CERTIFICATION OF U.S.INTERNATIONAL MONITORING SYSTEM STATIONS

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ABSTRACT

All stations planned for the International Monitoring System (IMS) must be certified by the Provisional Technical Secretariat (PTS) prior to acceptance to ensure that the monitoring stations initially meet the required specifications. Working Group B of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty has established requirements for the quality, availability, and surety of data received at the International Data Centre (IDC). These requirements are verified by the PTS during a 3-component process that includes initial station assessment, testing and evaluation, and certification.

Sandia National Laboratories has developed procedures, facilities, and tools that can be used to assist in evaluating IMS stations for compliance with certification requirements. System evaluation includes station design reviews, component testing, and operational testing of station equipment. Station design is evaluated for security and reliability considerations, and to ensure that operational procedures and documentation are adequate. Components of the station are tested for compliance with technical specifications, such as timing and noise levels of sampled data, and monitoring of tamper detection equipment. Data sent from the station in an IMS-standard format (CD-1 or IMS-1) are analyzed for compliance with the specified protocol and to ensure that the station data (sensor and state-of-health) are accurately transmitted. Data availability and authentication statistics are compiled and examined for problems.

OBJECTIVE

The Provisional Technical Secretariat (PTS) has established procedures for certifying monitoring stations in the International Monitoring System (IMS) [1]. Each station operator is responsible for supporting PTS certification activities. The objective of this work was to assist U. S. station operators in meeting IMS certification requirements.

RESEARCH ACCOMPLISHED

IMS Station Certification Overview

The PTS may certify a station once it has been demonstrated that the site, station equipment, and infrastructure substantially meet the minimum technical requirements for IMS stations [1]. The station operator is responsible for preparing the station to meet these requirements. To accomplish certification, the PTS forms a technical Certification Team for each station under consideration. The Certification Team evaluates the station and recommends corrective actions if needed. Once satisfied that the station meets IMS requirements, the Certification Team presents its recommendation to the PTS Certification Group, which reviews the certification request and approves the certification.

For U. S. IMS stations, Sandia National Laboratories (SNL) serves as a common point of contact for the PTS Certification Teams. SNL works with the station operator to compile the needed documentation and evaluates station components and station design to ensure that IMS requirements are met. SNL conducts a mock certification visit to ensure readiness of the station and prepares a Certification Manual for the station. The U. S. Department of

Defense, Nuclear Treaty Program Office delivers the Certification Manual to the PTS for review and schedules the PTS Certification Team site visit. The flow chart shown in Figure 1 illustrates the steps required for each station. Note that many of these steps may be underway concurrently.

Compilation of Station Documentation

The PTS has written a series *Operational Manuals* and *Guidelines for Station Operators on Certification of IMS Stations* for each type of IMS station [2-9]. SNL reviews these two types of documents and develops both a Documentation Checklist and a Station Compliance Checklist. Because the two types of PTS documents are subject to change, SNL frequently reviews the documents and adapts the checklists to reflect changes. These checklists are then sent to the station operators along with a description of the needed documentation. When possible, this is done during station installation so that the operators can begin gathering the documentation while much of the work is being done.

The documentation required by the PTS to support certification is comprehensive. It includes:

1. General station information
   - IMS Station Questionnaire
   - land ownership/leases and any restrictions
   - ownership of equipment
2. Infrastructure
   - site surveys
   - maps of the area and of the site layout, sensor coordinates
   - block diagrams of both the equipment and facility
   - descriptions and diagrams of the power supply systems
   - descriptions and diagrams of the physical security systems
3. Data Acquisition System information
   - sensor specifications
   - digitizer specifications
   - data authentication
   - equipment specifications
   - noise plots
   - user manuals
   - meteorological sensor information
4. Central Processing Facility information
   - software descriptions and commands
   - data format and protocols
   - command authentication
   - data authentication
   - environmental control of the facility
5. Communications
   - descriptions and specifications on all communications equipment (for both intra-site and external communications)
   - any licensing required
   - a layout of the system including cabling
6. Station Inventory
   - listing of all equipment
   - spare sensors and their calibration sensitivities

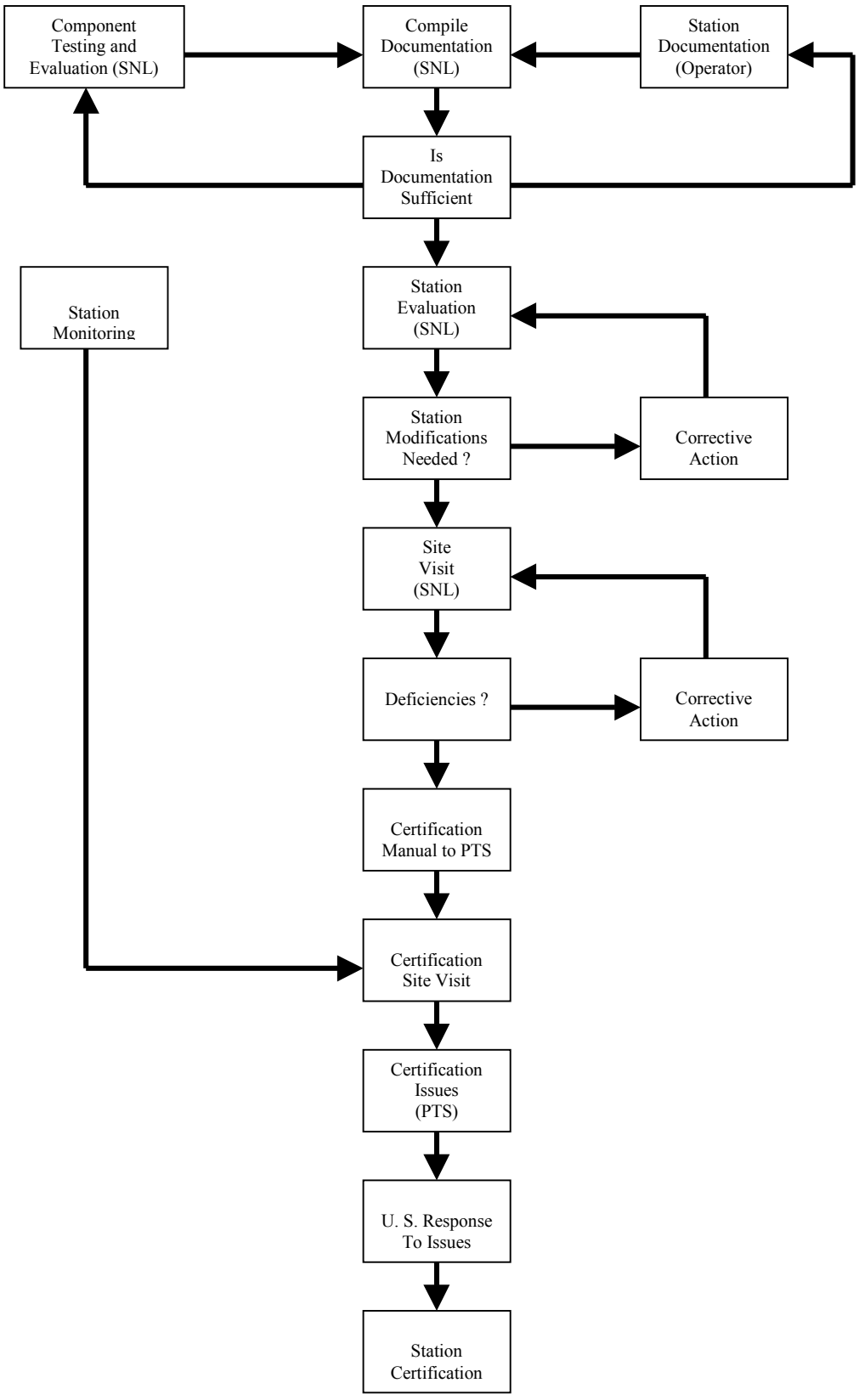

Figure 1. U. S. Station Certification Process.

7. Operation and Maintenance documentation
    - data and state-of-health monitoring
    - staff members and their experience
    - procedures for troubleshooting and repairing equipment
    - calibration procedures and schedules
    - preventive maintenance procedures and schedules
    - record keeping procedures
    - equipment failures and system outages
    - data availability.

Once the documentation is received at SNL, it is checked for completeness and thoroughness. Everything listed on the checklist must be addressed and the information must answer the questions posed by the PTS. The station operator is consulted to resolve any problems.

Component Testing

The testing required for hardware components to determine compliance with IMS requirements for station certification is performed in three parts: sensor performance, data acquisition system performance, and station performance. The tests used by SNL are described here.

IMS Sensor Testing

Information on sensor performance (sensitivity and self-noise) is obtained from the manufacturer's data sheets and/or sensor testing.

Sensor testing is performed by comparing the IMS sensor to a known calibrated sensor using side-by-side coherence testing between the two sensors. Using this technique, the relative gain and phase of the IMS sensor to reference the sensor is determined. Sensor self-noise is determined by using side-by-side coherence testing between the two IMS sensors to determine an average self-noise.

IMS Data Acquisition System (DAS) Testing

Information on data acquisition system performance is obtained from the manufacturer's data sheets and/or system testing.

An assortment of tests is performed to measure the conformance of the DAS to IMS requirements:

- Digitizer DC Accuracy (Sensitivity)
  This test determines the counts/volt or digitizer bit-weight using a Standard Voltage Source as a stimulus to the DAS input(s).
- Digitizer Input Terminated Noise (Self-noise)
  This test determines DAS self-noise by terminating DAS input(s) with appropriate resistor termination.
- Digitizer Time-Tag Accuracy
  This test determines DAS sample timing accuracy by using a GPS synchronized signal generator as a stimulus to the DAS input(s).

IMS System Performance

Information on station performance is obtained from historical data and the results of sensor and data acquisition system testing.

System resolution and noise are determined by converting the data acquisition system characteristics to sensor units using the sensor transfer function. System noise, in geophysical units, is compared to historical backgrounds to determine the system's ability to measure signals to the required resolution.

Station Evaluation and Testing

SNL examines the station documentation for compliance with the specifications listed in the *Operational Manual*. The complete system is evaluated for reliability and security as well. Station design problems may be discovered and corrected at this time.

Testing the integrated station equipment is also very important. The preferred method to verify that station operation will meet IMS operating requirements is to test the completed station, including the communications network, in a monitoring environment.

SNL has developed a system to receive and analyze data from a station in CD-1 format. This software stores all of the CD-1 data frames on disk in a human-readable format. These files are searched for particular problems or conditions. For example, the occurrence of short data segments, indicating a data dropout at some point, can be found and examined. The handshaking and configuration frames are examined to ensure correct connection. The sensor data values are examined for problems. Also, this system allows the raw protocol frames to be stored on disk for later review or playback. This system was used to receive data from PS47 (forwarded through the U. S. National Data Center) to support testing of the data availability, status flags, and authentication for the PS47 certification.

Data Surety and Authentication

Correct implementation of data and command authentication at monitoring stations has been problematic, at least in part, because detailed PTS authentication specifications have not been available to station operators and equipment manufacturers. SNL has demonstrated authentication technology applied to various station configurations [10,11]. These activities helped clarify the station requirements for authentication.

Authentication equipment that will meet certification requirements is now available commercially. SNL has performed detailed, formal evaluations on some authentication devices to support use at U. S. stations [e.g. 12]. For these evaluations, test plans were developed, the equipment was tested in a simulated station environment, and results were documented in detail. The tests included evaluation of the station design, physical security of the authentication device, intrusion monitoring, data and command authentication, remote key change operation, and a software security review.

SNL developed software tools and procedures to support this testing, including a CD-1 data receiver with digital signature verification and X.509 key management software. This software has been under development for a number of years. It has been used for authentication demonstrations as well as device testing. Also, SNL has developed tools to demonstrate and test S/MIME authentication techniques as required by Radionuclide and Auxiliary Seismic stations.

Since many data surety requirements are system oriented, data surety must be evaluated in the context of a complete monitoring system. In addition to the secure operation of specific authentication equipment, station security and access authorization are important to data surety and are thoroughly reviewed.

Station Monitoring

The PTS requires long-term operation of the station (at least three months for some stations) prior to certification. The station is monitored for outages, data gaps, spikes, state-of-health, and overall station operability. Data availability statistics are calculated for data received at the data center. SNL monitors these quantities with assistance from the U. S. NDC and the pIDC. Station configuration changes during this evaluation period may cause a delay in the evaluation process.

Mock Certification

Upon completion of the documentation process and initial evaluations, SNL conducts a mock certification site visit. The site visit allows SNL to verify station documentation and perform station testing. First, station configuration is examined to confirm that the collected station documentation is accurate. Block diagrams and circuit drawings are checked against actual configurations, the station inventory is compared with that given in the documentation, and on-site measurements are taken to determine if any changes in the system have occurred. Next, SNL conducts tests that the PTS has identified (e.g. power failure recovery, system reboot, loss of GPS, security system performance, partial loss of data, parallel recording of data, command authentication and remote key change, and system calibration). During this process SNL collects data to determine if the data are formatted correctly, that status is reported correctly, that authentication is functioning, and that data are buffered and retransmitted during communication outages. On completion of the site visit, SNL coordinates correction of any deficiencies discovered with the station operator. Finally, SNL writes a report detailing tests and tasks completed.

PTS Certification Site Visit and Response

Following the completion of the station monitoring process and the correction of any deficiencies discovered during the mock certification site visit, the U. S. sends the Certification Manual to the PTS Certification Team and schedules a certification site visit. SNL serves as U. S. Team Leader during the certification site visit. The certification visit begins with a meeting of U. S. representatives, SNL, the Station Operator, and the PTS Certification Team to discuss any questions the PTS may have concerning the documentation or the station itself. The PTS Certification Team may present the U. S. with a schedule of events, or inform the group of the next task they would like to complete as the visit progresses. During the station site visit, the PTS and U. S. teams complete a variety of tests as requested by the PTS Certification Team.

At the conclusion of the certification site visit, a closeout meeting is held to discuss any issues that surfaced either during the visit or with the Certification Manual. Later, the PTS Certification Team presents any certification issues in a formal document to the U. S. These may be presented in four categories: Actions Required Before Certification, Strong Recommendations, Additional Information Required, and Documentation Corrections. SNL and the Station Operator coordinate the resolution of the issues raised by the PTS Certification Team. The U. S. then provides a Response to Issues to the PTS Certification Team. Discussions may continue until the PTS Certification Team feels that all of their concerns have been resolved. At that time the PTS Certification Team will present its recommendation to the PTS Certification Group. If the Certification Group concurs with the Certification Team recommendation, it will notify all parties that the station is certified for operation in the IMS.

CONCLUSIONS AND RECOMMENDATIONS

Sandia National Laboratories has developed processes and procedures to assist operators of U. S. IMS stations in preparing for PTS certification activities. SNL has developed test and evaluation techniques to ensure station components are acceptable and system properties are adequate. These techniques were used in the successful certification process of PS47 (NVAR, Mina, Nevada) and it is expected that the techniques will be used in the certification processes of all remaining U. S. IMS stations.

Key Words: certification, IMS, authentication, station assessment

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