

IDC RE-ENGINEERING REPORT

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IDC Re-Engineering Phase 2 System Requirements Document Version 1.3

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Document History

Version	Date	Description
1.0	2014-07-21	Baseline version
1.1	2014-11-19	<p>Added SRD-623.</p> <p>Removed SRD-501 as it is redundant with SRD-361.</p> <p>Reworded SRD-410 to replace the term “grammar” with “language”.</p> <p>Reworded SRD-189 to replace the term “database” with the more general “data management system”.</p>
1.2	2015-05-08	Added SRD-624, SRD-625,SRD-626,SRD-627 dealing with event consistency requirements.
1.3	2015-12-15	Renumbered one of two requirements that were numbered SRD-448 to SRD-653, added SRD-83 Note to define late arriving detections, updated SRD-395 to clarify moment tensor calculation, updated SRD-137 Note to clarify interactive selection of earth models, updated SRD-262 to clarify performance needed for origin beams, removed SRD-345 dealing with Training Subsystem availability.

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1 INTRODUCTION

1.1 Scope

This System Requirements Document (SRD) defines waveform data processing requirements for the International Data Centre (IDC) of the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO). The IDC applies, on a routine basis, automatic processing methods and interactive analysis to raw International Monitoring System (IMS) data in order to produce, archive, and distribute standard IDC products on behalf of all States Parties. The routine processing includes characterization of events with the objective of screening out events considered to be consistent with natural phenomena or non-nuclear, man-made phenomena. This document does not address requirements concerning acquisition, processing and analysis of radionuclide data but includes requirements for the dissemination of radionuclide data and products.

1.2 Documents.

Requirements in this document are drawn from multiple source documents. These requirements are crafted to take into account or be consistent with governing documents.

Source Documents.

- UN General Assembly A/RES/50/245, Comprehensive Nuclear Test-Ban Treaty, 17 September 1996
- Operational Manual for Hydroacoustic Monitoring and the International Exchange of Hydroacoustic Data, CTBT/WGB/TL-11, 17/16, Latest Revision
- Operational Manual for Infrasound Monitoring and the International Exchange of Infrasound Data, CTBT/WGB/TL-11, 17/17, Latest Revision
- Operational Manual for Seismological Monitoring and the International Exchange of Seismological Data, CTBT/WGB/TL-11, 17/15, Latest Revision
- International Data Centre Draft Operational Manual, CTBT/WGB/TL-11, 17/23, Latest Revision.

2 ABOUT THE REQUIREMENTS

Requirements in the SRD are high-level and are intended to capture areas of functionality rather than describe in detail how the system will perform a specific function. The requirements were iteratively compiled from several sources and associated with unique identifiers (E.g. SRD-122). The order of these identifiers has no meaning.

2.1 Tags.

Each requirement is appended by four annotations: Status, Priority, Type, Functional Area.

- “Status” notes whether a requirement is a “Current,” “Current-Partial,” or a “New” capability.

- “Priority” identifies the requirements as being either “Threshold”, “Objective, Priority 1”, “Objective, Priority 2”, or “Extensibility”.

- “Threshold” requirements are those that shall be met during IDC Re-engineering Phase 3.

- “Objective” requirements, as prioritized, are those that are desired to be met.
 - “Extensibility” requirements refer to future capabilities for which consideration must be given to the future integration of the capability, but are not current development projects.
- “Type” defines the type of the requirement as either a constraint, functional, non-functional, or project issue.
- “Functional Area” defines the functional area impacted by the requirement. A requirement should be mapped to at least one of these tags, but may be mapped to multiple.
- A more complete description of these tags is found in Appendix 2 of this document.

2.2 Requirements Verification

SRD requirements will be derived into lower level System Specification requirements in the System Specification Document (SSD). The SSD requirements are intended to be specific and measurable. The software to be constructed in IDC Re-engineering Phase 3 will be tested against the requirements in the SSD using the following methodologies: Inspection, Analysis, Demonstration, and Test. For some requirements, multiple verification methods may be employed. The following section describes each verification method.

2.2.1 Verification Methodologies.

2.2.1.1 Inspection (I).

Inspection is accomplished by physically examining hardware, source code, parameter files, and/or other physical manifestations of hardware and software, such as software-generated printouts and diagrams. Inspection implies observation/examination to verify requirements, usually without the need for analysis, demonstration, or test. Inspection does not involve software execution.

2.2.1.2 Analysis (A).

Analysis is accomplished by examining and analyzing the internal structure of hardware and software. This will most likely be required when a requirement cannot be directly tested and observed. Analysis may require a review or study of data, mathematical expressions, or software models.

2.2.1.3 Demonstration (D).

Demonstration is accomplished by observing the performance of software or hardware, where specific inputs have an expected result, and when the software is executed on the hardware according to the test procedure.

2.2.1.4 Test (T).

Test is accomplished by exercising software or hardware with pre-determined inputs and then recording and analyzing the measurable response. Test involves measurements or quantitative observations of the performance of a function or equipment. The requirement is verified by comparing test results with quantitative criteria such as predicted values, a range of values, accuracies, or tolerances.

3 Requirements.

The following sections spell out the requirements for the IDC waveform processing system.

3.1 Data Acquisition and Forwarding

The system requires the hardware and software necessary to acquire, organize, and distribute waveform data, in near-real-time, from a global network of sensors. Communications services to outside systems, along with the operation of external data sources, are outside the scope of the system.

3.1.1 The system shall acquire continuous waveform data from seismic primary, infrasound and hydroacoustic stations of the IMS network.

SRD Number: SRD-430

Status: Current

Priority: Threshold

Type: Functional

Function: Data Acquisition, Data Management, External Interfaces

3.1.2 All data acquired from stations that are available for external release shall be stored in the data acquisition subsystem.

SRD Number: SRD-431

Status: Current

Priority: Threshold

Type: Functional

Function: Data Acquisition, Data Management

3.1.3 The system shall acquire waveform data from auxiliary seismic stations of the IMS network through requests for data segments.

SRD Number: SRD-432

Status: Current

Priority: Threshold

Type: Functional

Function: Data Acquisition, Data Management, External Interfaces

3.1.4 The ALT subsystem shall, under fail-over conditions, acquire continuous waveform data from seismic primary, hydroacoustic and infrasound stations of the IMS network.

SRD Number: SRD-433

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: Data Acquisition, Data Management, External Interfaces, Subsystem - ALT

NOTE: The final requirements for the ALT subsystem are incomplete and awaiting input from stakeholders and a recovery plan. These requirements address fail-over conditions only at this time. The use of the phrase 'under fail-over conditions' may become too restrictive and could be removed.

3.1.5 The ALT subsystem shall, under fail-over conditions, acquire waveform data from seismic auxiliary stations of the IMS network through requests for data segments.

SRD Number: SRD-434

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: Data Acquisition, Data Management, External Interfaces, Subsystem - ALT

3.1.6 The system shall validate signed station data.

SRD Number: SRD-9

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Data Acquisition

3.1.7 The system shall perform retrospective authentication of CD-1.1 frame data (retrieve historical key and data frame, apply key to data frame, display results).

SRD Number: SRD-10

Status: Current-Partial

Priority: Objective / Priority 1

Type: Functional

Function: Data Acquisition, Data Management

3.1.8 The system shall indicate data completeness and distinguish between missing data (available but not received yet) and incomplete data (not available).

SRD Number: SRD-11

Status: Current

Priority: Threshold

Type: Functional

Function: Data Acquisition, Performance Monitoring

NOTE: Waveform data acquired is stored in the data acquisition data store (GDR). Data is then copied to the OPS subsystem data store. Missing data is data that is not yet present in the OPS data store but is present in the acquisition data store. Incomplete data is that that has not been received from the station.

3.1.9 The system shall include a real-time display of data acquisition status.

SRD Number: SRD-12

Status: Current

Priority: Threshold

Type: Functional

Function: Data Acquisition, Interactive Monitoring, Performance Monitoring

3.1.10 The system shall provide a user interface to start and stop data acquisition.

SRD Number: SRD-13

Status: Current

Priority: Threshold

Type: Functional

Function: Data Acquisition, Interactive Monitoring

3.1.11 The system shall be able to support 10 days of buffered data in case of a communications outage.

SRD Number: SRD-436

Status: Current

Priority: Threshold

Type: Constraint

Function: Data Acquisition, Data Management

NOTE: Data is acquired, stored, processed, and archived and there are other requirements that state that stored data shall be accessible for the life of the system. This requirement states that any data buffers associated with acquisition be capable of storing 10 days of data that has not yet been stored for access to the processing system.

3.1.12 The system shall acquire bulletin data from other similar systems.

SRD Number: SRD-15

Status: Current-Partial

Priority: Objective / Priority 1

Type: Functional

Function: Data Acquisition, External Interfaces

NOTE: Currently bulletin data from similar systems (e.g. USGS, national bulletins) is used for quality control in special event analysis. The intent of this requirement is to operationalize this informal process by providing support for storing and processing this data.

3.1.13 The system shall acquire other (i.e. non-IMS) waveform data according to projections.

SRD Number: SRD-611

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: Data Acquisition, External Interfaces

NOTE: This is intended to include open-source data as provided by, for example, IRIS or other contributed data from Member States. Contributed data in this case is not considered to be from a Contributing National Facility, which has a very specific Treaty meaning.

3.1.14 Auxiliary station data in the data acquisition subsystem shall be made available to processing subsystems upon request by the processing pipelines.

SRD Number: SRD-438

Status: Current

Priority: Threshold

Type: Functional

Function: Data Acquisition, Signal Processing

3.1.15 The system shall authenticate its data requests as specified by the specific request protocol.

SRD Number: SRD-21

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: Data Acquisition, External Interfaces

NOTE: This is intended to be implemented using a Public Key Infrastructure to certify and verify entities, including people and systems.

3.1.16 The system shall forward data in near-real-time to internal and external organizations.

SRD Number: SRD-22

Status: Current

Priority: Threshold

Type: Functional

Function: Data Acquisition, External Interfaces

3.1.17 The system shall complete transfer of waveform data from the data acquisition subsystem to the processing subsystems within 5 minutes of receipt of the data.

SRD Number: SRD-441

Status: Current

Priority: Threshold

Type: Constraint

Function: Data Acquisition

3.1.18 The system shall make selected acquisition statistics available to customers via a website.

SRD Number: SRD-25

Status: Current

Priority: Threshold

Type: Functional

Function: Data Acquisition, Reporting

NOTE: This includes access to different sets of acquisition statistics for internal and external customers. Statistics for internal stakeholders include information about continuous waveform data forwarded as well as information about whether a station's PKI signature can be verified or not.

3.1.19 The system shall compute data availability metrics for data acquisition as specified in the Draft IDC Operational Manual.

SRD Number: SRD-442

Status: Current

Priority: Threshold

Type: Functional

Function: Data Acquisition, Reporting

NOTE: This refers to the various metrics currently being computed by cdqual.

3.1.20 The system shall allow authorized users to securely command/control the seismic, hydroacoustic and infrasound stations of the IMS network according to the IDC Formats and Protocols.

SRD Number: SRD-493

Status: Current-Partial

Priority: Threshold
Type: Functional
Function: Data Acquisition, External Interfaces, Security

NOTE: This requirement is meant to cover support for command and control messages for SHI station calibration and PKI Key management, as described in CTBT/WGB/TL-1/33/Rev.2 "Command and Control of IMS Stations: Procedures for Issuing Commands"

3.1.21 Acquiring Meteorological Data

High resolution (1 deg/1 hour or higher) meteorological data are used to provide up-to-date 3-D (e.g. lat, lon, Z) infrasound velocity and attenuation models in order to more accurately identify infrasound phases, locate infragenic sources, and measure source energy. The data should be acquired in time to satisfy the operational requirements for publishing the event. The most sophisticated 2/3-D propagation models for infrasound include the effect of atmospheric gravity waves. Meteorological data referred to in this section does not include meteorological data acquired at IMS radionuclide and infrasound stations.

3.1.21.1 The system shall request global meteorological data from ground-level to at least 120 km altitude.

SRD Number: SRD-411
Status: Current-Partial
Priority: Threshold
Type: Constraint
Function: Data Acquisition

3.1.21.2 The system shall request global meteorological data within 10 minutes of its availability.

SRD Number: SRD-600
Status: Current-Partial
Priority: Threshold

NOTE: The global meteorology data is assumed to be published on a schedule. The system will request the required data (for example an hourly snapshot) within 10 minutes of its scheduled availability.

3.1.21.3 The system shall derive the 3-D horizontal windspeed and temperature from the meteorological data.

SRD Number: SRD-652
Status: Current-Partial
Priority: Threshold
Function: Earth / Propagation Models

NOTE: This is a 3-D model, sampled, for example, every hour. It is intended to be a snapshot of current meteorological conditions and not intended to be used to reconstruct the full 4-d (time-varying windspeed and temperature) model. The acoustic propagation in a static 3-D model is currently possible, although challenging. A snapshot of the conditions may be used to model network performance, improve location, and more reliably associate infrasound signals with events.

3.1.21.4 The system shall provide an atmospheric gravity wave model.

SRD Number: SRD-601

Status: New

Priority: Extensibility

3.2 Station Processing

3.2.1 Data QC.

Data Quality Control (QC) is required on the system to identify nonstandard or problematic waveforms and remove undesirable waveform data from processing. The goal of Data QC is to automatically scan channel waveform data and produce QC masks as well as to allow users to apply or remove QC Masks. Certain QC Masks should be subsequently used to exclude from data processing portions of waveforms that contain gaps, spikes, drop-outs, invalid channel gains, timing errors, etc. QC Masks should also be used to identify nonstandard or problematic waveforms to the analyst which are still used in processing (e.g., origin beams built with a subset of channels due to a "significant" percentage of missing/noisy channels).

3.2.1.1 The system shall automatically identify any nonstandard or problematic waveform.

SRD Number: SRD-406

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Quality Control

NOTE: Each instance of a channel waveform quality problem is referred to as a QC mask. This requirement covers waveform quality problems reflected in the Draft IDC Operational Manual as well as other quality criteria such as timing problems, authentication failure, calibration, unusual noise.

3.2.1.2 The system shall automatically identify channel waveform data having insufficient quality for use in data processing.

SRD Number: SRD-29

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Quality Control

NOTE: Each instance of a channel waveform quality problem is referred to as a QC mask.

3.2.1.3 The system shall interactively identify nonstandard or problematic waveform data.

SRD Number: SRD-407

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Quality Control

3.2.1.4 The system shall categorize any identified problematic waveform data according to the type of problem.

SRD Number: SRD-492
Status: Current-Partial
Priority: Threshold
Type: Functional
Function: Quality Control

3.2.1.5 The system shall interactively identify channel waveform data having sufficient/insufficient quality for use in data processing.

SRD Number: SRD-30
Status: Current
Priority: Threshold
Type: Functional
Function: IPRA, Interactive Monitoring, Quality Control

NOTE: The users can add/change/remove QC masks, or identify additional waveform data having insufficient quality, as necessary.

3.2.1.6 The system shall interactively identify channel waveform data anticipated in the future to have insufficient quality for use in data processing.

SRD Number: SRD-31
Status: Current
Priority: Threshold
Type: Functional
Function: Interactive Monitoring, Quality Control

NOTE: This mitigates situations where the waveform data has not yet been recorded but the analyst would like to be certain that QC masks are created for the data.

3.2.1.7 The system shall separately store each change/removal/addition to the QC masks, to include the time the change/removal/addition was performed, for the life of the system.

SRD Number: SRD-32
Status: New
Priority: Threshold
Type: Functional
Function: Data Management, Quality Control

NOTE: One intent of this is to record exactly what masks were in place at a given time, not just the current masks.

3.2.1.8 The system shall exclude from both automatic and interactive processing any channel waveform data for which an active QC mask exists for a set of specified mask types.

SRD Number: SRD-33
Status: Current
Priority: Threshold
Type: Functional
Function: IPRA, Quality Control, Signal Processing

NOTE: The active time will usually be the current time, but can be set to a time in the past for testing or research purposes.

3.2.1.9 The system shall provide an indication of channel waveform data that is excluded from processing for a given active time.

SRD Number: SRD-34

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: IPRA, Interactive Monitoring, Quality Control

NOTE: The intent of this requirement is twofold. First to provide an overall view into the masks being generated for all the stations being QC'd. Second to provide the analyst the ability to see masks on individual waveforms during event analysis. The active time will usually be the current time, but can be set to a time in the past for testing or research purposes.

3.2.1.10 The system shall store complete information about how a masked out waveform data segment was used in a processing step.

SRD Number: SRD-444

Status: New

Priority: Threshold

Type: Functional

Function: IPRA, Quality Control

3.2.2 Single- and Multi-Channel Signal Processing.

Single- and Multi-Channel Signal Processing refers to waveform processing such as filtering, beamforming, and polarization analysis.

3.2.2.1 Filtering.

3.2.2.1.1 The system shall filter station data and beams.

SRD Number: SRD-38

Status: Current

Priority: Threshold

Type: Functional

Function: Signal Processing, Waveform Filtering

NOTE: The filter library/service shall be designed to allow easy extensibility for additional filters in the future. Filters should be able to be cascaded and include:

- Butterworth Filter
- Autoregressive Filter

- Phase Match Filter (PMF)
- Pseudo Correlation Filter (PCF)
- Finite Impulse Response (FIR)
- Infinite Impulse Response including Chebychev Filters (IIR)
- Generic Coefficient Filter (GCF) The generic coefficient filter provides a mechanism for passing new filter coefficients into processing for implementing filtering techniques that are not available in the filter library.

3.2.2.1.2 The system shall remove group delay (e.g., instrument, filter).

SRD Number: SRD-39

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: Signal Processing, Waveform Filtering

3.2.2.2 Frequency-Wavenumber (fk) Analysis.

3.2.2.2.1 The system shall compute frequency-domain measurements.

SRD Number: SRD-41

Status: Current

Priority: Threshold

Type: Functional

Function: Frequency-Wavenumber (fk) Analysis, Multichannel Processing, Signal Processing

NOTE: Measurements will include attributes such as frequency content and power.

3.2.2.2.2 The system shall compute frequency-wavenumber (fk) measurements.

SRD Number: SRD-42

Status: Current

Priority: Threshold

Type: Functional

Function: Frequency-Wavenumber (fk) Analysis, Multichannel Processing, Signal Processing

NOTE: Measurements will include Azimuth, Slowness, Fstat, delaz, and del slo.

3.2.2.3 Beamforming and Three Component Processing.

Data from sensor arrays and three component seismometers are used to enhance signal characteristics for detection processing and feature extraction. Beamforming is a multichannel signal processing technique that focuses the elements of an array in a specific direction. This provides a signal-to-noise ratio gain via constructive interference of coherent directional signals and destructive interference of incoherent background noise. Data from a three

component seismometer is rotated to the signal's angle of arrival to form traces that correspond to radial and transverse ground motion.

3.2.2.3.1 The system shall perform polarization analysis on multi-component (e.g., 3-component) waveform data.

SRD Number: SRD-44

Status: Current

Priority: Threshold

Type: Functional

Function: Multichannel Processing, Signal Processing

3.2.2.3.2 The system shall rotate data from three-component seismometers according to user-specified reference frame.

SRD Number: SRD-382

Status: Current

Priority: Threshold

Type: Functional

Function: Multichannel Processing, Signal Processing

NOTE: Example reference frames include radial/transverse/vertical directions relative to an event, P/SV/SH relative to a ray direction, Hilbert-transformed radial and tangential/vertical relative to an event (for surface waves). Rotated beams shall be formed from data acquired by a three component seismic array.

3.2.2.3.3 The system shall automatically generate arrival beams, from frequency and wave number (fk) processing, for all primary seismic stations in the IMS network.

SRD Number: SRD-446

Status: Current

Priority: Threshold

Type: Functional

Function: Frequency-Wavenumber (fk) Analysis, Multichannel Processing, Signal Processing

3.2.2.3.4 The system shall automatically generate origin beams, in the predicted arrival time window, and steered to an origin, for seismic array sensor stations that do not have associated detections.

SRD Number: SRD-447

Status: Current

Priority: Threshold

Type: Functional

Function: Frequency-Wavenumber (fk) Analysis, Multichannel Processing, Signal Processing

3.2.2.3.5 The system shall both automatically and interactively form beams based on configurable criteria.

SRD Number: SRD-384

Status: Current

Priority: Threshold
Type: Functional
Function: Multichannel Processing, Signal Processing

NOTE: Beams are normally formed based on events, origins, arrivals, detections etc. Beams should be able to be formed for the following, but not be limited to:

- Vertical and 3-component Array beams
- Radial and Transverse beams
- Broadband to Long Period (BBLP) beams

Beam parameters' configurable criteria should include, but not limited to:

- Input channels
- Phase-ID
- Length or duration
- Start time (prior to a specific phase)
- End time (after a specific phase)
- Number and type of beams. (i.e., fk vs. event beams; teleseismic vs. regional; long-period vs. short-period.)

3.2.3 Detection.

3.2.3.1 The system shall pre-process unprocessed data prior to signal detection.

SRD Number: SRD-52
Function: Data Management

NOTE: Pre-processed data includes pre-filtering data prior to beam forming (essential for LP arrays which have one BB site); configuration of beam parameters, recipe files, and filters; conditioning of the waveform to include removal of system transfer function; and conditioning of the waveform to include filtering for passbands of interest.

3.2.3.2 The system shall perform signal detection on waveform data.

SRD Number: SRD-653
Status: Current
Priority: Threshold
Type: Functional
Function: Detection, Signal Processing

NOTE: The following signal detection strategies shall be implemented but not limited to:

- non-central F-detector (Fisher Detector)
- correlation detectors including the Progressive Multi-Channel-Correlation (PMCC) detector
- Power detector (STA/LTA detector)
- Z detector

- Log-Z detector

The detector implementation should accommodate the loss of coherence between sensors.

3.2.3.3 The system shall accommodate variations in the background noise at individual sensors and field sites without disrupting normal operations.

SRD Number: SRD-54

Status: Current

Priority: Threshold

Type: Non-Functional

Function: Detection, Signal Processing

NOTE: It should be understood that this includes sensors from all waveform technologies.

3.2.3.4 The system shall allow for the simultaneous detection of multiple signals on different detection beams.

SRD Number: SRD-55

Status: Current

Priority: Threshold

Type: Functional

Function: Detection, Signal Processing

NOTE: Functionality is configurable on a station-by-station basis. Examples of configurable detection processing functionality are:

- To prevent a Pg detection from obscuring an Lg detection.
- To prevent teleseismic P parameters from being used for Pn and Lg feature extraction.
- When the maximum peak in the fk spectrum is associated to a STA peak as opposed to the peak for the STA/LTA detection.
- Superimposed signals (e.g., a low SNR teleseismic P gets "missed" because of the presence of a high SNR Rg).

3.2.3.5 The system shall allow all detection and feature extraction parameters to be specified on a detection-beam by detection-beam basis.

SRD Number: SRD-56

Status: Current

Priority: Threshold

Type: Non-Functional

Function: Detection, Signal Processing

3.2.4 Signal Characterization / Feature Extraction.

Signal characterization/feature extraction requirements cover a range of data processing which centers on measuring alphanumeric parameters of waveform data (e.g., amplitude, period, azimuth, velocity) and making determinations based on those values (e.g., initial Phase ID). Note that there is considerable overlap between feature extraction and signal detection.

3.2.4.1 The system shall compute time-domain measurements.

SRD Number: SRD-62

Status: Current

Priority: Threshold

Type: Functional

Function: Signal Characterization / Feature Extraction, Signal Processing

NOTE: These measurements should include the following:

- onset time,
- Amplitude - peak-trough, 0-peak, rms,
- period, peak-trough, zero-crossings
- polarization,
- closure and consistency (for infrasound signals)
- coda duration

3.2.4.2 The system shall recalculate derived computations, measurements, etc., by various pipeline processes and users.

SRD Number: SRD-63

Status: Current

Priority: Threshold

Type: Functional

Function: Signal Characterization / Feature Extraction, Signal Processing

NOTE: Derived alphanumeric information and measurements for late data and/or analyst added or modified arrivals will be computed on demand by the user or the post analyst review automated pipeline.

3.2.4.3 The system shall perform initial phase identification based on available signal characteristics.

SRD Number: SRD-64

Status: Current

Priority: Threshold

Type: Functional

Function: Signal Characterization / Feature Extraction, Signal Processing

NOTE: Phase identification should be understood to cover all technologies. Specific phases are covered in other requirements. This requirement should also be understood to cover cross-technology phase identification, including seismic phases on hydrophone stations, hydro-acoustic signals on seismic stations (including the so-called T-stations), and seismic phases on infrasound stations.

3.2.4.4 The system shall identify detected signals based on available signal characteristics.

SRD Number: SRD-620

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: Signal Characterization / Feature Extraction, Signal Processing

NOTE: 'Signals' are distinct from 'phases' in that the source of a 'phase' may be inferred. Automatic identification of phases shall be done for all phenomenology types and may include identification of noise phases.

3.2.4.5 The system shall identify the direct hydroacoustic phase and the converted tertiary (T) phase.

SRD Number: SRD-65

Status: Current

Priority: Threshold

Type: Functional

Function: Signal Characterization / Feature Extraction, Signal Processing

NOTE: As noted in SRD-64, specific phase identifications are called out in the requirements, for example, this one.

3.2.4.6 The system shall make additional types of feature measurements.

SRD Number: SRD-66

Status: New

Priority: Threshold

Type: Functional

Function: Magnitude, Signal Characterization / Feature Extraction, Signal Processing

Background: The system needs the ability to use the latest state-of-the-art measurements. These measurements include but are not limited to: coda amplitudes, envelopes for the complex analytic signal, and three-component amplitude measurements.

NOTE: This implies an extensible design, not an Extensible priority.

3.2.4.7 The system software shall include logic to detect signals of interest in the presence of local noise sources.

SRD Number: SRD-67

Status: Current

Priority: Threshold

Type: Functional

Function: Detection, Signal Characterization / Feature Extraction, Signal Processing

Background: Erroneous fk parameters frequently lead to missed/screened detections. Two examples of situations that lead to erroneous fk parameter estimates and missed/screened detections are:

- When the maximum peak in the fk spectrum is associated to a STA peak as opposed to the peak for the STA/LTA detection.
- Superimposed signals (e.g., a low SNR teleseismic P gets missed because of the presence of a high SNR Rg).
- The fk analysis was initially added to the system to "interpolate" between detection beams. The fk analysis should not be allowed to wander off on its own and return features for sidelobes or signals that are of no interest.

3.2.4.8 The system shall provide access to full transfer functions for all station channels.

SRD Number: SRD-512

Status: Current-Partial

Priority: Threshold
Type: Functional
Function: Signal Characterization / Feature Extraction, Signal Processing

NOTE: "Full transfer function" for seismic and hydroacoustic arrays is as conventionally understood. However the full transfer function for infrasound stations will include the spatial-filter used to reduce the effect of turbulence. This function shall accommodate all signal arrival directions and trace velocities. In effect, for seismic and hydroacoustic components, the instrument response is essentially FAP (or a pole-zero+filter equivalent). For infrasound components, the instrument response is FAPSA where SA indicates vertical slowness and azimuth.

3.3 Network Processing

After signals are detected, they are associated to common events/origins.

3.3.1 Association.

3.3.1.1 The system shall use the latest approved path dependent Earth models for time, azimuth and slowness prediction during automated association.

SRD Number: SRD-71
Status: Current
Priority: Threshold
Type: Functional
Function: Association, Earth / Propagation Models

3.3.1.2 The system's association logic shall include station-to-event distance, event magnitude, and dynamic consideration of waveform data quality, availability and station noise level when forming events.

SRD Number: SRD-72
Status: Current-Partial
Priority: Threshold
Type: Functional
Function: Association

3.3.1.3 The system shall combine phenomenology when forming events.

SRD Number: SRD-73
Status: Current
Priority: Threshold
Type: Functional
Function: Association

NOTE: Seismic, hydroacoustic and infrasound can each be used independently, or combined to form a single event. The intent of this requirement is to also plan for future phenomenologies and their integration with the current ones.

3.3.1.4 The system shall use event location to assign phase identification based on predicted and/or available empirical phase ID matching.

SRD Number: SRD-74

Status: Current
Priority: Threshold
Type: Functional
Function: Association, Location, Signal Characterization / Feature Extraction

3.3.1.5 The system shall automatically group phases from a single station that belong to the same event.

SRD Number: SRD-75
Status: Current
Priority: Threshold
Type: Functional
Function: Association

3.3.1.6 The system shall automatically group phases from multiple stations that belong to the same event.

SRD Number: SRD-76
Status: Current
Priority: Threshold
Type: Functional
Function: Association

3.3.1.7 The system shall automatically use multiple techniques to group phases from multiple stations that belong to the same event.

SRD Number: SRD-77
Status: Current
Priority: Threshold
Type: Functional
Function: Association

NOTE: This requirement is meant to describe the methods used to group phases which may include, but is not limited to, grid search methods and correlation methods.

3.3.1.8 The system shall modify phase identifications from multiple phenomenologies, as appropriate, when automatically associating phases to events.

SRD Number: SRD-78
Status: Current
Priority: Threshold
Type: Functional
Function: Association, Signal Characterization / Feature Extraction, Signal Processing

3.3.1.9 The system shall automatically form and refine events using signal association as signals become available.

SRD Number: SRD-79
Status: Current
Priority: Threshold
Type: Functional
Function: Association

NOTE: Event formation and association shall occur for near-real-time data as well as late data. Currently late association is triggered by a newly added arrival.

3.3.1.10 The system shall provide automated notification of new associations to new or existing events of interest resulting from automated association of late-arriving detections.

SRD Number: SRD-80

Status: New

Priority: Threshold

Type: Functional

Function: Association, Events of Interest, IPRA

3.3.1.11 The system shall perform automated association of late-arriving detections that were not available in previous network association, between interactive stages of pipeline processing.

SRD Number: SRD-81

Status: New

Priority: Threshold

Type: Functional

Function: Association, IPRA

3.3.1.12 The system shall form new events with late-arriving detections and preexisting unassociated detections, in such a way that events previously rejected in user review are not formed again.

SRD Number: SRD-82

Status: New

Priority: Threshold

Type: Functional

Function: Association, IPRA

3.3.1.13 The system shall automatically associate late arriving and existing unassociated detections to user-reviewed events without altering the event location or magnitude.

SRD Number: SRD-83

Status: New

Priority: Threshold

Type: Constraint

Function: Association

NOTE: "Late arriving detections" in this requirement refer to detections made after initial association is made either due to data arriving after processing or detection processes run after association.

3.3.1.14 The system shall support variable resolution of earth model information used in association (to reflect the network's ability to resolve/distinguish signals emanating from events in that region).

SRD Number: SRD-84

Status: Current

Priority: Threshold

Type: Non-Functional

Function: Association, Earth / Propagation Models

3.3.1.15 The system shall generate an Event Quality metric for each event formed.

SRD Number: SRD-85

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Location, Quality Control

NOTE: An event Quality metric indicates the quality of the event. This metric utilizes associated Station Quality metrics/information, STA/LTA noise levels, location, etc. as input; and is represented as a number between zero (0) and one (1).

3.3.1.16 The system shall perform initial event confirmation screening of automatically formed events based on the Event Quality metric (e.g., screening of likely false events based on a configurable Event Quality metric threshold).

SRD Number: SRD-86

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Association, Location, Quality Control

3.3.1.17 The system shall update Event Quality metrics based on interactive review.

SRD Number: SRD-87

Status: New

Priority: Threshold

Type: Functional

Function: IPRA, Location, Quality Control

3.3.1.18 The system's automatic and interactive software shall compute, and preserve in the database, an Event Quality metric.

SRD Number: SRD-88

Status: New

Priority: Threshold

Type: Functional

Function: Data Management, IPRA, Location, Quality Control

Intent: This metric shall encapsulate information about: detecting/non-detecting stations that are up/down, detecting/non-detecting station sensitivity (i.e., array vs. non-array sites), current noise levels at detecting/non-detecting sites, station magnitude/amplitude residuals (bases on the network magnitude), and time, azimuth and apparent velocity residuals (weighted by measurement and modeling uncertainties).

Background: The associator's event confirmation and conflict resolution parameters need to be dynamic. A high station quality increases the weight of that station for the cells for which that station is a driver. However, bogus events have been observed with the nearest seven (7) stations non-observing; this should not happen. The ultimate goal is to use "noise" statistics to determine a (dynamic) detection threshold/probability of detection on a station-by-station basis. See for example the following paper regarding station detection capabilities that vary on a daily and seasonal basis: F.Ringdal and H.Bungum, Noise level variation at NORSAR and its effect on detectability, BSSA, Vol.67, no.2, 489-492, 1977. An event quality/likelihood metric for automatic and user built events will be extremely useful for tuning and training. Such a metric would make it easy to, for example, tell the associator not to build events using a Pn and two PKP's if the three closest array sites did not contribute to the event (provided they were up at the time); this type of illogical event is not uncommon in the current system.

3.3.1.19 The system shall use available station quality information to calculate station quality metrics for use in event generation and event quality calculations.

SRD Number: SRD-408

Status: Current

Priority: Threshold

Type: Functional

Function: Location, Quality Control

NOTE: The station quality metrics may include, but are not limited to, station noise level, data availability, and QC Masking.

3.3.1.20 The system's station quality values shall be used as weighting factors for event confirmation and conflict resolution.

SRD Number: SRD-89

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Association, Quality Control

3.3.2 Location.

Due to the heterogeneity of the Earth, location of events in three dimensions is a scientifically challenging problem. The system must integrate the constantly evolving state-of-the-art earth models and location algorithms.

3.3.2.1 The system shall compute a location using seismic and/or hydroacoustic and/or infrasonic data.

SRD Number: SRD-92

Status: Current

Priority: Threshold

Type: Functional

Function: Location

NOTE: Location is defined by latitude, longitude, depth, origin time, and uncertainty measure. The uncertainty measure must be sufficient to calculate the confidence and coverage ellipses or ellipsoids for any confidence limit.

3.3.2.2 The system shall locate events using teleseismic and regional seismic phases.

SRD Number: SRD-93

Status: Current

Priority: Threshold

Type: Functional

Function: Location

NOTE: This requirement implies that the regional seismic travel time model is consistent with the teleseismic velocity model.

3.3.2.3 The system shall compute and store multiple (unique) origin solutions for any event (e.g., Unrestrained and/or restrained to any combination of lat, lon, depth, time, stations, or phases.

SRD Number: SRD-94

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Association, Data Management, Location

3.3.2.4 The system shall designate a preferred origin for each event for each stage of processing.

SRD Number: SRD-95

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Data Management, Location

3.3.2.5 The system shall allow each event solution to be associated to a specific processing stage.

SRD Number: SRD-96

Status: Current

Priority: Threshold

Type: Non-Functional

Function: Data Management, Location

NOTE: This intent of this requirement is to support event reviews from least to most experienced analyst through a named pipeline of processing stages. However, this requirement should not limit the number of reviews.

3.3.2.6 The system shall allow an event to be tracked across processing stages.

SRD Number: SRD-448

Status: Current-Partial

Priority: Threshold

Type: Non-Functional

Function: Data Management

3.3.2.7 The system shall identify each origin as located in a defined geographic region based on origin solution.

SRD Number: SRD-98

Status: Current

Priority: Threshold

Type: Functional

Function: Geographic Information System, Location

NOTE: The defined geographic regions include the Flinn-Engdahl regions, but the requirement is general enough to cover other regionalizations.

3.3.2.8 The system shall use empirical travel time, azimuth, apparent velocity, and historical probability of detection information, where available, in event formation processing.

SRD Number: SRD-99

Status: Current

Priority: Threshold

Type: Functional

Function: Earth / Propagation Models, IPRA, Location, TTAS

NOTE: Populate the associator grid with empirical data where applicable.

3.3.2.9 The system shall re-compute the solutions based on modified observations and location parameters.

SRD Number: SRD-100

Status: Current

Priority: Threshold

Type: Functional

Function: Earth / Propagation Models, IPRA, Location

3.3.2.10 The system shall compute an event location using any combination of time, azimuth, and slowness observations from single or multiple stations.

SRD Number: SRD-101

Status: Current

Priority: Threshold

Type: Functional

Function: Association, Earth / Propagation Models, Location, TTAS

3.3.2.11 The system shall compute and store arrival measurement and model a priori uncertainties, and incorporate these uncertainties in event location calculations.

SRD Number: SRD-102

Status: Current

Priority: Threshold

Type: Functional

Function: Confidence, Data Management, Earth / Propagation Models, Location, TTAS

3.3.2.12 The system shall modify defining observations (e.g., select, deselect, add, delete, retime).

SRD Number: SRD-103

Status: Current

Priority: Threshold

Type: Functional

Function: IPRA, Location

3.3.2.13 The system shall use current high resolution meteorological data to associate infrasound phases and locate infrasound sources.

SRD Number: SRD-418

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Location

3.3.2.14 The system shall calculate infrasound travel-time, slowness, attenuation and associated uncertainties for global three-dimensional atmospheric models for the refinement of source location and parameter estimation.

SRD Number: SRD-419

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: Location

NOTE: This requirement is intended to specify the capability to model infrasound propagation through 3-D models, which are derived on a schedule, e.g. every hour. The requirement is not intended to imply that there is the capability to model propagation through a time-varying model.

The system must provide an infrasound propagation model and tool that will allow for the refinement of infrasound

source location and parameter estimation. For example, this could be:

- a 3D ray tracing model that has been benchmarked by the research community
- reduced mode propagation models
- other propagation models.

Multiple tools may be provided that apply various degrees of approximation to be used in different contexts depending on the performance required. This is analogous to the seismic or hydroacoustic case, except the model is time dependent.

3.3.2.15 The system shall merge existing events with overlapping sets of associated arrivals and unassociated arrivals into a single event list.

SRD Number: SRD-421

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Location

NOTE: This function is a common task during an association algorithm, and generalized it becomes a powerful tool in analysis and joining processing streams. It allows, for example, (1) phase prediction for later phases, (2) introducing a regional event list to find common events and phases (3) merging results from two or more processing streams - for example one tuned for aftershocks and another searching globally.

3.3.3 Magnitude Estimation.

After events are located, magnitude is determined as a function of the relevant feature measurements, the distance between the source and receiver(s), and known attenuation factors.

3.3.3.1 The system shall compute and store single-station and network magnitude estimates, including but not limited to: ml, mb, mbMLE, ms, msMLE, msVMAX, mwcoda, mbrel and infrasound magnitude.

SRD Number: SRD-106

Type: Functional

Function: Data Management

NOTE: IDC cannot currently calculate all of these magnitudes.

3.3.3.2 The system shall use station, path, and frequency specific attenuation information to compute magnitude estimates.

SRD Number: SRD-107

Status: Current-Partial

Priority: Threshold

Type: Non-Functional

Function: Attenuation, Earth / Propagation Models, Magnitude, TTAS

NOTE: path and frequency-dependent attenuation is applicable to some magnitude measures, e.g. msVMAX, or a moment magnitude, if the IDC chooses to begin calculating it. Frequency dependent attenuation is important for event screening measurements.

3.3.3.3 The system shall compute and store uncertainties for all magnitude estimates.

SRD Number: SRD-108

Status: Current

Priority: Threshold

Type: Functional

Function: Attenuation, Confidence, Data Management, Earth / Propagation Models, Magnitude

3.3.3.4 The system shall provide the ability to specify magnitude defining stations and phases for computing network averages.

SRD Number: SRD-110

Status: Current

Priority: Threshold

Type: Non-Functional

Function: Magnitude

3.3.3.5 The system shall automatically or interactively compute deviatoric moment tensor solutions from filtered three-component long-period regional waveforms.

SRD Number: SRD-394

Status: Current-Partial

Priority: Objective / Priority 1

Type: Functional

Function: Earth / Propagation Models, Magnitude

NOTE: The moment-tensor elements, fault-plane solution, seismic moment, origin time, depth, percent double-couple and fit uncertainty should be saved to the database.

3.3.3.6 The system shall automatically or interactively compute full moment tensor solutions in addition to and in the same manner as deviatoric moment tensor solutions.

SRD Number: SRD-395

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: Earth / Propagation Models, Magnitude

NOTE : The isotropic and deviatoric components shall be computed from the full moment tensor and be plotted on a source type plot (i.e., Hudson et al., 1989) along with associated error ellipses (i.e., Ford et al., 2009) computed from bootstrap resampling.

3.4 Interactive Monitoring, Processing, Review, and Analysis.

The purpose of Interactive Review is to provide the user with the capability to review, refine, correct, and/or display the currently available results, regardless of whether they have been generated directly from the automated

processing system or from previous analysis by another user.

3.4.1 Systems Control.

3.4.1.1 The system shall display system State-of-Health (SOH) information.

SRD Number: SRD-120

Status: Current

Priority: Threshold

Type: Functional

Function: Interactive Monitoring, Performance Monitoring

3.4.2 Operations Manager Log

3.4.2.1 The system shall provide a GUI for the entry, retrieval, display, and archiving of Operations Manager Log information.

SRD Number: SRD-122

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Data Management, Interactive Monitoring

NOTE: An Operator is assumed to be one of the actors in the system and represents a human user who configures, runs and monitors SHI automatic processing software. Actors are described in the described in the Use Case Document and are associated with system roles and privileges. See sections 3.6 (Reporting) and 3.17 (Security) for requirements regarding how users are to be authorized to fulfil system roles. The Operator Log records some automated system activities and allows the operators to input text describing the on-going operational activities. The Operator Log is persisted.

3.4.3 Analyst/Evaluator

3.4.3.1 The system shall provide the full range of interactive processing functionality.

SRD Number: SRD-124

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: IPRA

NOTE: Including but not limited to:

- Manual signal detection
- Flexible trace windowing and manipulation (e.g., zoom, scale)
- Channel sorting, manipulation, and expansion of arrays and three-component data.
- Filtering

- Spectral analysis
- fk and polarization analysis
- Beamforming (both fk and event beams)
- 2-D and 3-D component rotation
- Amplitude and period measurements
- Single and multi-station location
- Prediction of most of the known seismic phases (approximately 75 phases)
- Mapping (e.g., displaying results on maps including the location of known infrasound sources such as mines, volcanoes, space centres, etc.)
- Displaying detection feature maps and their associated detection parameters: azimuth, trace velocity, correlation, RMS amplitude, PP amplitude, Number of sensors (participating in the solution), Fstat, etc
- Spectrograms
- F-beams
- LP-dispersion
- Phase-matched-filter
- Correlation with selected reference event.

A capability of displaying eigenrays and attenuation maps for infrasound source locations.

3.4.3.2 The system shall present results of correlation analysis via dendrogram.

SRD Number: SRD-125

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: IPRA, Signal Processing

3.4.3.3 The system shall synchronize GUIs based on user action.

SRD Number: SRD-126

Status: New

Priority: Objective / Priority 1

Type: Non-Functional

Function: IPRA

NOTE: For example, as a user selects an event, the map automatically centers on the selected event, while the event information display shows the associated alphanumeric, and the waveform display shows the associated waveforms.

3.4.3.4 The system shall allow users to process a specified time block.

SRD Number: SRD-127

Status: New

Priority: Objective / Priority 1

Type: Non-Functional

Function: IPRA

3.4.3.5 The system shall allow users to process events in any order.

SRD Number: SRD-128

Status: Current

Priority: Threshold

Type: Non-Functional

Function: IPRA

3.4.3.6 The system shall allow interactive relative event relocations.

SRD Number: SRD-129

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: IPRA, Location

NOTE: Often a series of events with similar sources will occur where it is more effective to locate them relative one another rather than individually.

3.4.3.7 The system shall allow the users to update an interactive session to display newly acquired waveform data.

SRD Number: SRD-130

Status: New

Priority: Objective / Priority 2

Type: Functional

Function: Data Acquisition, IPRA

3.4.3.8 The system shall notify the user if new waveform or alphanumeric data arrives during an interactive processing session.

SRD Number: SRD-131

Status: New

Priority: Objective / Priority 2

Type: Functional

Function: Data Acquisition, IPRA

3.4.3.9 The system shall provide feedback functionality for user training.

SRD Number: SRD-133

Status: Current-Partial

Priority: Objective / Priority 1

Type: Functional

Function: IPRA, Subsystem - Training

NOTE: The system needs a mechanism by which changes - in particular analyst changes - are tracked. For example, more experienced users can provide feedback to the less advanced when re-analyzing data. Similarly, the user changes to an automatically detected event would provide insight into how to improve automatic processing.

3.4.3.10 The system shall support analysts working from a remote location over a secure connection.

SRD Number: SRD-450

Status: Current-Partial

Priority: Threshold
Type: Functional
Function: IPRA, Security, System-wide

NOTE: Transfer and storage of data outside the IDC for the purposes of supporting analysts working from remote locations will be minimized as this represents a security risk.

3.4.3.11 The system shall use the same algorithms during interactive processing as those used in automated processing.

SRD Number: SRD-135

Status: Current

Priority: Threshold

Type: Project Issues

Function: IPRA, Signal Characterization / Feature Extraction

3.4.3.12 The system shall display and modify results from any/all stages of data processing.

SRD Number: SRD-136

Status: Current

Priority: Threshold

Type: Functional

Function: Association, Data Management, Frequency-Wavenumber (fk) Analysis, Geographic Information System, IPRA, Location, Magnitude, Signal Characterization / Feature Extraction, Signal Processing

NOTE: Including but not limited to:

- Re-time
- Add or remove arrivals
- Redefine phase designation
- Modify amplitude measurements
- Adjust beams, and add channels.
- Manual signal detection.
- Flexible trace windowing and manipulation (e.g., zoom, scale).
- Channel sorting, manipulation, and expansion of arrays and three-component data.
- Filtering.
- Spectral analysis.
- fk analysis.
- Beamforming (both fk and event beams).
- 2-D and 3-D component rotation.
- Amplitude and period measurements.
- Single and multi-station location.
- Prediction of most of the known seismic phases (approximately 75 phases).

- Mapping (e.g., displaying results on maps).
- Detection feature maps.
- Spectrograms
- F-beams
- LP-dispersion
- Phase-matched-filter
- Correlation with selected reference event

Some of these capabilities are not yet integrated, reflected in Status.

3.4.3.13 The system shall provide an interactive interface to select earth model parameters for use in location and prediction.

SRD Number: SRD-137

Status: New

Priority: Threshold

Type: Functional

Function: Earth / Propagation Models, IPRA, Location

NOTE: Under routine operations, a standard velocity model is used and there is little need for an analyst to switch between velocity models. This capability will be useful for users acting in the research role.

3.4.3.14 The system shall interactively form new event hypothesis, associate additional corroborating arrivals to existing events, and review the results.

SRD Number: SRD-138

Status: Current

Priority: Threshold

Type: Functional

Function: Association, IPRA, Location

NOTE: The intent of this requirement is to provide an interactively initiated function to automatically generate additional event hypotheses for evaluation and to automatically associate existing arrivals to events. The event formation criteria will likely be different from those in automatic processing. The newly formed events will not modify any other user-reviewed events. The new associations to existing user reviewed events will be non-defining, so as not to modify their solution. This processing mode should apply to seismic, hydroacoustic, and infrasonic signals and events.

3.4.3.15 The system shall preserve a complete history/audit trail for every saved event and allow users to recall and review an event at any point in its history.

SRD Number: SRD-139

Status: Current-Partial

Priority: Threshold

Type: Non-Functional

Function: Data Management, IPRA

NOTE: Analyst tools will allow the analyst to select a specific saved version of an event and will display the event and its associated attributes as originally seen by the analyst that saved the event. This will include, but not be limited to, associations, origin solutions, defining flags, and magnitudes.

3.4.3.16 The system shall allow interactive retrieval of data at any time regardless of processing status to allow analysts to open an event before post processing is completed.

SRD Number: SRD-140

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: Data Management, IPRA

3.4.3.17 The system shall recall and review event and waveform data from a reference event database.

SRD Number: SRD-141

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: Data Management, IPRA

3.4.3.18 The system shall, as selected by the user, allow the arrival selection criteria that defines which stations are to be used for which functions to be based on a time interval for an entire network, a time interval for a selected subset of stations, or a set of individually selected arrivals.

SRD Number: SRD-142

Status: New

Priority: Objective / Priority 1

Type: Non-Functional

Function: IPRA

3.4.3.19 The system shall display continuous beams for virtual origins steered to predefined locations/geographic regions.

SRD Number: SRD-144

Status: Current

Priority: Threshold

Type: Functional

Function: IPRA, Multichannel Processing, Signal Processing

3.4.3.20 The system shall manually create beams steered to a user specified/selected point in slowness space.

SRD Number: SRD-145

Status: Current

Priority: Threshold

Type: Functional

Function: IPRA, Multichannel Processing, Signal Processing

3.4.3.21 The system shall provide a Graphical User Interface to display information about station instrumentation, deployment, and configuration parameter values for detection and feature extraction functions, based on user selection of a station and the information to be displayed.

SRD Number: SRD-398

Status: Current

Priority: Threshold

Type: Functional

Function: IPRA

3.4.3.22 The system shall provide a mechanism for each analyst to save comments/observations with each saved event.

SRD Number: SRD-400

Status: Current

Priority: Threshold

Type: Functional

Function: Data Management, IPRA

NOTE: Saved analyst comments should always be available for view when an event is opened or reviewed.

3.4.4 Processing Stage Workflow

3.4.4.1 The system shall provide for an incremental processing stage workflow.

SRD Number: SRD-402

Status: Current

Priority: Threshold

Type: Functional

Function: IPRA, System-wide

NOTE: The intent of this requirement is for the system to support the passing of data and events through multiple reviews. These may be automated or human-generated and should be flexible enough to change for specific situations or to support changes in operational processing concepts.

3.4.4.2 The system shall provide user interfaces to view the status of the processing stage workflow.

SRD Number: SRD-403

Status: Current

Priority: Threshold

Type: Functional

Function: IPRA, System-wide

NOTE: The intent of this requirement is to provide an overall workflow monitoring concept allowing users to see the current stage and status of any data moving through the processing stages.

3.4.4.3 The system shall provide user interfaces for the allocation of workflow processing stages to users.

SRD Number: SRD-404

Status: Current

Priority: Threshold

Type: Functional

Function: IPRA

3.4.5 Event Consistency

An assessment of Event Consistency can be performed for each Seismic, Hydroacoustic and Infrasound event that is

formed after automatic or interactive processing. This check is based on how closely an event matches the event requirements as stipulated in the IDC Analyst Rules and Guidelines document. When an event fails to meet all the criteria a warning message indicating the level of severity needs to be issued.

NOTE: included here will be:

- the expected list of phases for the magnitude under consideration given the hypothesized source location and a knowledge of historical seismicity
- a warning if phases are out of order: S before P for example
- expected depth phases
- illegal defining attributes
- slow, az, time residuals exceeding a specified limit
- expected phases/stations for a hypothesized event location
- etc.

3.4.5.1 The system shall assess the Event Consistency, which is determined by how closely an event's properties match specific Event Criteria.

SRD Number: SRD-424

Status: Current

Priority: Threshold

Type: Functional

Function: IPRA, Quality Control

NOTE: The specific Event Criteria are currently detailed in the document: "Analyst Instructions for Seismic, Hydroacoustic and Infrasonic Data 6.2.5 Rev 1". A subset of the Event Consistency checks can be applied either automatically in the bulletin migration stage, or at any time by any authorized user.

3.4.5.2 The system shall assess the Event Consistency automatically for saved events.

SRD Number: SRD-490

Status: Current

Priority: Threshold

Type: Functional

Function: Quality Control

3.4.5.3 The system shall interactively assess the Event Consistency, e.g. for events defined during analyst review.

SRD Number: SRD-491

Status: Current

Priority: Threshold

Type: Functional

Function: IPRA, Quality Control

3.4.5.4 The system shall produce a report containing the Event Consistency check for a single event within 3 s.

SRD Number: SRD-425

Status: Current

Priority: Threshold

Type: Functional
Function: IPRA, Quality Control, Reporting

3.4.5.5 The system shall automatically correct event parameters based on the Event Consistency Report.

SRD Number: SRD-427
Status: Current
Priority: Threshold
Type: Functional
Function: IPRA, Quality Control

3.4.5.6 The system shall check that the event definition criteria are satisfied for each event hypothesis.

SRD Number: SRD-624
Status: Current
Priority: Threshold
Type: Functional
Function: Quality Control

NOTE: This is important from an IDC processing perspective as we filter events in the bulletin migration stage: LEB and REB are based on the success of this step. Separate out the requirement that there are at least 3 primary stations, and that the event weight is above a specified threshold.

3.4.5.7 The system shall check that all event-related database tables are internally consistent and populated with valid types for each event hypothesis.

SRD Number: SRD-625
Status: Current
Priority: Threshold
Type: Functional
Function: Quality Control

NOTE: BullQC scripts check if database event tables are consistent. Checks include 1: if there is a valid magnitude entry in the netmag table, is it reflected in the origin table, 2: are there any events that that are not present in the origin or the discard table, 3: are there any unassociated arrivals, and 4: are any unsupported amptypes or magtypes present in the tables.

3.4.5.8 The system shall check that event information is consistent for an event located at the hypothesised source location with the magnitude estimate.

SRD Number: SRD-626
Status: Current
Priority: Threshold
Type: Functional
Function: Data Management, Quality Control

NOTE: The following checks are made - 1: do close events have an appropriate list of regional phases, 2: is there a deep event with ML estimate, 3: are the phases in the correct order, 4: should PKP actually be PKhKP, 5: are the correct list of stations seeing this event of a particular magnitude in this geographic location (similar check for the phases and their ordering), 5: when compared with the network magnitude, are there magnitude outliers coming from the station magnitude estimates

3.4.5.9 The system shall check the defining attributes are correctly set for the event hypothesis and that azimuth, slowness and time residuals are within bounds.

SRD Number: SRD-627

Status: Current

Priority: Threshold

Type: Functional

Function: Quality Control

NOTE: following checks are made - 1: are azimuth and slowness defining but time is not-defining, 2: is the time residual too large for time to be defining.

3.4.6 Event Screening

NOTE: The intent of these criteria is to allow screening out of events that are consistent with non-nuclear phenomena. Specific criteria to be used for screening are specified in Annex 2 to the Protocol of the CTBT as follows.

For events detected by the International Monitoring System seismic component, the following parameters, *inter alia*, may be used:

- location of the event;
- depth of the event;
- ratio of the magnitude of surface waves to body waves;
- signal frequency content;
- spectral ratios of phases;
- spectral scalloping;
- first motion of the P-wave;
- focal mechanism;
- relative excitation of seismic phases;
- comparative measures to other events and groups of events; and
- regional discriminants where applicable.

For events detected by the International Monitoring System hydroacoustic component, the following parameters, *inter alia*, may be used:

- signal frequency content including corner frequency, wide-band energy and mean centre frequency and bandwidth;
- frequency-dependent duration of signals;
- spectral ratio; and
- indications of bubble-pulse signals and bubble-pulse delay.

For events detected by the International Monitoring System infrasound component, the following parameters, *inter*

alia, may be used:

- signal frequency content and dispersion;
- signal duration; and
- peak amplitude.

The system shall be sufficiently flexible so as to allow new criteria to be introduced as well as allow individual users (i.e. on behalf of individual Member States) to select their own screening criteria to be applied to events in specific regions.

3.4.6.1 The system shall assign a numerical metric for each event and each accepted screening criterion indicating the extent to which that event meets, or does not meet, each event screening criterion.

SRD Number: SRD-613

Status: Current

Priority: Threshold

Type: Functional

Function: Event Screening

NOTE: From the IDC Draft Operational Manual: On an event by event basis, previously calculated event characterization parameters are compared to the various event screening criteria for the parameters, taking into account the uncertainties in the parameter estimates, to provide a numerical metric which indicates the extent to which that event meets, or does not meet, each event screening criterion. The individual event metrics are combined in the screening process. For events that are not screened out using this procedure, the REB data and the calculated screening metrics are combined and define the Standard Screened Event Bulletin (SSEB).

3.4.6.2 The system shall assign each event an overall screening category based on an assessment of the individual screening criteria.

SRD Number: SRD-449

Status: Current

Priority: Threshold

Type: Functional

Function: Event Screening

3.4.6.3 The system shall allow an analyst to assess signal quality to indicate suitability for use in event screening.

SRD Number: SRD-623

Status: New

Priority: Threshold

Type: Functional

Function: Data Management, Event Screening, IPRA, Quality Control

NOTE: An example use-case would be to check for interfering seismic signals from another (e.g., local) source within the regional phase Pn and S/Lg time windows used in post- processing for the experimental high-frequency P/S screening criterion. If the analyst suspected interference then the time window could be flagged and not used in the standard event screening.

3.5 GIS (Geographical Information System)

The system data analysis involves the evaluation of geospatial relationships on a global scale and requires robust, flexible, interactive GIS capability. The GIS interface should allow an analyst to explore various aspects of the geographic inputs and products of the system.

3.5.1 Interactive

3.5.1.1 The system shall provide a GIS map capable of displaying origins, location uncertainty (e.g., coverage ellipse, confidence ellipse), arrivals (plotted as great circle paths using the fk azimuth and slowness to infer distance), and stations.

SRD Number: SRD-149

Status: Current

Priority: Threshold

Type: Functional

Function: Geographic Information System, IPRA

NOTE: When displaying location uncertainty, the system should always default to coverage ellipse.

3.5.1.2 The system shall display origins, location uncertainty (e.g., coverage ellipse, confidence ellipse), arrivals, and stations on a GIS map upon request.

SRD Number: SRD-150

Status: Current

Priority: Threshold

Type: Functional

Function: Geographic Information System

NOTE: When displaying location uncertainty, the system should always default to coverage ellipse.

3.5.1.3 The system shall simultaneously display events and defined geographic region boundaries.

SRD Number: SRD-151

Status: Current

Priority: Threshold

Type: Functional

Function: Geographic Information System

3.5.1.4 The system shall use temporal and spatial predicates to determine if events are located within defined geographic region polygons.

SRD Number: SRD-152

Status: Current

Priority: Threshold

Type: Functional

Function: Geographic Information System

3.5.1.5 The system shall display a variety of types of geographic vector and raster data to aid in the interpretation of

displayed event information.

SRD Number: SRD-153

Status: Current

Priority: Threshold

Type: Non-Functional

Function: Earth / Propagation Models, Geographic Information System

NOTE: Types of geographical data include but not limited to:

- topography
- defined geographic region polygons
- seismicity from catalogs.
- political boundaries
- station locations
- attenuation maps
- blockage maps
- meteorological data at various levels
- propagation models in map view and in cross section
- propagation paths projected onto map view
- propagation paths projected onto cross section, particularly for infrasound, but also for hydro-acoustic and seismic propagation
- surface-wave dispersion data
- gridded data used in association

3.5.1.6 The system shall support both a 2D (projection) and a 3D (virtual globe) view of the world.

SRD Number: SRD-451

Status: Current

Priority: Threshold

Type: Functional

Function: Geographic Information System

3.5.1.7 The system shall provide functionality to export the current view to a standard graphical format.

SRD Number: SRD-452

Status: Current

Priority: Threshold

Type: Functional

Function: Geographic Information System

NOTE: Possible standard formats include TIFF, JPG or PNG.

3.5.1.8 The system shall allow the user to select objects on the current view such as events and stations and export them to a standard geographic format.

SRD Number: SRD-453

Status: Current

Priority: Threshold

Type: Functional

Function: Geographic Information System

3.5.1.9 The system shall generate high quality graphical and tabular presentations of the results of spatial processing of geographically referenced data.

SRD Number: SRD-154

Status: Current

Priority: Threshold

Type: Functional

Function: Geographic Information System

3.5.2 Determine Spatial Relationships

3.5.2.1 The system shall use spatial predicates to automatically and interactively determine spatial relationships between geographic features including, but not limited to, points, lines and polygons.

SRD Number: SRD-156

Status: Current-Partial

Priority: Threshold

Type: Non-Functional

Function: Geographic Information System, IPRA

NOTE: This requirement is intended to provide a full GIS search capability to include percentage of event ellipse within a defined geographic region polygon.

3.6 Reporting

NOTE: Reporting requirements will necessarily differ between monitoring sites based on mission and security. Therefore, the document separates requirements related to report content from requirements related to report delivery mechanisms. The reporting requirements include but are not limited to dissemination of data and products specified in [IDC 3.4.1 Rev 6] to authorized users. In particular, standard formats are emerging and need to be considered, at least for those aspects of the reporting system that need to be integrated with external sources and recipients.

NOTE: CTBT Treaty language refers to IDC 'reporting products', or, more simply, 'products', but it should be clear that these are synonymous with reports. Documents frequently refer to 'IMS data and IDC products', which approximately describes the roles of the two Treaty-specified entities.

3.6.1 The system shall restrict access to reports to authorized internal and external users.

SRD Number: SRD-482

Status: Current

Priority: Threshold
Type: Functional
Function: External Interfaces, Security

3.6.2 The system shall validate the authorization of internal and external users based on assigned roles and privileges.

SRD Number: SRD-483
Status: Current
Priority: Threshold
Type: Functional
Function: External Interfaces, Security

3.6.3 The system shall limit which data and products are available to each user based on roles/privileges.

SRD Number: SRD-160
Status: Current
Priority: Threshold
Type: Functional
Function: External Interfaces, Security

NOTE: For any authorized user, internal/external access may be filtered differently.

3.6.4 The system shall provide internal and external authorized users access to reports as specified in the IDC Formats and Protocols document.

SRD Number: SRD-505
Status: Current-Partial
Priority: Threshold
Type: Functional
Function: External Interfaces, Security

NOTE: This requirement is intended to cover access to those reports specified in the formats and protocols description, which includes email and file-transport.

3.6.5 The system shall provide internal and external authorized users access to reports via SMTP.

SRD Number: SRD-654
Status: Current
Priority: Threshold
Type: Functional
Function: External Interfaces, Security

3.6.6 The system shall provide internal and external authorized users access to reports through a machine-to-machine interface.

SRD Number: SRD-506
Status: Current
Priority: Threshold
Type: Functional
Function: External Interfaces, Security

NOTE: Machine-to-machine here means by a non-interactive interface. The machine-to-machine interface may use HTTPS or another data transport protocol with similar capabilities (speed, security) comparable with HTTPS. The machine-to-machine interface should incorporate the web-services capabilities.

3.6.7 The system shall provide internal and external authorized users access to reports through a GUI.

SRD Number: SRD-621

Status: Current

Priority: Threshold

Type: Functional

Function: External Interfaces, Security

NOTE: A GUI includes, but is not limited to a web (i.e. Browser) interface.

3.6.8 The system shall provide internal and external authorized users access to reports through a GIS (i.e. map-based) GUI.

SRD Number: SRD-484

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: External Interfaces, Geographic Information System, Security

3.6.9 The system shall distribute reports to authorized internal and external authorized users on a subscription basis.

SRD Number: SRD-507

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Events of Interest, External Interfaces, Security

NOTE to system specifiers: 'Reports' encompass many things, including alerts regarding system status or events of interest. Subscription services refers to all of these and not necessarily restricted to those called out in the [IDC 3.4.1 Rev 6].

3.6.10 The system shall automatically create reports based on user specified criteria (e.g., geographic region, time, magnitude).

SRD Number: SRD-165

Status: Current

Priority: Threshold

Type: Functional

Function: Events of Interest, External Interfaces, IPRA

NOTE: Reports may include but are not limited to event web pages, and event bulletins. Event bulletins should include, but not be limited to, basic event (e.g. latitude, longitude, time, depth, and size) and station phase arrival (e.g. phase type, station, time, and size information).

This requirement implies user-customized subscription reports.

3.6.11 The system shall allow authorized users to interactively modify the near real-time automated event warning/notification parameters.

SRD Number: SRD-220
Status: New
Priority: Threshold
Type: Non-Functional
Function: Data Management

3.6.12 The system shall provide the reports specified in the most recent revision of document IDC Formats and Protocols.

SRD Number: SRD-485
Status: Current
Priority: Threshold
Type: Functional
Function: External Interfaces, Security

NOTE: This requirement is intended to cover the content of the reports, as separate from the format/protocol.

3.6.13 The system shall apply user-specified processing to existing data and products to create custom reports for authorized internal and external users.

SRD Number: SRD-508
Status: New
Priority: Extensibility
Type: Functional
Function: External Interfaces, Security

3.6.14 The system shall provide a verifiable guarantee that reports are delivered unaltered.

SRD Number: SRD-619
Status: Current-Partial
Priority: Threshold
Type: Functional
Function: External Interfaces, Security

NOTE: This requirement is currently implemented using the PKI to apply a digital signature to the report.

The system shall protect the data transfers using the CTBTO PKI infrastructure by:

- ensuring integrity of the products sent to the users
- ensuring non-repudiation of the requests sent by the users.

3.6.15 The system shall support at least 1000 authorized users with each user requesting up to 4GB of data per day.

SRD Number: SRD-509
Status: Current
Priority: Threshold
Type: Constraint

Function: External Interfaces, Security

3.6.16 The system shall support at least 30000 requests for data and products per day.

SRD Number: SRD-510

Status: Current

Priority: Threshold

Type: Constraint

Function: External Interfaces

3.6.17 The system shall provide consistent, responsive delivery of requested data and products despite variations in system load.

SRD Number: SRD-511

Status: New

Priority: Objective / Priority 1

Type: Constraint

Function: External Interfaces

NOTE: Factors affecting system load include, for example, the volume of data processed by the system and volume of user requests within a given time period. This requirement also covers prioritization of queued requests based on the type of access, such that reports provided through a GUI are served faster.

3.6.18 The system shall be extensible to support future data and products.

SRD Number: SRD-409

Status: Current

Priority: Threshold

Type: Non-Functional

Function: External Interfaces

NOTE: The monitoring system is expected to evolve and new products and data should be anticipated, particularly as technologies become more mature and more analysis is integrated.

3.6.19 The system shall provide a language for formulating requests, in addition to the IMS2.0 language specified in document [IDC 3.4.1 Rev 6].

SRD Number: SRD-410

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: External Interfaces

NOTE; This requirement is intended to support SRD-619 and 409, and SRD-165.

3.6.20 The system shall integrate and provide internal and external access to third-party reports.

SRD Number: SRD-163

Status: Current-Partial

Priority: Threshold

Type: Non-Functional

Function: External Interfaces

NOTE: For example, one might imagine a new product that combines information from IDC bulletins with USGS or ISC data.

3.6.21 The system shall export all waveform data for an event that satisfies a user-specified set of rules.

SRD Number: SRD-616

Status: New

Priority: Threshold

Type: Functional

Function: Data Management, Reporting

Notes: Rules include phase-dependent and distance-dependent time windows, existence of a associated phases, estimated of probability of signal detectability based on noise characteristics, historical observations, etc. This requirement should be satisfied in a way that broadly supports diverse functions in reporting and analysis.

3.7 Data Management.

Data management requirements address the management of waveform, database storage, and archiving. NOTE: Many data management requirements exist in other sections of this document with the words “store” or “retain” and are not repeated here.

3.7.1 The system shall backup all information necessary to reconstruct the entire system both off-line and off-site.

SRD Number: SRD-168

Status: Current

Priority: Threshold

Type: Constraint

Function: Data Management

NOTE: The intent of this requirement is to be able to reconstruct the entire system, software and data, and to resume operations and maintenance in the event of a major disaster.

3.7.2 The system shall use the data management system to store and retrieve alphanumeric results from computations (e.g., amplitude measurements, station and network magnitudes).

SRD Number: SRD-169

Status: Current

Priority: Threshold

Type: Constraint

Function: Data Management

3.7.3 The system shall save the defining/non-defining phase information for all origins in the database.

SRD Number: SRD-170

Status: Current

Priority: Threshold
Type: Functional
Function: Association, Data Management, Location, Magnitude

3.7.4 The system shall provide access to all raw and derived waveform data, beams and beam parameters for the life of the system.

SRD Number: SRD-171
Status: Current
Priority: Threshold
Type: Functional
Function: Data Management

NOTE: Some derived waveform data is not persisted beyond the operational time period.

3.7.5 The system shall save waveform data and quality metrics.

SRD Number: SRD-172
Status: Current-Partial
Priority: Threshold
Type: Functional
Function: Data Acquisition, Data Management, Quality Control

3.7.6 The system shall store third party information (e.g. received bulletins) in the system bulletin format for the life of the system.

SRD Number: SRD-174
Status: New
Priority: Threshold
Type: Functional
Function: Data Management, External Interfaces

3.7.7 The system shall store public keys used in the authentication of acquired data frames.

SRD Number: SRD-179
Status: New
Priority: Extensibility
Type: Functional
Function: Data Acquisition, Data Management

3.7.8 The system shall maintain derived waveforms for which there are no associated arrivals for at least the operational processing time period.

SRD Number: SRD-180
Status: Current
Priority: Threshold
Type: Non-Functional
Function: Data Management

NOTE: The operational processing time period is the time during which events may be revised and saved without special procedures.

3.7.9 The system (OPS and ALT subsystems) shall import data stored on off-line computer storage from either subsystem.

SRD Number: SRD-184

Status: Current

Priority: Threshold

Type: Functional

Function: Data Management, Subsystem - ALT, System-wide

NOTE: The intent of this requirement is to allow a restore from tape backup in the case where an outage makes use of the network inadvisable. An outage may be a loss of disk or a long term outage of either the OPS or ALT subsystem requiring high density backup restore.

3.7.10 The system shall provide read/write access to all raw and derived waveform and alphanumeric data for a user-specified time-block (not to exceed six-hours) within the operational processing time period with a latency not to exceed five (5) seconds (with a one (1) second objective).

SRD Number: SRD-185

Status: Current

Priority: Threshold

Type: Constraint

Function: Data Management, IPRA

NOTE: The operational processing time period is the time during which events may be revised and saved without special procedures.

3.7.11 The system shall provide read/write access to all raw and derived waveform and alphanumeric data for a user-specified time-block (not to exceed 6-hours) outside the operational processing time period (i.e., all historical data) with a latency not to exceed ten (10) seconds (two (2) second objective).

SRD Number: SRD-186

Status: Current

Priority: Threshold

Type: Constraint

Function: Data Management, IPRA

NOTE: Events processed that are older than the operational time period will be read from a database and special procedures will be required to handle re-processing.

3.7.12 The system shall confirm 100% of data transfer and data integrity prior to deleting data from source storage.

SRD Number: SRD-187

Status: Current

Priority: Threshold

Type: Functional

Function: Data Management, System-wide

NOTE: Refers to data acquisition to data processing, OPS/ALT, and archive transfers.

3.7.13 The system shall use the data management system to store and retrieve automatic and interactive processing parameters and results for use by subsequent processing.

SRD Number: SRD-189
Status: Current-Partial
Priority: Threshold
Type: Non-Functional
Function: Data Management

Background: The system needs an infrastructure that will encapsulate processing parameter and recipe information with each event/origin/detection. Every automatic and interactive processing application should use this infrastructure to initialize data structures and processing parameters/recipes, and to track changes in processing parameters/recipes. This infrastructure is necessary to insure that processing results can be recreated from one processing stage to the next (e.g., for both interactive and automatic fk analysis, use the same stations (spatial sampling), frequency-band (frequency sampling), lead and lag (temporal sampling), and QC mask). Processing parameters must be treated as dynamic values and preserved at each processing stage, rather than treated as static values. For example, a default parameter may exist for the onset filter for a signal arriving at a specified vector from a station. However, if an analyst subsequently uses a different filter to enhance SNR and saves the result, then that change should be reflected in the database, and when the next automatic process or user retrieves that channel, the new filter should automatically be applied.

3.7.14 The system shall retain the meteorological data and derived products used in infrasound event detection.

SRD Number: SRD-610
Status: New
Priority: Threshold
Type: Non-Functional
Function: Data Management

NOTE: Derived products include, for example, effective sound-speed or attenuation models.

3.7.15 The system shall interactively create training data sets that include user specific parametric, alphanumeric, geographic, and waveform data from configurable processing stages.

SRD Number: SRD-192
Status: New
Priority: Threshold
Type: Functional
Function: Data Management, Subsystem - Training

NOTE: Along with the waveform data and alphanumeric products, the training data set comprises the the parametric information and geographic data, including data used to process infrasound (e.g. propagation models derived from the meteorological inputs).

3.7.16 The Training subsystem shall automatically compare a selected student's processing results to the instructor's processing results or to a model/baseline bulletin and create a report highlighting the differences.

SRD Number: SRD-193

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: Data Management, Subsystem - Training

3.7.17 The Training subsystem shall include a GUI that allows instructors to selectively delete student and/or instructor alphanumeric and/or waveform data from the database.

SRD Number: SRD-194

Status: Current

Priority: Threshold

Type: Functional

Function: Data Management, Subsystem - Training

Intent: This function will allow the instructor to delete any combination of student and/or instructor waveform and alphanumeric data.

3.8 Earth/Propagation Models - Travel-time/Azimuth/Slowness.

Requirements that deal with the calculation of the time for propagation of the wavefront from the source to the receiving station. The computation of travel-time, azimuth, and slowness may be a sophisticated calculation (ray-tracing), or a table look-up, which may itself be the result of a previous calculation. A basemodel may be either a velocity model or a 3-D table.

3.8.1 The system shall compute predicted slowness and associated uncertainties from user specified one-dimensional, phase-specific basemodels.

SRD Number: SRD-197

Status: Current

Priority: Threshold

Type: Functional

Function: Confidence, Earth / Propagation Models, TTAS

3.8.2 The system shall compute predicted slowness and associated uncertainties from user specified three-dimensional basemodels.

SRD Number: SRD-198

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: Confidence, Earth / Propagation Models, TTAS

3.8.3 The system shall compute predicted azimuths and associated uncertainties from user specified three-dimensional basemodels.

SRD Number: SRD-199

Status: New

Priority: Objective / Priority 1

Type: Functional
Function: Confidence, Earth / Propagation Models, TTAS

3.8.4 The system shall compute predicted travel-times and associated uncertainties from user specified one-dimensional, phase-specific basemodels.

SRD Number: SRD-200
Status: Current
Priority: Threshold
Type: Functional
Function: Confidence, Earth / Propagation Models, TTAS

3.8.5 The system shall compute predicted travel-times and associated uncertainties from user specified two-dimensional, phase-specific basemodels.

SRD Number: SRD-201
Status: New
Priority: Threshold
Type: Functional
Function: Confidence, Earth / Propagation Models, TTAS

3.8.6 The system shall compute predicted travel-times and associated uncertainties from user specified three-dimensional basemodels.

SRD Number: SRD-202
Status: Current-Partial
Priority: Threshold
Type: Functional
Function: Confidence, Earth / Propagation Models, TTAS

3.8.7 The system shall apply empirically derived travel-time corrections to basemodel predictions and uncertainties. (Includes correction surfaces and master event corrections).

SRD Number: SRD-203
Status: Current
Priority: Threshold
Type: Functional
Function: Confidence, Earth / Propagation Models, TTAS

3.8.8 The system shall apply empirically derived azimuth and slowness corrections to seismic and hydro-acoustic basemodel predictions and uncertainties.

SRD Number: SRD-204
Status: Current
Priority: Threshold
Type: Functional
Function: Confidence, Earth / Propagation Models, TTAS

NOTE: This is not just a requirement for the locator; for example, interactive tools mark the predicted azimuth and slowness for the sta, phase, origin; The system uses this information to create origin beams, etc. Empirically-derived corrections are not applicable to infrasound.

3.8.9 The system shall incorporate temporal variations of blockage.

SRD Number: SRD-205

Status: Current
Priority: Threshold
Type: Non-Functional
Function: Earth / Propagation Models

NOTE: This applies only to hydroacoustic data.

3.8.10 The system shall incorporate temporal and spatial variations of travel times.

SRD Number: SRD-206
Status: New
Priority: Objective / Priority 1
Type: Non-Functional
Function: Earth / Propagation Models

NOTE: This applies to hydroacoustic and infrasound data. For infrasound, for example, the requirement can be satisfied using 3-D models derived from snapshot of the current meteorological conditions.

3.9 Earth/Propagation Models - Attenuation.

Requirements that deal with the reduction in signal amplitude during the propagation of the wavefront from the source to the receiving station.

3.9.1 The system shall compute predicted amplitude attenuation factors and associated uncertainties from user specified one-dimensional, phase and frequency dependent basemodels.

SRD Number: SRD-209
Status: Current
Priority: Threshold
Type: Functional
Function: Attenuation, Confidence, Earth / Propagation Models

3.9.2 The system shall compute predicted amplitude attenuation factors and associated uncertainties from user specified three-dimensional frequency dependent basemodels.

SRD Number: SRD-211
Status: New
Priority: Extensibility
Type: Functional
Function: Attenuation, Confidence, Earth / Propagation Models

3.9.3 The system shall apply empirically derived frequency dependent amplitude attenuation corrections to basemodel predictions and uncertainties.

SRD Number: SRD-212
Status: Current-Partial
Priority: Threshold
Type: Non-Functional
Function: Attenuation, Confidence, Earth / Propagation Models

3.9.4 The system shall incorporate temporal variations of attenuation.

SRD Number: SRD-213
Status: New
Priority: Extensibility
Type: Non-Functional
Function: Attenuation, Earth / Propagation Models

NOTE: This applies only to hydroacoustic and infrasound data.

3.10 Processing Modes.

3.10.1 The system's software shall operate on stand-alone systems (i.e., Field laptops, host-country analysis systems, and other NDC like systems).

SRD Number: SRD-216
Status: Current-Partial
Priority: Threshold
Type: Non-Functional
Function: IPRA, Security, System-wide

NOTE: The interactive analysis software shall be designed as a modular system, with the intent of there being a version with a superset of functionality for the system, and a subset version for host and site survey use; the latter version will run on an open source database, e.g. PostgreSQL database.

Although this requirement is related to providing a remote analysis capability, it extends it by specifying its use for other, non-IDC, analysis tasks. The intention of this requirement is to provide the Member States with the IDC software that can be used to validate IDC results. It is intended to complement, and where feasible integrate with the NDC-in-a-Box.

3.10.2 The system shall automatically initiate processing based on configurable criteria.

SRD Number: SRD-217
Status: Current
Priority: Threshold
Type: Non-Functional
Function: System-wide

NOTE: These criteria include, as a minimum, time, the availability of new data from the Data Acquisition System, the completion of prior processing steps (e.g., detection processing complete for a given time interval), and the completion of analyst review (e.g., new/updated events available for post-analyst processing).

3.10.3 The system shall allow users to re-process historical data.

SRD Number: SRD-218
Status: Current-Partial
Priority: Threshold

Type: Non-Functional
Function: Data Management, IPRA, Security

NOTE: This includes re-processing of historic data using interactive and post-analysis automated processing tools where relevant historical and site information exists.

3.10.4 The system shall provide the capability to restore the configuration that was valid at a specific time in the past.

SRD Number: SRD-651
Status: Current-Partial
Priority: Threshold
Type: Non-Functional
Function: Data Management, IPRA, Security

3.11 Event of Interest

The system defines specific criteria such as geographic area, magnitude, etc., for which notification is desired. An automated event solution meeting these criteria is considered an automated event of interest. The system notifies authorized users as soon as any automated events of interest are built or modified.

NOTE: Requirements covering events of interest are in Section 3.6 “Reporting”.

3.12 Performance Monitoring.

Performance Monitoring (PM) requires the calculation, display and archiving of key indicators for each component of the data processing system. The key indicators are statistically derived values that provide the empirical validation for theoretical forecast models and that provide the inputs to system capability reporting. The archiving of the key indicators has a threefold mission of maintaining appropriate resolution, providing a baseline to gauge the impact of changes to the system, and establishing compatibility with forecast models. PM also needs to be readily accessible for users to view key indicators and receive automated notification when a key indicator reaches a critical status. The viewing of key indicators needs to support trend analysis of PM through automated reporting and interactive querying.

3.12.1 System

3.12.1.1 The system shall monitor, store, and display in near real time the state of health of critical hardware components (e.g., system up-time, network traffic and data rates, CPU process loads, and used/available disk storage).

SRD Number: SRD-225
Status: Current-Partial
Priority: Threshold
Type: Functional
Function: Data Management, Interactive Monitoring, Performance Monitoring

3.12.1.2 The system shall monitor and display in near real time the state of health of critical software components.

SRD Number: SRD-226

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Data Management, Interactive Monitoring, Performance Monitoring

NOTE: Examples of items to monitor include, but are not limited to; program load time, memory usage, and dead/orphan processes.

3.12.1.3 The system shall automatically detect, collect, and categorize (e.g., critical, non-critical) failures.

SRD Number: SRD-227

Status: Current

Priority: Threshold

Type: Functional

Function: Performance Monitoring

3.12.1.4 The system shall provide an infrastructure for the storage and reporting of failures.

SRD Number: SRD-228

Status: Current

Priority: Threshold

Type: Functional

Function: Data Management, Interactive Monitoring, Performance Monitoring

NOTE: The intent of this requirement is to provide a common method for the system to notify users and administrators of errors or warnings from the system even in conditions when major components of the infrastructure (such as the e-mail system) are down and even if administrators are not on the premises. These notifications should be able to provide audible and visual indications of critical failures, in particular for user errors.

3.12.1.5 The system shall provide a user configurable graphical display for all reported (logged) failures.

SRD Number: SRD-229

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Interactive Monitoring, Performance Monitoring

3.12.2 Data Acquisition

3.12.2.1 The system shall collect, display, and store the timeliness of waveform data intervals by determining the latency between data recording at the station and receipt in the system.

SRD Number: SRD-232

Status: New

Priority: Threshold

Type: Functional

Function: Data Acquisition, Data Management, Interactive Monitoring, Performance Monitoring

3.12.2.2 The system shall collect, display, and store waveform data availability at specific points of time.

SRD Number: SRD-233

Status: New

Priority: Threshold

Type: Functional

Function: Data Acquisition, Data Management, Interactive Monitoring, Performance Monitoring

NOTE: The intent of this requirement is to allow the display of the exact data availability at any point in the processing history for either automatic or interactive processing.

3.12.3 Data Processing and Quality

3.12.3.1 The system shall interactively compare automatic and interactive data quality control results (e.g., compare data masks between processing stages and between subsystems).

SRD Number: SRD-237

Status: New

Priority: Threshold

Type: Functional

Function: Interactive Monitoring, Performance Monitoring, Quality Control

3.12.3.2 The system shall compute, display, and store station ambient noise amplitude and variance levels via different metrics (e.g., spectrograms, incoherent/coherent beam Power Spectral Density (PSD) and incoherent/coherent beam PSD Probability Density Functions (PDFs)).

SRD Number: SRD-238

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Data Management, Interactive Monitoring, Multichannel Processing, Performance Monitoring, Signal Characterization / Feature Extraction, Signal Processing

3.12.3.3 The system shall interactively compare near real-time station ambient noise amplitudes with historical averages (e.g., spectrograms, incoherent/coherent beam Power Spectral Density (PSD) and incoherent/coherent beam PSD Probability Density Functions (PDFs)).

SRD Number: SRD-239

Status: New

Priority: Threshold

Type: Functional

Function: Interactive Monitoring, Performance Monitoring

3.12.3.4 The system shall automatically compute, store and display station processing statistics and report when measured parameters exceed configurable thresholds (e.g., total versus associated arrivals, time/azimuth/slowness/magnitude residuals).

SRD Number: SRD-240

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Data Management, Interactive Monitoring, Performance Monitoring

3.12.3.5 The system shall interactively compare near real-time station processing statistics with historical results (e.g.,

total versus associated arrivals, time/azimuth/slowness/magnitude residuals).

SRD Number: SRD-241

Status: New

Priority: Threshold

Type: Functional

Function: Interactive Monitoring, Performance Monitoring

3.12.3.6 The system shall compute and store empirical station magnitude detection thresholds, to include the uncertainty associated with such threshold calculations.

SRD Number: SRD-242

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Data Management, Interactive Monitoring, Performance Monitoring

NOTE: Station magnitude detection thresholds will be estimated based on the events from historic bulletins that were observed or not observed at each station. These statistics will be computed for geographic regions with observed historic seismicity. Thresholds will also be computed using all events at a particular distance from each station in order to estimate the magnitude detection threshold for aseismic geographic regions.

3.12.3.7 The system shall generate and display event statistics for any user specified geographic region.

SRD Number: SRD-243

Status: Current-Partial

Priority: Threshold

Type: Functional

Function: Geographic Information System, Interactive Monitoring, Performance Monitoring

NOTE: Event statistics can include metrics such as: number of defining phases, number of defining stations, closest observing station, location azimuthal gap, and location error ellipse results based on operational discriminants.

3.12.3.8 The system shall generate and display event detection threshold information for any user-specified geographical region.

SRD Number: SRD-244

Status: New

Priority: Threshold

Type: Functional

Function: Geographic Information System, Interactive Monitoring, Performance Monitoring

NOTE: This functionality should include the capability to produce real-time estimates of event detection, and location based on empirical and model based parameters including; data availability, quality statistics, and capability to simulate system capability due to missing or additional stations.

Infrasound displays should include the current meteorological data and values derived from this data (e.g. the effective sound-speed ratio).

3.12.3.9 The system shall provide software tools to support tuning and evaluation of geophysical performance (e.g., receiver operating characteristics, array coherence).

SRD Number: SRD-245

Status: New

Priority: Threshold

Type: Functional

Function: Interactive Monitoring, Performance Monitoring

NOTE: The intent of this requirement is to support tuning and evaluation efforts. Software and scripts may be written to aid in tuning the system. These changes should be incorporated into the software baseline to ensure that they continue to function as the system evolves over time. This requirement also covers the ability to produce debugging information that can be reviewed and manipulated using third-party software. An example from the current system is the ability to configure DFX to dump time-series data (including filtered and un-filtered beams, short-term and long-term averages, SNR, etc.) to SAC format files.

3.12.4 Bulletin Comparison

3.12.4.1 The system shall have a user configurable tool to automatically compare two bulletins, identify unique and common events and arrivals, and characterize their differences (e.g., location, depth, associations).

SRD Number: SRD-247

Status: Current

Priority: Threshold

Type: Functional

Function: Interactive Monitoring, Performance Monitoring

3.12.5 Analyst Based Products

3.12.5.1 The system shall measure and report tool usage statistics.

SRD Number: SRD-249

Status: New

Priority: Objective / Priority 1

Type: Functional

Function: Interactive Monitoring, Performance Monitoring

3.13 System Performance

System performance refers to data processing timeliness and system loading requirements.

3.13.1 Overall System Performance.

3.13.1.1 The system shall report the data available and the data used to analyse an event.

SRD Number: SRD-617

Status: New

Priority: Threshold

Type: Functional
Function: Data Management, Reporting

NOTE: This capability can be used to verify that all relevant data has been analysed for an event.

3.13.1.2 The system shall support a swarm processing load of 2,000 events per day.

SRD Number: SRD-253

Status: Current

Priority: Threshold

Type: Constraint

Function: System-wide

NOTE: This requirement is intended to describe a "worst case" scenario and not a minimum or maximum. This requirement impacts at least CPU usage, database, disk/memory storage, and user interfaces.

3.13.1.3 The system shall produce an automated bulletin in near real-time during both normal and swarm conditions without disrupting operations.

SRD Number: SRD-255

Status: Current

Priority: Threshold

Type: Constraint

Function: System-wide

3.13.2 Interactive

The volume of data and the number of events processed by the system have grown dramatically in the past decade. Projecting future growth, the interactive data processing software needs to be designed with a possible 2,000 events per day . The design of interactive applications should take into account the current loads on the users as well as changes in the future to ensure the tools are capable of supporting the users in both normal and swarm conditions. These requirements impact not only the memory and CPU loads of the tools but also the presentation of the data to the users. This may include getting data to the user quickly, proving the "next step" to the user automatically, or ensuring communication between multiple windows/applications in both the current user's session as well as other users.

3.13.2.1 The system shall provide user requested waveform data within one (1) minute of acquisition.

SRD Number: SRD-261

Status: Current

Priority: Threshold

Type: Constraint

Function: Data Acquisition, Data Management, System-wide

3.13.2.2 The system shall generate virtual origin beams for a user specified location in less than 1 second for a time interval up to 2 hours and an array station up to 20 channels.

SRD Number: SRD-262

Status: Current

Priority: Threshold

Type: Constraint
Function: Multichannel Processing, Signal Processing

3.13.2.3 The system shall provide automated measurements to support interactive analysis with execution in less than three (3) seconds for an average event.

SRD Number: SRD-263
Status: New
Priority: Threshold
Type: Constraint
Function: IPRA, Signal Processing

3.13.2.4 The system shall generate and display spectrograms at the users request for any infrasonic, hydroacoustic or seismic channel.

SRD Number: SRD-264
Status: Current-Partial
Priority: Threshold
Type: Functional
Function: IPRA, Signal Processing

3.13.2.5 The system shall make late-arriving data available to the user within one (1) minute of receipt by the data processing component.

SRD Number: SRD-265
Status: Current
Priority: Threshold
Type: Constraint
Function: Data Acquisition

3.14 Design Constraints

3.14.1 The system's software shall use a common object model (data and methods) to promote the reuse of data structures and software.

SRD Number: SRD-268
Status: Current-Partial
Priority: Objective / Priority 1
Type: Non-Functional
Function: Data Management, System-wide

3.14.2 The system shall allow the components of the automated processing pipeline to be initiated in stand-alone mode.

SRD Number: SRD-270
Status: Current
Priority: Threshold
Type: Non-Functional
Function: System-wide

NOTE: Examples of mechanisms for initiation of routines include, but not be limited to, Graphical User Interfaces (GUIs), shell scripts, and command line/parameter file execution.

3.14.3 The system shall store all data and derived processing results to non-volatile persistent storage as soon as the data and/or derived processing results are available.

SRD Number: SRD-271

Status: Current-Partial

Priority: Threshold

Type: Non-Functional

Function: Data Management, System-wide

NOTE: The intent of this requirement is to prevent work and/or data loss in the event of an application crash.

3.14.4 The system software shall utilize a minimum number of programming languages and support toolkits.

SRD Number: SRD-272

Status: Current

Priority: Threshold

Type: Project Issues

Function: System-wide

NOTE: ‘Support toolkits’ refers to, for example, GUI toolkits and frameworks. The objective is to minimize the dependencies on external packages and make it easier to achieve a consistent look and feel to all interfaces (GUI, command-line).

3.14.5 The system shall make maximum use of suitable existing software including open source software and commercial off-the-shelf (COTS).

SRD Number: SRD-273

Status: Current

Priority: Threshold

Type: Project Issues

Function: System-wide

NOTE: Candidates for reuse include but are not limited to:

- cbase: distribution of common libraries for SHI applications
- sbase: distribution of scientific libraries for SHI applications
- libCD: library for handling continuous data in CD1.0 and CD1.1 formats
- libidwcf: library for reading and writing waveform data in various formats
- code computing quality metrics from the cdqual application
- code that merges waveform segments, handles gaps in frames from cd2wng
- code for parsing requests and generating products in accordance to IDC 3.4.1 “Formats and Protocols for Messages”.

The system should also minimize the number of external dependencies in order facilitate building and running the software on external platforms.

3.14.5.1 Open-source software shall be preferred to commercial software.

SRD Number: SRD-460
Status: Current-Partial
Priority: Threshold
Type: Non-Functional
Function: System-wide

NOTE: the intent of this requirement is to minimize cases where functionality that is already available as open source is re-implemented.

3.14.5.2 The system shall run on relational database management systems that support ACID transactions, referential integrity and fine grained locking.

SRD Number: SRD-461
Status: Current-Partial
Priority: Threshold
Type: Non-Functional
Function: System-wide

NOTE: Supported databases include Oracle and at least one leading open source relational database management system, such as PostgreSQL

3.14.6 The system shall allow multiple users to process data at the same time on a non-interference basis.

SRD Number: SRD-274
Status: Current
Priority: Threshold
Type: Non-Functional
Function: IPRA

3.14.7 The system shall provide configurable process sequencing.

SRD Number: SRD-276
Status: Current
Priority: Threshold
Type: Non-Functional
Function: System-wide

NOTE: Processes are executed in sequential or parallel order as required, and/or based on success or failure of other tasks.

3.14.8 The system shall accommodate missing data without disrupting operations.

SRD Number: SRD-277
Status: Current
Priority: Threshold
Type: Constraint
Function: System-wide

3.14.9 The system shall accommodate the addition of new stations without disrupting operations.

SRD Number: SRD-278
Status: Current
Priority: Threshold
Type: Constraint
Function: System-wide

3.14.10 The system shall accommodate variations in the number of operating stations or instruments without disrupting operations.

SRD Number: SRD-279
Status: Current
Priority: Threshold
Type: Constraint
Function: System-wide

3.14.11 The system shall accommodate variations in the quantity and timing of data without disrupting operations.

SRD Number: SRD-280
Status: Current
Priority: Threshold
Type: Constraint
Function: System-wide

3.14.12 The system shall recognize and accommodate leap years and seconds.

SRD Number: SRD-281
Status: Current
Priority: Threshold
Type: Non-Functional
Function: System-wide

NOTE: One way to accomplish this is to specify that system functions and algorithms be synchronized to Coordinated Universal Time, which allows for leap years and seconds.

3.14.13 The system shall use four-digit years in all dates.

SRD Number: SRD-282
Status: Current
Priority: Threshold
Type: Non-Functional
Function: System-wide

3.14.14 The SUS/TST Subsystem shall provide the ability to recall past data into an automated pipeline.

SRD Number: SRD-414
Status: New
Priority: Threshold
Type: Functional
Function: System-wide

NOTE: While a perfect reproduction of the complex sequence of events which occur on the OPS pipeline is not

practical, a major step forward would be to simply have a mode where a tester can request a timeframe of data to be processed; that timeframe of data will be retrieved from the OPS framestore, along with the latency information about each frame's arrival sequence, and that data is then fed to the test pipeline in a simulated real-time mode, consistent with the recorded latency. This will allow consistent regression testing of software, and most importantly allow station and network processing tuning changes to be tested against actual events of interest, rather than waiting for them to occur.

3.15 User Interfaces.

3.15.1 The system's User Interfaces (UIs) shall have a consistent look and feel.

SRD Number: SRD-285

Status: Current-Partial

Priority: Threshold

Type: Non-Functional

Function: IPRA, Interactive Monitoring

NOTE: Standard functionality includes but is not limited to: drag & drop widgets, docking or undocking widgets, customizing (adding, removing, re-arranging) menus/buttons, themes/colors, undo, redo, and hot-keys.

3.15.2 The system shall provide command-line interface to applications.

SRD Number: SRD-286

Status: Current-Partial

Priority: Threshold

Type: Non-Functional

Function: IPRA, Interactive Monitoring

3.15.3 The system shall provide an iterative undo/redo back to the last saved state of an event.

SRD Number: SRD-287

Status: New

Priority: Threshold

Type: Non-Functional

Function: IPRA

3.15.4 The system shall control (e.g., start and stop) and monitor processes via an interactive UI.

SRD Number: SRD-288

Status: Current

Priority: Threshold

Type: Functional

Function: Interactive Monitoring

3.15.5 The system shall provide warnings and notifications based on configurable criteria of system events (e.g., errors, late data, etc.).

SRD Number: SRD-289

Status: Current

Priority: Threshold

Type: Non-Functional

Function: Events of Interest, System-wide

3.15.6 The system shall provide a Warning/Notification UI for configuring and reporting all warnings and notifications.

SRD Number: SRD-290

Status: Current

Priority: Threshold

Type: Non-Functional

Function: Events of Interest, Interactive Monitoring

3.15.7 The system shall allow authorized users to interactively control the default contribution behavior for each station and phase toward the event solution.

SRD Number: SRD-291

Status: Current

Priority: Threshold

Type: Non-Functional

Function: IPRA, Location, Magnitude, Security, System-wide, TTAS

NOTE: This default behavior should be granular enough to allow default contribution based on each type of observable. It should be controllable by network, station or channel. For the interactive software, the default behavior should also define whether the contribution setting can be overridden by the user.

3.16 Interfaces.

3.16.1 The system shall make read-only data available to authorized systems and users without negatively impacting operational performance.

SRD Number: SRD-297

Status: Current

Priority: Threshold

Type: Constraint

Function: Data Management, External Interfaces, System-wide

3.16.2 The system shall allow authorized systems and users to access, modify, create, compile, run, and test source code and configuration files.

SRD Number: SRD-298

Status: Current

Priority: Threshold

Type: Non-Functional

Function: Security, System-wide

3.16.3 The system shall allow authorized systems and users to access, modify, run, and test existing and/or new processes in an operational-like mode.

SRD Number: SRD-299

Status: Current

Priority: Threshold

Type: Non-Functional

Function: Security, System-wide

3.16.4 The system shall provide for importing and exporting data (e.g. to support the exchange of data

between subsystems and with external support organizations).

SRD Number: SRD-300

Status: Current

Priority: Threshold

Type: Non-Functional

Function: External Interfaces, Subsystem - Training

NOTE: This includes conversion of waveform data to/from standardized formats (e.g. SEED/miniSEED), and conversion of station configuration to/from standardized formats (e.g. SEED, StationXML, SC3 Inventory XML).

3.16.5 The system database shall provide an ANSI/ISO standard SQL interface.

SRD Number: SRD-301

Status: Current

Priority: Threshold

Type: Non-Functional

Function: Data Management, System-wide

3.16.6 The system shall interface with the CTBTO State-Of-Health application to provide system and processing state-of health data.

SRD Number: SRD-622

Status: Current-Partial

Priority: Objective / Priority 1

Type: Functional

Function: Data Management, System-wide

3.17 Security

The system must protect all information from unauthorized access and corruption and shall protect all controlled data from inadvertent or unauthorized release.

3.17.1 Authorization

3.17.1.1 The system shall provide identification and authentication (user ID and password) controls.

SRD Number: SRD-316

Status: Current

Priority: Threshold

Type: Non-Functional

Function: Security

3.17.1.2 The system shall allow only authorized users to initiate and terminate processing.

SRD Number: SRD-317

Status: Current

Priority: Threshold

Type: Non-Functional

Function: Security

3.17.1.3 The system shall reject and log processing requests from unauthorized users.

SRD Number: SRD-318
Status: Current-Partial
Priority: Threshold
Type: Functional
Function: Security

3.17.1.4 The system shall enforce individual accountability by uniquely identifying users.

SRD Number: SRD-319
Status: Current-Partial
Priority: Threshold
Type: Non-Functional
Function: Security

3.17.1.5 The system shall prevent unauthorized external access.

SRD Number: SRD-320
Status: Current
Priority: Threshold
Type: Non-Functional
Function: Security

3.17.2 The system shall audit processes to collect information for monitoring its use and to support investigations of possible misuse or attempts to breach security.

SRD Number: SRD-324
Status: Current-Partial
Priority: Threshold
Type: Non-Functional
Function: Performance Monitoring, Security

NOTE: This monitoring would include, but not be limited to, user logon/logoff; object creation, deletion, and modification; unsuccessful logon attempts; and attempts to access protected files (e.g., audit or password files).

3.17.3 The system shall, for each auditable event, record the date, time and type of event; the success or failure of the event; and the name of the object introduced, accessed, modified, or deleted.

SRD Number: SRD-325
Status: Current
Priority: Threshold
Type: Functional
Function: Security

3.17.4 The system shall provide a secure and accredited method for authorized users to review waveform and alphanumeric data from a remote location.

SRD Number: SRD-328
Status: New
Priority: Objective / Priority 1
Type: Functional
Function: Events of Interest, External Interfaces, IPRA, Security

3.18 Environment.

3.19 Reliability, Maintainability, Availability

3.19.1 The system shall not permanently lose data due to a single failure.

SRD Number: SRD-334

Status: Current

Priority: Threshold

Type: Constraint

Function: Hardware, System-wide

3.19.2 The system (OPS and ALT subsystems) shall support mission duration of 24 hours per day, seven (7) days per week, 365 days per year.

SRD Number: SRD-336

Status: Current-Partial

Priority: Threshold

Type: Constraint

Function: Hardware, System-wide

3.20 Computer Resources.

3.20.1 The system shall provide storage for all existing data and five (5) additional years of data based on projections.

SRD Number: SRD-349

Status: Current

Priority: Threshold

Type: Constraint

Function: Data Management

3.20.2 The Training subsystem shall provide a minimum on-line storage equivalent to thirty (30) 24-hour days of multi-technique waveform data.

SRD Number: SRD-351

Status: New

Priority: Threshold

Type: Constraint

Function: Subsystem - Training

3.21 Systems

3.21.1 General

3.21.1.1 The system shall be partitioned into the following discrete subsystems:

- Operational (OPS) subsystem
- Testbed (SUS/TST) Subsystem
- Alternate (ALT) Operational subsystem

- **Development (DEV) subsystem**
- **Continuous Automated Testing (CATS) subsystem**
- **Training subsystem**
- **Standalone subsystems.**

SRD Number: SRD-500

Status: Current-Partial

Priority: Threshold

Type: Constraint

Function: System-wide

3.21.1.2 The system shall utilize configuration management and control software for all discrete subsystems.

SRD Number: SRD-355

Status: Current

Priority: Threshold

Type: Non-Functional

Function: System-wide

3.21.1.3 The system shall automatically execute system processes.

SRD Number: SRD-356

Status: Current

Priority: Threshold

Type: Non-Functional

Function: System-wide

3.21.1.4 The system shall perform a planned shutdown in an orderly fashion within 30 minutes.

SRD Number: SRD-357

Status: Current

Priority: Threshold

Type: Constraint

Function: Hardware, System-wide

3.21.1.5 The system shall perform an unplanned urgent shutdown within 15 minutes without damage to the system.

SRD Number: SRD-358

Status: Current

Priority: Threshold

Type: Constraint

Function: Hardware, System-wide

3.21.1.6 The system shall attain operational capability within 1 hour of a hardware restart.

SRD Number: SRD-415

Status: Current

Priority: Threshold

Type: Constraint

Function: Hardware, System-wide

3.21.1.7 The system shall attain operational capability within 30 minutes of a software restart.

SRD Number: SRD-416

Status: Current

Priority: Threshold

Type: Constraint

Function: System-wide

3.21.2 ALT Subsystem.

3.21.2.1 The system shall control, monitor and remotely operate the ALT subsystem from the OPS subsystem under normal operating conditions.

SRD Number: SRD-360

Status: New

Priority: Threshold

Type: Functional

Function: Interactive Monitoring, Subsystem - ALT

3.21.2.2 The ALT subsystem shall be a duplicate of the OPS subsystem's software and hardware at a separate location not physically collocated with OPS.

SRD Number: SRD-361

Status: New

Priority: Threshold

Type: Non-Functional

Function: Subsystem - ALT

3.21.2.3 A planned switch between the OPS and ALT subsystems shall occur without loss of data or data consistency.

SRD Number: SRD-472

Status: New

Priority: Threshold

Type: Constraint

Function: Subsystem - ALT

3.21.2.4 An unplanned urgent switch between the OPS and ALT subsystems shall occur with an interruption in streaming data to external users of at most 1 hour.

SRD Number: SRD-473

Status: New

Priority: Threshold

Type: Constraint

Function: Subsystem - ALT

NOTE: The allowance of 1 hour is arbitrary at this time in the absence of a detailed study of the user requirements for a backup to the IDC.

3.21.2.5 Switching between the OPS and ALT subsystems shall be initiated by an operator.

SRD Number: SRD-474

Status: New

Priority: Threshold

Type: Functional

Function: Subsystem - ALT

3.21.2.6 In a disaster recovery scenario, the ALT subsystem shall resume automatic processing, interactive review and dissemination of data and products, within 6 hrs of the time when the switch to the ALT subsystem was initiated.

SRD Number: SRD-475

Status: New

Priority: Threshold

Type: Constraint
Function: Subsystem - ALT

NOTE: The current idea of ALT and OPS is that the systems are symmetric. If ALT becomes OPS, then OPS becomes ALT. Therefore requirements, like this one, cover any switching between one or the other sites. Requirements related to ALT are preliminary.

3.21.3 SUS/TST Subsystem

3.21.3.1 The SUS/TST subsystem shall support a full development test and evaluation with no impact to the OPS subsystem.

SRD Number: SRD-366
Status: Current
Priority: Threshold
Type: Non-Functional
Function: Subsystem - SUS/TST

3.21.3.2 The SUS/TST subsystem shall be fully functionally redundant with the OPS subsystem, with no shared components between systems except for data feeds.

SRD Number: SRD-367
Status: Current
Priority: Threshold
Type: Non-Functional
Function: Subsystem - SUS/TST

3.21.4 CATS Subsystem

3.21.4.1 The CATS subsystem shall perform regression, unit, system and integration testing of IDC automatic processing software with no impact on the OPS subsystem.

SRD Number: SRD-615
Status: New
Priority: Threshold
Type: Functional
Function: Subsystem - CATS

NOTE: CATS subsystem shall operate in two distinct modes: "Triggered-by-commit" testing mode and "Continuous" testing mode.

3.21.4.2 The CATS subsystem shall support semi-automatic testing of stations prior to release for operational use.

SRD Number: SRD-496
Status: New
Priority: Threshold
Type: Functional
Function: Subsystem - CATS

3.21.5 Training Subsystem

3.21.5.1 The Training subsystem shall reliably simulate system operations, and support the training of personnel capable of performing to documented standards in this critical environment.

SRD Number: SRD-369

Status: New

Priority: Threshold

Type: Non-Functional

Function: Subsystem - Training

3.21.5.2 The Training subsystem software shall be upgraded periodically with OPS subsystem changes.

SRD Number: SRD-370

Status: New

Priority: Threshold

Type: Non-Functional

Function: Subsystem - Training

NOTE: The intent is to keep the Training and OPS subsystems synchronized.

3.21.5.3 The Training subsystem shall include a central instructor workstation that interfaces with all student workstations, either individually or simultaneously.

SRD Number: SRD-371

Status: New

Priority: Threshold

Type: Non-Functional

Function: Subsystem - Training

3.21.5.4 The Training subsystem shall include an interface to allow two-way interaction between student and instructor workstations.

SRD Number: SRD-372

Status: New

Priority: Threshold

Type: Non-Functional

Function: Subsystem - Training

3.21.5.5 The Training subsystem shall automate the installation/deletion of waveform and alphanumeric data using start time, end time, technique, and stations to specify which data is to be loaded.

SRD Number: SRD-373

Status: New

Priority: Threshold

Type: Non-Functional

Function: Subsystem - Training

3.21.5.6 The Training subsystem shall store data processing results and associated data individually by student.

SRD Number: SRD-374

Status: New

Priority: Threshold

Type: Non-Functional

Function: Subsystem - Training

3.21.5.7 The Training subsystem shall store all event solutions individually by student.

SRD Number: SRD-375

Status: New
Priority: Threshold
Type: Non-Functional
Function: Subsystem - Training

3.21.5.8 The Training subsystem shall project the instructor workstation display onto any or all of the students' workstation displays.

SRD Number: SRD-376

Status: New
Priority: Threshold
Type: Functional
Function: Subsystem - Training

3.21.5.9 The Training subsystem shall project any selected student's workstation display onto the instructor's workstation display.

SRD Number: SRD-377

Status: New
Priority: Threshold
Type: Functional
Function: Subsystem - Training

3.21.5.10 The Training subsystem shall prevent stored analysis results from being overwritten by a new computed solution unless requested by the instructor and/or student.

SRD Number: SRD-378

Status: New
Priority: Threshold
Type: Constraint
Function: Subsystem - Training

3.21.5.11 The Training subsystem shall store data and results for simulated events to be analyzed by a student.

SRD Number: SRD-618

Status: New
Priority: Threshold
Function: Subsystem - Training

4 APPENDIX A - GLOSSARY

Acronym Definitions

ACID	Atomicity, Consistency, Isolation, Durability: set of properties of a database management system that guarantees that transactions are processed reliably.
ALT	Alternate Subsystem: system that supports mission critical business function of the IDC in the event of a natural or human-induced disaster.

ANSI/ISO	American National Standards Institute / International Organization for Standardization
Authorized User	An 'authorized user' is a person or system who can present the necessary security credentials permitting them to access a specific system capability to fulfil a specific system role. In this document, the term Authorized User is not restricted to NDC Authorized Users.
BB	Broadband
BBLP	Broadband to Long Period
BSSA	Bulletin of the Seismological Society of America
CATS	Continuous Automatic Testing Framework
CD1.1	Continuous Data version 1.1 (for IMS Continuous Data Exchange)
COTS	Commercial Off-the-shelf
CTBT	Comprehensive Nuclear Test Ban Treaty
DA	Data Acquisition
DBDD	Database Design Document
DEV	Development Subsystem
DFX	Detection and Feature Extraction
FIR	Finite Impulse Response
fk	Frequency-Wavenumber
Fstat	Fischer Statistic
GCF	Generic Coefficient Filter
GCI	Global Communications Infrastructure

GDR	GCI Data Repository: The data repository of the waveform acquisition subsystem. Waveform data stored in the GDR is made available to OPS in accordance to policies (upon request by the SHI processing pipelines for auxiliary stations and automatically upon receipt for all other SHI stations).
GUI	Graphical User Interface
IDC	International Data Centre
IMS	International Monitoring System
IPRA	Interactive Processing, Review, and Analysis
IRIS	Incorporated Research Institutions for Seismology
LP	Long Period
mb	Narrow-band body wave magnitude
Ms	Narrow-band surface wave magnitude
NDCs	National Data Centres
NORSAR	Norwegian Seismic Array
OPS	Operational Subsystem
PCF	Pseudo Correlation Filter
PDF	Probability Density Function
PKI	Public Key Infrastructure
PM	Performance Monitoring
PMF	Phase Match Filter
PSD	Power Spectral Density
QC	Quality Control

RF	Radio Frequency
SAC	Seismic Analysis
SNR	Signal-to-Noise Ratio
SOH	State-of-Health
SRD	System Requirements Document
SSD	System Specification Document
STA/LTA	Short Term Averaging / Long Term Averaging
SUS	Alternate name for the TST (Testbed) subsystem.
TST	Testbed subsystem
UI	User Interface
UN	United Nations
USGS	United States Geological Survey

5 APPENDIX B - TAGS

5.1 B.1 Status Tags

These tags define the implementation status of this requirement within the existing system. Each requirement must be mapped to one and only one of these.

- **Current:** Current requirements are fully implemented within the current system
- **Current-Partial:** Current-Partial requirements have some aspects which are met in the current system but are not completely fulfilled.
- **New:** New requirements are not met by the current system.

5.2 B.2 Priority Tags

These tags define the need for this requirement in the modernization effort. Each requirement must be mapped to one and only one of these.

- **Threshold:** Threshold requirements must be met during IDC Re-engineering Phase 3.
- **Objective/Priority 1:** These higher priority requirements are desired to be met during IDC Re-engineering

Phase 3.

- **Objective/Priority 2:** These lower priority requirements are desired to be met during IDC Re-engineering Phase 3.
- **Extensibility:** Extensibility requirements refer to future capabilities for which consideration must be given to the future integration of the capability, but are not current development projects.

5.3 B.3 Type Tags

The tags define the type of requirement. Each requirement must be mapped to one and only one of these.

Constraint: A constraint requirement defines one of the following:

- Purpose of the product
- Client, Customer, or other Stakeholders (like environments available)
- Users of the system
- Requirements constraints (limitations)
- Naming Conventions
- Relevant Facts
- Assumptions

Functional: Functional requirements are used to define the scope of IDC Re-engineering Phase 3 and deal with functionality or data. These requirements define specific behavior or functions.

Non-Functional: A non-functional requirement is one that specifies criteria that can be used to judge the operation of a system, rather than specific behaviours. Non-Functional requirements may deal with the following:

- Look and Feel
- Usability
- Maintainability / Portability
- Security
- Cultural / Political
- Legal
- Other “-ilities”

In general, functional requirements define what a system is supposed to do whereas non-functional requirements define how a system is supposed to be. Functional requirements are usually in the form of "system shall do <requirement>", while non-functional requirements are "system shall be <requirement>".

Project Issues: Project Issue requirements document issues that have existed, or currently exist in the system and should be avoided or corrected in IDC Re-engineering Phase 3.

5.4 B.4 Function Tags

The tags define the functional area impacted by the requirement. A requirement should be mapped to at least one of these tags, but may be mapped to multiple.

Confidence: Confidence requirements describe the system’s ability to compute and store an estimate of measurement accuracy. Examples include estimates of event location uncertainty such as coverage and confidence ellipses, and event magnitude uncertainty.

System-wide: These requirements impact the system as a whole and generally aren't allocated to any other functional area.

Data Acquisition: The requirements for the software necessary to acquire, organize, and store waveform data, in near-real-time, from a global network of sensors. This also encompasses syncing data across all portions of the IDC to include OPS and ALT locations and the acquisition partition to processing partition data movement.

Events of Interest: Events selected based on criteria specified by authorized users.

External Interfaces: External Interfaces deal with all internal and external system stakeholders. These interfaces include forwarding of seismic data, generating and distributing bulletins and reports and providing access to data and products.

Data Management: Data management requirements address the management of waveform, database storage, and archiving.

Quality Control: Data Quality Control (QC) is required in order to remove undesirable data from processing. The goal of QC is to pre-process waveform data and produce masks which remove from processing any data which has gaps, spikes, drop-outs, invalid channel gains, timing errors, etc.

Signal Processing: Signal Processing refers to any waveform processing such as filtering, beamforming, and polarization analysis.

Waveform Filtering: Waveform filtering deals with the algorithms and processing needed to filter a waveform for analysis or review. The filter library/service shall be designed to allow easy extensibility for additional filters in the future. Filters should be able to be cascaded and include:

- Butterworth Filter
- Autoregressive Filter
- Phase Match Filter (PMF)
- Pseudo Correlation Filter (PCF)
- Finite Impulse Response (FIR)
- Infinite Impulse Response (IIR)
- Generic Coefficient Filter (GCF).

Frequency-Wavenumber (fk) Analysis: The fk Analysis requirements deal with computation and display of frequency domain and frequency wavenumber measurements.

Multichannel Processing: Beamforming and Three Component Processing. Data from sensor arrays and three component seismometers are used to enhance signal characteristics for detection processing and feature extraction. Beamforming is a multichannel signal processing technique that focuses the elements of an array in a specific direction. This provides a signal to noise ratio gain via constructive interference of coherent directional signals and destructive interference of incoherent background noise. Data from a three component seismometer is rotated to the signal's angle of arrival to form traces that correspond to radial and transverse ground motion.

Detection: The system is designed to automatically and continuously detect signals of interest.

Signal Characterization / Feature Extraction: Signal characterization/feature extraction requirements cover a range of data processing which centers on measuring alphanumeric parameters of waveform data (e.g., amplitude, period, azimuth, velocity) and making determinations based on those values (e.g., initial Phase ID). Note that there is considerable overlap between feature extraction and signal detection.

Association: Association requirements deal with the association of signals to a source event.

Location: Due to the heterogeneity of the Earth, location of events in three dimensions is a scientifically challenging problem. The IDC must integrate the constantly evolving state-of-the-art earth models and location

algorithms.

Magnitude Estimation: After events are located, seismic magnitude is determined as a function of the ground motion measurements, the distance between the source and receiver(s), and known attenuation factors.

Interactive Monitoring: Interactive Monitoring requirements deal with Human-Machine Interfaces (HMI) specifically for the monitor and control of the source system. This encompasses SOH of stations and the system as a whole as well as the status of individual applications that are part of the IDC.

Interactive Processing, Review, and Analysis: The purpose of Interactive Processing, Review, and Analysis requirements is to provide the user with the capability to review, refine, correct, and/or display the currently available results, regardless of whether they have been generated directly from the automated processing system or from previous analysis by another user.

Geographic Information System: Data analysis performed by IDC/MDA analysts involves the evaluation of geospatial relationships on a global scale and therefore requires robust interactive GIS capability.

Earth/Propagation Models: Due to the heterogeneity of the Earth, complex propagation models are required to determine the source location of an event (travel time/azimuth/slowness models) and the magnitude (attenuation models).

Travel Time/Azimuth/Slowness: Travel Time requirements deal with the calculation of the time for propagation of the wavefront from the source to the receiving station.

Attenuation: Attenuation requirements deal with the reduction in signal amplitude during the propagation of the wavefront from the source to the receiving station.

Performance Monitoring: The purpose of Data Processing Performance Monitoring is twofold: to provide a method to monitor components of the data processing system, and to quantify the level of performance. This functionality will allow users of the system to observe changes in performance as components of the system change (i.e., new versions of data processing software, addition of stations or techniques, new processing algorithms, etc.). It will allow for comparison of processing results within the data processing system (i.e., automated vs. interactive processing results). It will also provide the baseline knowledge necessary to implement incremental improvements in the data processing system. The foundation of the Data Processing Performance Monitoring system will be the collection of appropriate data and the statistical analysis and interpretation of results based on these data.

NOTE: There is considerable overlap between performance monitoring for system problems (e.g., notification of failure of automated processes), and performance monitoring from a perspective of geophysical signal processing (statistics regarding data acquisition, signal detection, event formation, bulletin comparisons, etc.). As much as possible, requirements for monitoring system problems are located in the "Reliability, Maintainability, Availability" section of this SRD, requirements for monitoring geophysical signal processing are in the performance monitoring section.

Security: The system must protect information from unauthorized access and corruption and shall protect all sensitive data from inadvertent or unauthorized release.

Subsystem - ALT: These requirements deal with a separate, fully functional copy of the system at an Alternate location for the purposes of Disaster Recover.

Subsystem - CATS: Continuous Automatic Testing Framework Subsystem.

Subsystem – SUS/TST: These requirements deal with the maintaining of a Sustainment/Testbed copy of the system used for testing of new functionality before promotion to operational status.

Subsystem - Training: These requirements deal with a small, separate training system with minimal capabilities used to train new analysts.