SANDIA REPORT
SAND2015-1065
Unlimited Release
February 2015

IDC Reengineering Phase 2 Project Scope

Version 1.1

James Mark Harris

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Sandia National Laboratories

Issued by Sandia National Laboratories, operated for the United States Department of Energy by Sandia Corporation.

Printed in the United States of America. This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from
U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831

Telephone:	(865) 576-8401
Facsimile:	(865) 576-5728
E-Mail:	reports@adonis.osti.gov
Online ordering:	http://www.osti.gov/bridge

Available to the public from
U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Rd.
Springfield, VA 22161

Telephone:	(800) 553-6847
Facsimile:	(703) 605-6900
E-Mail:	orders@ntis.fedworld.gov
Online order:	http://www.ntis.gov/help/ordermethods.asp?loc=7-4-0#online

SAND2015-1065
Unlimited Release
February 2015

IDC Reengineering Phase 2 Project Scope

James Mark Harris
Next Generation Monitoring Systems Department
Sandia National Laboratories
P.O. Box 5800
Albuquerque, New Mexico 87185-MS0401

Abstract

This report provides a brief description of the scope of the IDC Reengineering Phase 2 project. It describes the goals and objectives of reengineering, the system definition, and the technical scope of the system.

REVISIONS

Version	Date	Author/Team	Revision Description	Authorized by
1.0	9/25/2014	SNL IDC Reengineering Team	Unlimited Release for I2	M. Harris
1.1	28/01/2015	IDC Reengineering Team	Align with previous IDC scope document	E. Tomuta

CONTENTS

1 INTRODUCTION

The Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) operates the International Data Centre (IDC) to support treaty verification activities by Member States. The IDC collects, stores, processes, and distributes data from seismic, hydroacoustic, infrasound, and radionuclide stations. A significant component of the IDC is the seismic, hydroacoustic, and infrasound (SHI) processing system. The IDC has recognized the need to reengineer the SHI processing system and has defined a three-phase reengineering effort.

IDC Reengineering Phase 1 (RP1) started in 2011 with the goal to significantly modernize SHI automatic and interactive data processing software, focusing on enhancements to individual components of the system.

Reengineering Phase 2 (RP2), started in 2014, addresses the task of specifying a unified architecture for all SHI software, across processing stages, to pave the way for further software development and sustainment in the future. A key objective of RP2 is an architecture sufficient to provide a basis for a cost estimate for the development or enhancement of the software components and subsystems.

Reengineering Phase 3 (RP3) will address implementation of software components based on this architecture. RP3 will begin with the creation of an implementation plan that will include priorities and timelines for developing software components complying with the architecture created in Phase 2. It is expected RP3 will start in 2017, as RP2 comes to an end. Following terminology of the Rational Unified Process software development methodology (e.g. http://en.wikipedia.org/wiki/Rup) RP2 covers the Inception and Elaboration stages, while RP3 will cover the Development and Transition stages.

This report provides a brief description of the scope of the IDC Reengineering Phase 2 project. It describes the goals and objectives of reengineering, the system definition, and the technical scope of the system. This report expands upon the "Scope for IDC Reengineering Phase 2", July 2014, ECS-DIS-WGB-43-PTS-MATERIAL-12-ADD-1, produced by the IDC.

1.1 Need

In the last 16 years, since the delivery of the first version of the SHI acquisition, processing and product dissemination software by the PIDC, major components of the system have been replaced in response to advances in monitoring technologies leading to new functional requirements and infrastructure changes. In the absence of an up-to-date overarching architecture, the result of these development activities is an increasingly fragmented software landscape with little software reuse, code duplication, and outdated technologies. Such a system is increasingly difficult to maintain and enhance as new technologies become available. This project aims to develop a modern, model-based component architecture as the foundation for a cost-effective, maintainable and extensible system that will allow the CTBTO to meet its treaty monitoring requirements for the next 20+ years.

1.2 Goals

The goals of the system to be developed in RP2 and RP3 are to:

1. Unify SHI processing software used in all processing stages and provide a modern approach to integrating new components.
2. Provide a basis for enhancing and extending SHI interactive software with a modern User Interface (UI) design, improved security and support for remote analysts.
3. Ensure reproducibility of results of SHI analysis
4. Add new data and product acquisition and distribution mechanisms following latest industry standards.
5. Provide a basis for an IT Disaster Recovery System in accordance to CTBTO Business Continuity requirements. (A 'disaster' is any situation that interrupts the routine operation of the processing system to the extent that the system hardware and software can no longer adequately function for a sustained period of time on order of several days or longer).
6. Provide a training platform to integrate new staff.
7. Integrate new data sources, including data from Contributing National Facilities, National Technical Means, other openly-available SHI data and meteorological data required to analyze infrasound signals.
8. Enable the IDC to efficiently provide special event analysis at the request of the Member States.

1.3 Objectives

The following objectives support the goals of RP2.

1. The proposed software implementation is faithfully represented and documented in a hierarchical UML-style model that guides software operation, maintenance and development, and is continuously updated to be synchronized with the current system.
2. All waveform technologies are fully integrated in the processing and analysis toolsets.
3. The software architecture supports analysis based on scientifically-sound fit-for-purpose geophysical models, wave propagation algorithms and inference methods.
4. The system architecture is:
   - 4.1. Modular, with well-defined interfaces that enable software developers from different organizations to build applications that can be integrated directly.
   - 4.2. Layered, with a clear understanding of responsibilities between layers and with minimal coupling between layers.
5. The system architecture encourages code reuse and uses encapsulation, with data accessed through a conceptual data layer that simplifies access, hides the implementation details of the storage mechanism, and minimizes the impact to client applications of changes in the physical data layer.
6. The system architecture builds on the results of Phase 1, taking advantage of ongoing developments in automatic processing, advanced scientific algorithms, and interactive analysis, product distribution, and automated testing.
7. Analysis provenance is captured and easy to access; system configuration history is maintained and accessible.
8. The software architecture explicitly recognizes the need to provide a platform for training new analysts and processing engineers as well as improving the skills of existing ones.

9. The architecture encourages the development of open software using open-source components and the interoperability with 3rd-party software through standard interfaces.
10. External data sources can be accommodated and integrated into SHI analysis to support activities and analysis requested by the Member States.
11. Software is developed in a consistent style using a minimal set of prevalent, modern programming languages.
12. Interactive analysis software tools are implemented following modern best practices in UI design.
13. New computer technologies can be incorporated efficiently.
14. Analysis and system monitoring may be performed remotely.
15. System alerts and notifications are performed in a consistent way to provide all responsible and otherwise authorized parties with access to timely information about system status and events of interest.
16. System performance is monitored and reported to authorized users, including Member States.
17. System Design explicitly meets requirements for an IT disaster recovery system.

1.4 Stakeholders

CTBTO International Data Centre (IDC) Division has overall responsibility for the specification, development, deployment, interfaces, operation, maintenance, and enhancement of the IDC SHI system.

CTBTO International Monitoring System (IMS) Division is responsible for the technical operation of the IMS, including maintenance, calibration, and control of the IMS stations.

IDC Operations Section is responsible for maintenance of the Global Communication Infrastructure (GCI) used to transmit data from IMS stations to the IDC, as well as for various aspects related to the operation of IMS stations.

IDC Automatic Processing Systems Section is responsible for data acquisition, automatic data processing and data product distribution.

IDC Monitoring and Data Analysis Section is responsible for data analysis.

IDC Capacity Building and Training Section is responsible for distribution of and training on stand-alone systems.

IDC Software Applications Section is responsible for software enhancement and maintenance.

IMS Network and Systems Support Section is responsible for hardware maintenance.

External stakeholders receive data and processing results from the IDC system, and provide additional data and processing capabilities to the IDC system. External stakeholders include Member States, National Data Centers (NDCs), researchers, and data providers such as other data centers and station operators.

SNL is responsible for execution of the reengineering project in collaboration with IDC Software Applications Section.

1.5 Development Process

The IDC RP2 project follows the IBM Rational Unified Process (RUP), an industry-standard software lifecycle development methodology that promotes an iterative, risk-driven approach. RUP defines four major project phases: Inception, Elaboration, Development, and Transition. Each phase is organized into iterations of roughly six-month duration to promote incremental development and anticipate change. RUP identifies the activities in each phase and “artifacts” that should be produced.

SNL and IDC work collaboratively to develop the modernized system architecture. IDC has allocated significant resources of system engineering and scientific experts for this effort. SNL has implemented a development environment including requirement management and software modeling tools (IBM Rational tools). SNL periodically provides requirements and model files to IDC for review and revision. IDC regularly provides information on system needs and capabilities and reviews project work.

1.6 Artifacts

The IDC RP2 project will create a number of artifacts related to the project and the technical solution. The technical artifacts include the software models that may be used in the modeling tool environment to develop and maintain the system.

Project management artifacts for the Inception and Elaboration phases include:

- Iteration Reviews
- Project Scope Document
- Integrated Master Plan (IMP) and Integrated Master Schedule (IMS)
- Use Case Model Survey (UCMS)
- Risk assessment
- Initial Implementation Cost Estimate
- Configuration Management Plan & Development Phase Plan
- Inception Phase Review & Elaboration Phase Review

Technical artifacts include:

- System Requirements Document (SRD) reviews
- System Specification Document (SSD)
- Use Case Model (UCM) using the Unified Modeling Language
- User Interface Storyboards & Use Case Realizations (UCR)
- System Architecture Document (SAD)
- System Test Plan (STP)
- Demonstration of architectural prototype & Demonstration of executable architecture
- Documentation outlining the principal elements of the physical data model that are required to support the architecture specified in the SAD.

2 SYSTEM DEFINITION

The modernized IDC system is iteratively defined by system requirements, system specifications, and use cases. As the project proceeds through the phases and iterations, more detailed definitions and implementations are created.

2.1 System Requirements

The System Requirements Document (SRD) is an IDC-produced record of the capabilities required in the system. IDC and SNL have jointly reviewed and modified the SRD to enhance understanding of the system requirements. The SRD is a source document used as a guide to define the detailed functionality and behavior of the system.

2.2 System Specifications

The System Specification Document (SSD) provides a set of specification requirement statements that will satisfy the SRD requirements. The SSD items are written to be testable in the final system implementation, so tend to be concise statements of functionality. If the set of SSD items are verified, then the SRD items are satisfied by the system. The full set of specifications defines the full scope of the functionality of the system.

2.3 Use Cases

Use cases are statements of the behavior required by the system, from the point of view of the users interacting with the system. Actors are defined to represent the user interactions, organized by the type of functionality being used. The full set of use cases defines the full scope of the behavior of the system. Actors defined during the Inception phase are shown in Figure 1. The top-level use cases are shown in Figure 2. Most of these use cases are decomposed into more detailed use cases that define interaction details for various system functions.

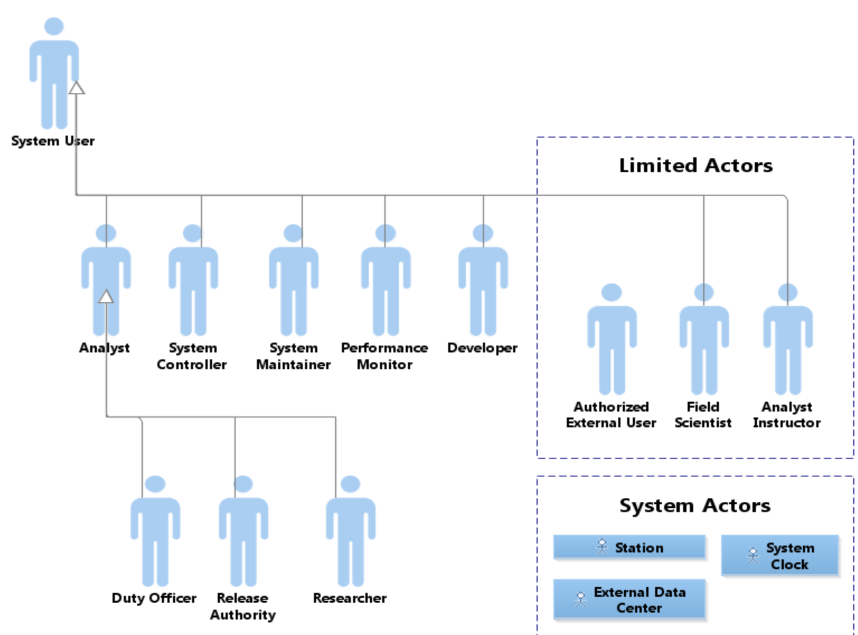

Figure 1. IDC Actor hierarchy.

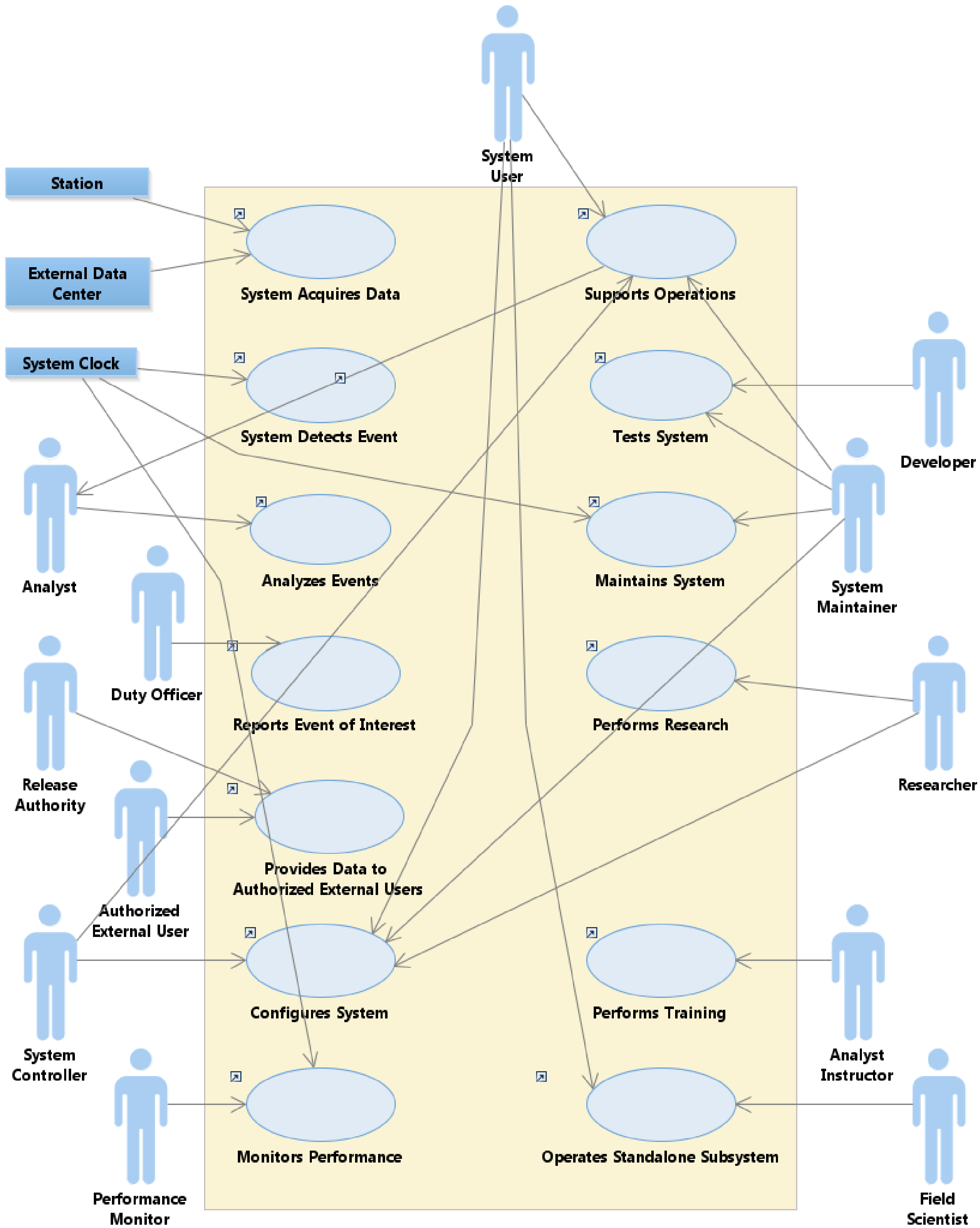

Figure 2. Top-level IDC Use Cases. The full set of use cases defines the scope of behavior of the system.

2.4 Architecture

Architecture is the process of defining the organization of a system by its components and the relationships between components, so that a set of system-wide requirements and qualities are satisfied. An "architecture" is also the resulting product of the architecture process, often captured as a set of models, diagrams, or views. A goal of the IDC Reengineering project is to produce a full set of models and views using standard software modeling techniques. These views are illustrated by the 4+1 View Model.

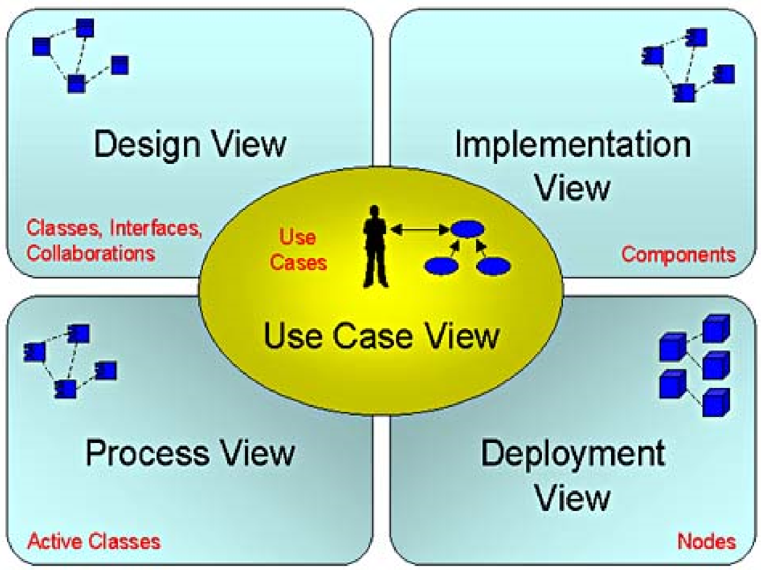

Figure 3. 4+1 View Model.

3 TECHNICAL SCOPE

3.1 System Context

Raw and processed data are received from stations and data centers, and provided to external data users through various communication systems. Station command and control functions, beyond requesting calibration and key management operations, are not part of the IDC system but may be performed based on status observed by the IDC system. Researchers interact with the system to access data and provide algorithms and parameters to improve performance. Other IDC systems (such as the radionuclide processing system) interact with the SHI system to utilize data and processing capabilities or provide data. Finally, processing results are provided in various forms to a set of authorized external users.

The following components are in scope of the RP2 system architecture:

- Continuous Data Acquisition: (1) IMS waveform data are automatically forwarded to the IDC; (2) data are reformatted, archived, and made available for processing.
- Data Forwarding: IMS waveform data are automatically forwarded to states parties (states parties control what data to receive).
- Auxiliary Data Acquisition: (1) IMS data from the Auxiliary seismic network are requested and integrated into the processing stream. (2) Auxiliary seismic stations may be switched to Primary in the event of a failure of a Primary station, as authorized according to the Draft IDC Operational Manual.
- Data Import: Other data from, e.g. Cooperating National Facilities (CNF), or National Technical Means (NTM) are acquired and imported into the processing environment according to the protocol for integrating these data with IMS data.
- Data Processing: (1) Data are processed to detect and characterize events (e.g. lat, lon, depth, time, magnitude).
- Interactive Analysis: 1) automatically detected events are reviewed and corrected; 2) missed events are manually added.
- Event Screening: (1) event features are computed to accomplish screening of non-explosions and other screening based on user (i.e. Member State) specified criteria.
- Special Event Analysis: Special analysis of events of interest may be analyzed using data from CNF and NTM sources integrated with IMS data.
- Data and Product Dissemination: various event lists (automatic, analyst reviewed, screened), waveform data, radionuclide data, station quality products.
- System Monitoring and Control.

The following is out of scope of the RP2 system architecture:

- Specification of hardware architecture to host the system.
- IMS Station State of Health, except the information that is part of the CD protocol.
- Station and network operation, including GCI, IRS.
- Radionuclide data acquisition, processing, and analysis (radionuclide data and product dissemination is considered in scope).

The following figure shows the IDC system in context with these other concerns, providing a general boundary of the technical scope of the system. Details of the functionality included within the boundary are defined by specifications and use cases. The IDC system interacts with the outside systems via defined interfaces.

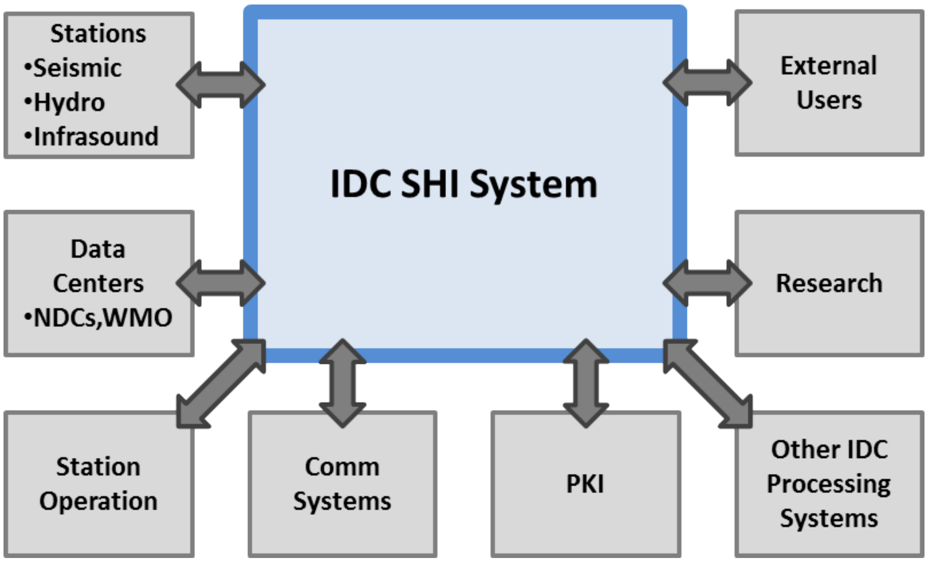

Figure 4. Scope and interfaces of the IDC System.

3.2 Processing Components

Data acquisition, signal detection, event detection, analysis, and reporting are accomplished using a distributed, modular software architecture.

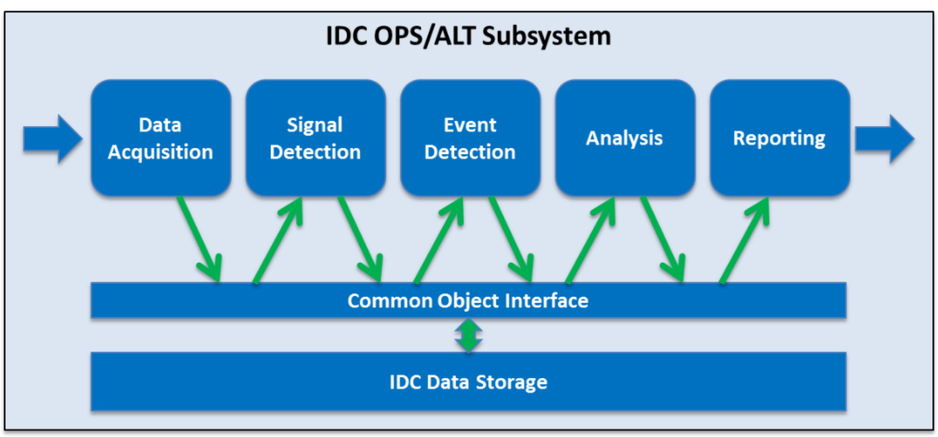

Figure 5. Primary data processing functions.

3.3 Users

Multiple levels of event review are supported by analysts with increasing proficiency. Researchers use the system to access data and system capabilities. Authorized external users access the system in a controlled way to view data and processing results. The IDC system provides interactive software applications designed for each of these users. For architecture modeling, users are abstracted as a set of actors.

4 ASSUMPTIONS AND CONSTRAINTS

The following assumptions and constraints are in effect for the duration of the IDC project:

- The minimum sensor network (size and complexity) is specified in the Treaty.
- The available SHI stations that may be imported for special processing will increase over time. The number of openly available stations currently numbers in the 1000's. A substantial number of additional stations may be provided by Member States through National Technical Means. Stations contributing data as Cooperating National Facilities represent yet another source of data. Each of these data sources will be subject to different protocols regarding their use in the products of analysis.
- It is assumed that the current requirement of acquiring data from Auxiliary seismic stations through explicit data requests will remain valid in the long term.
- The system will be supported by an international team, all with limited term appointments.
- Most of the software development will be contracted, potentially to several geographically dispersed teams.
- A full-time CTBTO software engineer will be assigned to the project for its full duration.
- Project stakeholders will be available to review and provide input on the project deliverables.
- Components of the core system architecture shall be specified to a sufficient level of detail (in terms of protocols and interfaces) to allow the CTBTO to use different components developed according to the same specifications by other organizations (e.g. software donated by Member States as contribution in kind or software developed by external contractors).
- The system must initially implement the procedures, services, products and metrics described in the Draft IDC Operations Manual.
- Stakeholders include the Member States, and their experts will be invited to provide input on software requirements.
- The system must run on commodity hardware.
- Hardware and system software for the current and modernized IDC system will be procured and deployed by IDC.
- No system transition down time. The old/new system must continue to function consistently and reliably as components are modified/replaced, in a staged manner, during the period of modernization
- The modernized system must be sustainable and adaptable to an evolving mission for next ~20 years.
- RUP will be used for the complete lifecycle of the RP2 project.

Sandia National Laboratories