NOTE: Revision 10 of the IMS Operational Manuals is prepared for the first System-Wide Performance Test (SPT1). It will be reviewed using the SPT1 results and experience.
TASK LEADER NOTES

This Manual is prepared for infrasound monitoring and the international exchange of infrasound data after entry into force of this Treaty. Before entry into force, this Manual can be used as a reference, and the term “Technical Secretariat” to mean “Provisional Technical Secretariat,” the term “Director-General” to mean “Executive Secretary,” and the term “States Parties” to mean “State Signatories and, when appropriate, those States hosting or otherwise taking responsibility for stations of the International Monitoring System”, but some requirements in this Manual may be relaxed or waived.

Comments on the Comprehensive Nuclear-Test-Ban Treaty International Monitoring System Draft Operational Manuals are invited, particularly from users of the manuals, such as Technical Training Program attendees and personnel involved with station installation, operation and maintenance. Improved versions of the draft manuals can be issued until the manuals are approved by the first session of the Conference of States Parties. Please submit your comments through the Experts Communication System of the Provisional Technical Secretariat (https://ecs.ctbto.org) or by email, fax, or letter to the Task Leader:

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To be complete, each comment should clearly identify the following:

- Name and address of commentator
- Contact details for commentator
- Which Operational Manual the comment addresses
- Section number of Operational Manual the comment addresses
- Comment, including suggestions for new text.

Thank you for your help in making these important documents as useful as possible.
PREFACE

Article IV, paragraph 1, of the Comprehensive Nuclear-Test-Ban Treaty requires that the Treaty’s verification regime, including the International Monitoring System element thereof, be capable of meeting the verification requirements of the Treaty at its entry into force. Part I, paragraph 2 of the Protocol to the Treaty requires that the International Monitoring System fulfil the technical and operational requirements specified in the relevant operational manuals. Thus, this manual was prepared by the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization, pursuant to the Annex to the Resolution Establishing the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty (CTBT/MSS/RES/1). Following entry into force of the Treaty on [date to be determined], the first session of the Conference of States Parties approved the manual on [date to be determined].

The Operational Manual for Infrasound Monitoring and the International Exchange of Infrasound Data has been prepared in accordance with, inter alia, Article IV, Sections A and B, of the Comprehensive Nuclear-Test-Ban Treaty and Part I of the Protocol to the Treaty. The manual is an elaboration of the applicable provisions of the Treaty and its Protocol, but the manual is not integral to the Treaty or its protocol. In any case of conflict between this manual and the Treaty and its Protocol, the provisions of the Treaty and its Protocol govern. Additionally, this manual is not to be used to circumvent any provisions of the Treaty and its Protocol.

[TL Note: The text in this paragraph was not yet agreed and it will be discussed at a later date.]

This manual may be supplemented by supporting documents that could provide additional details about selected topics.
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CHAPTER 1 - Introduction

1.1. Purpose

Under the Comprehensive Nuclear-Test-Ban Treaty (document [1]), the Technical Secretariat is charged with developing and maintaining operational manuals, subject to approval of the Executive Council, to guide operation of various components of the verification regime (Article II, paragraph 44 of the Treaty). These include operational manuals for each of the four monitoring technologies (seismological, radionuclide, hydroacoustic and infrasound) that constitute the International Monitoring System. The Operational Manual for Infrasound Monitoring and the International Exchange of Infrasound Data in the International Monitoring System under the Comprehensive Nuclear-Test-Ban Treaty provides the specific guidelines for the infrasound portion of the International Monitoring System.

Following its approval by the Conference of States Parties at its initial session upon Treaty entry into force (ref. Article II, section B, paragraph 26(h) of the Treaty), this Operational Manual is intended to be a stable document that can be changed by the Technical Secretariat, subject to approval by the Executive Council.

1.2. Operational Manual Overview

The Operational Manual has five chapters and six appendices.

Chapter 1 defines the purpose of the Infrasound Operational Manual.

Chapter 2 provides an overview of the role and functions of the Infrasound network in the International Monitoring System.

Chapter 3 describes the technical requirements for an International Monitoring System Infrasound station.

Chapter 4 describes how International Monitoring System Infrasound stations are operated.

Chapter 5 describes how the International Monitoring System Infrasound stations are maintained and repaired.

The Appendices include a description of station requirements, a description of the content of required reports, a list of documents referenced in the manual, requirements for station-specific documentation and a glossary.

1.3. Submitting Comments and Recommendations on the Content of the Manual

Comments on the Comprehensive Nuclear-Test-Ban Treaty International Monitoring System Operational Manuals are invited, particularly from Station Operators and NDCs.
Comments should be submitted to the Technical Secretariat. Submissions by email are encouraged to imsops@ctbto.org. Submissions should contain:

- Name and address of commentator
- Contact details for commentator
- Which Operational Manual the comment addresses
- Section number of Operational Manual the comment addresses
- Comment, including suggestions for new text.

1.4. Configuration Control of the Operational Manual

The Technical Secretariat, being responsible for supervising and coordinating the operation of the International Monitoring System (Comprehensive Nuclear-Test-Ban Treaty Article II, paragraph 43(a)), is the proper authority for making changes to the Operational Manual. These changes are subject to approval by the Executive Council.

Comments will be accepted from Station Operators in coordination with the appropriate States Parties.

Bold is used in the International Monitoring System Operational Manuals to highlight areas of common text, as a reminder that changes to those parts must be made in all the manuals. In this manual, bold type is used to indicate areas which are common to all four IMS Manuals and areas which are common to the three waveform technologies.
CHAPTER 2 - Overview of the Infrasound Monitoring Network

The infrasound technique complements the other two waveform techniques (seismic and hydroacoustic) by measuring signals in the earth’s atmosphere.

Infrasound monitoring measures pressure fluctuations in the atmosphere and is capable of detecting sub-acoustic signals, including signals from atmospheric explosions and shallow underground and near-surface underwater explosions.

2.1. The International Monitoring System

The International Monitoring System is composed of facilities for seismological monitoring, radionuclide monitoring, including certified laboratories, hydroacoustic monitoring, infrasound monitoring, and respective means of communications and is supported by the International Data Centre of the Technical Secretariat.

In order to ensure good operation of the monitoring system, common protocols, software, formats and reporting requirements should be used throughout the IMS/IDC system, as appropriate.

2.2. The Global Network of Infrasound Monitoring Stations

The infrasound portion of the International Monitoring System consists of a global network of infrasound stations. The network of 60 infrasound stations is specified in Table 4 of Annex 1 of the Protocol to the Treaty. Continuous near-real-time data from the stations are transmitted directly or through a National Data Centre or an appropriate communication node to the International Data Centre.

The types of communications topology are as follows:

Basic Communications Topology (Direct Station-to-International Data Centre Communications interface): Each station whose data are routed directly to the International Data Centre via the Basic Global Communications Infrastructure Topology interfaces to the Global Communications Infrastructure equipment at the station site, as described in Chapter 3.

Partitioned Communications Topology (Station-to-International Data Centre data transmission): Data are routed through a National Data Centre or an appropriate communication node using a Global Communications Infrastructure interface. Each station whose data are routed directly to the International Data Centre or via a National Data Centre or an appropriate communication node using the Global Communications Infrastructure partitioned topology interfaces to the Global Communications Infrastructure equipment at the station site, as described in Chapter 3.

Independent Subnetwork Topology: In the case of independent subnetwork topology, the station data pass through a National Data Centre or an appropriate communication node before reaching the Global Communications Infrastructure interface.
2.3. Infrasound Station

The infrasound stations shall fulfil the technical and operational requirements specified in the Operational Manual for Infrasound Monitoring and the International Exchange of Infrasound Data.

2.4. Station Operator

The Station Operator is responsible for station operation and maintenance and is the point of contact for the Technical Secretariat. The Station Operator is identified as such by the National Authority or the responsible State Party or State hosting the International Monitoring System station.

For stations that are unmanned or are located in remote areas with limited resources, some tasks and responsibilities of the Station Operator may be carried out by the Technical Secretariat, if requested by the State Party hosting the station.

The name, address, telephone number, fax number and email address of the Station Operator are normally provided at the time of certification. These must be kept up to date and any changes should be notified promptly to the Technical Secretariat.

2.5. Certification of Stations

Station certification ensures that all station equipment and infrastructure, as well as the station environment, meet the Treaty verification requirements described in document [2]. A subsequent major upgrade or a relocation of a station may require a new certification.

The station site is approved in the site-certification process, as specified in the station-certification process document [2], which states: “A station site is approved when the station site characteristics substantially meet the site survey requirements.” (This means that not all technical requirements are rigorously met but that any variations are minor and are made known to all States Parties and States hosting International Monitoring System infrasound stations through regular reporting by the Technical Secretariat).

Equipment approval is part of the station certification process as specified in the station certification process document [2] which states: “Equipment is approved when requirements are substantially met.” The equipment checks must be performed using Technical-Secretariat-approved standards and methods and confirm the quality of the instrument as specified in the provider’s certificate. Equipment approval can be on the basis of a generic test on a particular constituent, for example a particular digitizer, or from a list of pre-approved system components. Thereafter, components similar to those that passed the generic test are regarded as pre-approved for use. Any components not pre-approved must meet the particular requirements. Individual components must perform properly when integrated into the total system such that the data availability and performance requirements are met.

A station may be certified when:

- The station site, station equipment and the infrastructure substantially meet the
technical specifications for International Monitoring System stations;
- Data Authentication devices, including anti-tampering devices, are in place and have been demonstrated to function properly;
- For a station that is directly connected to the Global Communications Infrastructure, the station interface to the Global Communications Infrastructure is in place and has been demonstrated to function properly. For the case where a station is linked to the Global Communications Infrastructure through an independent subnetwork, the communication link through the subnetwork is in place and demonstrated to function properly.

2.5.1. Information Required

The information required for the station certification process is maintained in the station-specific documentation for future reference. Information required for station certification includes:

**Accurate Location:** the absolute geographic locations of the pressure sensors or of the central summing manifold, as appropriate, to be known to within 100 m referenced to World Geodetic System 84. The relative locations of array sensors are required to be known to within 1 m with respect to the location of the centre element.

**Instrument Characteristics:** the detailed station-specific installed instrument information, required to show that the station substantially meets the International Monitoring System specifications, is provided. This information includes: a description of sensor and digitizer type, and their technical specifications and nominal operational settings, information for each array element on installed wind noise reducing system, meteorological station, timing systems, their technical specifications and nominal operational settings and installation date, power supply systems for all array elements, the central processing station, description of the central processor and data back-up storage unit, including all peripheral equipment, communications hardware, manufacturer, date of installation, contracts and provisions with communication providers, and a complete description of the local array telemetry system, including circuit diagrams and specifications. Overview block diagram of the infrasound array and the elements should also be provided.

**Site Characteristics:** detailed station-specific site information, such as:
- Maps of the array showing the routing of cable or location of radio towers and location of sensors, remote operating facilities and terrain features;
- Drawings of equipment grounding systems showing connection points and names of equipment assigned to each connection;
- Drawings of the facility compound showing location of infrastructure buildings, permanently installed equipment, roads and parking areas;
- Drawings of any facility floor plans;
- A description of station security procedures;
- Descriptions of the primary source of power and of any back-up power supplies, including plans where appropriate;
- Map of local area showing location of the facility relative to topographic and noise-generating features such as major roads, towns, rivers, buildings, etc.
2.5.2. Official Registration of Station Name

The station names, codes and channel reference names must be properly registered with the Technical Secretariat (document [3]).

2.5.3. Certification Procedures

Certification procedures are specified in Appendix VI.

2.6. Station Operation and Maintenance

The station operation and maintenance is the next step taken after a station is completed and has gone through the certification process. The operation and maintenance is designed so that the station will continue to properly meet the requirements, especially with regard to data availability.

2.7. Cooperating National Facilities

National infrasound stations that are not formally part of the International Monitoring System may be designated Cooperating National Facilities by the Technical Secretariat, following a request by the hosting State Party and subject to the agreement of the Executive Council, in order to make available to the International Data Centre supplementary infrasound data from these facilities. The Technical Secretariat must first certify that such a facility meets the technical and operating requirements specified for an International Monitoring System infrasound station in this Operational Manual and arrange for the authentication of its data (document [1], article IV, paragraph 28(a)). All specifications and procedures detailed in this Operational Manual are also valid for Cooperating National Facilities, with the exception of data retrieval conditions.

The International Data Centre, when requested by a State Party, will call upon raw data from stations certified as Cooperating National Facilities for the purpose of facilitating consultation and clarification, and the consideration of on-site inspection requests. These purposes are achieved through additional analyses, augmented by Cooperating National Facilities data, which can improve event characterization by the respective technology.

[TL Note: Discussion to be continued in future.]
CHAPTER 3 - Technical Requirements for Infrasound Stations

This chapter specifies the technical requirements for an International Monitoring System infrasound station as defined in the International Monitoring System station specification document (Appendix I).

3.1. Station Configuration

An infrasound station is an array with three basic components located at each array element: a pressure transducer (or microbarometer) to measure the micropressure variations in the atmosphere; a recording system, transforming analog data in digital format with an accurate time stamp; and a communication system interface. In addition a meteorological sensor, recording wind speed, wind direction and temperature, is located at one or more of the array elements, preferably the central one. Meteorological information allows the States Parties and the Technical Secretariat to monitor the environmental conditions of the International Monitoring System infrasound stations.

Each array element has a power supply unit.

The minimum requirement for an infrasound station is a four-element array with three elements forming a triangle, spaced 1 to 3 km apart, and the fourth element located at the centre. However, the array robustness and performance could be improved by additional array elements. Accurate measurements of the difference of arrival time of the infrasound signals between different array elements allow the determination of infrasound azimuth and velocities. Meteorological data are complementing the information on the micropressure variations in the atmosphere.

The enhancements recommended for noise and spatial aliasing reduction consist, respectively, in a wind noise reducing system connected to the microbarometer and in the use of a high number of array elements. A wind noise reducing system is used at each element of an infrasound station. The same type of wind noise reducing system should be used at all array elements.

The infrasound array is set up in agreement with the requirements described in document [3].

3.2. Site Characteristics

Station siting characteristics are given in the International Monitoring System site survey requirements (document [4]).

Each array element must be located taking into consideration security, noise levels and environmental conditions.

There are sites where temperatures are more extreme than the required operating temperature range of the equipment, as specified in Appendix I. In those cases, the equipment and utilities are specified to ensure that the data availability requirements will be met.

3.3. Equipment

The required characteristics of the equipment are defined in the glossary and specified in Appendix I.
3.3.1. Sensors

The required characteristics of the pressure transducer, listed below, are defined in the glossary and specified in Appendix I.

- Sensor type
- Sensor response
- Passband
- Sensor noise
- Wind noise reducing system.

The requirements for the meteorological sensors are, listed below and specified in Appendix I:

- Wind direction
- Wind speed
- Temperature.

3.3.2. Data Acquisition and Storage

The data acquisition system consists of those portions of the infrasound station that receive the analog signal from the sensor, convert it to a digital signal with timing and environmental, state-of-health and authentication information, transmit the signal to a central location, combine it with the signals from the other station elements into a signal of the proper format, store the signals against the possibility of a Global Communications System failure.

The required characteristics of the data acquisition and storage system, listed below, are defined in the glossary and specified in Appendix I:

- Sampling Rate
- Absolute Timing Accuracy
- Dynamic Range
- Buffer at Station or a National Data Centre or an appropriate communication node
- Data Format
- Data Frame Length.

When station elements are transmitting data to the central recording facility, it is recommended that sufficient buffering occurs at the element to allow for retransmission of the signal to the central recording facility in the event of failure of receipt of the complete data packet.

3.4. State of Health

State-of-health information is transmitted to the International Data Centre in the appropriate format.

State-of-health information enables the States Parties and the Technical Secretariat to monitor the operational state of the International Monitoring System infrasound stations.
The minimum specifications for an infrasound station (Appendix I) do not explicitly state the status bits that should be transmitted with the data. In order to be consistent with the other technologies, and with the data format being used, the minimum state-of-health information required is: clock status; calibration status, enclosure status; and telemetry status.

- Clock status indicates whether the clock is synchronized to Coordinated Universal Time.
- Calibration status indicates whether a calibration signal is on or off.
- Enclosure status indicates whether the lid or door of the equipment vault is open or closed.
- Telemetry status indicates whether the intra-site communications are functioning properly.

Problems with state-of-health status indicators may be reported in the form of a Problem Report to the Technical Secretariat.

3.5. Station and Channel Naming

The IMS document [3] establishes the conventions to be used in naming stations, array sites and data channels for stations in the IMS network. Stations of the IMS network will be referred to using either the Treaty Identifier, based on the tables in Annex 1 of the Protocol to the CTBT (document [1]) or a Station Code. New stations will be assigned station codes in accordance with existing conventions.

3.6. Calibration

The calibration requirements are described in Section 4.5 and specified in Appendix I.

3.7. Data Transmission

Data from infrasound stations are sent continuously to the International Data Centre, directly or through a National Data Centre or an appropriate communication. Transmission of data follows CD-x formats and protocols (CD-x). When data flow from an infrasound station has been interrupted, the buffered data must be available for retransmission to the International Data Centre.

3.8. Station Security and Data Surety

3.8.1. Station Security

Station documentation includes details of all anti-tampering systems and authentication systems, as well as maps or plans showing station security measures (e.g., fence enclosures) and security survey (e.g., manpower survey).

The need for specific actions against local nuisances or thefts may require the use of intrusion switches and the installation of fences surrounding the installations. Security measures against hazards (forest fires or flooding) must also be considered in the location of sensors. Detailed plans of the security measures are provided.

The information systems of the station must be protected from inadvertent or malicious modification or damage. This may require secure interfaces (i.e., firewalls), logging of all
access, protection of authentication key management systems, and anti-virus systems. All remote station command and control should be signed and verified with the approved digital signature algorithm with private keys generated under the International Data Centre key management system.

3.8.2. Data Surety

Data surety for the International Monitoring System infrasound stations is provided by tamper detection of the equipment enclosures and authentication of the infrasound data.

All International Monitoring System infrasound data and selected status monitors must be signed with the approved digital signature algorithm and a private key in a manner consistent with the authentication reference document [6]. These signatures are routinely verified at the International Data Centre.

Authentication is required for all infrasonic data channels, including the associated status bits defined in Section 3.4. Authentication is optional on other state-of-health information and meteorological data. In conjunction with other required tamper indications, data authentication allows detection of attempts to tamper with the data.

3.9. Data Availability

The terms Delay in Transmission, Data Availability and Timely Data Availability refer to data received at the International Data Centre, which is responsible for calculating statistics within the International Monitoring System.

The Delay in Transmission, which, for an infrasound station, is the time allowable between the time when the sensor acquires a signal and the time that the signal reaches the International Data Centre, is required to be less than or equal to 5 minutes. The Delay in Transmission includes any delay introduced in the communication system itself as well as by routing the data through a National Data Centre or an appropriate communication node.

Minimum data availability standards are required for the International Monitoring System infrasound network in order to ensure proper monitoring of the Comprehensive Nuclear-Test-Ban Treaty. The standards account for the performance of the communication system.

Data Availability, identified in the minimum specifications listed in Appendix I, is defined as follows: If, for a particular time period, data from a sufficient number and configuration of channels of an IMS station necessary to meet station specific mission capability requirements (Appendix I) are received by the IDC, data are available for that time period, regardless of data quality, which is considered separately. Otherwise, data are not available for that time period.

Timely Data Availability, identified in the minimum specifications listed in Appendix I, is defined as follows: If, for a particular time period, data are available for a specific station as defined in the paragraph above within the allowable time delay of five minutes the data are timely available. Otherwise, the data are not timely available.
Short term computations of completeness and timeliness of data arriving at the IDC are addressed in section 4.3.2.

**Stations in the infrasound network:**

- Each station must meet a Data Availability requirement of at least 98%, measured as percentage of the time that data were available for this station over a one year period.
- Each station must meet a Timely Data Availability requirement of at least 97%, measured as a percentage of the time that data were timely available for this station over a one year period.

3.10. Utilities

Data availability is strongly tied to station power and communication considerations.

3.10.1. Power Supply

The station must have a reliable primary power source capable of meeting the data availability requirements. A secondary source of power is required for those parts of the station where failure of the primary power system would automatically result in loss of mission capability of the station. Power supplies should be regulated and protected from surges, including lightning strikes.

3.10.2. Field Communication Equipment

Communications that meet the data availability requirements must be provided.

3.11. Interface with the Global Communications Infrastructure

Data from infrasound stations are sent continuously to the International Data Centre directly or through a National Data Centre or an appropriate communication node. The main physical interface between the infrasound stations and the Global Communications Infrastructure is defined in the Global Communications Infrastructure specifications (document [6]).
CHAPTER 4 - Operational Requirements

This chapter describes how the International Monitoring System infrasound stations are operated in order to fulfill their functions in the International Monitoring System. This includes the information required for proper station operation: data acquisition, communication, state of health, system calibration, data surety and reporting requirements.

4.1. Concept of Operation

The Technical Secretariat is responsible for the supervision and coordination of network operations and providing assistance for the proper functioning of the stations. The Technical Secretariat ensures the operation of the International Monitoring System by concluding arrangements, agreements or contracts with Station Operators. The coordination of operations between the Technical Secretariat and Station Operators is done through a common reporting and messaging system.

Station Operators are responsible for the operation of the individual IMS facilities. The Station Operator will ensure that the station is operating properly, especially in meeting the data availability requirements. The duties of the Station Operator will include filing the proper reports with the Technical Secretariat, scheduling routine maintenance in advance, and providing timely trouble-shooting and repair in times of unscheduled data outage.

Operational and maintenance procedures are designed to ensure that the infrasound station remains fully operational. The requirement is to keep the station mission capable. An infrasound station is considered mission capable when at least the minimally specified number and required distribution of sensors are operational, as defined in Appendix I and clarified below, and in the station siting requirements in [4]. Thus certain configurations of infrasound stations may retain mission capability in the event of failure of selected instruments. Stations that are not mission capable require urgent repair as described in Chapter 5.

An infrasound station is considered mission capable if, for a four-element array, three or more elements of the array are operational, and the data are being transmitted to the interface between the International Monitoring System infrasound station and the Global Communications Infrastructure. For arrays of more than four elements, the configuration and geometry of the array determine the combinations of element failures that may occur before mission capability is lost. Mission capability for such arrays should be clarified on a case-by-case basis in the station site-specific documentation; notwithstanding, the case-by-case determination of mission capability should ensure that at least 70% of the elements of the array are operational in order for the array to be considered mission capable. Data availability statistics for arrays should be measured based on the mission capability status of the array as a whole.

A station specific definition of mission capability is part of the station specific documentation required to be at the station (Appendix IV).

It is recognized that, whereas the Station Operator is responsible for the functioning of the station itself, other components of the data system, such as the Global Communications Infrastructure, are not the responsibility of the Station Operator. Similarly, the period for which a station is awaiting setting or replacement of authentication keys is not the
responsibility of the Station Operator. In calculating Delay in Transmission, Data Availability and Timely Data Availability, the Technical Secretariat should distinguish the causes of failure in order to define appropriate responsibility.

Where the Station Operator is remotely located from the station, access to the Global Communications Infrastructure may be required. In such a case, it is the responsibility of the Technical Secretariat to provide to the Station Operator access to the Global Communications Infrastructure in order to provide the required level of operation. The State Party hosting the station is responsible for establishing communication channels among the National Authority, Station Operator and Technical Secretariat.

4.2. Personnel

Station Operator staff must be and capable of running the station in accordance with this manual. Points of contact should be designated in conjunction with the Technical Secretariat, and updated when appropriate by the Station Operator. The use of a generic email address is encouraged.

Where a station is unmanned but has a caretaker, appropriate contact information for the caretaker should be provided.

4.3. Data Monitoring

Data from the station is monitored by both the Station Operator and the Technical Secretariat. Data availability is computed regularly by the Technical Secretariat. The Station Operator monitors data availability, instrument calibration, and station State-of-Health information, reports problems to the Technical Secretariat, initiates repairs, and reports to the Technical Secretariat when the problem is resolved. Maintenance procedures are described in Chapter 5. The Technical Secretariat monitors some data quality parameters (such as data availability and State-of-Health) directly on receipt of data, and other data quality parameters (such as background noise levels, excessive spiking or gapping) through data processing. When the Technical Secretariat becomes aware of a station condition that affects data processing, the Technical Secretariat reports the problem to the Station Operator, and the Station Operator initiates repairs, and reports to the Technical Secretariat when the problem is resolved.

4.3.1. Data Quality

The Station Operator may discover deterioration in data quality (see glossary) during routine monitoring of the data. In such a case the Station Operator will immediately communicate the finding to the Technical Secretariat and begin to seek a solution to the problem. The Technical Secretariat may also discover deterioration in data quality during monitoring and processing of the data. In this case the Technical Secretariat will communicate with the Station Operator to begin to seek a solution to the problem.

4.3.2. Data Availability

Data availability is computed regularly by the Technical Secretariat. The standard data availability figure is calculated with a delay of seven days, to account for any data arriving late during catch-up. Any non-standard values are clearly identified as such.
Other computations of completeness and timeliness of data arriving at the IDC are performed at the IDC, measuring the percentage of data that reaches the IDC for a specific time interval, and reflecting the status of the station equipment, communications link, and IDC receiving software. These measurements are used to monitor station performance and trigger maintenance activity.

Should the data availability begin to fall, the Technical Secretariat will communicate with the Station Operator to begin investigation of the cause(s).

The Station Operator may compute data availability separately. The procedures for computing data availability statistics are determined by the Technical Secretariat, and these same procedures are used by the Station Operator, International Data Centre and National Data Centre to ensure compliance of results. In comparing the data availability results produced by Station Operator or NDC with those produced by the IDC, differences may be noticed due to the performance of the communication system and the IDC receiving software.

4.3.3. State of Health

The minimum state-of-health information for infrasound stations is defined in Section 3.4. The Station Operator should check state-of-health information, transmitted for each channel on a continuing basis, at least once every 24 hours, in order to ensure the integrity of the system environment, including tamper-protected enclosures. A change in the state of health should be identified to the Technical Secretariat in a Problem Report.

4.3.4. Noise

Regular monitoring of noise level should be carried out. Long-term changes in noise level may require station relocation in accordance with relevant Treaty provisions. For infrasound stations, it may be appropriate to relocate particular elements without relocating the station or alter the configuration of the array in response to changes in noise conditions.

Changes in noise level may also indicate instrumental malfunction or a problem with the wind-noise-reducing system.

The Station Operator may discover an increase in infrasonic noise during routine monitoring of the data. Should this occur, the Station Operator will attempt to seek the cause(s) of the increased noise and communicate the findings to the Technical Secretariat. The Technical Secretariat will estimate noise levels on all channels on a regular basis (e.g. quarterly) for comparison with the initial noise levels at the time of station certification. Significant increases in noise levels will be communicated by the Technical Secretariat to the Station Operator for action to investigate the possible source of the noise increase.

[TL Note: the procedure for noise determination will be made available by the Technical Secretariat.]
4.3.5. Site Characteristics

The Station Operator makes surveys of changes in site characteristics that may potentially alter station operational characteristics as noted during station certification. The area surrounding the station should be examined for encroachment of cultural features that could act as possible noise sources, e.g. new roads. Also, the area around the station should be examined for degradation of infrastructure, involving power, communications circuits and access to sites. Such features should be noted and added to the station site-specific documentation and the Technical Secretariat notified in the Monthly Report or a Problem Report, if appropriate.

4.3.6. Power Supply

The Station Operator monitors power supplies to ensure that they are reliable and have operational back-up systems where necessary.

4.4. Command and Control

The Station Operator must be able to command and control his station. This function may be performed by the Technical Secretariat (see Section 2.4).

Typical commands include those needed to perform calibration, reset the system or parts of it when a failure occurs, or for key management functions. Additional commands, which could include change sample rate, apply data compression, are highly dependent on the specific system that installed, and will be specified in the station documentation.

Command and control procedures for the stations in the International Monitoring System network are specified in reference [7]. These should be followed where appropriate.

4.5. Calibration

Each infrasound station is provided with the means to carry out a calibration that can be compared to a reference that was established at the time the station was certified. The exact method of calibration will vary from station to station, and is described as part of the station-specific documentation as defined in Appendix IV.

[TL Note: Technology specific details to be added. The infrasound specific text under 4.5 and 4.5.1 uses old text from CTBT/TL-11/35, and it will be discussed in future.]

The calibration requirements for infrasound stations do not currently include phase measurements; however these measurements are necessary for an understanding of the full instrument response. An appropriate level of accuracy for these measurements may be suggested in future, after the Technical Secretariat and Station Operators have more experience operating these stations.

4.5.1. Calibration Methods

A periodic sensor calibration check is carried out at least once a year on site. Additional calibration checks can be achieved by comparing all array element sensor outputs in the presence of strong signals.
Calibrations required for infrasound network stations are as follows:

Laboratory Calibration: All sensors are calibrated by the manufacturer or a suitably equipped laboratory over the full frequency range and temperature range. For calibration, certified signal generators of sinusoidal pressure output over the passband of interest can be used.

On-Site Calibration: The air inlets of the sensor are connected to the calibrator, using hoses that are thick enough to ensure a good insensitivity to any change in microbarometric pressure. On-site calibration may also be performed using a precalibrated, certified microbarometer, either as an exterior device or as a built-in component of the microbarometer.

The microbarometer output is measured as follows:

- For absolute sensors: with up to 100 hPa overpressure and with up to 100 hPa underpressure.
- For differential sensors: with up to 10 Pa overpressure and up to 10 Pa underpressure.

The ambient temperature is measured during the calibration.

The Station Operator is responsible for calibrating each channel once a year on a day and at a time coordinated with the Technical Secretariat. Calibrations are made only one sensor at a time. Calibrations that would take the station out of mission-capable status should not be carried out. When a calibration is performed and results are not within tolerances, the Station Operator informs the Technical Secretariat and initiates required maintenance.

Polarity Checks: Polarity Checks are performed whenever analog data signal or analog calibration circuits have been physically disconnected in the electronic box termination units or the pressure sensor is adjusted or repaired. When both data signal and calibration circuits have been physically disconnected, circuit polarity should be verified by comparing relative channel first motion responses to an impulsive signal of known direction.

Full-Frequency-Response Calibration: Microbarometers and their associated electronics that have been repaired or new microbarometers and/or electronics are subject to a full-frequency-response calibration. If this calibration is carried out by the equipment manufacturer, then the calibration is verified after the unit has been reinstalled in the array. The variation of the microbarometer sensitivity with temperature should be supplied according to specifications by the manufacturer. Microbarometers should not be removed from the array element equipment enclosure unless they require repair or replacement.

4.5.2. Calibration Schedule

The calibration process affects recording for the time interval during which the channel is under calibration. An infrasound array is still mission-capable during calibration if the station operator calibrates one element of the array at a time. The infrasound stations are normally calibrated once a year, unless specified differently in the
station-specific calibration procedures required in Appendix IV, on a schedule predetermined by the Technical Secretariat. The schedule specifies a window of three days during which the calibration can take place. The Station Operator notifies the Technical Secretariat of their intention to carry out a calibration, and the date of that calibration, at least seven days in advance of the first day of the nominated calibration period. Within two days from this notification the Technical Secretariat, using its knowledge of problems or planned outages at other stations, either accepts or rejects the proposed date. If the proposed date is rejected, a discussion ensues to find a mutually suitable date.

Any other calibrations should be coordinated with the Technical Secretariat.

4.5.3. Calibration Procedures

The Station Operator gives the Technical Secretariat one day’s advance notice of the time(s) of the calibration. The Station Operator reports the actual time(s) of the calibration within one day of the end of the calibration. The Station Operator reports the results of the calibration, whether the station is in tolerance or not, to the Technical Secretariat within five days of the end of the calibration.

The procedures for reporting calibration results are described in the document [7]. The Technical Secretariat will determine whether any actions are required as a result of this calibration.

4.5.4. Unscheduled Calibration

When equipment maintenance has been performed that may affect the baseline calibration, the Station Operator performs all necessary calibrations and checks prior to returning the affected channels to service. The results of this calibration are reported to the Technical Secretariat in the Station Operator’s report on the results of the maintenance.

4.6. Communications

4.6.1. Intra-Site Communications

The Station Operator responsible for an infrasound array operates and maintains any intra-site communications in accordance with the technical requirements described in document [8]. Detailed procedures for the operation and maintenance of intra-site communications must be included in the station specific documentation. A detailed description of the intrasite communications equipment, procedures, and routing architectures for each infrasound station is included in the station specific documentation.

4.6.2. Support to Global Communications Infrastructure

The Technical Secretariat is responsible for the Global Communications Infrastructure. The States Parties responsible for the International Monitoring System infrasound stations are required to ensure that the data reach the Global Communications Infrastructure in a timely and reliable fashion.
At stations using the basic and partitioned sub-network topologies, operations and maintenance of the Global Communications Infrastructure equipment at the station are the responsibility of the Technical Secretariat.

At stations using an independent subnetwork topology, operations and maintenance of the independent subnetwork communications equipment at the station are the responsibility of the State Party. The agent authorized to carry out this task by the State Party may be the National Data Centre or the Station Operator. The authorized agent is responsible for keeping all records for the communications link up to date. The Station Operator should notify the Technical Secretariat using a Problem Report of any local problem that may affect data transmission over the independent sub-network.

4.7. Configuration Management

Configuration Management provides the capability at any time to know and control the exact configuration of any element of an IMS station, by:

- Ensuring the station continues to meet specifications
- Controlling the interfaces between the station and other parts of the verification system
- Providing accurate inputs to the logistics support system
- Providing accountability of operations and maintenance expenditures.

Initial baseline station configuration information is provided to the Technical Secretariat during the certification process, and can include information on hardware, software, firmware, procedures, databases and pre-set values in files and database tables. A station-specific list of configuration items is included as part of the station-specific information defined in Appendix IV. The Technical Secretariat must be informed of, and give approval for, any configuration change by the Station Operator.

Configuration is managed between the Station Operator and the Technical Secretariat using two types of reports, the Configuration Change Request and the Configuration Change Notification. Templates for these reports are given in Appendix II. Configuration Change Requests are submitted by the Station Operator for changes in any equipment in the list of configuration items in Appendix IV, at least twenty days in advance of the planned configuration change. Configuration Change Notifications are submitted for all changes that are made to equipment in the list of configuration items, after the change has been made.

If certified or approved spare parts for the list of configuration items already exist at the station, the replacement can be done immediately and only a Configuration Change Notification is required.

4.8. Record Keeping and Documentation

The Technical Secretariat is responsible for maintenance of the configuration management database and will provide access for the Station Operator.

The Station Operator will maintain up-to-date records for all the items in Appendix IV which are not under configuration management and supply this information to the Technical Secretariat in a timely manner.
4.9. Reporting

Messages, reports and more general communications procedures are supported by the Technical Secretariat through the IMS Reporting System (IRS), which handles all of the reports submitted by Station Operators and Technical Secretariat staff, and communicates them to the proper personnel while maintaining an auditable database of the communications. The IRS requires that the Station Operator uses templates (see Appendix II) for submitting all reports by email.

There are five required reports for infrasound stations:

- Monthly Reports are summary reports covering one calendar month and should be submitted by the 10th of the month after the reporting period.
- Problem Reports are submitted whenever there is a problem with the station. This includes problems that have already been solved by the Station Operator.
- Outage Reports are submitted when the Station Operator plans an outage at the station. The report should be submitted at least five days prior to the planned start of the outage. The actual outage and any unplanned outages should be reported using a Problem Report.
- Configuration Change Requests are described in 4.7.
- Configuration Change Notifications are described in 4.7.
CHAPTER 5 - Maintenance and Repairs

5.1. Maintenance Concept

This chapter describes the maintenance and repair requirements and schedule for the International Monitoring System infrasound stations, for periodic maintenance, for checks requested by the Technical Secretariat and for problem identification and resolution.

At this time of drafting this Operational Manual (2004), a full integrated logistic support strategy for the IMS networks has not been completed, although investigations are under way for the development of an operation and maintenance plan for the long term sustainment of the networks. Such a plan will address the maintenance philosophy, i.e., the degree to which spare parts are stocked at the station, at the equipment suppliers, in regional depots or at the Technical Secretariat headquarters; the type of maintenance the Station Operator is expected to perform; the type of maintenance the equipment suppliers may perform, at the station or at their premises; and the type of maintenance that the Technical Secretariat may perform at its headquarters.

As this plan develops, this Operational Manual will be updated as appropriate.

Operational and maintenance procedures are specified to ensure that the infrasound station remains fully operational.

A three-level repair prioritising scheme is used to ensure that all stations maintain or return to mission-capable status as soon as possible after experiencing maintenance problems: urgent (priority 1), enhanced (priority 2) and other (priority 3).

Urgent repairs (priority 1) are required whenever a station becomes non-mission capable. Urgent repairs require immediate actions to restore mission capability.

Enhanced repairs (priority 2) are required whenever a station approaches non-mission capable status. The factors that trigger enhanced repairs are station specific (e.g. station configuration, number of array elements, site access consideration, etc.).

Other repairs (priority 3) are required when the station experiences any failure that does not require enhanced or urgent maintenance.

Periodic preventive maintenance, as specified in Section 5.2, is lower priority than any repair action.

For a general guidance on mission capability and maintenance priorities, see Section 4.1.

5.2. Scheduled Maintenance

The Station Operator shall, inter alia:

- Maintain wind noise reducing systems, microbarometers, meteorological sensors, associated electronic components and tamper switches at each element site;
- Maintain the data acquisition and central timing systems, if applicable, at the central facility, and all elements of the cabled or non-cabled intra-array communications system;
• Maintain the primary and backup power supply equipment;
• Maintain the central facility buildings and associated structures; and
• Periodically verify that no obstacles are in the line of sight from the antenna to the satellite, if any, and to the degree agreed between the Station Operator and the Technical Secretariat assist with the maintenance of the Global Communications Infrastructure.

5.3. Unscheduled Maintenance

This section establishes the schedule and reporting requirements for resolving station faults or anomalous conditions. The objective is to maintain or to restore the station to mission-capable status as soon as possible, ensuring minimum impact on data availability.

Problems that may lead to loss of mission-capable status are responded to and worked on by the Station Operator (see discussion of enhanced repairs in Section 5.1) as soon as possible to prevent the problem from causing the station to become non-mission capable.

The Station Operator is responsible for planning the timely availability of spare parts. The Station Operator will make all arrangements for sending defective parts or equipment for repair work and receiving, storing the repaired/new part of the Station Equipment.

The Station Operator should establish station-specific fault isolation routines, including detailed fault isolation diagrams, procedures, and available diagnostic checks.

5.3.1. Problem Identification and Resolution

For problem identification and resolution, which involves fault isolation, as well as determination of the cause of the fault to reduce future occurrences, the Station Operator may be assisted by the Technical Secretariat.

Unscheduled station repairs are authorized by the Technical Secretariat and formal approval is required before initiating repairs unless the remedial action required involves a simple adjustment or replacement of the Station Equipment using available spares. In that case the Station Operator carries out such adjustment or replacement without any delay.

In the event of an unexpected malfunction of the Station, the Operator shall:

• Notify the Technical Secretariat with a Problem Report;
• Once the fault has been isolated, include in the open Problem Report a proposed solution and estimated time required to remedy the defect;
• If technical assistance and support from the Technical Secretariat is needed, include in the Problem Report a description of the technical assistance and support requested;
• If, following the review of this information, the Technical Secretariat decides that the repair shall be performed, carry out the work as agreed by both Parties;
• Notify the Technical Secretariat using the opened Problem Report that the maintenance has been carried out;
• Update the Station Documentation as required;
• If a configuration change occurred in the process of solving the problem, notify the Technical Secretariat with a Configuration Change Notification (CCN).
5.3.2. Responding to Station Problems Detected and Reported by the Technical Secretariat

The Station Operator responds to the notification of station problems detected and reported by the Technical Secretariat with the diagnosis of the problem and the type of maintenance required to solve it and follows the same procedures as given in 5.3.1.
APPENDIX I

INFRASOUND STATION SPECIFICATIONS,
INCLUDING METEOROLOGICAL SENSORS

A. Introduction
(from CTBT/PC/II/1/Add.2, Appendix X)

The International Monitoring System station specifications are based on the Treaty text and on reports by the Expert Groups of the Ad Hoc Committee in 1995 (e.g. [9], [10] and [11]). These specifications are defined for the four required technologies: seismic (primary and auxiliary), infrasound, hydroacoustic (T-phase and hydrophone) and radionuclide (particulate and noble gas).

General requirements

1. Environmental specifications, such as temperature range of operation or downtime, are standard values. They might be adapted for specific sites where conditions are extreme (the Arctic region or Antarctica for example).
2. Data availability or timely data availability is computed over a period of one year. It is highly dependent on power failure, lightning, and communication reliability.
3. To reach the required availability and limit future maintenance costs, it is essential that stations be as autonomous and low consuming as possible. This limits power backing equipment. Solar power is preferred when possible. Stations are hardened against lightning.
4. When indoors, systems requiring no or limited ambient room temperature control are preferred.
5. Field communication equipment is part of the station. It should also comply with the above requirements.
6. Surveys are conducted to ensure that siting does not alter station operational characteristics.
7. There is some level of protection against physical damage to the field equipment.
8. New stations should comply with specifications. Existing stations are upgraded to meet specifications. Planning of upgrading is adapted to budget.
9. Certification procedures for compliance of stations with requirements will have to be defined.
### Specifications for infrasound stations

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>MINIMUM REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor type</td>
<td>Microbarometer</td>
</tr>
<tr>
<td>Number of sensors</td>
<td>4-element array¹</td>
</tr>
<tr>
<td>Geometry</td>
<td>Triangle with a component at the centre</td>
</tr>
<tr>
<td>Spacing</td>
<td>Triangle basis: 1 to 3 km²</td>
</tr>
<tr>
<td>Station location accuracy</td>
<td>&lt;100 m</td>
</tr>
<tr>
<td>Relative sensor location</td>
<td>&lt;1 m</td>
</tr>
<tr>
<td>Measured parameter</td>
<td>Absolute³ or differential pressure</td>
</tr>
<tr>
<td>Passband</td>
<td>0.02 to 4 Hz</td>
</tr>
<tr>
<td>Sensor response</td>
<td>Flat to pressure over the passband</td>
</tr>
<tr>
<td>Sensor noise</td>
<td>≤18 dB below minimum acoustic noise⁴</td>
</tr>
<tr>
<td>Calibration</td>
<td>≤5% in absolute amplitude³</td>
</tr>
<tr>
<td>State of health</td>
<td>Status data transmitted to the International Data Centre</td>
</tr>
<tr>
<td>Sampling rate</td>
<td>≥10 samples per second</td>
</tr>
<tr>
<td>Resolution</td>
<td>≥1 count per 1 mPa</td>
</tr>
<tr>
<td>Dynamic range</td>
<td>≥108 dB</td>
</tr>
<tr>
<td>Timing accuracy</td>
<td>≤1 ms⁶</td>
</tr>
<tr>
<td>Standard temperature range</td>
<td>-10°C to +45°C</td>
</tr>
<tr>
<td>Buffer at station or at National Data Centre</td>
<td>≥7 days</td>
</tr>
<tr>
<td>Data format</td>
<td>Group of Scientific Experts format</td>
</tr>
<tr>
<td>Data frame length</td>
<td>&lt;30 seconds</td>
</tr>
<tr>
<td>Data transmission</td>
<td>Continuous</td>
</tr>
<tr>
<td>Data availability</td>
<td>≥98%</td>
</tr>
<tr>
<td>Timely data availability</td>
<td>≥97%</td>
</tr>
<tr>
<td>Mission-capable array</td>
<td>&gt;3 elements operational</td>
</tr>
<tr>
<td>Acoustic filtering</td>
<td>Noise reduction pipes (site dependent)</td>
</tr>
<tr>
<td>Auxiliary data</td>
<td>Meteorological data⁸</td>
</tr>
</tbody>
</table>

¹ In case of noisy sites or when increased capability is required, number of components could be increased.
² 3 km is the recommended spacing.
³ Used for daily state of health.
⁴ Minimum noise level at 1 Hz : ~5 mPa.
⁵ Periodicity : once per year (minimum).
⁶ Better than or equal to 1 ms.
⁷ Temperature range to be adapted for some specific sites.
⁸ Once per minute.
C. Requirements for Meteorological Sensors

<table>
<thead>
<tr>
<th>Name of Equipment:</th>
<th>Solid State Wind Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind speed*:</td>
<td>Minimum range</td>
</tr>
<tr>
<td></td>
<td>0 to 50 meters / second</td>
</tr>
<tr>
<td>Threshold</td>
<td>Less than 0.2 meters / second</td>
</tr>
<tr>
<td>Accuracy</td>
<td>± 0.2 meters / second</td>
</tr>
<tr>
<td>Resolution</td>
<td>Less than 0.2 meters / second</td>
</tr>
<tr>
<td>Wind direction:</td>
<td>Range</td>
</tr>
<tr>
<td></td>
<td>0 to 360 degrees</td>
</tr>
<tr>
<td>Threshold</td>
<td>Less than 0.2 meters / second</td>
</tr>
<tr>
<td>Accuracy</td>
<td>± 2.5 degrees</td>
</tr>
<tr>
<td>Resolution</td>
<td>1.0 degree</td>
</tr>
</tbody>
</table>

Name of Equipment Temperature Sensor

<table>
<thead>
<tr>
<th>Name of Equipment:</th>
<th>Temperature Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature*: Minimum range</td>
<td>-40 to +50 degrees Celsius</td>
</tr>
<tr>
<td>Accuracy</td>
<td>± 0.3 degrees</td>
</tr>
</tbody>
</table>

Accessories

<table>
<thead>
<tr>
<th>Accessories</th>
<th>Appropriate radiation shield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heaters for anemometer where required</td>
</tr>
</tbody>
</table>

* The wind speed and temperature ranges may be adapted for some specific sites.
APPENDIX II
TEMPLATES FOR REQUIRED REPORTS

1. This Appendix reflects current procedures used within the PTS. It may need to be amended if those procedures change.

2. Reports should be sent by email to imsops@ctbto.org.

3. The email should be plain text. Do not send reports formatted using HTML or RTF formatting, or as an attachment. If your email software inserts line feeds, please ensure that the line length is at least 72 characters.

4. There are five required reports for all IMS stations and three for radionuclide laboratories.

5. Reports for IMS stations:

   The Monthly Report is a summary report covering one calendar month and should be submitted by the 10th of the month after the reporting period.

   A Problem Report is submitted whenever there is a problem with the station. This includes problems that have already been resolved by the station operator.

   An Outage Request should be submitted when the station operator plans an outage at the station. The report should be submitted at least five working days prior to the planned start of the outage. The actual outage, and any unplanned outages, should be reported using a Problem Report.

   A Configuration Change Request should be submitted in advance for any change to the equipment or software at the station included in the baseline configuration and should normally be submitted at least 20 working days in advance of the planned change.

   A Configuration Change Notification is sent when anything is changed at the station. This includes changes already covered by a Configuration Change Request.

6. Reports for radionuclide laboratories:

   The Laboratory Operations Report is a summary report covering an agreed period of operations and should be submitted by the 10th of the first month after the reporting period.

   Both planned and unplanned outages, *ie* periods when the laboratory is not available for IMS sample analysis, should be reported using a Laboratory Outage Notification. The Laboratory Outage Notification should also be sent to confirm that laboratory is available again.
A Configuration Change Notification is sent in connection with a change at the laboratory that has significance in the IMS sample analysis.

7. Each report has a number of fields, some required, some optional. The field name is designated using the character #. The data for that field should be entered on a single line after the designator. The only exceptions to this are #Description which can be followed by as many lines of free-format text as necessary and the #Equipment fields in the Problem Report, Configuration Change Request and Notification.

8. Use the station and laboratory codes that are used in IDC processing and in the station hardware, eg CKP23, EKA, I07AU, H11N, ARL01. A report can cover more than one station if necessary.

9. For reports which cover more than one station, the station codes of those additional stations that are affected should be entered in the “#Other stations affected” field all on the same line, separated by commas.

10. The Subject of the email should start with the form “Report – report type – station code”. The report type can be either spelt out or abbreviated as shown in the following examples. The Subject can optionally include a brief description after a further “-“.

   Report – Problem Report – EKA
   Report – PR – EKA
   Report – Outage Request – I07AU
   Report – OR – I07AU – from 10:00 on 23/01/2001
   Report – Configuration Change Request – CKP23
   Report – CCR – CKP23
   Report – Configuration Change Notification – CKP23
   Report – CCN – CKP23
   Report – Laboratory Operations Report – ARL01
   Report – Laboratory Outage Notification – AUL02

11. Other email communications to imsops@ctbto.org should always have the station code at the start of the subject line.

12. When replying to any communication from imsops, please use the “Reply” feature of your email software, to preserve the subject line and the body of the message. The required format of the reply will be specified in the original message.
TEMPLATE FOR MONTHLY REPORT

#Report type
Monthly Report

#Station code
[Insert station code here.]

#Other stations affected (optional)
[Insert other station codes, separated by commas.]

#Source
Station - New Report

#Period covered
January 2001 [use suitable date]

#Submitted by
[Insert name of person submitting report.]

#email (optional)
[Insert an email address that should be used for communications instead of the normal point of contact for a station.]

#Description
[Insert text of report in free format. It should include the following sections.]

1 INTRODUCTION

2 EQUIPMENT PERFORMANCE

3 DATA REPORT

4 OUTSTANDING PROBLEMS, COMMENTS

5 OTHER MATTERS
TEMPLATE FOR PROBLEM REPORT

#Report type
Problem Report

#Station code
[Insert station code here.]

#Other stations affected (optional)
[Insert other station codes, separated by commas.]

#Source
Station - New Report

#Site (optional for array stations)
[Insert site code here, CF for central facility.]

#Submitted by
[Insert name of person submitting report.]

#email (optional)
[Insert an email address that should be used for communications instead of the normal point of contact for a station.]

#Heading
[Insert one-line description of problem.]

#Station reference (optional)
[Insert any local reference number.]

#Priority
[1,2,3 or 4 as per operational manuals.]

#Start date of problem (UTC)
2001/01/23 12:00 [time is optional]

#End date of problem (UTC) (optional)
2001/01/23 12:01 [time is optional]

#Data quality
[Insert a brief description of the effect on data quality, eg “No data”, “Noisy data”.

#Equipment affected
[Insert one item of equipment per line.]

#Description
[Insert text of report in free format.]
TEMPLATE FOR OUTAGE REQUEST

#Report type
Outage Request

#Station code
[Insert station code here.]

#Other stations affected (optional)
[Insert other station codes, separated by commas.]

#Source
Station - New Report

#Site (optional for array stations)
[Insert site code here, CF for central facility.]

#Submitted by
[Insert name of person submitting report.]

#email (optional)
[Insert an email address that should be used for communications instead of the normal point of contact for a station.]

#Heading
[Insert one-line description of reason for outage.]

#Station reference (optional)
[Insert any local reference number.]

#Start date of requested outage (UTC)
2001/01/23 12:00 [time is optional]

#End date of requested outage (UTC) (optional)
2001/01/23 12:01 [time is optional]

#Mission capable
[Insert “no” if the station will not be mission capable during the outage, “yes” otherwise.]

#Data quality
[Insert a brief description of the effect on data quality, eg “No data”, “Noisy data”.]

#Equipment affected (including serial/version number)(optional)
[Insert list of equipment affected by outage.]

#Description: reason for outage
[Insert text of report in free format.]
TEMPLATE FOR CONFIGURATION CHANGE REQUEST

#Report type
Configuration Change Request

#Station code
[Insert station code here.]

#Other stations affected (optional)
[Insert other station codes, separated by commas.]

#Source
Station - New Report

#Urgency (if less than 20 working days notice is given)
[Insert how soon a response is needed.]

#Submitted by
[Insert name of person submitting report.]

#email (optional)
[Insert an email address that should be used for communications instead of the normal point of contact for a station.]

#Heading
[Insert one-line description of change.]

#Station reference (optional)
[Insert any local reference number.]

#Start date for requested change (UTC)
2001/01/23 12:00 [time is optional]

#Equipment to be removed (including serial/version numbers)
[Insert one item of equipment per line.]

#Equipment to be installed (including serial/version numbers)
[Insert one item of equipment per line.]

#Description: reason for change
[Insert text of report in free format.]
TEMPLATE FOR CONFIGURATION CHANGE NOTIFICATION

#Report type
Configuration Change Notification

#Station/Laboratory code
[Insert station/laboratory code here.]

#Other stations affected (optional)
[Insert other station codes, separated by commas.]

#Source
Station - New Report [or]
Laboratory – New Report

#Submitted by
[Insert name of person submitting report.]

#email (optional)
[Insert an email address that should be used for communications instead of the normal point of contact for a station.]

#Configuration Change Request
[Insert reference number of associated Configuration Change Request or “not required”]

#Heading
[Insert one-line description of change.]

#Station reference (optional)
[Insert any local reference number.]

#Start date of configuration change (UTC)
2001/01/23 12:00 [time is optional]

#End date of configuration change (UTC)
2001/01/23 12:01 [time is optional]

#Equipment removed (including serial/version numbers)
[Insert one item of equipment per line.]

#Equipment installed (including serial/version numbers)
[Insert one item of equipment per line.]

#Description: reason for change
[Insert text of report in free format.]
TEMPLATE FOR LABORATORY OPERATIONS REPORT

#Report type
Laboratory Operations Report

#Laboratory code
[Insert laboratory code here.]

#Source
Laboratory - New Report

#Period covered
[e.g. January 2001 - June 2001]

#Submitted by
[Insert name of person submitting report.]

#email (optional)
[Insert an email address that should be used for communications if it is not the same as the sending address.]

#Description
[Insert text of report in free format. It should include the following sections.]

1 Sample Analysis
[Sample type, number of samples
SRID, receipt time, preliminary report time, final report time]

2 Laboratory availability/unavailability
[Period(s) of availability and unavailability during the reporting period]

3 Data quality issues
[List of evaluated spectral parameters and equipment specifications with comments (QA/QC)]

4 Major equipment
[Problems and repairs, instrument calibrations, maintenance]

5 Changes to CTBT specific documentation and/or procedures forIMS sample analysis
[Short description of any changes during the period of this report, reference to the latest version of the documentation.]

6 Other matters
TEMPLATE FOR LABORATORY OUTAGE NOTIFICATION

#Report type
Laboratory Outage Notification

#Laboratory code
[Insert laboratory code here.]

#Source
Laboratory - New Report

#Submitted by
[Insert name of person submitting report.]

#email (optional)
[Insert an email address that should be used for communications if it is not the same as the sending address.]

#Heading
[Insert one-line description of the outage, eg “Not Available from xx to yy”, “Available again from zz”.

#Laboratory reference (optional)
[Insert any local reference number.]

#Start date of outage (UTC)
2001/01/23 12:00 [time is optional]

#End date of outage (UTC) (optional)
2001/01/30 12:00 [time is optional]

#Description
[Insert text of report in free format.]
APPENDIX III

REFERENCE LIST


APPENDIX IV

REQUIREMENTS FOR STATION-SPECIFIC DOCUMENTATION
FOR INFRASOUND STATIONS

This Appendix contains a summary of the station-specific documentation to be held at each infrasound station and at the Technical Secretariat. This information includes:

- A description of the site facilities and infrastructure
- A brief description of the station equipment
- Detailed specifications of all station equipment
- Description of communications system:
  - Intra-site communications system description to include diagrams and details for each communications path.
  - External communications system description to include complete documentation of the path taken to provide the data to the Global Communications Infrastructure/International Data Centre.
- Procedures for instrument calibration
- An inventory of equipment, spare parts and components
- A list of operational and maintenance manuals provided by manufacturers of equipment
- Equipment maintenance protocols and schedules
- A station-specific list of configuration items
- A station-specific definition of mission capability.
APPENDIX V

GLOSSARY

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute Timing Accuracy</td>
<td>The allowable deviation from Coordinated Universal Time for any particular data sample.</td>
</tr>
<tr>
<td>Allowable Time Delay</td>
<td>See Delay in Transmission.</td>
</tr>
<tr>
<td>Authentication</td>
<td>See Data Authentication.</td>
</tr>
<tr>
<td>Basic Communications Topology</td>
<td>The arrangement of communications equipment at stations whose data are routed directly to the International Data Centre via the Global Communications Infrastructure.</td>
</tr>
<tr>
<td>Calibration</td>
<td>Determination, by measurement or comparison to a standard, of parameters needed to properly interpret recorded signals. In the case of instrument calibration (for all four International Monitoring System technologies), the parameters typically calibrated are those associated with the instrument response or transfer function (e.g., detector or other sensor efficiencies and/or gains, amplifier gains, bandwidths, delays, phase shifts, linearity, etc.).</td>
</tr>
<tr>
<td>Certification</td>
<td>The assessment against the International Monitoring System specifications and other criteria of the equipment and instrumentation, associated facilities, and operational performance pertaining to a seismic, hydroacoustic, infrasound, or radionuclide monitoring station. Successful certification leads to the formal acceptance of the station into the International Monitoring System. The procedures for international monitoring system station certification are described in CTBT/PTS/INF.144/Rev.2 and CTBT/PC-9/1/Annex II.</td>
</tr>
<tr>
<td>Communication Node</td>
<td>Intermediate data collection point where data are collected for forwarding to the International Data Centre.</td>
</tr>
<tr>
<td>Cooperating National Facility</td>
<td>A monitoring facility, operated by a State Party, that has been designated, following a request by the hosting State Party and subject to the agreement of the Executive Council, and certified by the Technical Secretariat to provide authenticated data to the International Data Centre when requested by a State Party, but that is not formally a part of the International Monitoring System.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
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<tr>
<td>----------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Coordinated Universal Time (UTC)</td>
<td>International basis of civil and scientific time, implemented in 1964. UTC is widely broadcast by precisely coordinated radio signals; these radio time signals ultimately furnish the basis for the setting of all public and private clocks. Since 1 January 1972, UTC has been obtained from atomic clocks. The unit of UTC is the atomic second (SI). (Encyclopedia Britannica)</td>
</tr>
<tr>
<td>CTBT</td>
<td>The Comprehensive Nuclear-Test-Ban Treaty.</td>
</tr>
<tr>
<td>CTBTO</td>
<td>The Comprehensive Nuclear-Test-Ban Treaty Organization, headquartered at the Vienna International Centre, and charged with monitoring and verifying the treaty through a network of seismic, hydroacoustic, infrasound and radionuclide stations that comprise the International Monitoring System and that relay data to the International Data Centre for processing and analysis. The CTBTO is also responsible for confidence-building measures, on-site inspections, and coordinating consultation and clarification.</td>
</tr>
<tr>
<td>Data Authentication</td>
<td>Measures taken to ensure that the integrity of the data from the monitoring stations in the International Monitoring System network has not been compromised, either accidentally or maliciously, by some action at the station or in transmission to the International Data Centre, or at any time thereafter.</td>
</tr>
<tr>
<td>Data Availability</td>
<td>The percentage of the data, on time or delayed, that reaches the International Data Centre per year.</td>
</tr>
<tr>
<td>Data Buffer</td>
<td>A temporary record of station data maintained at the station or a National Data Centre or an appropriate communication node to minimize loss of data during a period of communication outage with the International Data Centre.</td>
</tr>
<tr>
<td>Data Format</td>
<td>The particular structure of the information contained in a digital file (or collection of files), and the relationships between the data contained within related files.</td>
</tr>
<tr>
<td>Data Frame Length</td>
<td>The length, in time, of a unit of data, packaged for communication, containing waveform and associated header information, including authentication and state of health. The data frame should be the same for all data coming from one station.</td>
</tr>
<tr>
<td>Data Quality</td>
<td>A measure of how well data from a monitoring station are within tolerances, adhere to calibration and certification standards and are free of aberrations such as spikes and gaps.</td>
</tr>
<tr>
<td><strong>Data Surety</strong></td>
<td>Methods for ensuring that the data from a monitoring station are not tampered with before, during or after transmission to the International Data Centre.</td>
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<td>-----------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Data Time Stamp</strong></td>
<td>A record of absolute Coordinated Universal Time, attached to a unit of data, that provides the time those data were sampled.</td>
</tr>
<tr>
<td><strong>Delay in Transmission</strong></td>
<td>For continuous data, the time allowable between the time when the sensor acquires a signal and the time that the signal reaches the International Data Centre. This amount of time includes any delay introduced in the communication system itself as well by routing the data through a National Data Centre or an appropriate communication node.</td>
</tr>
<tr>
<td><strong>Dynamic Range</strong></td>
<td>The ratio of the largest to smallest signal amplitude that the system can linearly process.</td>
</tr>
<tr>
<td><strong>Enhanced Repair</strong></td>
<td>See Priority Two Repair.</td>
</tr>
<tr>
<td><strong>Existing Station</strong></td>
<td>An International Monitoring System station that was originally installed and maintained by an entity other than the Technical Secretariat.</td>
</tr>
<tr>
<td><strong>Full-Frequency-Response Calibration</strong></td>
<td>This calibration measures instrument characteristics at all frequencies and checks them against the nominal values.</td>
</tr>
<tr>
<td><strong>Global Communications Infrastructure</strong></td>
<td>The worldwide communication system to enable station sensor data, state-of-health data, meteorological data (if appropriate), and other supplementary data, to be transmitted to the International Data Centre, and for the dissemination of International Monitoring System data and International Data Centre processed data to the States Parties.</td>
</tr>
<tr>
<td><strong>Independent Subnetwork</strong></td>
<td>In this arrangement, the station data pass through a National Data Centre or an appropriate communication node before reaching the Global Communications Infrastructure interface. Operation and maintenance of the communication node or station/National Data Centre communications link are the responsibility of the Station Operator or the National Data Centre, as authorized per internal State Party agreement.</td>
</tr>
<tr>
<td><strong>Infrasound Array</strong></td>
<td>Multiple infrasound sensors arranged in a geometric configuration to allow estimates of bearing and phase velocity.</td>
</tr>
<tr>
<td><strong>Mission Capability</strong></td>
<td>A mission capable station is one that properly acquires the appropriate amount of data from the sensors and transmits these data to the IDC while meeting the data availability, timely data availability, and data quality requirements imposed on an IMS station.</td>
</tr>
</tbody>
</table>
Monthly Station Log  A record of station-related activity that affects station operations. This log consists of three sections: Equipment Failure Reporting, Data Reporting, and Remarks and Comments.

National Authority  As required under Article III of the Comprehensive Nuclear-Test-Ban Treaty, the body designated by a State Party to be the national focal point for liaison with the CTBTO and with other States Parties.

National Data Centre  A data centre, operated and maintained by a State Party, whose functions may include sending International Monitoring System data to the International Data Centre and/or receiving data and products from the International Data Centre.

Operational Manual  The document that describes, in broad and general terms, the responsibilities of International Monitoring System stations and the roles of the States Parties, National Data Centres, International Monitoring System and Technical Secretariat in ensuring that reliable, authenticated data are transmitted within specified time constraints to the International Data Centre. The operational manuals refer to operations that apply to all stations within a technology (seismological, hydroacoustic, infrasonic and radionuclide). Procedures that apply to individual stations and details of operation are described in the station-specific manuals.

Other Repair  See Priority Three Repair.

Partitioned Communications Topology  The arrangement of communications equipment at stations where data are routed through a National Data Centre or an appropriate communication node using a Global Communications Infrastructure interface at the site.

Passband  The half-power bandwidth of a system limited by a lower and an upper frequency at which the system attenuates signals by 3 dB below maximum transmissibility.

Polarity Check  This operation verifies circuit polarity by comparing relative channel first motion responses to impulsive events with a known direction of first motion.

Priority One (Urgent) Repair  For seismic, hydroacoustic and infrasound stations, Level One (Urgent) Repairs are required whenever a station becomes non-mission capable, a situation which requires immediate action to restore mission capability.
| **Priority Two**
| **(Enhanced) Repair** | For seismic, hydroacoustic and infrasound stations, Level Two (Enhanced) Repair is required whenever a station approaches non-mission-capable status. The elements that trigger enhanced repair are station specific (e.g., station configuration, number of array elements, site access considerations, etc.). Maintenance is required as soon as is feasible to ensure that the station remains mission capable. |
| **Priority Three**
<p>| <strong>(Other) Repair</strong> | For seismic, hydroacoustic and infrasound stations, Level Three (Other) Repair is required when the station experiences any failure that does not require enhanced or urgent repair. |
| <strong>Resolution</strong> | The theoretical minimum change that a digital system can sense. |
| <strong>Sampling Rate</strong> | The number of samples per unit of time that are converted from analog to digital signals at uniform time intervals. |
| <strong>Sensor Response</strong> | Response of the sensor to an impulse of pressure. The response is conveniently described by a constant and a set of ‘poles and zeros’. |
| <strong>Sensor Type</strong> | The type of sensor used in a particular technology; pressure transducer for this Manual. |
| <strong>Site Survey</strong> | Detailed study of the proposed location of the International Monitoring System station, covering all features of the site that may affect the operation of the station and the quality of the monitoring data provided by the station, such as accessibility, available infrastructure, technical support, meteorological factors, site security, background, and potential sources of anthropogenic factors that might affect the data. |
| <strong>Station</strong> | The equipment, facilities, infrastructure and staff required to carry out monitoring at a designated location within the International Monitoring System network. This includes all operational systems necessary for this function. In addition, the station may include the equipment necessary to provide ancillary data, such as meteorological information and state-of-health sensors. |
| <strong>State of Health</strong> | Supplementary data provided by sensors connected to, or associated with, equipment and instrumentation at the station, to provide information on the operational status of the station and quality of the raw monitoring data being transmitted from the station. |
| <strong>State Party</strong> | A treaty signatory that has deposited instruments of ratification. |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Station-Specific Manual</strong></td>
<td>Documentation that comprises a description of and technical details pertaining to an individual station, including monitoring equipment and instrumentation, communication systems, operational procedures, maintenance protocols, and identification of authorized station personnel.</td>
</tr>
<tr>
<td><strong>System Configuration Change Report</strong></td>
<td>This report describes any change to the station system configuration that might affect quality, calibration, integrity, availability or transmission of station data.</td>
</tr>
<tr>
<td><strong>System Noise</strong></td>
<td>Self noise of the acquisition system, excluding the microbarometer.</td>
</tr>
<tr>
<td><strong>Technical Secretariat</strong></td>
<td>The body established by the Executive Council to implement the technical provisions of the treaty, including oversight of the International Monitoring System and the International Data Centre.</td>
</tr>
<tr>
<td><strong>Timely Data Availability</strong></td>
<td>The percentage of data from a station that reaches the International Data Centre within the allowable time delay per unit of time.</td>
</tr>
<tr>
<td><strong>Urgent Repair</strong></td>
<td>See Priority One Repair.</td>
</tr>
<tr>
<td><strong>Wind Noise Reducing System</strong></td>
<td>A filtering system physically connected to the sensor which is designed to improve the signal-to-noise ratio.</td>
</tr>
</tbody>
</table>
APPENDIX VI

PROCEDURES FOR INTERNATIONAL MONITORING
SYSTEM STATION CERTIFICATION

1. INTRODUCTION

The aim of this paper is to specify the procedures that will be used by the PTS for certifying stations prior to entry-into-force as called for in the Resolution Establishing the Preparatory Commission (CTBT/MSS/RES/1).

The PrepCom has provided guidelines on certification in report CTBT/PC/III/1/Add.2. This paper follows these guidelines, Task Leader papers and the discussions that have taken place in subsequent Working Group B sessions. It expands inter alia, on the following topics:

- The definition of certification;
- The composition of the pts certification group responsible for certification;
- The cost-effective means of combining information on site characteristics, instrument specifications, communication system performance and data quality into the certification process; and
- A description of the steps involved in the certification process and the documentation necessary for this purpose.

2. DEFINITION OF CERTIFICATION

A station may be certified when:

- The PTS is assured that the site, the station equipment and the infrastructure substantially meet the technical specifications for IMS stations (CTBT/PC/II/Add.2). The PTS interprets the term “substantially meet” to mean that minor variations may be accepted on a case-by-case basis provided that such variations do not degrade the effectiveness of the station or the quality and timeliness of the data provided to the IDC. Any such variations will be clearly reported to Working Group B by the PTS and the record will be preserved for future reference.

- Data authentication devices, including anti-tampering devices, are in place and have been demonstrated to function properly. The authentication implementation plan (CTBT/PTS/INF.100/Rev.1) which has been approved by the Eighth Session of the PrepCom (CTBT/PC-8/1/Annex II, decision 3) allows data signature at the sensor/digitiser or, as an interim measure for some IMS technologies, at the central facility.

* This Appendix is a revision of CTBT/PC-9/1/Annex II based on procedures developed in the PTS.
• The station interface to the GCI is in place and has been demonstrated to function properly. In cases where a station is linked to the GCI through an independent subnetwork, the communication link through the subnetwork shall be in place and demonstrated to function properly.

3. POST-CERTIFICATION SUPPORT

Once certification is granted, the station would be funded in accordance with Treaty procedures and the IMS budget approved by the Prepcom (CTBT/PC/III/1/Add.2). The amount to be allocated for this purpose will be the subject of negotiations between the PTS and the technical organization designated by the host country as the station operator.

4. ESTABLISHMENT OF THE PTS CERTIFICATION GROUP

As tasked by the Guidelines on certification issued by the PrepCom, PTS submits the following composition of the PTS Certification Group to WGB for approval:

- Director, IMS Division (Chairman),
- Coordinator, IMS Division (Vice-Chairman),
- Chief of the responsible technology section,
- Representative of the IDC Division,
- Technical experts of the PTS as required.

5. CERTIFICATION PROCESS

Based on the procedures outlined by the PrepCom (CTBT/PC/III/1/Add.2), the PTS envisages that the procedure for certifying stations to be followed by the PTS will comprise the following phases.

5.1. Initial Station Assessment

Once the PTS determines or is notified that a station is ready for certification, the PTS will commence the collection and assessment of all appropriate information about the station. The procedures for station assessment will differ for existing and new stations. For existing stations, primarily seismic but including some hydrophone and T-phase hydroacoustic stations, there may be considerable operating experience and data on which to draw for the station assessment. For new or upgraded stations many of the aspects of certification related to technical specifications will be covered in the procurement phase of the equipment, and emphasis will be put on the functioning of the station during the testing and evaluation phase to collect the required data.
5.2. Testing and Evaluation

An important part of the commissioning of an IMS station once it has been upgraded or recently installed is a period of testing and evaluation to be certain that it functions reliably. Some technical specifications defined by the PrepCom require long-term monitoring in order to have enough data for a statistical measurement of some parameters.

5.3. Certification

Once the PTS is satisfied that the requirements listed in Section 2 of this paper are met, it will issue the station certification through formal notification of the host country and the PrepCom through Working Group B.

6. CERTIFICATION STEPS

The following steps can to some degree be carried out in parallel, and each step will be initiated at the earliest practical time. It is particularly important that as much available information as possible be compiled before any station visit takes place. In this way, the station visit can focus on issues that are not possible to resolve by other available means.

Step 1: Formal arrangements

- A formal notification from the PTS to the host country to initiate the certification process, it being understood that an agreement to proceed with certification has been made under a facility agreement/arrangement or in an exchange of letters.
- An agreement between PTS and a technical organization designated by the host country to elaborate procedures for field inspection (as appropriate) and provision of information during the certification process.

Step 2: Compilation of technical material

- The division of responsibility between the designated technical organization and the PTS for compiling the necessary technical material will be specified in the agreement.
- The material and information to be compiled by the host country will be specified in guidelines prepared by the PTS and made available to the designated technical organization well in advance of the certification visit.

Step 3: Station visit / station review (as necessary)

- Preparation for station visit by a PTS team when necessary.
- Conduct of the station visit to review the facilities and discuss the station with its managers and operators, including the preparation of a formal report of findings.
- In cases where it is impractical or unnecessary to carry out a station visit, conduct a review of station characteristics with representatives of station operator.
Step 4: Issuing station certification

- Final review by the Certification Group of available material on the station.
- Formal approval by the Certification Group regarding station certification.
- Official station certification issued by the PTS to the host country.
- Notification of certification to the PrepCom through WGB, the certification date and the relevant technical details of the process.

Step 5: Record keeping / Documentation control

- Establish, organize and maintain a well-organized archive of pertinent material.
- Organize information relevant to station certification in a data base accessible to appropriate PTS personnel and States Signatories.
- Develop procedures to ensure that information is accurately recorded, and that various related data bases (e.g. IDC documentation and IMS records) are consistent.

7. LONG-TERM QUALITY CONTROL

- Develop procedures in accordance with the IMS Quality Assurance Plan.
- Monitor and record station performance on a continued basis, and keep PTS archives properly updated.
- Interact with station operator as needed to maintain satisfactory operational performance.
- Ensure that recommendations for improvements and modifications are followed up, and that upgrades required as technology becomes available are implemented in a timely and cost-effective manner.
- Periodically review station status with the PTS Certification Group and take appropriate action if station performance is unsatisfactory.