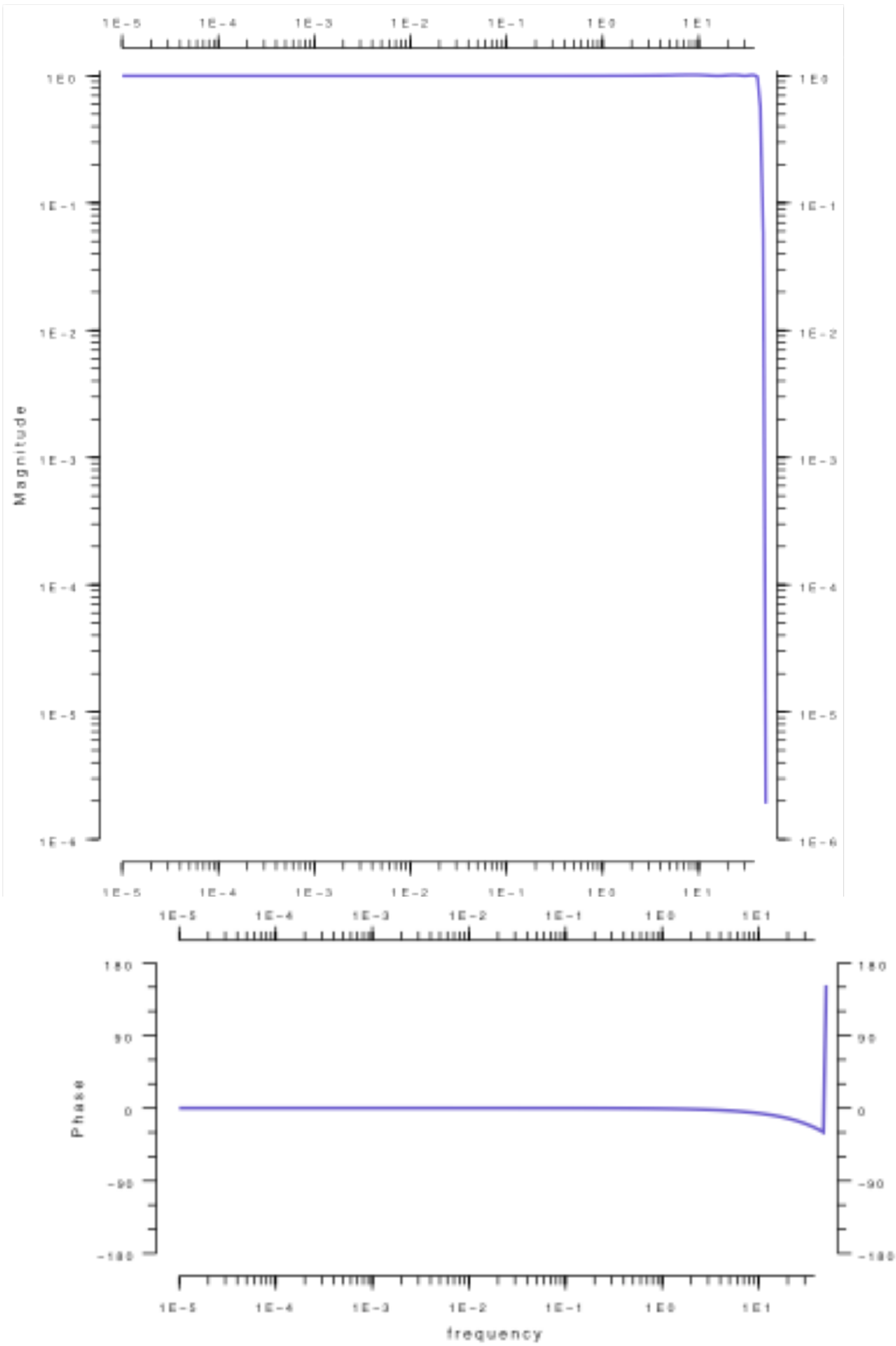

Figure 1. Typical GRNDACC Response Curve

3.2 Mathematical Theory

Please refer to Scherbaum (2007)

3.3 Known Theoretical Limitations

None

3.4 Revision History

No revisions to date.

4 Implementation

4.1 Overview

The output of the OBSBB instruments includes the seismic data and is formatted for transmission via SEEDlink protocol and diverted by the US Navy for inspection using Antelope Orb. After Navy inspection of the data, it is returned, with its time-stamps, to the OOI ION system for storage. Some data may not be returned, for security reasons. The output of the OBSBB instrument comprises SEED blockettes using the SEEDlink protocol. Data are acquired using slink2orb, which takes SEEDlink packets and inserts into an import BRTT Antelope Orb in the US Navy data diversion switch and is not accessible to OOI. Data are exported from the US Navy data diversion switch from another Orb that makes these data available to the OOI. The original SEED blockettes (L0 data) can be pulled from the above mentioned export orb and converted to standard OOI format for L1 data.

All reference documents are listed in section 2.4 above.

This is the same data stream process as for the short period ground velocity, broadband ground velocity, and the low frequency acoustic pressure waves data products. See Data Product Specifications for SGRDVEL (DCN 1341-00110), GRNDVEL (DCN 1341-00090), and HYDAPLF (DCN 1341-00821) for additional details.

4.2 Inputs

Inputs are: Miniseed packets acquired from an Antelope Orbserver.
Dbbuild parameter file for metadata

Input Data Format

- See observer.5.pdf, packets.5.pdf, css3.0.pdf, and the SEED manual referenced in Section 2.4

4.3 Processing Flow

The specific steps necessary to create all calibrated and quality controlled data products for OBSBB and OBSBK core instruments are described in the instrument-specific Processing Flow documents (DCN 1342-00090 and 1342-00100). These processing flow documents contain flow diagrams detailing all of the specific procedures (data product and QC) necessary to compute all levels of data products from the instrument and the order in which these procedures occur.

The processing flow for the broadband seismogram computation is as follows:

1. Build seismic metadata using command
   dbbuild -b rsnsp rsnsp-dbbuild
2. Generate dataless seed using command
   mk_dataless_seed rsnsp
3. Send *rsnsp_dataless_seed* to IRIS Data Management Center
4. Establish connection to diversion switch export orb at ip_address:port_number
5. Write data to disk using command
   orb2wf -dbm dbmaster/rsnsp ip_address:port_number rsnsp

4.4 Outputs

The output of the calibration computation is

- L1 GRNDACC Time-series in meters/sec^2.
- Attachment – dataless seed file named rsnsp_dataless_seed

See Appendix B for a discussion of the accuracy of the output.

Automated QC algorithms are performed using range checks, which will generate QC flags for GRNDACC. See Data Processing Flow Diagrams for OBSBB (DCN1342-00090) and OBSBK (1342-00100) for details.

4.5 Computational and Numerical Considerations

4.5.1 Numerical Programming Considerations

These codes and APIs depend on the Antelope software.

4.5.2 Computational Requirements

Linux platform with Antelope installed

4.6 Code Verification and Test Data Set

Gain = 1500 Volts/meter/sec * 787401.57 counts/volt;

1) Untar the file tar_data
2) Cd data
3) Run program trsample to show L0 data values for first 10 data points

```
trsample -T -n 10 rsn
 SUM1   LHZ    10 (calib=0.503809)  1/15/2013 (015)  0:00:00.000


 1/15/2013   0:00:00.000 3371
 1/15/2013   0:00:01.000 3113
 1/15/2013   0:00:02.000 2378
 1/15/2013   0:00:03.000 2130
 1/15/2013   0:00:04.000 2649
 1/15/2013   0:00:05.000 3419
 1/15/2013   0:00:06.000 2988
 1/15/2013   0:00:07.000 2382
 1/15/2013   0:00:08.000 2413
 1/15/2013   0:00:09.000 2627
```

4) Run program trsample to show L1 data values for first 10 data points in units of nanometers/sec

```
palapa% trsample -c -T -n 10 rsn
 SUM1   LHZ    10 (calib=0.503809)  1/15/2013 (015)  0:00:00.000
```

1/15/2013	0:00:00.000	1698.339444574
1/15/2013	0:00:01.000	1568.356775722
1/15/2013	0:00:02.000	1198.057312132
1/15/2013	0:00:03.000	1073.11273122
1/15/2013	0:00:04.000	1334.589495306
1/15/2013	0:00:05.000	1722.522266686
1/15/2013	0:00:06.000	1505.380676472
1/15/2013	0:00:07.000	1200.072547308
1/15/2013	0:00:08.000	1215.690619922
1/15/2013	0:00:09.000	1323.505701838

Appendix A Example Code

None.

Appendix B Output Accuracy

The time-series voltage is digitized at 24-bits resolution, and has an accuracy of better than 1 / (1500 Volts/meter/sec * 787401.57 counts/volt.)

Appendix C Sensor Calibration Effects

No calibration is performed on the unfiltered time-series data.