The International Seismographic Station Registry (IR): Implementation of the new IASPEI Station Coding Standard - Agency.Deployment.Station.Location.Channel

January 2013

INTRODUCTION

The International Seismograph Station Registry (IR) has been jointly maintained by the ISC and NEIC since the 1960s. Station operators wishing to participate in international data exchange apply to the IR for a globally unique international station code. At present, the IR uses a single three-to-five character station code that uniquely identifies a station's geographic location. Due to the evolving nature of station ownership, operation, and processing of seismic data, the five-character coding standard currently used by the IR is no longer able to meet the needs of network operators, international data centres and data users.

For instance, it has become common for seismic stations to be owned, hosted and operated by a combination of different agencies as opposed to just one agency as was often the case in the past. Other agencies, in addition to station operators themselves, report parametric measurements based on the station waveform recordings freely available on-line. Stations often belong to several different local, regional or international networks. All the above mentioned types of agencies require credit for the waveform and parametric data that they provide. The IR, in its original form, is unable to provide an appropriate station attribution to serve this purpose.

The IR is also unable to record the temporal variability in station positions. Seismic stations are often moved by local operators to address alterations in local conditions such as changes in the noise level or land ownership. On the other hand, those researchers simultaneously using measurements made during different periods of a particular station's operation require knowledge of the entire history of station movements.

The International Federation of Digital Seismograph Networks (FDSN) adopted a Network.Station.Location.Channel nomenclature where the sensor's geographic position is derived from the combination of a station code and a two-character network code. Unfortunately, the FDSN network and station code combination does not fully address the before mentioned concerns.

At the 2005 IASPEI Assembly in Santiago, Chile, the IASPEI Commission on Seismological Observation and Interpretation (CoSOI) set up a working group on Seismic Network and Station Codes that began discussions on the update of the IR coding standard under the leadership of Avi Shapira of the ISC. The working group included representatives of several major data centres, network operators, FDSN and all interested professionals.

At the 2007 IASPEI meeting in Perugia, Italy, recommendations of the working group were also discussed with representatives of the Federation of Digital Seismograph Networks (FDSN) in

order to make sure that the operations of both waveform and parametric data centres were closely coordinated. Relevant corrections were introduced into the aliasing system to guarantee an uninterrupted operation of existing data centres.

Recommendations from the Santiago meeting were discussed in 2007 at the annual NEIC-ISC-EMSC Coordination meeting with an accent on the implementation of the new system. Ray Buland of NEIC then assumed the working group Chair following Avi Shapira's departure from the ISC.

The following draft coding standards have been constructed by Ray Buland based on the CoSOI/IASPEI recommendations, FDSN comments on these recommendations as well as input from a number of network operators.

At the 2009 IASPEI meeting in Cape Town, South Africa the proposed standards were discussed by CoSOI and FDSN once again and finally approved by the IASPEI. This is reflected in Resolution 3 listed below:

Resolution 3: **International Registry of Seismic Stations**
IASPEI
RECOGNIZING that the International Registry of Seismic Stations no longer meets the needs of the seismological community,
RECOMMENDS adoption of newly developed seismic network and station coding standards developed by IASPEI to promote compatibility between waveform and parameter data exchange, attribution of parameter data, and flexibility for seismic network operators to better support earthquake monitoring and hazard assessments.

Since 2009, the NEIC and ISC have worked together to update the IR and use the new IASPEI station coding nomenclature that is described later in this document. The prototype IR database currently resides at the ISC and is used by NEIC. In this database, we addressed the issues of backward compatibility with the existing IR coding standard and aliasing with FDSN coding system based on SEED standards. NEIC and ISC, in cooperation with the EMSC are now planning the roll-out of the system in the international community as well as necessary correction to the number of principal data standards such as the QuakeML, ISF etc.

This document describes how the coding standards would be used to register stations, submit parameter data to data centers and attribute data summarized in catalogs to the correct agency. General steps and institutional responsibilities for implementing the new coding standard are also discussed. However, details of the associated software implementation are beyond the scope of this document.

In this document the words "shall" or "must" denote proposed mandatory standards, while the word "should" denotes strongly recommended (non-mandatory) standards. The word "may" denotes acceptable options for usage.

CODING STANDARDS

The location of seismic instrumentation shall be designated by the four fields: *Agency.Deployment.Station.Location.* The specification of a channel in connection with parameter data (e.g., to specify the channel from which a measurement was derived) shall be designated by the five fields: *Agency.Deployment.Station.Location.Channel*. Derived parameters (e.g., picks, amplitudes, hypocenters, magnitudes, etc.) shall be attributed to *Agency* or *Agency.Deployment*.

All fields shall be coded in alphabetic Latin characters (without diacritical marks) and/or Arabic numerals (i.e., characters represented by printable ASCII characters with numerical equivalents less than 128). Non-blank characters in any field shall be left justified and have no imbedded blanks. Non-blank characters in fixed field formats shall be blank padded to the right. All fields shall be case insensitive and have no other restrictions or extensions except as noted in the following. The fields shall be coded as follows:

- Agency: 2-5 alphanumeric characters.
- Deployment: 1-8 alphanumeric characters.
    - Special case: FDSN network codes used as deployment codes shall be case sensitive as required by the SEED v2.4 standard (note that in this case, the agency must be "FDSN").
- Station: 1-5 alphanumeric characters (this relaxes current International Registry standards, but remains consistent with the SEED v2.4 standard).
- Location: 0-2 alphanumeric characters (e.g., SEED v2.4 compatible).
- Channel: 3 alphanumeric characters following the SEED v2.4 coding standard.

Agencies, deployments, stations, locations, and channels shall be defined in discrete time periods called epochs in the following. Each epoch shall be defined by start and end date-times. The end date-time of the current epoch shall be coded as "undetermined". The relevant epoch shall be deduced by context (e.g., the date-time of parameter data) and looked up by date-time range rather than explicitly coded as an instance.

USAGE STANDARDS

The following usage standards are required or recommended:

- The new coding standards will necessitate a significant revision in the role and operation of the International Registry. However, the ISC and the NEIC, in close cooperation, will continue to act as the central authority for collecting, organizing, and distributing basic seismic station information (e.g., coordinates, owners, operator(s), etc.). This will include tools supporting the simultaneous use of parametric and waveform data (e.g., providing the correspondence between the new coding standard and FDSN nomenclature).
- Scope rules:
    - Agency codes shall be centrally assigned (i.e., guaranteed to be globally unique by the International Registry).

- Deployment codes shall be created by agencies as needed, but *Agency.Deployment* must be unique at any one time (i.e., duplicated *Agency.Deployment* codes must belong to non-overlapping epochs; see Example 8).
- Station codes shall be created by agencies as needed, but *Agency.Deployment.Station* must be unique at any one time.
- Location codes shall be created by agencies as needed, but *Agency.Deployment.Station.Location* must be unique at any one time.
- The *Agency.Deployment.Station.Location.Channel* designation is intended to be applicable to all types of seismic installations (e.g., fixed and portable seismic networks, seismic arrays, strong motion networks, and strong motion arrays; see Examples 6-9).

- Reporting rules:
  - Deployment, station, location, and channel codes shall be reported to the International Registry for tracking purposes (e.g., to uniquely identify stations and channels and ensure correct attribution in the global bulletins).
    - Channel codes that are unavailable shall be assumed to be SHZ (i.e., short period vertical).
  - Channel codes should be reported along with parametric data to specify the waveform from which the parameters were derived.
  - Latitude, longitude, and elevation associated with each *Agency.Deployment.Station.Location* shall be reported to the International Registry for tracking purposes. Coordinates shall be reported relative to the WGS84 datum (or the actual datum shall be specified). Elevation shall be the elevation at the sensor.
  - Epochs defining the validity of an *Agency.Deployment.Station.Location* designation or changes in associated latitude, longitude, and elevation shall be reported to the International Registry for tracking purposes.
  - Stations, locations, channels, and epochs already documented in a dataless-SEED volume need not be reported separately.

- Usage rules:
  - *Agency.Deployment.Station.Location* shall uniquely identify the location of one or more seismic sensors or, alternatively, one or more seismic channels. This implies that each *Agency.Deployment.Station.Location* shall be associated with one latitude, longitude, and elevation from which parametric data is measured.
    - One *Agency.Deployment.Station.Location* may be used for more than one set of co-located seismic sensors (e.g., seismometers and accelerometers operated by one agency).
    - More than one *Agency.Deployment.Station.Location* may be associated with the same latitude, longitude, and elevation (e.g., to designate co-

located sensors operated by different agencies or to avoid the duplication of channel codes).

- *Agency.Deployment.Station.Location.Channel* shall uniquely identify one channel associated with a particular sensor. Channels from co-located sensors that have the same names under SEED v2.4 rules shall have different *Agency.Deployment.Station.Location* designations (e.g., typically the location is made different).
- The following guidelines for assigning station and location codes are recommended:
  - Station and/or location codes may be changed even if sensors have not been moved.
  - Elements of an array may be assigned the same station code and different location codes regardless of the scale of the array (see Example 6).
  - For the convenience of seismic analysts, it is strongly recommended that existing station codes should not be changed more often than absolutely necessary.
  - It is strongly recommended that station and/or location codes should be changed if the associated sensors are moved far enough to result in a significant teleseismic travel-time residual discrepancy (e.g., more than 0.2 s or about 1.2 km).

ALIAS STANDARDS

Although each *Agency.Deployment.Station.Location* must be associated with a unique latitude, longitude, and elevation, the inverse is not true (or desirable):

- Different *Agency.Deployment.Station.Location* codes may be associated with the same set of sensors (i.e., they are equivalent or aliased):
  - For compatibility:
    - "FDSN" shall be assigned as an agency code.
      - FDSN network codes are legal deployment codes (although they are a special case because they are case sensitive).
      - When distributing seismic waveform data in FDSN standard SEED or mini-SEED, the FDSN centrally assigned network code shall be used.
        - Note that there is no intent for *Agency.Deployment* to replace the FDSN network code now or in the future.
      - For correct attribution of parameter data, FDSN.*Network* designations can and should be aliased with the *Agency.Deployment* of the owner/operator (see Example 2).
      - All stations currently registered in the IR shall have an FDSN *Agency.Deployment* alias of FDSN.IR (as well as International

Registry *Agency.Deployment* codes of ISC.IR and NEIC.IR; see Example 2).

    - To designate joint ownership/operation:
        - Many stations are owned/operated cooperatively by two or more agencies. Aliasing multiple *Agency.Deployment.Station.Location* codes provides a means for sharing attribution (see Example 4).
    - To designate logical participation:
        - Many stations may be thought of as being part of one or more networks (e.g., IMS) that have no role in owning or operating them (see Example 4).

- Completely separate (i.e., non-aliased) *Agency.Deployment.Station.Location* codes:
    - Shall be associated with the same latitude, longitude, and elevation to designate co-located sensors operated by different agencies or as part of different deployments (see usage rules above and Example 3).
    - May be associated with the same latitude, longitude, and elevation to designate co-located sensors operated by the same agency (see usage rules above and Example 7).
    - Shall be associated with channels from co-located sensors that have the same names under SEED v2.4 rules (see usage rules above).

It is clear that in practice it will be desirable to create aliases at all levels in the *Agency.Deployment.Station.Location.Channel* hierarchy. For example, it may be desirable to alias all stations and locations associated with two or more equivalent *Agency.Deployment* identifiers or it may be desirable to alias all locations associated with two or more equivalent *Agency.Deployment.Station* identifiers. In addition, because aliases may be used for backwards compatibility, to show joint ownership, or to show affiliation with more than one network, it will be necessary to flag the type of each aliases.

EPOCH STANDARDS

The following epoch standards are required or recommended:

- Epochs shall be associated with agencies, deployments, stations, locations, channels, and aliases.
- Agency and deployment epochs:
    - If possible, the start date-time of the earliest epoch should be associated with the creation of the agency or deployment.
    - Agency and deployment epochs shall be closed when the agency or deployment is terminated or its name is changed.
    - If an agency or deployment is renamed, a new epoch with the start date-time of the renaming shall be created for the new *Agency.Deployment*.
- Station and location epochs:

- If possible, the start date-time of the earliest epoch should be associated with the opening of the station or the installation of equipment at a location.
- Station and location epochs shall be closed when the station or location is closed, moved, or renamed.
- If stations or locations have been moved or renamed, new epochs with the new coordinates or names shall be created.
- For deployments adhering to FDSN rules, station, location, and channel epochs shall be coincident with station and channel epochs documented in the network SEED volumes.

- Alias epochs:
  - Aliases may change with time (e.g., if the agency operating a station changes or the agency changes names). These changes shall be documented in epochs associated with the aliases (see Example 5).
  - Alias epochs shall align with *Agency.Deployment.Station.Location* epochs when possible.

DISPLAY STANDARDS

It is expected that the *Agency.Deployment.Station.Location{.Channel}* nomenclature may be used in a variety of ways. The following display standards are recommended:

- Fixed format:
  - Each string should be left justified and blank padded within its field. A null location code should be represented as two blanks.
- Variable format:
  - Represented as a dotted string of the form Agency.Deployment.Station.Location{.Channel} with all blanks and trailing dots omitted (see Example 1).

AGENCY/DEPLOYMENT STYLE GUIDE

The coding standard provides considerable flexibility in assigning agency and deployment codes. However, in creating and discussing the examples (below), it has become clear that some care should be taken in assigning agency codes in particular. For example, it is tempting to think of agencies within a larger organization as deployments (e.g., USGS.NEIC). However, since NEIC can also be considered an agency, this creates confusion and reduces flexibility (because it does not allow for deployments within NEIC).

For this reason, it is strongly suggested that agencies should be organizational units that operate networks or create parameter data. This allows agencies to have multiple network deployments. The fact that an agency may be part of a larger organization will be captured in the description of each agency (e.g., NEIC can be described as the National Earthquake Information Center, US Geological Survey, Department of Interior, US Federal Government).

IMPLEMENTATION

The ISC and NEIC will work together to implement the revised International Registry. This will include:

- Developing the underlying database structures to support the new coding, epochs, and aliases.
- Populating the new database with the currently registered stations (using the ISC.IR, NEIC.IR, and FDSN.IR deployments).
- Populating the new database with channels currently documented in dataless SEED volumes.
- Working with the seismological agencies and the FDSN to create aliases to existing FDSN network codes.
- Revising web forms to register agencies and report deployments, stations, locations, channels, epochs, and aliases.
- Updating the database from the web form input.
- Making the contents of the new database accessible by means of an interactive (i.e., human) web interface and a software accessible (i.e., program-to-program) network service.
- Developing strategies to attribute parameter data contributed in existing formats to the correct agencies.
- Working with seismic processing system developers to add *Agency.Deployment.Station.Location.Channel* information to contributed parameter data.

EXAMPLES

In the following, the symbol == is used to designate an alias. Note that in the following there are examples of *Agency.Deployment* aliasing, *Agency.Deployment.Station* aliasing, *Agency.Deployment.Station.Location* aliasing, and *Agency.Deployment.Station.Location.Channel* aliasing. While some attempt has been made to find real-world examples, these examples have been modified as needed to illustrate particular points.

Example 1 – displaying a null location code: The US National Earthquake Information Center (NEIC) operates the Advanced National Seismic System (ANSS) Backbone network, which includes station Dugway (DUG). Dugway has only one location, which has a null location code. The station could be designated as NEIC.ANSSBN.DUG. The broadband, high-gain, vertical channel could be designated as NEIC.ANSSBN.DUG..BHZ.

Example 2 – default aliasing: The Geological Survey of Canada (GSC) operates the Canadian National Seismograph Network (CNSN), which includes the station Whitehorse (WHY). By default this station might be known as GSC.CNSN.WHY == ISC.IR.WHY == NEIC.IR.WHY. If the network had also been assigned an FDSN network code (CN in this case), it would also have aliases of FDSN.CN.WHY and FDSN.IR.WHY

Example 3 – designating co-located stations: The Geophysical Institute of Israel (GII) operates the Israeli Seismic Network (ISN), the Israeli Seismic Network Backup (ISNB) and the Israeli Strong Motion Array (ISMA), all of which have sensors located at Eilat (EIL). These sensors might be registered separately as GII.ISN.EIL (== FDSN.IS.EIL), GII.ISNB.EIL, and GII.ISMA.EIL respectively. Note that only one of these stations would be aliased with ISC.IR.EIL, NEIC.IR.EIL, and FDSN.IR.EIL (e.g., with GII.ISN.EIL, but not with GII.ISNB.EIL or GII.ISMA.EIL).

Example 4 – designating a cooperative station: The Geophysical Institute of Israel (GII) operates the Israeli Seismic Network (ISN), which includes station Eilat (EIL). EIL is also part of the GeoForschungsZentrum (GFZ) GEOFON network and is station AS48 of the Comprehensive Test Ban Treaty Organization (CTBTO) International Monitoring Network (IMS). These relationships might be shown by aliasing GII.ISN.EIL == GFZ.GEOFON.EIL == CTBTO.IMS.AS48. Note that these aliases may not imply the same sort of relationship (e.g., GII and GFZ may have cooperated in establishing the station, but the GII may only be contributing data to the CTBTO).

Example 5 – alias epochs: The University of Utah at Salt Lake City (UUSLC) operates a statewide network, which includes the station San Rafael Swell (SRU). After July 1, 2007, this station became affiliated with the ANSS Backbone network. Therefore, prior to July1, 2007 the aliasing might have been UUSLC.UU.SRU == FDSN.UU.SRU. After July 1, 2007, the aliasing might be UUSLC.UU.SRU == FDSN.UU.SRU == NEIC.ANSSBN.SRU. That is, a new alias epoch would show that the station was not part of the ANSSBN deployment before July 1, 2007.

Example 6 – designating an array: The US National Data Center (USNDC) operates a number of arrays as the US contribution to the Comprehensive Test Ban Treaty Organization (CTBTO). The thirteen elements of the Pinedale (PDAR) array could be designated as CTBTO.USNDC.PD01, CTBTO.USNDC.PD02,… or as CTBTO.USNDC.PDAR.01, CTBTO.USNDC.PDAR.02,…. Array elements can be treated as separate stations or as locations of one station, regardless of the separation.

Example 7 – designating co-located sensors: The US National Data Center (USNDC) operates a number of arrays as the US contribution to the Comprehensive Test Ban Treaty Organization (CTBTO). The central array element includes co-located broadband and short period sensors. These could be shown as CTBTO.USNDC.PD31..BHZ and CTBTO.USNDC.PD32..SHZ or as CTBTO.USNDC.PD31..BHZ and CTBTO.USNDC.PD31..SHZ. That is, the station codes could follow either the USNDC convention (different station codes for co-located sensors) or the current IR convention.

Example 8 – designating portable deployments: Suppose US National Earthquake Information Center (NEIC) portable networks are deployed in Marble, Colorado, USA at two different times. These might both be designated as NEIC.MARBLE in two non-overlapping epochs (e.g., epoch 1 from 1997-06-15 to 1997-07-02 and epoch 2 from 2001-08-22 to 2002-06-10).

Example 9 – designating a strong motion array: Suppose the US National Strong Motion Program (NSMP) deployed a strong motion array in the (fictional) Benz building. The basement sub-array might be designated NSMP.BENZ.BSMT.NE, NSMP.BENZ.BSMT.NW,….