Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation

Report

Exchange protocol for (near) real time parametric data

Activity:	*Networking accelerometric networks and SM data users*
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Summary

Accelerometric networks in the larger European region that participated in the NERIES NA5 and NERA NA3 work packages have started a coordinated effort to provide a common access to their strong motion data. In the framework of the current NERA NA3 project, there are two main objectives: (1) to facilitate near realtime accelerometric data exchange, which after a major seismic event in Europe will rapidly making available both waveforms and useful information on the severity of the shaking and (2) to develop and maintain a peer-reviewed, high quality European accelerometric database for use by the earthquake engineering and engineering seismology commuities. In the Task 3.1, the NERA NA3 partners address the first issue have developed a common strategy to provide real time exchange of the strong motion data provided by the accelerometric networks, to rapidly characterise the available seismic ground motion, and to make the data immediately available to the open community. The infrastructure used in this strategy builds on existing tools developed and supported by the European seismological community (SeedLink, EIDA, SeisComp3, seismicportal.eu). We expect this effort will define an enduring standard for efficient data exchange and automated strong motion data processing, which will be crucial to the development of the accelerometric community in Europe by motivating other European networks to participate in open data exchange and dissemination.

Introduction

The primary goal of an accelerometric network is to record the strong ground motion produced by earthquakes. Strong ground motions are the basic data used by the earthquake engineering and engineering seismology both 1) in the immediate aftermath of a destructuve earthquake to estimate the severity of the ground shaking, and 2) at a scientific and engineering level to understand the amount and the distribution of the seismic damages and casualties. Moreover, accelerometric data are integral to the defintion of the national building codes in order to estimates the seismic ground motion for seismic scenario or/and probabilistic seismic hazard assessment.

The FP6 NERIES project gathered fundamental information on the existing accelerometric networks in Europe and Mediterranean and initiated a pilot effort to establish a basic mechanism to extract and disseminate accelerometric data to the end users (Roca et al., 2010; Pequegnat et al., 2010). The number and quality of strong-motion stations in Europe continues to increase rapidly. New generation instruments can record weak-to-strong motions using continuous and real-time data transmission. These new instruments can thus contribute to establish early-warning systems, shake-maps and rapid damage evaluation scenarios helping the crisis management and the seismic information dissemination. National agencies in Europe (Pequegnat et al., 2007; Clinton et al., 2011; Paolucci et al., 2011) began constructing the infrastructure for collecting, managing and disseminating accelerometric data in real- or near real-time, including estimates of ground motion parameters.

What is urgently needed are common protocols for the networking and integration of additional European strong motion networks alongside data from the seismological networks (such as broad-band data) that currently provide seismic event characterization and post-earthquake damage assessment. NERA NA3-task 3.1 extends the initial promising accomplishments from NERIES NA5 to reflect recent infrastructure development and application needs of the engineering and seismological community in Europe.

In the framework of NERA-NA3 task 3.1 activity, we propse a scheme for exchanging data in real- or near-real time, providing access to the accelerometric data and ground motion information following major earthquakes in the greater European region. The basic schema is shown in Fig. 1. This scheme will be discussed in detail the following section.

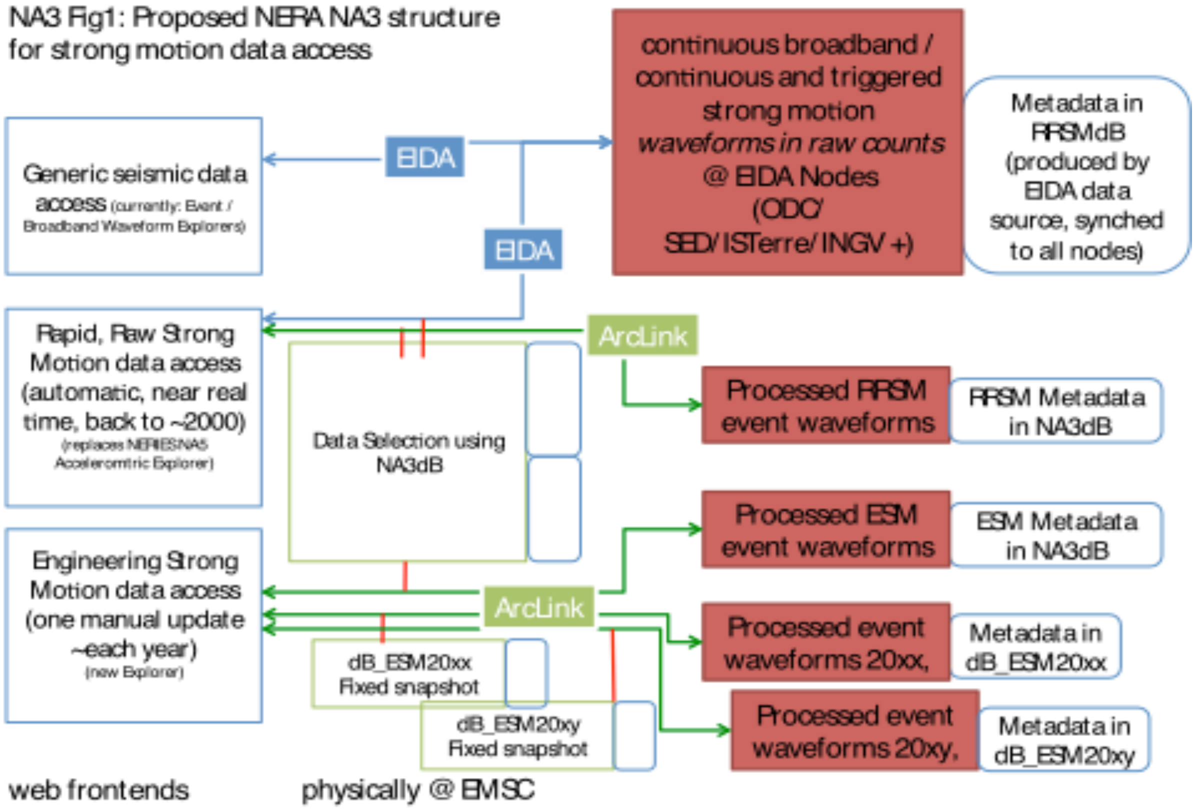

Figure 1: Overview scheme for the NA3 activities. This scheme may change and evolve for the ESM and RRSM links.

General implementation structure and policy.

Partners involved in the NERA NA3 project.

The partners involved in the NA3 task 3.1 are three institutes, ETHZ, INGV and ISTerre-CNRS, each of these institutes manage their national accelerometric

network and each also manages a major seismological network and so they are appropriate partners to combine the recent developments made during the NERIES project with current state of the art software from the seismic network and strong motion communities with regards to data exchange and dissemination.
METU is the coordinator of the NA3 activity, and their knowledge of the engineering seismology and earthquake engineering community and contributes to the definition of the end user needs.
The last two partners, EMSC/CSEM and ORFEUS, also contribute to this activity- EMSC will be the host for data dissemination and further information through their development of web data exploration tools; ORFEUS data centre will host the NA3dB / RRSMdB with station information.

Existing infrastructure.

The distributed infrastructure that was designed for european accelerometric data within the context of the NERIES project (2006-2010) was based on a dedicated exchange protocol (XML messages) sent over AMQP for metadata, and on FTP protocol for data exchange. This architecture has been completely redefined in the context of Nera NA3 in order to taking advantage of the rapidly increasing number of the new continuous and real-time accelerometric stations in the region.

The goal is to make accelerometric data available at the appropriate regional nodes in the European EIDA virtual archive (http://www.neries-eu.org/?subpage=/projectweb/portalproject/EIDA.html). Realtime data will be transferred to the EIDA nodes via SeedLink and archived in SDS structure. Data will be distributed via the ArcLink software distributed as part of SeisComP3 (SC3). SC3 is an integrated earthquake monitoring software developed by GFZ (Germany) and GEMPA, which includes a real time data acquisition component (based on the protocol seedlink), modules for the detection / automatic location and quantification of earthquakes, as well as a distribution tool for archived data (arclink). Various geographically distributed Arclink nodes are combined into EIDA using a synchronization mechanism for the metadata. The heart of SC3 is a database whose schema is based on the standard model quakeML (https://quake.ethz.ch/quakeml). All data accelerometer available on EIDA will be fully open.
To date, three partners have set up NA3 nodes EIDA in operation: SED (eida.ethz.ch: 18001) for the Switzerland network (code CH), INGV (eida.rm.ingv.it: 18002) for the Italian network (code IV), and ORFEUS (bhlsa04.knmi.nl: 18,002) in Netherlands for the European Archive stored at the Orfeus Data Center (ODC). The arclink node for accelerometric French data (eida.resif.fr:18002, code RA) is under construction and will be available at the beginning of 2012.

The Swiss EIDA node provides access to Swiss data and metadata for 94 accelerometric stations, including triggered data, as well as an additional 34 broad-band stations.

Italian network gives access to data and metadata for 188 broad-band stations (8 with restricted access) and no accelerometric stations through the EIDA. Nevertheless, a large number of sites are mixed (BB+SM) and they will be included in EIDA.

French network will give access to data and metadata for 150 accelerometrics stations (including triggered data since 1995), 50 BB stations, and data of all the french mobile experiments.

A special effort will be done to include data made openly accessible within the Neries NA5 framework: those data (and metadata) will be integrated at the ORFEUS EIDA node. They contain:

TS : institute of engineering and earthquake Greece : 107 station, 25 events
ITPDC : italian strong motion network : 141 stations, 80 events
IST : instituto superior tecnico : 39 stations, 27 events
IGC : institut geologic de catalunya : 10 stations, 22 events

The Rapid Raw Strong Motion databank RRSM

The Rapid, Raw Strong Motion databank, RRSM will provide rapid broad community access to strong motion records immediately following an earthquake. Networks which provide continuous realtime strong motion data, or have rapid access to triggered data, make the data available through EIDA. Following a large earthquake, a SeisComp3 server retrieves the waveforms on EIDA, and using the an open source SC3 module, will automatically estimate the ground motion parameter. Figure 2 show the technical scheme and route of the data expected for the RRSM.

Event information will be provided by the EMSC/CSEM institute, activities already done by this partner, each event being referenced following an unique identification (UNID) already implemented at EMSC/CSEM for the NERIES project.

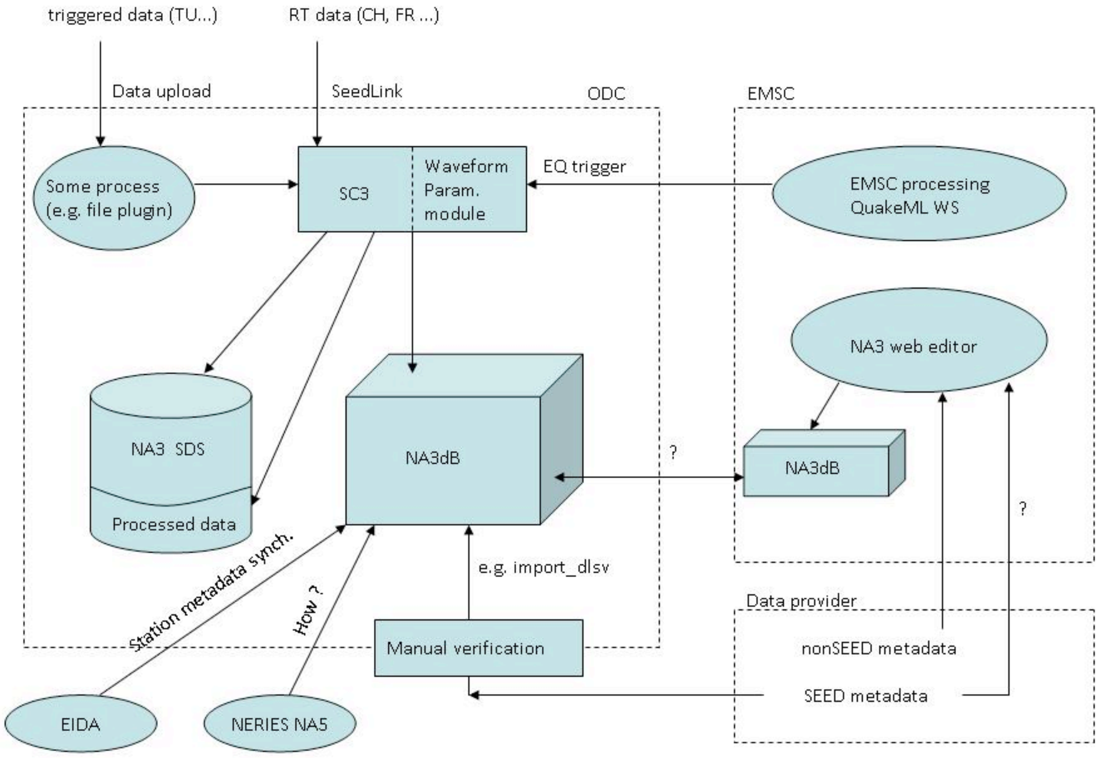

Figure 2: Technical scheme and route of the data imagined for Rapid Raw Strong Motion infrastructure

The architecture will take advantage of the clear and strong recent developments in the European seismological community though MERIDIAN, NERIES and continuing now in NERA: data exchange is now being performed in realtime as standard (SeedLink). Sophisticated seismic network data processing software (SC3) is now routinely operated based on a data model that combines near complete instrumentation metadata as well as event information (quakeML, inventory XML / SC3 data model). Archived waveform data can also be easily accessed rapidly, near real time using local (ArcLink) and distributed storage (EIDA).

The requirements for running the RRSM are:

1. an instance of SeisComp3, using an SC3 extended dB structure, that will be a component of the *NA3dB* (see Fig2) and capable of connecting to EIDA and running the SC3 module extension software *wfparam* that processes waveforms.
2. The SC3 instance subscribes to EMSC earthquake locations.
3. Following an EMSC location, the *wfparam* module will extract all onscale data in the vicinity of the EMSC location and parameterize the waveforms. Processed miniSEED data will be locally stored in an arclink mounted SDS structure.
4. EIDA station information in *NA3dB* is synched with EIDA and hence always up-to-date.

5. RRSM part of the *NA3dB* can be accessed by RRSM web portal to be designed by EMSC, which will use the *NA3dB* as the source for to strong motion inventory:
    a. event information (added by EMSC location);
    b. waveform information for a given event (eg PGA/ PGV);

The inventory can be accessed and queried, and used to select a subset of strong motion waveforms to download (either raw data via EIDA, or processed data via the local ArcLink.)

Data Collection

As previously mentioned, two sorts of accelerometric data can be integrated into the RRSM structure. Realtime continuous data already can be introduced into EIDA infrastructure and these do not required new developments. Triggered data which will continue to form the majority of accelerometric stations in Europe, must also be integrated to the EIDA structure in order to be disseminated following the same process as continuous data. In the next session, we detail the two processes.

Initial population of NA3dB can be done following these 4 ways:

SEED metadata from EIDA stations:	ArcLink synchronization
SEED metadata from non-EIDA stations:	Importing via dataless SEED, NA3 web editor ...
nonSEED metadata (EIDA or non-EIDA stations):	NA3 web editor
NERIES NA5:	implemented by ISTerre on the base of the available data after the end of the NERIES project

The NA3 web editor will be developed in the next year by EMSC. This will be an inventory of all strong motion stations in Europe, and will be capable of being kept current as it will be synched with EIDA metadata for stations contributing to EIDA. Station operators responsible for strong motion stations outside of EIDA will be able to modify and add their own inventory directly from the web editor. The web editor should not allow modifications of SEED metadata from EIDA stations. Such changes should be inserted after which the NA3dB is synchronised with EIDA. The web editor should connect to a (copy) of the NA3dB at EMSC for the duration of the project. Some form of validation is required before the information will be stored in the dB. ORFEUS validates SEED metadata before it is entered into the database, EMSC will hopefully do this for the nonSEED metadata.

ORFEUS (ODC) will be responsible for waveform data collection, both real-time waveforms and triggered data, for stations that are not part of other EIDA nodes. This data will be stored (in the Seiscomp Data Structure SDS) at ODC. An EMSC location will trigger the SC3 waveform parameterization module running at ODC. Processed waveform data are stored at ODC and can be accessed by a variety of services (including Arclink).

The SC3 system at ODC for NA3 will be a different instance from the EIDA SC3 system. This is required as the dB is and extended version, and the purpose is only to operate the *wfparam* module and connect to the EMSC station database website and webaccess portal for data dissemination.

Real time continuous data

Realtime waveforms in raw digital counts are collected by the data providers. The national infrastructure is under the responsability of the data providers and the minimal requirement is to convert the data in realtime to miniSEED packets, using standard SEED naming conventions.

In the case where the accelerometric network is not an EIDA node, it requires that ODC is the EIDA node for all networks that do not have a local EIDA node to use.

Waveforms in raw digital counts are transferred to appropriate EIDA node datacenters (e.g. Orfeus) using a pre-agreed, robust, automatic mechanism, typically using NAQS (in this case, EIDA node converts to mseed) or SeedLink. Waveforms are archived in SDS structure. If the data provider is an EIDA node, then data transfer is not needed. Initial processing will be based on ODC seedlink, and reprocess after some time, to allow different EIDA nodes with different archiving strategies to bring their data on arclink. The Waveform parameterization module developed by SED / gempa already contains this feature and this soft will be hosted at ODC.

Dataless SEED files must be created and information added to SC3 database at EIDA nodes; if the data provider is not already an EIDA node, dataless SEED preparation is required by the local data provider and this should be sent and checked by an EIDA node in advance of realtime data flow. A routine will be proposed by ISTerre for helping the construction of the dataless.

- Examples.
  - ✓ Swiss realtime strong-motion data (in general acceleration + braod-band velocity on-scale): SED responsible; realtime strong-motion stations automatically archived via slarchive in SeedLink to SDS archive (Strore system of the data); immediately available via SED internal ArcLink and SED local EIDA node.
  - ✓ French realtime strong motion station: ISTerre responsible; realtime strong-motion stations automatically archived via slarchive in SeedLink to SDS archive; ISTerre expects to operate an EIDA node, data will be accessible via this EIDA node.

Triggered data

Waveforms in raw digital counts are downloaded and collected by the data providers. If not already done, they are converted into miniSEED packets, using standard SEED naming conventions.

Waveforms in raw digital counts are transferred to appropriate EIDA node datacenters (e.g. Orfeus) using a pre-agreed, robust, preferably automatic mechanism, but likely includes some manual interaction agreed to by both network operator and EIDA node. At this stage waveforms are archived in SDS structure; if the data provider is an EIDA node, then data transfer is not needed.

As with realtime continuous data, dataless SEED files or equivalent information in inventory XML or SC3 key file format must be created and information added to SC3 dB at EIDA nodes. If the data provider is not already an EIDA node, dateless SEED preparation is required by the local data provider and the metadata should be sent and checked by an EIDA node in advance of realtime data flow. It is expected if a network does not have a national EIDA datacenter, or they do not wish to use the national datacenter, they can send data to ODC EIDA node (this will require agreement with ODC, likely depends on only transferring reasonable volumes / existence of high quality metadata). SED specifies the format for non-SEED station descriptors, EMSC develops a web tool for non-SEED station descriptor, ISTerre provides support for dataless preparation.

Station information needs to be completed when a new station is added. Most information is contained in dataless SEED and so available via EIDA synchronization, but other stations information, i.e., the non-SEED station descriptors (geology / vault, as discussed in Zürich), need to be directly added via EMSC strong motion inventory website.

- Examples.

  - ✓ Swiss triggered 12bit/16bit triggered strong-motion data: SED responsible; data are downloaded in GSE2 format, converted into miniSEED and archived in SDS structure with proper naming convention; metadata were prepared in advance. For example, SED received from ISTerre dataless examples following the protocol developed for last NERIES project. Data are available via SED internal ArcLink and SED local EIDA node as soon as downloaded and processed (hours to days).
  - ✓ French triggered 24bit triggered strong-motion data: ISTerre responsible; data are downloaded in native format, converted into miniSEED and archived in SDS structure with proper naming convention; metadata were prepared in advance. Data are available via ISTerre internal ArcLink and ISTerre local EIDA node as soon as downloaded and processed (hours to days).

ODC, with METU, should take responsibility with coordinating the political minefield and creating a memorandum of understanding for adding other data providers.

Ground motion parameter processing and event-record relationship

EMSC locations trigger a dedicated RRSM SeisComP3 instance attached to the NA3dB. ODC runs the waveform parameterization module and is connected to an EIDA node. This SC3 instance will be running at the same institute hosting the *NA3dB* (i.e. ORFEUS). For the RRSM, at this stage we expect only critical event parameters already available from EMSC in near realtime (lat / long / depth / preferred magnitude, UNID) to be used to characterize the RRSM events. More complex information, such as fault mechanism, finite fault, multiple magnitude types, are not expected to be added by the end of the Nera project. The EMSC UNID will be used as an identifier. The waveform processing module decides whether magnitude threshold is reached. This requires SC3 to be notified of all events, not just the simple subset of large events available by simply subscribing to the EMSC email alerts. Discussions done during the last NERIES project will be used for this part.

Module tries to download all available data via EIDA as soon as it is notified about event. At first stage, it should have all realtime continuous data available. It will re-run again a configurable intervals (+1hr, +2hr, +6hr, +12hr, +48hr, +1week) to re-process late arriving triggered data at EIDA node. Configuration can be done using the SC3 configuration options.

The ground motion parameters selected are peak values of ground motions, significant duration and selected spectral ordinates (e.g. for ShakeMap spectral values as a minimum). They are saved into the extended SC3 *NA3dB* database. Na3db and the ground motion parameters should be available for the portal for possible request on this parameters. Parameters will be transmitted to EMSC into their event information database and the processed waveforms will be locally stored at ODC.

- Example.

  - ✓ An earthquake occurs somewhere in the Euro-mediterranean region. At the EMSC, an UNID is send to ODC. The waveform parameterisation module running on the RRSM SC3 instance is triggered by this new EMSC location. The module uses EIDA and ArcLink to access waveforms within a predefined distance range from the epicenter, based on the triggering magnitude. The waveforms are collected and processed, providing ground motion parameters. The derived parameters are stored into the properly extended *NA3dB* database. PNG images also need to be capable of being stored.

Data dissemination

Raw waveforms are physically hosted at ODC and accessed using ArcLink. Processed waveforms are at ODC and accessed using EIDA and ground motion parameters hosted by EMSC.

An internet portal which reads the extended SC3 *NA3dB* database and capable of requesting waveform data via EIDA is made available to the public. This portal is planed to be hosted at EMSC/CSEM.

The users query the RRSM part of the NA3dB database and once records are selected, they can download 1) raw waveforms in digital counts with associated metadata; 2) automatically processed waveforms with associated metadata. The user can also view snapshots of processed waveform as they search through data, so they can decide whether to download data.

By now, the minimum query options:

  - ○ Event magnitude (event property)

  - PGA / PGV (stream property)
  - Dist to epicenter (stream property)
  - Vault type / geology contained at the station book developed by EMSC

Waveforms are available in different formats: ISTerre implements tools for format conversions and coordinates with ODC and EMSC for installation.

There is practically no human control on the data (similar to USGS ShakeMap), thus implementation of visualization tools is required for the users.

Archive creation

The NERIES waveform dataset actually available will be added to an EIDA node: ISTerre will support this activity.

The RRSM can be populated with old events using EMSC locations from the last decade and running ‘offline’ the waveform parameterization module to access all available waveforms on EIDA from this period, including the subset of NERIES data from CH, FR, INGV for this period.

Example

An earthquake occurs somewhere in the EUME region. The earthquake is large enough to generate significant ground motions and is recorded in the near field by strong motion sensors. Realtime data is collected by local network, sent to an EIDA node and archived. Triggered data is downloaded from the field, and automatically / manually added to an EIDA node also in near realtime. The event is located by EMSC, their location / magnitude is received by the SC3 RRSM machine at ODC where the location is saved to the *NA3dB* database and the waveform parameterization module is triggered. This module retrieves all waveforms within a given distance available over EIDA for processing. If the data is on-scale and has significant signal-to-noise ratio, it is processed automatically; key ground motion parameters are saved to the SC3 *NA3dB* database; and processed acceleration waveforms and images of the processed data are also locally archived. Once this is completed, typically within 2-3 minutes of the EMSC location being available, experienced seismologists / engineers who wish to have the most rapid access to raw and processed waveform data in the format of their choice (and can accept the fact that automatic processing can periodically include some errors), can use the RRSM webportal and query the RRSM part of the *NA3dB* database using a variety of search options, e.g. PGA, PGV, a few spectral ordinates, soil categories… The result of the query points to a subset of the available stations. The recorded raw and processed waveforms can be downloaded via ArcLink/EIDA. Data conversion is provided on the fly at download stage.

Conclusion

The NA3 implementation and deployment will produce an efficient rapid accelerometric data dissemination from a single European portal for all rapidly available strong motion information after a major earthquake, regardless of network origin. This will be a unique effort for Europe. The design of the infrastructure follows the seismological infrastructure developed in Europe and so will continue to be supported by the European existing infrastructures (ORFEUS, EMSC/CSEM). It will facilitate the sustainability of the NA3 RRSM database and the addition of new partners.

Standards in acquisition and storage will allow a quick exchange and handling of the data.

As specified at the beginning of this document, the NA3 activities are also devoted to the construction of an Engineering database, the link between the RRSM and the ESM databases will be debated during the rest of the projetc.

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Appendix A: Proposed naming convention for processed data

Subject to change, the final decision is not urgent

Premise: for raw data, the SEED naming convention (*www.iris.edu/**manuals/ SEEDManual**_V2.4.pdf*) and the SDS structure must strictly followed.

Required Naming Convention for permanent archival:
Network_code.Station_code.Location_code.Channel_code.D.Year.Julian_day

Raw Data in RRSM

Example:
CH.DIX..HHZ.D.2011.151

Detailed Definitions
Network Code:

CH: Swiss national network
RA: French strong motion network
FR: French broadband network and co-located strong motion
IV: INGV national network
??: Turkish METU strong motion
??: DPC….

<Note: networks without official FDSN network codes need to request one for this project: see http://www.fdsn.org/forms/netcode_request.htm>

Station Code:

3-5 letter name of station,
eg DIX: Grande Dixence, Switzerland
LSD: Lago Serru – Ceresole Reale, Italy

Location Code:

location code is empty for CH, typically 00 for RA and FR

Channel Code:

Consists of 3 characters, eg with own meaning:
[band code][instrument code][orientation code]
HHZ = broadband high-gain velocity sensor, vertical component
HGE = broadband strong motion sensor, East comp.
HNE = broadband strong motion sensor, East comp.
EHN = short period high-gain velocity sensor, North comp.
…

preferred instrument code for strong motion is N, but L / G are also acceptable (G is used in CH)

D is the data type and means waveforms

Processed Data in RRSM / ESM

For processed data, we must keep the SDS structure and the raw mseed naming convention; the fact the data is processed is indicated by adopt the following instrument and location code convention:

Instrument Code:
X for processed acceleration
Y for processed velocity
Z for processed displacements (not present in RRSM, but present in ESM)

Location Code:
In the context of processed data, the location code can refer to the type of processing used. We propose an intuitive scheme to identify the kind of processing, i.e.:
EA = ESM accn, ie acceleration derived using the ESM software
EV = ESM vel, ie velocity derived using the ESM software
ED = ESM disp, ie displacement derived using the ESM waveform parameterisation software
RA = RRSM acc, ie acceleration derived using the RRSM waveform parameterisation software
RV = RRSM vel, ie velocity derived using the RRSM waveform parameterisation software

Important Note 1:
The SDS structure implies the use of day-long miniseed files. Multiple eventsof course can occur each day. In the SDS system, these event files need to be merged, eg using software qmerge. For example:

CH.SBUB.RA.HXE.D.2011.001 (note the use of FDSN network and station code)

is the miniseed file containing all the RRSM processed acceleration recordings for station SBUB, network CH, channel E, on 01.01.2011.

This needs to be carefully managed. The output files from the SA/LL processing software should instead of the appendix Year.Julian_day (YYYY.JJJ) have YYYY.JJJ.HH.MM, and once the data is ready to be transferred to EMSC for archival:

1. if only one event has occurred that day, simply deleted the .HH.MM part in the name
2. if more than one event has occurred that day, the network operator must , using qmerge, merge the multiple event files into a single file labeled with only the Julian Day.

Important Note 2:
All dates / times in the dB will use UTC, so timestamps must be in UTC, not local time

Important Note 3:

Response spectra cannot be distributed as the waveforms via ArcLink: they must be either saved into the db as frequency amplitude pairs; or as waveform files stored locally at the agency in charge of database maintenance. If we choose local file storage, we can use the instrument code W and add the origin time, plus an indication of the spectrum type e.g.:

CH.SBUB.RA.HWE.D.2011.001.hhmmss.psa

General Examples:

CH.SBUB..HGE.D.2011.001
Swiss continuous strong motion, raw counts, for RRSM
CH.PANIX..HHN.D.2011.217
Swiss continuous broadband, raw counts, for RRSM
CH.SEM1..HG2.D.2011.233
Swiss triggered strong motion, horizontal component on dam station (orientation not traditional E/W, so orientation code is2), raw counts, for RRSM
RA.OGSI.00.HNZ.D.2011.267
French continuous strong motion station, raw counts, for RRSM