IGS

IGS Site Guidelines

Infrastructure Committee
Central Bureau
cb@igs.org

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1. Introduction

The IGS network is a collection of heterogeneous stations operated by many different organizations pooling their resources under the IGS umbrella for the common good. Stringent rules are inconsistent with the voluntary nature of the IGS. However, participating stations must agree to adhere to the standards and conventions contained herein, which ensure the consistent high quality of the IGS network and products.

Of particular importance to the IGS is the stable, long-term operation of the network. Therefore, changes to any station's configuration or immediate surroundings should be carefully planned to minimize discontinuities in the station's position time-series. Special consideration should be given to designated reference frame stations that contribute to the realization of the International Terrestrial Reference Frame (ITRF)(see the IGS08.snx file for a listing of stations that contribute to the IGS reference frame). Any changes to these stations should be planned well in advance following the procedures in section 2.3 of these Guidelines.

Suggestions for additions or changes to these guidelines are welcomed at cb@igs.org

1.1. Purpose and Scope

This document lists the conventions that all IGS sites must follow, as well as additional desirable characteristics, which enhance a station's value to the IGS. It is intended to be useful reference to station owners and operators for site planning as well as during ongoing operations.

1.2. Structure of the guidelines

General station guidelines are presented in Section 2 of this document, which is organized into "strict guidelines" that must be adhered to and "recommended guidelines" that are less strictly enforced, though desired. Station upgrade guidelines, which have been more thoroughly defined since previous versions of this document, have also been included in section 2. Reference frame station requirements that were previously in Section 3 have been merged into section 2. Section 3 presents the additional guidelines for stations submitting data in hourly mode. Section 4 includes the guidelines for stations with meteorological equipment as part of the GNSS installation. High rate and real-time guidelines are in Section 5, though the real-time guidelines are still considered provisional as the IGS real-time service is in pilot phase with requirements still developing. The GLONASS guidelines that were previously in

Section 6 have been expanded to include new GNSS constellations and merged into Section 2. Guidelines for stations co-located at tide gauges in support of the TIGA Working Group's activities are in Section 6. Section 7 covers guidelines for timing stations connected to external frequency standards. Section 8 presents the station guidelines in what has been called a more "natural" organization from a station set-up point of view, by grouping them into; site physical requirements, monumentation, antenna, receiver, data availability, operations, station information and communication, and other station options.

Included in separate documents are notes and clarifications for the guidelines to help in the interpretation and a checklist to be followed in proposing new IGS stations.

1.3. Process for becoming an IGS station

The process for Station Owners or Operators (SO) to follow in proposing a new IGS station is outlined in the New Station Checklist (see separate document).

In planning the new station proposal, the SO should carefully review the guidelines contained within this document. The responsible agency must have an expectation that the station will operate perpetually, preferably as part of a national or regional reference network. The SO should consult with the Central Bureau to confirm that the proposed station will add value to the IGS network prior to submitting the application materials.

Stations located within the footprint of a national or regional reference network should first coordinate with the relevant reference network operator. Since most of the regional or national reference networks conform to IGS standards, prior acceptance within such network is considered favorable to IGS. The IGS CB and the reference network operator will decide whether the station should be proposed as an IGS station based on location, instrumentation, operational characteristics, and whether it is relevant to any IGS Pilot Project or Working Group.

The Central Bureau consults with the SO through the application process and reviews compiled information for accuracy, completeness and compliance with IGS guidelines. Completed station applications are presented to the Analysis Centers who may select the station for use in generating IGS products. Should a station be selected by at least one analysis center, it is formally accepted within the IGS network.

1.4. Waivers for non-compliant stations

On the occasion that a station does not comply with IGS Guidelines, but is still valuable to the IGS, a waiver may be granted to include the station within the IGS network, if agreed to by the Analysis Coordinator and Central Bureau. Such stations will be

identified to warn users that they do not comply with guidelines.

2. General Station Guidelines

This section presents the guidelines for an IGS station. They are applicable both to current active IGS stations and to proposed stations. Full compliance with these guidelines is clearly desired by the IGS, however where guidelines cannot be complied with, station operators are asked to consult with the Central Bureau.

2.1. Strict Station Guidelines

The IGS relies on many voluntarily contributed resources from different organizations. Of these contributions, the data recorded by GNSS receivers around the world is amongst the most important. For stations to be accepted and retained within the IGS network, operators must follow these guidelines over the lifetime of the installation. The IGS will monitor compliance with guidelines and work with station operators to address issues that may arise.

Note: items marked with an asterisk (*) are further clarified in the separate document entitled "IGS Site Guidelines Clarifications."

Guideline N°	Guideline
2.1.1	Station details and configuration over its lifetime shall be properly recorded in the dedicated station log*. See: • Blank Site Log Form ftp://igs.org/pub/station/general/blank.log • Site Log Instructions ftp://igs.org/pub/station/general/sitelog_instr.txt • Site Log Tester http://igs.org/network/sitelog_tester.php
2.1.2	Site location for the IGS station must be secured over the long-term so that changes of antenna location at the site are highly unlikely in the foreseeable future (no planned construction, demolition, etc in the site vicinity).*
2.1.3	The Station must be planned and installed for continuous and permanent operation.
2.1.4	The Station is operated by an established institution that is involved with scientific or infrastructure applications of GNSS. The station should be operated principally for public benefit by a Geodetic Agency, Space Agency, Scientific Foundation, Research Institution, or similar.
2.1.5	The Station is related to a national/regional geodetic network.*
2.1.6	Every effort shall be made not to disturb station equipment and configuration

Guideline N°	Guideline
	once installed except to upgrade station capabilities consistent with these guidelines.*
2.1.7	The GNSS receiver shall be set to track satellites at least down to 5° elevation.*
2.1.8	GNSS receivers must be set to track as many satellites, healthy and unhealthy (all-in-view tracking), from as many constellations as possible (within receiver limitations), always including all GPS satellites as a minimum.*
2.1.9	The GNSS receiver must record phase and code measurements (at least one of each) from at least two frequencies (three frequencies expected for new receivers). For 2 frequency GPS and GLONASS this includes: P1 (and/or C1), L1, L2, P2, (and C2, if available from the receiver), (see also 2.2.9).*
2.1.10	The GNSS station must provide observation files in RINEX mixed format files (RINEX M) tagged in GPS time (GLONASS-only 'R', or Galileo-only 'E' files, are not used by IGS, except as part of future experimental or pilot service work). The RINEX working group is responsible for maintaining the current IGS RINEX definition, currently version 2.11 (as of May 16, 2011), or version 3.02 (from April 3, 2013). See also 2.1.29.
2.1.11	The GNSS receiver must synchronize the actual instant of observation with true GPS time to within +/- 1 millisecond of the full second epoch.*
2.1.12	The station's GNSS antenna absolute calibration must be available in igs08.atx Converted field calibrations are no longer acceptable at new or upgraded stations.* See: ftp://igs.org/pub/station/general/igs08.atx.
2.1.13	The station's GNSS antenna must be leveled and oriented to True North using the defined antenna reference marker (see vendor instructions, Contact the Central Bureau with questions)*.
2.1.14	The station's GNSS antenna must be rigidly and securely attached to the top of the station monument.

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Guideline N°	Guideline
2.1.15	The Station monument should conform with current best practices observed by principal geodetic agencies. A drilled-braced tripod structure or tapered pillar type monument may are typically constructed.* Roof or structure mounted antennas should be avoided except under special circumstances that should be discussed with the Central Bureau prior to completing the IGS station application.
2.1.16	The Station monument foundation shall extend to bedrock or be deeply embedded into the stable subsurface and isolated from surface effects where bedrock is not accessible.
2.1.17	The Station should not be moved to a different monument unless absolutely necessary*. Moving to a new monument would require that a new station be established with a separate station ID and log.
2.1.18	The eccentricities (easting, northing, height) from the station permanent position marker to the antenna reference point (defined for each antenna type in ftp://igs.org/pub/station/general/antenna.gra) must be surveyed and reported in site logs and RINEX headers to ≤1 mm accuracy.
2.1.19	Each station's antenna eccentricity component (easting, northing, height) must be less than 5 m.*
2.1.20	Unless absolutely necessary for environmental or animal protection, using a radome over the station's GNSS antenna should be avoided.*
2.1.21	If an antenna radome is deemed necessary, the antenna+radome combination needs to have an absolute calibration available in the igs08.atx. ftp://igs.org/pub/station/general/igs08.atx
2.1.22	The radome, if used, should be spherical, mounted concentrically over the average phase center height of the antenna and properly aligned following the manufacturer instructions.
2.1.23	The Station must have a unique 4-character identifier.* The Central Bureau will assist The station operator should consult the ID checker application at SOPAC while selecting their unique ID http://sopac.ucsd.edu/scripts/checkSiteID.cgi.
2.1.24	The Station must have a unique IERS DOMES number from the Institut Géographique National (IGN) for the monument's permanent marker (see: http://itrf.ensg.ign.fr/domes_request.php) .*

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2.1.25	The Station permanent marker shall be appropriate to allow the assignment of an M-type IERS DOMES number, to indicate the antenna is referenced to a physical point on a monument or pillar (see: http://itrf.ensg.ign.fr/domes_desc.php).*
2.1.26	The Station's Operating Agency must maintain full capability to repair, upgrade and maintain the station.
2.1.27	The Station's data handling and transmission to the relevant Data Center must occur reliably as scheduled.
2.1.28	The Station's native format data should be archived by the station operator in case needed for data recovery or engineering purposes.*
2.1.29	The Station must report data in RINEX, currently v2.11 or v3.02 formats (or its future replacement data format: RINEX 3.XX/2.XX as may be adopted in the future by the RINEX Working Group) and transmit the data files to the designated Data Center, following guidelines provided by the Data Center.*
2.1.30	Even if the station receiver is capable of providing high rate or low latency data, daily and hourly data must be reported at 30 second intervals aligned to :00 and :30.*
2.1.31	The Station RINEX data file headers must match the station log. (ANT TYPE, MARKER NUMBER, etc. must all be complete and correct)*
2.1.32	The Station RINEX header or station log inconsistencies shall be quickly corrected when advised by the IGS Central Bureau.*
2.1.33	The station's data files must be transmitted to the Data Center by the station operator as soon as possible after the last recorded epoch and verified to be uncorrupted.*
2.1.34	Minimally, the station must provide 24hr Daily files at 30 sec sampling, delivered as soon as possible after 23:59:30 for the previous day.
2.1.35	After a communication outage at the station the data over the outage must be uploaded to the Data Center, if available. An IGSStation email shall be sent explaining the outage and the data availability over the period.
2.1.36	The Station should have a dedicated webpage with current pictures and

Guideline N°	Guideline
	configuration history, visit descriptions, etc maintained by the Station Operator (or its parent/regional/national organization)
2.1.37	The Station must have pictures available of the antenna installation in the 4 cardinal directions clearly labeled (as a minimum) through its webpage, or made available to the IGS.
2.1.38	The Station shall have recent pictures available, especially after configuration changes in the vicinity of the monument or with the antenna.*
2.1.39	The Station's Operator should not touch the station's equipment (especially the antenna) for the longest possible time (years if possible), except to correct a catastrophic failure, especially if being designated an IGS Reference Frame station.*
2.1.40	Station Operators must keep the IGS users informed of station events using the IGSMail and IGSStation lists. All messages related to a site need to have the 4 character ID of the station in the message Subject line.*
2.1.41	Station Operators shall use the IGSMail for general station announcements and the IGSStation email list for station operation details.*
2.1.42	Station changes should be forewarned via the IGSStation email list (see 2.1.35), 1 day in advance or more. All Station changes should be documented by filing an UPDATE site log with the Central Bureau.*
2.1.43	The Station Operator, or parent organization, must follow the IGSMail and IGSStation email lists regularly to remain informed on IGS developments and current station issues. Important announcements specifically for Station Operators will be sent using the IGS-SO mail list*. Mail lists can be subscribed to and viewed at http://igs.org/mail/index.html

2.2. Recommended Station Guidelines

IGS stations, to provide the best possible data, are requested to additionally follow the guidelines in this section.

Guideline N°	Guideline
2.2.1	The station GNSS receiver should be set to track all satellites down to 0° elevation.*

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2.2.2	The station GNSS receiver, and ideally other station equipment such as computers, should be protected against power failures by providing surge protection and backup power.
2.2.3	Precise meteorological equipment at station is recommended. Met data guidelines are included in Section 4. Met data is to be provided in Station's RINEX "m" where available.
2.2.4	Unique receivers and antennas are not encouraged at stations, except in support of pilot or experimental activities. Only previously known brands and models as described in the IGS rcvr_ant.tab and IGS08.atx file are accepted with full standing within the IGS network ftp://igs.org/pub/station/general/ .*
2.2.5	Station horizontal eccentricity (northing, easting) of 0 (zero) is preferred.*
2.2.6	One station should be designated as the principal IGS station at sites where more that one GNSS station is present. In cases where multiple GNSS receivers are split off of the same antenna, each GNSS receiver is considered a separate station and should have a different 4 character ID*.
2.2.7	Additional on-site monuments are desired for testing and operating equipment in parallel during upgrades as described in Section 2.3.*
2.2.8	Stations should provide the signal-to-noise values for all tracked signals: S1, S2, etc. in the RINEX files at the highest precision possible.
2.2.9	Station Operators should ensure that data files are complete at the time of submission to avoid resubmissions as far as possible.*
2.2.10	Station Operators should use data quality check programs such as TEQC on their data before publication in the Data Centers (check with your receiver vendor or see: http://facility.unavco.org/software/teqc/teqc.html).*
2.2.11	Stations with Hourly data file submissions (see Section 4) are preferred together with the Daily data file submission.*
2.2.12	The Station RINEX Daily files should be transmitted as soon as possible at the end of the day with less than 2 hour delay as a greater latency reduces the data's usefulness for most hourly applications.

Guideline N°	Guideline
2.2.13	Co--location with other geodetic techniques such as SLR, VLBI, DORIS or gravimeters is highly desired.
2.2.14	Co-located stations should have the 3D local ties accurate to 1 mm in all components.
2.2.15	The 3D ties to co-located instruments should be resurveyed as frequently as practical.*
2.2.16	Survey notes and intermediate results of the 3D ties shall be preserved and made available publicly.
2.2.17	The 3D tie survey data to other IERS and IGS markers shall be reduced in a geocentric frame (preferably ITRF) and the results be made available in SINEX, including full variance-covariance information (see: http://www.iers.org/IERS/EN/Organization/AnalysisCoordinator/SinexFormat/sinex__cont.html).*
2.2.18	Pseudorange and or phase smoothing should be completely disabled in the GNSS receiver. Please refer to the manufacturer instructions or ask the Central Bureau for assistance. In any case, the receiver settings in this regard shall be reported on the station log.*
2.2.19	Multipath mitigation should be disabled in the GNSS receiver. In any case, the receiver settings in this regard shall be reported via the station log.*
2.2.20	The GNSS receiver should be capable of providing third frequency measurements in the RINEX data files (L5) for all constellations.
2.2.21	The GNSS receiver should be capable of providing GLONASS, Galileo and BeiDou measurements (or easily upgradeable via firmware). If limited by number of receiver channels, the Central Bureau should be consulted in deciding what observations to provide.
2.2.22	The antenna must be setup to minimize CODE and PHASE reflections (multipath), by mounting it away from close reflecting surfaces or by applying some passive protection directly below the antenna (microwave absorbing material, etc)* Consult the Central Bureau for guidance, if necessary*.

Guideline N°	Guideline
2.2.23	The Station is expected to have very high-quality data (phase convergence in AC/PPP analysis < 15 mm)*
2.2.24	The Station is expected to have very good tracking (number of observations > 95% of expected)*
2.2.25	The Station is expected to have low multipath (< 0.3 m)*
2.2.26	The Station is expected to have a low number of cycle slips (< 1 per 1000 observations)*
2.2.27	The Station site should have additional monuments (3 recommended) available for future investigations, equipment upgrades (see section 2.3), etc.

2.3. Station Upgrade guidelines at Sites

An IGS station will need upgrades and maintenance over its lifetime. Please follow these guidelines when upgrading and/or recovering an IGS station.

Guideline N°	Guideline
2.3.1	Station receivers shall be upgraded with firmware upgrades from the manufacturer within 6 months of the firmware publication. Firmware updates shall be noted in the station log, and announced via an IGSStation mail message. Exceptions should be discussed with the Central Bureau.*
2.3.2	New equipment to be installed should be first installed on one of the additional monuments at the station site (see 2.3.4), or on a semi-permanent location at the site set up for this purpose. Data from the additional monument should be recorded for as long as possible with the new equipment (at least 1 month) in parallel to the original station (barring substitution after catastrophic failure).*
2.3.3	When upgrading a **Co-located** or a **Reference Frame station**, the parallel observation period should be 2 months or more. *A **Co-located** or **Reference Frame station** upgrade should have a **plan** designed by the Station Operator together with the Central Bureau, to minimize disruption and maximize potential benefits.*

2.3.4	The Parallel data recorded with the new equipment shall be made available to the Central Bureau in an accessible location to confirm RINEX files, check constellation visibility, data quality, to calculate ties as needed, etc.
2.3.5	Receiver and antenna changes at the IGS Station, after the successful "checkout" in the additional monument, shall be announced at least one day in advance via the IGSStation email list.
2.3.6	If upgrading a station from a bad monument design to a better antenna mount, involving moving the original marker, then the upgrade is essentially the commissioning of a new station, so all guidelines (Section 2.1, 2.2, etc) are fully applicable.*
2.3.7	When moving a **Co-located** or a **Reference Frame station** to a different monument at the site is unavoidable, parallel operations are required for as long as possible (3 months or more if possible) between the old and new station positions.*
2.3.8	If upgrading an un-calibrated antenna and radome at a **Co-located or Reference Frame station,** it is important to operate the original station without the radome for a period of at least 4 weeks before removing the old equipment.*
2.3.9	It is possible that un-calibrated antennas + radomes removed from stations may be calibrated for historical purposes. Please inquire with the Central Bureau prior to discarding old equipment.*

Note: A stable, traceable position time series is essential for the high accuracy applications of the IGS network, thus we emphasize that IGS Station Operators use special care in operating their IGS stations. Station Operators, in particular those of Co-located and Reference Frame stations, should observe and adhere to these upgrade guidelines. Please contact the Central Bureau with any questions.

3. Hourly Stations

Station Operators are encouraged to submit data on an hourly or more frequent basis. The hourly data files produce near-real-time IGS products, including the Rapid and Ultra-rapid orbit products.

Guideline N°	Section / Guideline Description
3.1	Hourly data from the Stations shall be submitted in RINEX format with the correct filenames; using the "letter hour" as specified in the v2.11 format definition, and the 'file preiod' field for the v3.02 (see: ftp://igs.org/pub/data/format/rinex211.txt, ftp://igs.org/pub/data/format/rinex302.pdf).
3.2	Hourly data from the Stations shall cover from 00:00 to 59:30 of each hour as specified in the RINEX format definition.
3.3	Hourly data from the Station shall be sent to at least two Data Centers.
3.4	Hourly data files should be transmitted as soon as possible following the end of the hour, preferably with less than 5 min delay each hour.
3.5	After a communication outage the missed hourly data files should be transmitted but **only** for files less than 3 days old.

4. Meteorological Data

IGS stations can benefit from having meteorological equipment installed as part of the station to better characterize and understand the station environment, to help improve the processing and scientific model development.

Guideline N°	Section / Guideline Description
4.1	It is encouraged to provide Pressure and Temperature at the station, as a minimum.*
4.2	The Station meteorological data shall be distributed in RINEX format.*

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Guideline N°	Section / Guideline Description
4.3	The Station meteorological data sampling interval shall be less than 60 min and is recommended to be 10 min.
4.4	The Station Pressure sensor noise must be accurate to within 0.5 hPa. *As specified by the meteorological probe sensor vendor information*
4.5	The Station Temperature sensor accuracy must be at least 1˚ K. *As specified by the meteorological probe sensor vendor information*
4.6	The Station meteorological equipment drift and bias must be minimized. *Ensuring correct operations as specified by the vendor instructions.*
4.7	Temperature effects on the pressure measurements should be minimized. *By using the correct solar shielding or by placing the sensor in a nearby building if necessary*
4.8	The Station meteorological instrument height measurement in relation to the GPS antenna mark must have an accuracy of 1 m or better.
4.9	The Station meteorological data is to be transmitted on the same schedule as the RINEX observation files (hourly or daily).
4.10	The Station meteorological instruments are to be calibrated periodically according to the manufacturer's recommendations to assure the above accuracy specifications are met. The calibration dates should be included in the site log.

5. IGS High-Rate Stations

High-Rate stations submit 30 second data in Hourly and Daily modes and also at 1 Hz sampling in 15 min files or in real-time through streaming. The high-rate data is used as part of the Low Earth Orbiter Pilot Project (LEO-PP) and several other Near-real time and real-time applications.

5.1. High-Rate Data files

Guideline N°	Section / Guideline Description
5.1.1	The Station shall submit 15 min 1 Hz files (observation and navigation) to support Near-Real-Time applications.*
5.1.2	The 15min 1 Hz files to support Near-Real-Time applications should cover each hour in 4 periods as follows: 00:00 to 14:59, 15:00 to 29:59, 30:00 to 44:59, 45:00 to 59:59, and be named as indicated in the RINEX file definition.*
5.1.3	The Stations participating in the high-rate data provision are encouraged to provide the files with a delay of 2 min or less from the last recorded observation epoch.

5.2. IGS Real-Time Stations

In addition to meeting the standards of a conventional IGS station, Real-Time stations must also stream 1-Hertz GNSS observation data over the Internet.

Guideline N°	Section / Guideline Description
5.2.1	Real-time station operators are asked to adhere to the following principles whenever possible: a) Reference frame stations are to be operated as real-time stations. This is to increase the likelihood that IGS real-time products are accurately and precisely tied to the IGS reference frame. b) Real-time stations should be configured to send a minimum of two data streams to two independent real-time data centers. This will provide a minimum level of redundancy in the event one of the two data centers is not operational. c) The station operator is responsible for their data stream broadcast. The streaming of data should not be done by other agencies without the station operator's consent.
5.2.2	Real-time station operators must strive to meet the following objectives:

Guideline N°	Section / Guideline Description
	a) The station Internet service should be sufficient to meet the minimum performance standards required to send 1-Hertz data to two or more real-time data centers. Generally speaking a latency of two seconds or less from station to data center is acceptable. *b)* Stream data should not affect completeness of the file based data sets. Hourly and daily files from streaming stations should contain all the data from each epoch and all epochs within the file period. In some cases the data sets will be based on raw data retrieved independent of the streamed data.
5.2.3	Real-time data centers (IGS-NTRIP Casters) will accept data streams in the RTCM3.x (x=0,1). RTCM 3.x GPS and GLONASS data streams must contain L1-C/A and L2-P data. (Note: In the future RTCM-Multiple Signal Messages (RTCM-MSM) will be adopted standard for streaming stations contributing to the IGS Real-Time Service. MSM information for streaming station operators will be found at http://rts.igs.org).
5.2.4	RTCM code and phase observations **shall not** be corrected to refer to the antenna reference point (this correction is typically known as the antenna phase center correction).
5.2.5	Stations streaming GPS RTCM 3.x (x=0,1) must contain message types a) 1004 b) 1006 (use 1005 only if 1006 is not available) c) 1008 (use 1007 only if 1008 is not available) d) 1019 – see table below. GPS/GLONASS stations streaming RTCM 3.x must stream message type 1012 and 1020. The coordination in message type 1006 (1005) should be in accordance with the IGS adopted reference frame (see table below). If other message types containing meta-data are streamed, their information should be in full accordance with the sitelog information, and antenna description and antenna calibration file available from the IGS Central Bureau http://igs.org

RTCM Message Number	Message Content
1004	GPS code and carrier phase observations + CNR (carrier to noise ratio)
1005	(X,Y,Z) coordinated of the antenna reference point

Guideline N°	Section / Guideline Description	
	1006	(X,Y,Z) coordinates of the antenna reference point + height of antenna reference point above marker
	1007	Antenna type description (using IGS naming conventions)
	1008	Antenna type description (using IGS naming conventions) and serial number
	1012	GLONASS code and carrier phase observations + CNR (carrier to noise ratio)
	1019	GPS satellite broadcast ephemeris
	1020	GLONASS satellite broadcast ephemeris
	RTCM 3.x (x=0,1) message types	

More information on IGS Real-Time Service is available at http://rts.igs.org

6. TIGA sites

The GPS Tide Gauge Benchmark Monitoring Working Group (TIGA) requires GNSS stations at or near tide gauges. Additional information can be found on the TIGA web page (see: http://www.igs.org/projects/tiga/index.html).

Guideline N°	Section / Guideline Description
6.1	The GNSS Tide Gauge data, preferably hourly data, must be stored at a Tide Gauge data center (e.g. PSMSL, UHSLC, NTF) or be made available to the public on request. *PSMSL: Permanent Service for Mean Sea Level* *UHSLC: University of Hawaii Sea level center* *NTF: National Tidal Facility (Australia)*
6.2	All Tide Gauge Benchmarks and additional benchmarks, including the GNSS Antenna Reference Point, must be re-leveled by a first-order leveling or GNSS ties on a routine basis. *The repetition period depends on the local geographical/geological situation. The ties should have an accuracy of a first order leveling.*
6.3	Metadata, including benchmark information, leveling ties, reference of the tide gauge zero to the GNSS benchmark, should be made available to the public. *Survey measurements, field notes should be preserved and be made publicly available.*
6.4	The TIGA GNSS station shall provide, if possible, the following meteorological data: Air pressure, temperature, wind speed, direction, and gust. (see section 5.1).
6.5	The TIGA GNSS station data latency shall be always less than 460 days.

7. IGS Timing sites

IGS stations that are connected to high-quality external frequency standards have these additional guidelines to help in the activities of the Clock Products Working Group (see: http://www.igs.org/projects/clock/index.html). Additional guidelines by Consultative Committee for Time and Frequency (CCTF) can be also found in http://www1.bipm.org/cc/CCTF/Allowed/15/CCTF_01_36.pdf.

Guideline N°	Section / Guideline Description
7.1	The Station GNSS receiver shall be connected to an external frequency standard (H-maser or Cesium).
7.2	The Station receiver must be set to be driven by the external reference, if connected. *Many modern receivers do not automatically use the external reference correctly. Please consult the vendor manuals and ensure the receiver is locking to the external frequency correctly.*
7.3	The time measured at the receiver shall track the external reference, and NOT the internal oscillator.
7.4	If the internal oscillator is locked to the external reference via an enslavement system, then the system should be described in full details by the manufacturer. This system should furthermore be designed to introduce no noise on the frequency.
7.5	H-maser frequency stability over a 1 day averaging interval shall be better than 7E-15 for passive and 2E-15 for active H-masers.
7.6	Cesium frequency stability over a 1 day averaging interval shall be better than 2E-14 for high-performance and 1E-13 for standard Cesium tube systems.
7.7	Antenna cables should be the low power loss type between 1-2 GHz *According to the cable's manufacturers specifications*
7.8	Stations' cables must be installed to minimize temperature variations: buried >1 meter and avoiding extreme uneven sunlight
7.9	Signal reflections in the cable shall be at least 40 dB below the direct signal at the receiver.

Guideline N°	Section / Guideline Description
7.10	Avoid sharp bends in the cable, areas of known vibrations, etc.
7.11	Ensure that all cable connections to the receiver are fast (use high-quality cabling)
7.12	Equipment carrying time/frequency signal (cable, amplifiers, multipliers, etc) to the receiver shall have low sensitivity to environmental variations *According to the manufacturer's specifications*
7.13	The location of the Timing receiver and the external frequency reference shall have a temperature stabilization of +/- 1˚ Celsius.
7.14	The station shall have a receiver designed for time transfer (in which case the RINEX observation data are reported to the receiver measurement point), not to another PPS signal through a time interval counter, which adds noise (as for example with the GTR50 and TTS3)

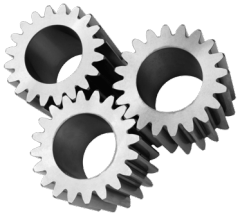
8. Station Logical Block Guideline Presentation

An IGS GNSS Station has to follow and apply the guidelines as directed. This section presents the IGS GNSS station guidelines re-organized using a more natural station installation point of view.

Site Physical and Institutional Guidelines	

2.1.2	Site location for the IGS station must be secured over the long-term so that changes of antenna location at the site are highly unlikely in the foreseeable future (no planned construction, demolition, etc in the site vicinity).*
2.1.3	The Station must be planned and installed for continuous and permanent operation.
2.1.4	The Station is operated by an established institution that is involved with scientific or infrastructure applications of GNSS. The station should be operated principally for public benefit by a Geodetic Agency, Space Agency, Scientific Foundation, Research Institution, or similar.
2.1.5	The Station is related to a national/regional geodetic network.*
2.1.6	Every effort shall be made not to disturb station equipment and configuration once installed except to upgrade station capabilities consistent with these guidelines.*
2.1.23	The Station must have a unique 4-character identifier.* The Central Bureau will assist The station operator should consult the ID checker application at SOPAC while selecting their unique ID http://sopac.ucsd.edu/scripts/checkSiteID.cgi.
2.1.24	The Station must have a unique IERS DOMES number from the Institut

	Géographique National (IGN) for the monument's permanent marker (see: http://itrf.ensg.ign.fr/domes_request.php) .*
2.1.39	The Station's Operator should not touch the station's equipment (especially the antenna) for the longest possible time (years if possible), except to correct a catastrophic failure, especially if being designated an IGS Reference Frame station.*
2.2.6	One station should be designated as the principal IGS station at sites where more that one GNSS station is present. In cases where multiple GNSS receivers are split off of the same antenna, each GNSS receiver is considered a separate station and should have a different 4 character ID*.
2.2.7	Additional on-site monuments are desired for testing and operating equipment in parallel during upgrades as described in Section 2.3.*

Operational Guidelines	

2.3.2	New equipment to be installed should be first installed on one of the additional monuments at the station site (see 2.3.4), or on a semi-permanent location at the site set up for this purpose. Data from the additional monument should be recorded for as long as possible with the new equipment (at least 1 month) in parallel to the original station (barring substitution after catastrophic failure).*
2.3.3	When upgrading a **Co-located** or a **Reference Frame station**, the parallel observation period should be 2 months or more. *A **Co-located** or **Reference Frame station** upgrade should have a **plan** designed by the Station Operator together with the Central Bureau, to minimize disruption and maximize potential benefits.*
2.3.4	The Parallel data recorded with the new equipment shall be made available to the Central Bureau in an accessible location to confirm RINEX files, check constellation visibility, data quality, to calculate ties as needed, etc.
2.3.5	Receiver and antenna changes at the IGS Station, after the successful "checkout" in the additional monument, shall be announced at least one day in advance via the IGSStation email list.
2.3.6	If upgrading a station from a bad monument design to a better antenna mount, involving moving the original marker, then the upgrade is essentially the commissioning of a new station, so all guidelines (Section 2.1, 2.2, etc) are fully applicable.*
2.3.7	When moving a **Co-located** or a **Reference Frame station** to a different monument at the site is unavoidable, parallel operations are required for as long as possible (3 months or more if possible) between the old and new station positions.*
2.3.8	If upgrading an un-calibrated antenna and radome at a **Co-located or Reference Frame station,** it is important to operate the original station without the radome for a period of at least 4 weeks before removing the old equipment.*

2.3.9	It is possible that un-calibrated antennas + radomes removed from stations may be calibrated for historical purposes. Please inquire with the Central Bureau prior to discarding old equipment.*

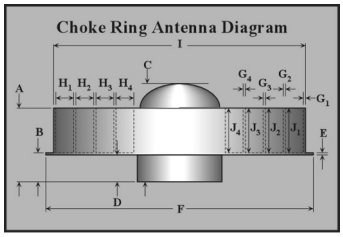
IGS Site Guidelines

Monumentation Guidelines	

2.1.15	The Station monument should conform with current best practices observed by principal geodetic agencies. A drilled-braced tripod structure or tapered pillar type monument may are typically constructed.* Roof or structure mounted antennas should be avoided except under special circumstances that should be discussed with the Central Bureau prior to completing the IGS station application.
2.1.16	The Station monument foundation shall extend to bedrock or be deeply embedded into the stable subsurface and isolated from surface effects where bedrock is not accessible.
2.1.17	The Station should not be moved to a different monument unless absolutely necessary*. Moving to a new monument would require that a new station be established with a separate station ID and log.
2.1.25	The Station permanent marker shall be appropriate to allow the assignment of an M-type IERS DOMES number, to indicate the antenna is referenced to a physical point on a monument or pillar (see: http://itrf.ensg.ign.fr/domes_desc.php).*
2.2.22	The antenna must be setup to minimize CODE and PHASE reflections (multipath), by mounting it away from close reflecting surfaces or by applying some passive protection directly below the antenna (microwave absorbing material, etc)* Consult the Central Bureau for guidance, if necessary*.
2.2.27	The Station site should have additional monuments (3 recommended) available for future investigations, equipment upgrades (see section 2.3), etc.

2.3.7	When moving a **Co-located** or a **Reference Frame station** to a different monument at the site is unavoidable, parallel operations are required for as long as possible (3 months or more if possible) between the old and new station positions.*

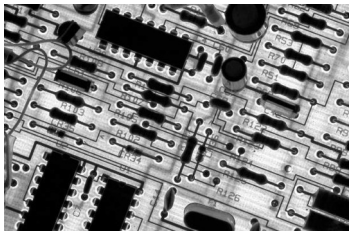
IGS Site Guidelines

Antenna Guidelines	

2.1.12	The station's GNSS antenna absolute calibration must be available in igs08.atx Converted field calibrations are no longer acceptable at new or upgraded stations.* See: ftp://igs.org/pub/station/general/igs08.atx.
2.1.13	The station's GNSS antenna must be leveled and oriented to True North using the defined antenna reference marker (see vendor instructions, Contact the Central Bureau with questions)*.
2.1.14	The station's GNSS antenna must be rigidly and securely attached to the top of the station monument.
2.1.18	The eccentricities (easting, northing, height) from the station permanent position marker to the antenna reference point (defined for each antenna type in ftp://igs.org/pub/station/general/antenna.gra) must be surveyed and reported in site logs and RINEX headers to ≤1 mm accuracy.
2.1.19	Each station's antenna eccentricity component (easting, northing, height) must be less than 5 m.*
2.1.20	Unless absolutely necessary for environmental or animal protection, using a radome over the station's GNSS antenna should be avoided.*
2.1.21	If an antenna radome is deemed necessary, the antenna+radome combination needs to have an absolute calibration available in the igs08.atx. ftp://igs.org/pub/station/general/igs08.atx
2.1.22	The radome, if used, should be spherical, mounted concentrically over the average phase center height of the antenna and properly aligned following the manufacturer instructions.

2.2.4	Unique receivers and antennas are not encouraged at stations, except in support of pilot or experimental activities. Only previously known brands and models as described in the IGS rcvr_ant.tab and IGS08.atx file are accepted with full standing within the IGS network ftp://igs.org/pub/station/general/ .*
2.2.5	Station horizontal eccentricity (northing, easting) of 0 (zero) is preferred.*
2.3.8	If upgrading an un-calibrated antenna and radome at a **Co-located or Reference Frame station,** it is important to operate the original station without the radome for a period of at least 4 weeks before removing the old equipment.*
2.3.9	It is possible that un-calibrated antennas + radomes removed from stations may be calibrated for historical purposes. Please inquire with the Central Bureau prior to discarding old equipment.*

IGS Site Guidelines

Receiver Guidelines	

2.1.7	The GNSS receiver shall be set to track satellites at least down to 5° elevation.*
2.1.8	GNSS receivers must be set to track as many satellites, healthy and unhealthy (all-in-view tracking), from as many constellations as possible (within receiver limitations), always including all GPS satellites as a minimum.*
2.1.9	The GNSS receiver must record phase and code measurements (at least one of each) from at least two frequencies (three frequencies expected for new receivers). For 2 frequency GPS and GLONASS this includes: P1 (and/or C1), L1, L2, P2, (and C2, if available from the receiver), (see also 2.2.9).*
2.2.1	The station GNSS receiver should be set to track all satellites down to 0° elevation.*
2.2.2	The station GNSS receiver, and ideally other station equipment such as computers, should be protected against power failures by providing surge protection and backup power.
2.2.4	Unique receivers and antennas are not encouraged at stations, except in support of pilot or experimental activities. Only previously known brands and models as described in the IGS rcvr_ant.tab and IGS08.atx file are accepted with full standing within the IGS network ftp://igs.org/pub/station/general/ .*
2.2.8	Stations should provide the signal-to-noise values for all tracked signals: S1, S2, etc. in the RINEX files at the highest precision possible.

2.2.18	Pseudorange and or phase smoothing should be completely disabled in the GNSS receiver. Please refer to the manufacturer instructions or ask the Central Bureau for assistance. In any case, the receiver settings in this regard shall be reported on the station log.*
2.2.19	Multipath mitigation should be disabled in the GNSS receiver. In any case, the receiver settings in this regard shall be reported via the station log.*
2.2.20	The GNSS receiver should be capable of providing third frequency measurements in the RINEX data files (L5) for all constellations.
2.2.21	The GNSS receiver should be capable of providing GLONASS, Galileo and BeiDou measurements (or easily upgradeable via firmware). If limited by number of receiver channels, the Central Bureau should be consulted in deciding what observations to provide.

2.3.1	Station receivers shall be upgraded with firmware upgrades from the manufacturer within 6 months of the firmware publication. Firmware updates shall be noted in the station log, and announced via an IGSStation mail message. Exceptions should be discussed with the Central Bureau.*

Station Data File Storage and Transfer Guidelines	

2.1.10	The GNSS station must provide observation files in RINEX mixed format files (RINEX M) tagged in GPS time (GLONASS-only 'R', or Galileo-only 'E' files, are not used by IGS, except as part of future experimental or pilot service work). The RINEX working group is responsible for maintaining the current IGS RINEX definition, currently version 2.11 (as of May 16, 2011). See also 2.1.29.

2.1.27	The Station's data handling and transmission to the relevant Data Center must occur reliably as scheduled.
2.1.28	The Station's native format data should be archived by the station operator in case needed for data recovery or engineering purposes.*
2.1.29	The Station must report data in RINEX, currently v2.11 format (or its future replacement data format: RINEX 3.XX/2.XX as may be adopted in the future by the RINEX Working Group) and transmit the data files to the designated Data Center, following guidelines provided by the Data Center.*
2.1.30	Even if the station receiver is capable of providing high rate or low latency data, daily and hourly data must be reported at 30 second intervals aligned to :00 and :30.*
2.1.31	The Station RINEX data file headers must match the station log. (ANT TYPE, MARKER NUMBER, etc. must all be complete and correct)*

2.1.33	The station's data files must be transmitted to the Data Center by the station operator as soon as possible after the last recorded epoch and verified to be uncorrupted.*

2.1.34	Minimally, the station must provide 24hr Daily files at 30 sec sampling, delivered as soon as possible after 23:59:30 for the previous day.
2.1.35	After a communication outage at the station the data over the outage must be uploaded to the Data Center, if available. An IGSStation email shall be sent explaining the outage and the data availability over the period.

2.2.9	Station Operators should ensure that data files are complete at the time of submission to avoid resubmissions as far as possible.*
2.2.10	Station Operators should use data quality check programs such as TEQC on their data before publication in the Data Centers (check with your receiver vendor or see: http://facility.unavco.org/software/teqc/teqc.html).*

2.2.11	Stations with Hourly data file submissions (see Section 4) are preferred together with the Daily data file submission.*
2.2.12	The Station RINEX Daily files should be transmitted as soon as possible at the end of the day with less than 2 hour delay as a greater latency reduces the data's usefulness for most hourly applications.

2.2.23	The Station is expected to have very high-quality data (phase convergence in AC/PPP analysis < 15 mm)*
2.2.24	The Station is expected to have very good tracking (number of observations > 95% of expected)*
2.2.25	The Station is expected to have low multipath (< 0.3 m)*
2.2.26	The Station is expected to have a low number of cycle slips (< 1 per 1000 observations)*

If the Station is additionally supporting the ***Hourly data*** efforts:

3.1	Hourly data from the Stations shall be submitted in RINEX format with filenames using the "letter hour" as specified in the RINEX format definition (see: ftp://igs.org/pub/data/format/rinex211.txt).
3.2	Hourly data from the Stations shall cover from 00:00 to 59:30 of each hour as specified in the RINEX format definition.
3.3	Hourly data from the Station shall be sent to at least two Data Centers.
3.4	Hourly data files should be transmitted as soon as possible following the end of the hour, preferably with less than 5 min delay each hour.
3.5	After a communication outage the missed hourly data files should be transmitted but **only** for files less than 3 days old.

If the Station is additionally supporting the ***High-Rate data*** efforts (1Hz data files):

5.1.1	The Station shall submit 15 min 1 Hz files (observation and navigation) to support Near-Real-Time applications.*
5.1.2	The 15min 1 Hz files to support Near-Real-Time applications should cover each hour in 4 periods as follows: 00:00 to 14:59, 15:00 to 29:59, 30:00 to 44:59, 45:00 to 59:59, and be named as indicated in the RINEX file definition.*
5.1.3	The Stations participating in the high-rate data provision are encouraged to provide the files with a delay of 2 min or less from the last recorded observation epoch.

If the Station is additionally supporting the ***data streaming*** efforts:

5.2.1	Real-time station operators are asked to adhere to the following principles whenever possible: d) Reference frame stations are to be operated as real-time stations. This is to increase the likelihood that IGS real-time products are accurately and precisely tied to the IGS reference frame. e) Real-time stations should be configured to send a minimum of two data streams to two independent real-time data centers. This will provide a minimum level of redundancy in the event one of the two data centers is not operational. f) The station operator is responsible for their data stream broadcast. The streaming of data should not be done by other agencies without the station operator's consent.

5.2.2

Real-time station operators must strive to meet the following objectives:

c) The station Internet service should be sufficient to meet the minimum performance standards required to send 1-Hertz data to two or more real-time data centers. Generally speaking a latency of two seconds or less from station to data center is acceptable.

d) Stream data should not affect completeness of the file based data sets. Hourly and daily files from streaming stations should contain all the data from each epoch and all epochs within the file period. In some cases the data sets will be based on raw data retrieved independent of the streamed data.

5.2.3

Real-time data centers (IGS-NTRIP Casters) will accept data streams in the RTCM3.x (x=0,1). RTCM 3.x GPS and GLONASS data streams must contain L1-C/A and L2-P data.

(Note: In the future RTCM-Multiple Signal Messages (RTCM-MSM) will be adopted standard for streaming stations contributing to the IGS Real-Time Service. MSM information for streaming station operators will be found at http://rts.igs.org).

5.2.4

RTCM code and phase observations **shall not** be corrected to refer to the antenna reference point (this correction is typically known as the antenna phase center correction).

5.2.5

Stations streaming GPS RTCM 3.x (x=0,1) must contain message types

e) 1004
f) 1006 (use 1005 only if 1006 is not available)
g) 1008 (use 1007 only if 1008 is not available)
h) 1019 – see table below.

GPS/GLONASS stations streaming RTCM 3.x must stream message type 1012 and 1020. The coordination in message type 1006 (1005) should be in accordance with the IGS adopted reference frame (see table below). If other message types containing meta-data are streamed, their information should be in full accordance with the sitelog information, and antenna description and antenna calibration file available from the IGS Central Bureau http://igs.org

RTCM Message Number	Message Content
1004	GPS code and carrier phase observations + CNR (carrier to noise ratio)
1005	(X,Y,Z) coordinated of the antenna reference point

1006	(X,Y,Z) coordinates of the antenna reference point + height of antenna reference point above marker
1007	Antenna type description (using IGS naming conventions)
1008	Antenna type description (using IGS naming conventions) and serial number
1012	GLONASS code and carrier phase observations + CNR (carrier to noise ratio)
1019	GPS satellite broadcast ephemeris
1020	GLONASS satellite broadcast ephemeris

RTCM 3.x (x=0,1) message types

IGS Site Guidelines

Station Information and Communication Guidelines	

2.1.1	Station details and configuration over its lifetime shall be properly recorded in the dedicated station log*. See: • Blank Site Log Form ftp://igs.org/pub/station/general/blank.log • Site Log Instructions ftp://igs.org/pub/station/general/sitelog_instr.txt • Site Log Tester http://igs.org/network/sitelog_tester.php
2.1.32	The Station RINEX header or station log inconsistencies shall be quickly corrected when advised by the IGS Central Bureau.*
2.1.36	The Station should have a dedicated webpage with current pictures and configuration history, visit descriptions, etc maintained by the Station Operator (or its parent/regional/national organization)
2.1.37	The Station must have pictures available of the antenna installation in the 4 cardinal directions clearly labeled (as a minimum) through its webpage, or made available to the IGS.
2.1.38	The Station shall have recent pictures available, especially after configuration changes in the vicinity of the monument or with the antenna.*
2.1.40	Station Operators must keep the IGS users informed of station events using the IGSMail and IGSStation lists. All messages related to a site need to have the 4 character ID of the station in the message Subject line.*
2.1.41	Station Operators shall use the IGSMail for general station announcements and the IGSStation email list for station operation details.*

2.1.42	Station changes should be forewarned via the IGSStation email list (see 2.1.35), 1 day in advance or more. All Station changes should be documented by filing an UPDATE site log with the Central Bureau.*
2.1.43	The Station Operator, or parent organization, must follow the IGSMail and IGSStation email lists regularly to remain informed on IGS developments and current station issues. Important announcements specifically for Station Operators will be sent using the IGS-SO mail list*. Mail lists can be subscribed to and viewed at http://igs.org/mail/index.html

IGS Site Guidelines

Meteorological Equipment Guidelines	

2.2.3	Precise meteorological equipment at station is recommended. Met data guidelines are included in Section 4. Met data is to be provided in Station's RINEX "m" where available.

4.1	It is encouraged to provide Pressure and Temperature at the station, as a minimum.*
4.2	The Station meteorological data shall be distributed in RINEX format.*
4.3	The Station meteorological data sampling interval shall be less than 60 min and is recommended to be 10 min.
4.4	The Station Pressure sensor noise must be accurate to within 0.5 hPa. *As specified by the meteorological probe sensor vendor information*
4.5	The Station Temperature sensor accuracy must be at least 1˚ K. *As specified by the meteorological probe sensor vendor information*
4.6	The Station meteorological equipment drift and bias must be minimized. *Ensuring correct operations as specified by the vendor instructions.*
4.7	Temperature effects on the pressure measurements should be minimized. *By using the correct solar shielding or by placing the sensor in a nearby building if necessary*
4.8	The Station meteorological instrument height measurement in relation to the GPS antenna mark must have an accuracy of 1 m or better.
4.9	The Station meteorological data is to be transmitted on the same schedule as the RINEX observation files (hourly or daily).
4.10	The Station meteorological instruments are to be calibrated periodically according to the manufacturer's recommendations to assure the above

	accuracy specifications are met. The calibration dates should be included in the site log.

TIGA Station Guidelines	

6.1	The GNSS Tide Gauge data, preferably hourly data, must be stored at a Tide Gauge data center (e.g. PSMSL, UHSLC, NTF) or be made available to the public on request. *PSMSL: Permanent Service for Mean Sea Level* *UHSLC: University of Hawaii Sea level center* *NTF: National Tidal Facility (Australia)*
6.2	All Tide Gauge Benchmarks and additional benchmarks, including the GNSS Antenna Reference Point, must be re-leveled by a first-order leveling or GNSS ties on a routine basis. *The repetition period depends on the local geographical/geological situation. The ties should have an accuracy of a first order leveling.*
6.3	Metadata, including benchmark information, leveling ties, reference of the tide gauge zero to the GNSS benchmark, should be made available to the public. *Survey measurements, field notes should be preserved and be made publicly available.*
6.4	The TIGA GNSS station shall provide, if possible, the following meteorological data: Air pressure, temperature, wind speed, direction, and gust. (see section 5.1).
6.5	The TIGA GNSS station data latency shall be always less than 460 days.

Timing Station Guidelines	

7.1	The Station GNSS receiver shall be connected to an external frequency standard (H-maser or Cesium).
7.2	The Station receiver must be set to be driven by the external reference, if connected. *Many modern receivers do not automatically use the external reference correctly. Please consult the vendor manuals and ensure the receiver is locking to the external frequency correctly.*
7.3	The time measured at the receiver shall track the external reference, and NOT the internal oscillator.
7.4	If the internal oscillator is locked to the external reference via an enslavement system, then the system should be described in full details by the manufacturer. This system should furthermore be designed to introduce no noise on the frequency.
7.5	H-maser frequency stability over a 1 day averaging interval shall be better than 7E-15 for passive and 2E-15 for active H-masers.
7.6	Cesium frequency stability over a 1 day averaging interval shall be better than 2E-14 for high-performance and 1E-13 for standard Cesium tube systems.
7.7	Antenna cables should be the low power loss type between 1-2 GHz *According to the cable's manufacturers specifications*
7.8	Stations' cables must be installed to minimize temperature variations: buried >1 meter and avoiding extreme uneven sunlight
7.9	Signal reflections in the cable shall be at least 40 dB below the direct signal at the receiver.

7.10	Avoid sharp bends in the cable, areas of known vibrations, etc.
7.11	Ensure that all cable connections to the receiver are fast (use high-quality cabling)
7.12	Equipment carrying time/frequency signal (cable, amplifiers, multipliers, etc) to the receiver shall have low sensitivity to environmental variations *According to the manufacturer's specifications*
7.13	The location of the Timing receiver and the external frequency reference shall have a temperature stabilization of +/- 1˚ Celsius.
7.14	The station shall have a receiver designed for time transfer (in which case the RINEX observation data are reported to the receiver measurement point), not to another PPS signal through a time interval counter, which adds noise (as for example with the GTR50 and TTS3)