SYSTEM REQUIREMENTS FOR MANAGEMENT OF THE DORIS STATION NETWORK

(Issue 2.1)

CONTENTS

ABBREVIATIONS

Sigle	Definition
AD	Applicable Document
B.C.T.	Balise de correction de temps (Time-Correction Beacon)
B.M.T.	Balise-Maîtresse de TOULOUSE (TOULOUSE Master Beacon)
B.M.K.	Balise-Maîtresse de KOUROU (KOUROU Master Beacon)
B.M.H.	Balise-Maîtresse de HARTEBEESTHOEK (HARTEBEESTHOEK Master Beacon)
B.M.P.	Balise-Maîtresse de PAPEETE (PAPEETE Master Beacon)
B.T.	Balise de Temps (Time Beacon)
B.TAI	Balise de transmission de la date TAI non ambiguë (Non-ambiguous TAI date Transmission Beacon)
B. TCH	Balise de téléchargement (Upload Beacon)
B.O.	Balise d'Orbitographie (Orbitography Beacon)
B.L.	Balise de Localisation (Positioning Beacon)
CNES	Centre National d'Etudes Spatiales (French Space Agency)
DORIS	Détermination d'Orbite par Doppler et Radiopositionnement Intégrés par Satellite (Doppler Orbitography and Radio Positioning Integrated by Satellite)
DORIS 2GM	Génération de récepteurs DORIS embarqués sur Jason-1 et SPOT5 (Generation of on-board DORIS receivers on Jason-1 and SPOT5)
DORIS 2GXX	Génération de récepteurs DORIS embarqués sur Jason-2 et Pléiades (Generation of on-board DORIS receivers on Jason-2 and Pleiades)
GECO	Groupe d'Exploitation et de Coordination des Opérations (Operation Use and Coordination Group)
MVR	Mesure de Vitesse Radiale" (DORIS Receiver Unit)
N/A	Not Applicable
OUS	Oscillateur Ultra-Stable (Ultra-Stable Oscillator)
RD	Reference Document
SIRS	Service d'Installation et de Rénovation des Stations (Station Installation and Refurbishment Department)
SMOS	Service de Maintenance et d'Opération des Stations (Station Maintenance and Operation Department)
SSALTO	Segment Sol multi missions ALTimétrie, Orbitographie et localisation précise (Multi-Mission Altimetry, Orbitography and Precise Positioning Ground Segment)
TAI	Temps Atomique International (International Atomic Time)
TAC	Temps Atomique CNES (CNES Atomic Time)
TBC	To be confirmed
TBD	To be defined
TCH	Téléchargement (Upload)

1. SUBJECT

The purpose of this document is to describe the DORIS system requirements applicable to the management of the DORIS station network.

2. SCOPE

This document applies to the DORIS station network for all DORIS instruments currently being developed or in use.

3. PRESENTATION OF THE DOCUMENT

This document starts by providing a few definitions regarding the way DORIS uses the network stations, making it possible to determine various functions (Orbitography Beacons, Time Beacons, etc.) and certain denominations (Master Beacons, etc.).

Chapter 5 details first the **functional** requirements specific to each function, and then the overall functional requirements.

Chapter 6 groups together the DORIS system **operational** requirements.

Chapter 7 groups together the requirements concerning the installation of a DORIS site.

Finally, section 8 specifies the requirement applicability.

4. DEFINITIONS

In the first section, the terminology used is specified. In the second section, a few definitions are given with regard to the way DORIS uses the network stations. We then go over the various beacon generations, and give details on a few common denominations (in particular on the notion of Master Beacon). Several of these functions/denominations are used for certain DORIS stations. For instance, the Toulouse station is simultaneously a Master Beacon, a Time Beacon and an Orbitography Beacon.

In the last section, we present the beacon configurations.

4.1 TERMINOLOGY

As a general rule, the following terms shall be used :

DORIS station : all equipment items (transmission and management units, main and backed-up power supply system, antenna, cables, weather station, accessories) installed on a given site as part of the DORIS system support,

DORIS Beacon : the transmission and management unit which generates the DORIS signal to be sent via the cables and the antenna,

DORIS Antenna : the antenna whose coordinates are being determined (Reference Point).

It should be noted that denominations such as “Master Beacon, Time Beacon, Positioning Beacon, Orbitography Beacon, etc.” are inappropriate, as they are often used to refer to the station. These terms are nonetheless common usage, and are used in this version of the document.

All the Orbitography stations together (B.O., see section 4.2.6) constitute the **DORIS Orbitography Network** (usually called the “permanent network”).

4.2 DIFFERENT STATION FUNCTIONS

4.2.1 “TIME CORRECTION BEACON” FUNCTION

These stations will hereinafter be referred to as B.C.T. (an even more precise denomination would be “On-Board Sequencing Correction Stations”).

The measurements acquired – when these stations are visible from the satellite - are used by the DORIS Flight Software Packages (in routine mode, i.e. throughout their life in orbit) to determine whether the internal sequencing of the DORIS instrument needs to be shifted in order to ensure proper synchronization when the Time Correction mode (CTA or CTE) is authorized.

The numbering of these stations is imposed, but not their location (the on-board sequencing setting does not use coordinates).

4.2.2 “UPLOAD BEACON” FUNCTION

These stations (BTCH) are used to transmit uploads to DORIS receiver-carrying satellites. These “extended” messages need to be sent earlier within the 10 second sequence. For this reason, the Synchronization Word transmission delay is different from that of the other stations.

These transmission nowadays concern “broadcast” uploads.

The numbering of these stations is also imposed, but not their location (the on-board sequencing setting does not use coordinates).

4.2.3 "TIME BEACON" FUNCTION

The term Time Beacons (B.T.) refers to stations whose time scale is driven by an atomic clock and known to a high degree of precision. In routine mode, i.e. throughout the lifetime of the receiver in orbit, the synchronization measurements performed on these stations are used to determine the on-board time scale (for on-board and for ground dating processing). The precision target is commensurable with the precision aimed at for position determination (target order of magnitude 500 nanoseconds = 3.5 millimetres on the position of the satellite along its path for the bias, 50 nanoseconds per day for the drift).

On-board knowledge of time beacons and of their characteristics is through regular ("Time Broadcast") broadcast of uploads giving the offset and drift parameters of the beacon time scale in relation to the TAI.

A Time Beacon cannot be servo-controlled by the TAI (which has no physical existence) : its time scale must be linked to the TAI. Two techniques can be used to link a B.T. time scale to the TAI :

a) either observe the behaviour of the clock through the processing of DORIS measurements at SSALTO (so called "Broadcasts" DORIS internal method);

b) or connect these Time Beacons to the TAI through external means (linking by the CNES Time-Frequency Department or by time receiver).

There must be at least one Time Beacon linked using technique b). This function is fulfilled today by the TOULOUSE station.

COMMENT : Specific features of the DORIS receiver self-initialization algorithm

The self-initialization of DORIS receivers (of the 2GM generation) uses Time Beacons to set the on-board sequencing. For this function, the need for time linking is less strict than in routine mode, and may be limited to 50 milliseconds.

The self-initialization of DORIS receivers (of the 2GXX generation and later) uses Time Correction Beacons to set the on-board sequencing.

4.2.4 "NON-AMBIGUOUS TAI DATE TRANSMISSION BEACON" FUNCTION

These stations (referred to as BTAI) transmit the TAI date rounded to 10 seconds as part of their message.

This function is provided by all beacons from the 3rd generation onwards.

4.2.5 "POSITIONING BEACON" FUNCTION

The Positioning Beacons (B.L.) are stations whose measurements are not used to determine the position of the satellites, but on the contrary to accurately determine the absolute position OF THE STATION. These stations are therefore used to observe local geophysical movements (fault widening, glacier movements, landslides, etc.).

On DORIS instruments equipped with the DIODE Navigator, the measurements performed on these stations are not used by DIODE to determine the position and speed of the carrier satellite in real time. Their Navigation indicators are set to "FALSE" both on board and on the ground.

The coordinates of these stations are not transmitted by Broadcast TCH but by specific TCH on the instruments whose mission is positioning. For these instruments, on board and on the ground, their Programming indicators are set to “TRUE”.

4.2.6 “Orbitography Beacon” Function

The Orbitography stations (B.O.) have antennae whose position is precisely linked to the International Terrestrial Reference Frame (ITRF). The DORIS measurements made when these stations are visible can therefore be used to work out an absolute and precise positioning of the carrier satellite, with a target order of magnitude of one centimetre.

On DORIS instruments equipped with the DIODE Navigator in particular, the measurements performed on these stations are used by DIODE to determine the position and speed of the carrier satellite in real time (Navigation Beacons).

These stations must be geographically stable in the long term. Their Flight Software identifies them using the Navigation indicator set to “TRUE”. Their coordinates are sent by Coordinate Broadcast TCH.

All the B.O.’s together constitute the DORIS Orbitography Network (commonly called the “permanent network”).

Depending on the circumstances, and according to level of trust we can place in the precision of its coordinates, a station may switch from the “Orbitography Beacon” status to the “Positioning Beacon” status and vice versa (this decision being the responsibility of GECO).

4.3 Different beacon generations

Several types of equipment are installed on DORIS stations. The messages sent differ according to the generation.

These different beacon generations are compatible with all on-board instruments (which have themselves changed over different generations). However, certain features of third-generation beacons are not or cannot be used by instruments from previous generations.

A few elements concerning the strategy for beacon deployment according to type can be found in two documents : SALP RD3 and RD4 “Beacon Fleet Management”.

4.3.1 1st generation beacons (1.0 or 1.1)

Deployment of these beacons started in 1986 (TRISTAN, 10/06/1986).

4.3.2 2nd generation beacons (2.0)

These beacons differ from the other generations due to their more compact, sealed packaging, their reduced consumption and a lower transmitted power.

4.3.3 3rd generation beacons

These transmit messages both on the 2 GHz channel and the 400 MHz channel.

They also feature a RESTART mode, where their modulation is offset so as to ensure reception by flight instruments without requiring any particular synchronization, thereby making commissioning easier.

They transmit a few additional parameters as part of their message :

- reinitialization with loss of synchronization or following an operator request (RS bit for the RESTART mode)),
- time elapsed since the OUS was last put on (DOUS),

- non-ambiguous TAI date rounded to 10 seconds (IN parameter).

4.4 DIFFERENT BEACON DENOMINATIONS

4.4.1 "MASTER BEACON" DENOMINATION

Historically, for DORIS, a Master Beacon was a station which combined the BCT and BTCH functions.

Today, the Master Beacon denomination is kept for stations providing all the following functions (BCT, BTCH, BT, BTAI), which, in particular, entails that they be third generation.

Conversely, a Non-Master Beacon is a station which does not feature one of the four functions above.

4.4.2 "TIME BEACONS" REFERENCED BY ATOMIC CLOCKS AND CONTROLLED

In routine mode, the part of Time Beacons is played by Beacons referenced by a clock with high, long-term stability. These clocks are controlled with respect to an international time scale, the International Atomic Time (TAI) with a tolerance of 50 microseconds. Measurements performed when these stations are visible from the satellite therefore benefit from long-term controlled dating, which allows their use as stable time references.

4.4.3 "TIME BEACONS" REFERENCED BY ATOMIC CLOCKS BUT NOT CONTROLLED

The distinctive characteristic of these beacons is that their clock is not bound to follow the TAI to closer than 50 microseconds (since they are not BCT); there is therefore no need for resetting. It is sufficient that their setting be known with appropriate precision (500 nanoseconds).

4.5 DIFFERENT BEACON CONFIGURATIONS

4.5.1 MASTER BEACON CONFIGURATIONS

A third-generation Master Beacon has been installed in Toulouse (B.M.T.) since 2001. Its configuration is described in document RD.7. This beacon is referenced and controlled by the CNES Atomic Time (TAC), computed by the CNES Time-Frequency Laboratory by means of ultra-stable atomic clocks. The TAC is itself very precisely controlled with respect to the International Atomic Time (TAI), to which it contributes.

The installation of a third-generation Master Beacon in Kourou (referred to as B.M.K.) in French Guiana was completed in November 2004. Its configuration is described in document RD.1. This beacon is also referenced and controlled by an atomic clock, itself monitored with respect to the TAI via a time receiver.

The installation of a third-generation Master Beacon in Hartebeesthoek (referred to as B.M.H.) in South Africa was completed in September 2005. Its configuration is described in document RD.10. This beacon is also referenced and controlled by an atomic clock, itself monitored with respect to the TAI via a time receiver.

The installation of a third-generation Master Beacon in Papeete (referred to as B.M.P.) in Tahiti was completed in November 2009. Its configuration is described in document RD.13. This beacon is also referenced and controlled by an atomic clock, itself monitored with respect to the TAI via a time receiver.

The nominal configuration of a Master Beacon must be as follows :

- A Beacon configured without OUS, with one of the numbers reserved for Master Beacons. It is also necessary that the synchronization bit transmission times be the same as those of a Master Beacon.
- An external reference (e.g. atomic clock) delivering 5 MHz and 1 Hz signals.

- If needed, a GPS time receiver and remote management equipment if connection of this Time Beacon to the TAI by external means is required (see §.4.2.3).
- A Beacon Management Equipment (PUMBA = transfer terminal).

4.5.2 Nominal Configuration of a Non-Master Time Beacon

The nominal configuration of a Non-Master Time Beacon must be as follows :

- A Beacon with configuration without OUS, with a number not from the numbers reserved for Master Beacons. It is also necessary that the synchronization bit transmission times be the same as those of a Non-Master Beacon.
- An external reference (e.g. Hydrogen Maser) delivering 5 MHz and 1 Hz signals.
- A cable for connection of the reference to the Beacon.
- If needed, a GPS time receiver and remote management equipment if connection of this Time Beacon to the TAI by external means is required (see §.4.2.3).

4.6 Colocation

Very important for geodetic applications is the definition of a colocation :

Colocating different techniques (DORIS, GNSS, VLBI, SLR, tide gauges …) consists in installation of these different techniques ***on a same geodetic site and on a same tectonic micro-plate*** (NB : different techniques instruments must have the same root for their DOMES number).

Such an installation allows then close comparison of the data delivered by each technique, in order to :

- compare positions and velocities for geodetic data,
- and to make correlations between tropospheric corrections or meteorologic information.

In this document, colocation is mentioned strictly with this definition.

Colocating techniques is a need expressed by geodetic community, especially for an ITRF realisation. It is one of the Global Geodetic Observing System recommandations in GGOS 2020. Precise geometrical linking is required at the millimeter level.

Geometrical linking is better when distance is reduced. By experience, maximal distance is around 1 km. Beyond this value, precise geometrical linking is difficult, and nearness becomes less interesting.

IMPORTANT colocation must not create jamming or Radio-Frequency interferences. A perfect knowing of interferences between techniques is compulsory, and minimum distances must be respected when they are necessary.

See recommendation F_181, F_182, and F_183 parag. 5.5.6.

5. FUNCTIONAL REQUIREMENTS

A UNIQUE mnemonic (4 characters) is associated with a SINGLE antenna position (and antenna type). The DORIS system associates this mnemonic with a REUSABLE whole on-board number between 1 and 511 and a non-reusable ground number (equal to the on-board modulo number 1000). The mnemonic-on-board number association is through Broadcasts TCH, and in on-board Quasi-Static Areas.

Any move of antenna on one site entails a change of mnemonic.

Every change of mnemonic entails a change of ground number.

5.1 "TIME CORRECTION BEACON" FUNCTION

5.1.1 ON-BOARD NUMBERS

These stations have predefined on-board numbers, known by the flight software and distributed into 4 families :

(1, 2, 3, and 4)	(129, 130, 131, and 132)	(257, 258, 259, and 260)	(385, 386, 387, and 388)

EX. F_10	**The on-board numbers and hexadecimal codes in the table above are reserved for the DORIS points of Time Correction Beacons, exclusively.**

The location of these stations is free (the coordinates are not used for on-board sequencing maintenance).

5.1.2 SETTING WITH RESPECT TO TAI

To maintain the on-board sequencing of DORIS receivers, it is essential that these beacons be set with respect to the TAI to less than 50 microseconds (see RD6).

EX. F_20	**The Time Correction Beacons must be set with respect to the TAI to less than 5 milliseconds.**

This value was only important for DORIS/SPOT4, where the Master Beacons are considered as perfectly set on the TAI (the instrument is not informed of the time setting for these beacons).

This requirement is modified after completion of the DORIS/SPOT4 mission. The new figure is driven by the instrument synchronisation need (10ms resolution).

5.2 "UPLOAD BEACON" FUNCTION

5.2.1 ON-BOARD NUMBERS

These stations have predefined on-board numbers, known by the flight software and distributed into 4 families :

(1, 2)	(129, 130)	(257, 258)	(385, 386)

EX. F_30	**The on-board numbers and hexadecimal codes in the table above are reserved for Upload Beacons, exclusively.**

5.2.2 BTCH INTERVISIBILITY

In order to maximize the chances of receiving these beacons and to avoid an awkward allocation of priorities, it is essential that the following constraint be imposed :

EX. F_40	**The Upload Beacons must have no co-visibility among each other for any of the DORIS receiver-carrying satellites in low orbit (except for MEO or GEO).**

In particular, it is absolutely necessary, during the installation of a new BTCH, to make sure that that there is no chance of it interfering with the transmissions of the BTCH already in operation.

This point shall require special attention if a satellite in high orbit (MEO, GEO) is one day equipped with a DORIS receiver.

5.3 "TIME BEACON" FUNCTION

5.3.1 ON-BOARD NUMBERS

Time Beacons may have either Master Beacon on-board numbers or the on-board numbers of random stations (case of Non-Master Time Beacons).

In the first case, it must be kept in mind that the definition of System Quasi-Static Areas integrated into Flight Software reserves the following on-board numbers :

	Number with TCH transmission	Number without TCH transmission
PAPEETE	001	003
KOUROU	130	132
TOULOUSE	258	260
HARTEBEESTHOEK	385	387

EX. F_50	**The on-board numbers in the table above are reserved for the DORIS points of Time Beacons in Toulouse, Kourou, HBK and Papeete, exclusively.**

In the case of Non-Master Time Beacons, do not use the on-board numbers reserved for BM's or an on-board number already used by another station.

5.3.2 TIME LINKING PRECISION

The Time Broadcasts TCH must provide sufficiently precise information to the Flight Software (and through them, to ground processing operations) so that the current accuracy of the on-board time-ground time correspondence is maintained (around 1 microsecond RMS on Jason-1, continuously checked against an external reference).

EX. F_60	**Accuracy of Time Beacon linking to TAI always better than 500 nanoseconds.**

This requirement entails both a high precision of the linking of the station to the TAI, and a high precision of the drift of its linking in time, since the drift uncertainty, when integrated over several weeks, quickly leads to a substantial uncertainty regarding the current linking of the station clock.

If this requirement cannot be met, the station loses its status as Time Beacon (and it might be decided to temporarily discontinue the Time Broadcast TCH transmission relating to the station concerned – ***warning : in some versions of the Flight Software, some elements of this feature do not comply, see requirement O_70).***

5.3.3 INITIAL TIME BEACONS

This term refers to Beacons which are declared as Time Beacons in the default Quasi-Static Area delivered with the Flight Software. These Beacons have nil time data, referenced to the 1st January 1950 (or 2000) at 10 seconds.

It is absolutely essential that these Beacons all be Upload Beacons; otherwise, in case of initialization or reinitialization of a DORIS receiver, the on-board TAI date would be set to the current date, with no certainty that a Time Broadcast TCH is received on board. Initialization would then probably be delayed (by the time it takes to acquire a Time Broadcast TCH, while the receiver only processes a few sequences on all beacons).

It is also absolutely essential that these Beacons all be Time Correction Beacons (so that their setting data with respect to the TAI can be set to 0).

EX. F_200	**The list of Initial Time Beacons must be exactly identical to the list of Master Beacons, exclusively. No Time Beacon which is not also both BCT and BTCH must appear in the Quasi-Static Areas by default.**

5.4 "ORBITOGRAPHY BEACON" FUNCTION

5.4.1 GEOGRAPHIC LINKING PRECISION

The coordinates entered in the Coordinate Broadcasts TCH must be sufficiently precise so as not to affect the precision of the on-board orbit calculation :

EX. F_90	**Precision of Orbitography Beacon coordinate determination always better than 3 centimetres.**

This requirement imposes both a high precision of station coordinates and a high precision of its speeds. The reason is that over several years, uncertainty on speeds quickly leads to a substantial uncertainty on the current position of the station.

If this requirement is not or no longer met, the station loses its status as Orbitography Beacon, and the GECO can decide to replace the transmission of Coordinate Broadcast TCH on the station concerned with the transmission of specific TCH (Navigation indicator = FALSE).

5.4.2 GEOGRAPHIC DURABILITY

In order to minimize the operations concerning several satellites, and to ensure that time series are as long as possible, it is necessary to guarantee maximum durability and stability of DORIS stations (see ANNEX 1).

In particular, in case of change or move of antenna on one site (move < 1 km), or of modification to the antenna support, it is essential that the new point should be very precisely linked to the old point.

EX. F_100	**In case of change or move of the antenna on one site (move < 1 km) or of modification to the antenna support, a highly precise linking has to be made between the old point and the new point : linking precision better than 3 millimetres.**

In case of move from one site to another site in the same region (move from 1 km to 500 km), linking (even if less precise) is also advisable.

5.4.3 ANTENNA SUPPORT

Except in the case of change of antenna or of monumentation, the antenna support must provide excellent point stability in the long term.

EX. F_190	**The antenna support must provide stability better than 3 millimetres over a ten-year period (TBC).**

This requirement complements the I_300 and I_310 installation requirements, and delimits their scope.

5.4.4 ANTENNA REPLACEMENT

During an antenna replacement, the 2 GHz Phase Centre might move by a few millimetres (antenna specifications, centering…).

EX. I_350	**No antenna replacement without geodesic linking between the old point and the new point.**

To improve network availability, it will be acceptable that the linking be performed after the antenna replacement, as this change can be carried out quickly by the host organization, whereas the linking mission can take place later. In such cases, the data users must imperatively be notified (DORIS Mail) in order to avoid false detections.

5.4.5 ANTENNE VERTICALITY

EX. F_178	**The verticality of the antenna (its parallelness w.r.t. local vertical) must be better than 0.5 for 1000 (0.5mm for 1 m).**

Measurement processing software implicitly locate the two centers of phase along the same local vertical.

5.5 GENERAL FUNCTIONAL REQUIREMENTS

5.5.1 MINIMUM OPERATING CONFIGURATION OF THE DORIS NETWORK

In routine mode (outside periods of initialization or reinitialization of a 2GM or 2GXX receiver), it is absolutely necessary that the DORIS network should include :

- An operational Time Beacon. A downtime period of 12 hours is acceptable, since during this length of time, the On-board time-Ground time correspondences should not deviate by more than a few microseconds.
- An operational Time Correction Beacon. In this case, a downtime of 24 hours is acceptable. Beyond this period, the TOUS dates may have deviated from the TAI by more than 10 milliseconds (17.3 milliseconds for an on-board frequency bias of 2.0^{e}-7), which could eventually lead to a deterioration of on-board reception of messages from certain stations.
- An operational Upload Beacon, so that on-board receivers are informed of changes to the DORIS network (deprogramming of stations no longer transmitting, or programming of stations starting to transmit again). A downtime of 72 hours is acceptable.

During the initialization or reinitialization period of a 2GM or 2GXX receiver, it is absolutely necessary to have (in addition to the minimum configuration) :

- A TAI date Transmission Beacon,
- at least one extra operational Time Beacon.

Since a reinitialization may occur unexpectedly, it is necessary for DORIS to have the following configuration at all times :

- one Time Beacons, (two for DGM receivers)
- one Time Correction Beacon,(two for DGXX and following receivers)
- one Upload Beacon
- at least one TAI date Transmission Beacon.

Finally, the **commitments made regarding the initialization times** for future DORIS instruments (CryoSat-2, Pléiades, etc.) are based on a network comprising THREE Time Beacons, for an instrument self-initialization time shorter than or equal to half a day.

Hence the following final requirements :

EX. F_110	**Always at least two operational Time Beacons.**
EX. F_120	**Always at least two operational Time Correction Beacons.**
EX. F_130	**Always at least one operational Upload Beacon.**

5.5.2 BEACON TIME AND FREQUENCY SETTING

The time and frequency setting of DORIS Beacons is monitored by the SSALTO operator and by the Beacon Installation and Maintenance Department, using the functions provided by SSALTO resources.

It is essential that the timing of the Beacons be properly set with respect to the TAI, so that their message is received by DORIS receivers in orbit.

EX. F_140	**The time lag of a beacon must not exceed 1 second in absolute value. Requirement F_20 is much stricter for BCT's.**

Departure from this requirement may be allowed (depending on the frequency and time shift values and signs).

5.5.3 BEACON REPLACEMENT

In case of failure of Beacon equipment (with no move of the antenna or change of the antenna type), the replacement equipment must be configured so as to have exactly the same number and the same hexadecimal code as the faulty equipment.

EX. F_160	**In case of failure of Beacon equipment, the replacement equipment must be configured so as to have exactly the same number and the same hexadecimal code as the faulty equipment.**

5.5.4 FREE MASTER-BEACON ON-BOARD NUMBERS

Now that SPOT4 and ENVISAT (and older Flight Software) are not in activity anymore, it is possible to use the following numbers for a new Master Beacon. The F_170 requirement is suppressed.

	On-board number (with TCH transmission)	On-board number (without TCH transmission)
	002	004
	129	131
	257	259
	386	388

5.5.5 RADIOFREQUENCY INTERFERENCES

The following information is very important especially in case of radiosounding, VLBI, Television Relay, …

EX. F_181	**The characteristics of each radiofrequency system on the station site shall be listed : frequencies used, emitting/receiving, permanently/episodically, power, …**

These information are to be refreshed as often as possible, at least at each operation on a site : situation changes fast.

EX. F_182	**Before installation, radiofrequency interferences with other systems SHALL BE MANAGED**

Since several DORIS beacon have been concerned (e.g. Monument Peak), no waiver will be accepted on this point.

Currently, installation constraints with geodetic techniques are :

DORIS – VLBI distance > 500m + mask between both antenna (TBC)

DORIS – GNSS no RF interference

DORIS – SLR no RF interference

DORIS – tide gauges : no RF interference

Other systems :

DORIS – ARGOS : no RF interference

DORIS – SVOM : no RF interference

DORIS – VSAT : no RF interference if recommendation followed

DORIS – WIMAX frequency (VINE system) : no RF interference

TV relay : interference has to be managed

Radiosoundings : interference has to be managed

A specific document is currently being written describing Radiofrequency Interferences between DORIS and other RF systems.

5.5.6 COLOCATIONS

Definition of a colocation is given in parag. 4.6

EX. F_183	**Colocation with other geodetic techniques (VLBI, SLR, tide gauges) will be furthered, as close as possible.**

(but EX. F_182 has to be respected).

5.5.7 ON-BOARD NUMBERS RESERVED FOR TESTS

On board numbers 99, 227,355 and 483 are reserved for tests and must not be allocated to a beacon in the **DORIS Orbitography Network** (“permanent network”) or to a positioning Beacon.

EX. F_185	On-board numbers 99, 227, 355 and 483 are reserved for tests and must not be allocated to any beacon**.**

6. OPERATIONAL REQUIREMENTS

6.1 TIME RESET OF A TIME BEACON

After turn ON of a Time Beacon referenced by an atomic clock (with servo-control + Caesium + time receiver, or simply a Maser) or in case of time reset of the Beacon or of its frequency pilot (i.e. when a 1 Hz resynchronization has been performed recently), the DELTA_T time lag can only be a multiple of 1 second, according to the 1 Hz top on which it was synchronized.

EX. O_10	**When the time has recently been reset on a Time Beacon or on its frequency driver, the DELTA T to be applied for time setting must be a multiple of 1 second.**

The reason is the following : as the beacon is referenced on the external 1 Hz signal, only the number of seconds must be modified, and no additional delay (fraction of seconds) shall be added. Even if the atomic clock is not synchronous with TAI, the DORIS beacon schedule must be the same as its reference.

If calculations of the time lag give a value slightly different from a multiple of 1 second, the difference (which in this case results from approximations in the calculation algorithm) will not be taken into account, and the Beacon shall be corrected with the closest integer value.

6.2 AFTER TURNING ON A NON-MASTER TIME BEACON (OR AFTER TIME RESET OF ITS CLOCK)

For a Non-Master Time Beacon, a distinction is made between a configuration “in observation” and a configuration “in operation” :

Configuration “in observation” :

- RS=0 (Pandor constraint),
- SY=0, and no Time Broadcast is transmitted concerning this beacon (constraint imposed by flight software)

In particular, if the beacon was already in operation and an incident occurred, it is necessary to make sure that its dating is no longer processed on board (no currently valid broadcast).

- (H=1 obviously for a clock with an external Frequency Reference)

Configuration “in operation” :

- RS=0,
- SY=1, and Time Broadcasts concerning this beacon are transmitted every week
- (H=1 obviously)

In all cases, whether the beacon is in operation or in observation, it is imperative that a system for determination of its time setting be implemented : either regular verification of the BTEMPS parameter of a Time receiver installed in the station, or regular activation of the Pandor software and of the “broadcasts” method…

EX. O_11	For a Non-Master Time Beacon, whether in operation or in observation, it is imperative that a system for determination of its time setting be used.

In addition, the following precaution should be taken for commissioning or recommissioning of a Non-Master Time Beacon after an incident of whatever nature (switch to RS=1, power supply loss…), even for a beacon which had been in operation for a long time.

EX. O_12	The introduction of a Non-Master Time Beacon into the system, or its recommissioning after an incident of whatever nature, will systematically involve a configuration “in observation” phase.

This is in order to guard against a possible change in time setting, and to check the predictability of future Broadcasts.

6.3 MANAGEMENT OF COORDINATE BROADCAST TCH FOR DISUSED SITES

When a DORIS point is abandoned (the station no longer transmits), it is necessary to continue transmitting a Broadcast TCH where its coordinates are reset to zero (so that it is removed from on-board networks).

EX. O_20	**If a DORIS point is abandoned, it is necessary to continue transmitting a Broadcast TCH where its coordinates are reset to zero (for as long as the disused station is still part of a Quasi-Static Area on board a receiver in flight or about to be launched).**

This transmission is maintained for as long as the disused station is still part of a Quasi-Static Area on board a receiver in flight or about to be launched.

This requirement is applicable to all types of stations registered in on-board Quasi-Static Areas and/or whose coordinates are transmitted by Broadcast TCH (Orbitography Beacons). By definition, the Positioning Beacons coordinates are not transmitted by Broadcast TCH but by a specific TCH.

The compatibility and content of all quasi-static areas (in flight or about to be launched) are managed by the DORIS System Consistency engineer.

6.4 MANAGEMENT OF COORDINATE BROADCAST TCH FOR A FORMER ORBITOGRAPHY BEACON

In cases where a B.O. which was present in a Quasi-Static Area by default should lose its status and become a Positioning Beacon again, it is also necessary to continue transmitting a cancellation Broadcast TCH (so that it is removed from on-board networks).

EX. O_50	**In case of loss of status of an Orbitography Beacon, it is necessary to continue transmitting a Broadcast TCH where its coordinates are reset to zero (for as long as the disused station is still part of a Quasi-Static Area on board a receiver in flight or about to be launched).**

In this case, the Beacon must change on-board number, as it cannot be reloaded on board missions with a positioning function by using a specific TCH, which would be permanently erased by the cancellation Broadcast.

This transmission is maintained for as long as the “downgraded” station is still part of a Quasi-Static Area on board a receiver in flight or about to be launched.

6.5 MANAGEMENT OF BROADCAST TCH AND DEFAULT QUASI-STATIC AREAS

To limit the occurrence of the point above, it is best that the Orbitography Beacons or the Positioning Beacons should not appear in the default Quasi-Static Areas. Only those Beacons likely to be useful during the receiver initialization phase will be kept, i.e. the Initial Time Beacons (see requirement F_20).

EX. O_60	**The default Quasi-Static Areas will be limited to Initial Time Beacons defined in requirement F_20.**

The flight software packages on board Jason-1, Spot5, H2A and H2B will not be compliant with this requirement before (future) version v2_09.

Earlier software packages (SPOT2, SPOT4, ENVISAT) do not process Broadcasts TCH.

6.6 MANAGEMENT OF BROADCAST TCH AND LOSS OF STATUS OF A TIME BEACON

In case of loss of status of a Time Beacon (see requirement F_60), it is necessary to ensure that this Beacon is no longer involved in processing the dating of the various flight software packages. The broadcasting of Time Broadcast relating to it must therefore be stopped.

Moreover, the current 2GM flight software packages (prior to 2GM version v2_09) present identified non-conformances with regard to this feature. If the Beacon concerned is a Master Beacon part of the default Quasi-Static area, so long as one of these Flight Software packages is in operation, it will be necessary to fully remove the beacon from the on-board networks through a coordinate cancellation Broadcast TCH.

EX. O_70	**The loss of Time Beacon status for the Master Beacon in TOULOUSE or KOUROU or HBK or PAPEETE must give rise to a coordinate cancellation Broadcast TCH on this beacon.**

This requirement is temporary, and shall be maintained so long as a version v2_08 or earlier LV is in operation. The flight software packages of subsequent generations do not present these non-conformances.

Such a loss of status should therefore be avoided as far as possible. Consequently, if there is no known way of restoring the normal situation in less than 24 hours, the beacon should imperatively be put on stand-by.

6.7 VOLUME OF COORDINATE BROADCAST TCH

In order to guarantee access to all information in minimal time for the various Flight Software packages, the number of transmitted Coordinates Broadcast TCH must imperatively be kept low, and more specifically, the coordinate cancellation Broadcast TCH must be reduced down to a strict minimum.

EX. O_80	**Reduce the transmission of coordinate cancellation Broadcast TCH down to a minimum.**

The transmission of a total of 50 Broadcast TCH requires 25 sequences, a minimum of 250 seconds to be received in total.

7. REQUIREMENTS CONCERNING THE INSTALLATION OF A DORIS SITE

Some of the requirements below are quite stringent with respect to the logistic constraints usually encountered in the field (example I_150, I_160), and are stricter than the recommendations which applied previously : the current network is therefore covered by a de facto waiver, as of September 2007. All these requirements shall be applied on subsequent renovations or installations.

In cases where certain requirements cannot be met, the waivers will be reviewed on a case-by-case basis.

7.1 FIRST SITE EXAMINATION, REQUIREMENTS IMMEDIATELY VERIFIABLE

7.1.1 DIRECT CONTRIBUTION TO THE GEOGRAPHICAL COVERAGE

The geographical coverage of an orbit is the percentage of visibility from one or more stations along this orbit, over a full cycle.

This criterion consists in assessing the "geometric" contribution by a site in terms of coverage for the various satellite families (overall coverage with this station - overall coverage without this station). This can be estimated by prior simulation while assessing a proposal for a new site. All that is needed is a set of approximate coordinates. See "Assessment criteria for a new DORIS site" and "Contribution to coverage by a site".

EX. I_10	**The contribution to geographic coverage criterion is a selection criterion which must be taken into account as part of the assessment of sites envisaged for installation of a station in the permanent DORIS orbitography network**

7.1.2 CONTRIBUTION TO NETWORK ROBUSTNESS

The robustness of the network is its ability to guarantee the best possible coverage in case of failure on one or more site(s).

This criterion consists in assessing the contribution to robustness, which can be quantified through the contribution to the coverage by assuming that the station closest to the one being assessed is not working. This can be estimated by prior simulation while assessing a proposal for a new site.

EX. I_275	**The contribution to network robustness criterion is a selection criterion which must be taken into account as part of the assessment of sites envisaged for installation of a station in the permanent DORIS orbitography network.**

7.1.3 INTERFERENCES

7.1.3.1 DORIS internal jamming

The jamming of DORIS transmissions by other beacons in the DORIS system is assessed through prior simulations based on a dedicated output of the DORIS Simulation Software, and on the "visiorb" utility.

Requirements shall be expressed based on this assessment method, once it has been stabilized.

EX. I_20	**The new station transmitting on the DORIS central frequency must generate less than 10% TBC of Doppler collisions with stations co-visible on the different DORIS orbit families in common use (at altitudes between 500 and 1350 km, and with inclinations between 60 and 100°).**

7.2 SECOND SITE EXAMINATION, REQUIREMENTS VERIFIABLE ON SITE

7.2.1 ACCESSIBILITY

- communication means : e-mail, fax, telephone
- customs clearance time
- presence on site or need for travel : feedback from the current network shows that on sites where there is no permanent presence, failures take a very long time to repair (occasionally several months).

EX. I_30	**The presence on site (i.e. at less than 30 minutes away from the beacon) of personnel qualified to carry out standard maintenance operations on DORIS stations is indispensable.** **This presence must be effective at least on business days and during business hours.**

In future, the above-mentioned requirement can be relaxed for sites equipped with remote management facilities, where a visit upon request will be sufficient within 48 hours maximum.

The site must also provide for year-round logistics in order to allow for a proper MCO.

EX. I_40	**The dispatch of equipment must be possible at least every two months, with a customs clearance time shorter than two months.**

A waiver can be granted in regions where such conditions do not prevail within less than 1000 km.

7.2.2 STAND-BY PROHIBITION

Whenever a station is put on stand-by, this reduces the number of measurements it performs, thereby causing a decrease in the “productivity” of this site.

On the other hand, the availability and robustness of operational missions only takes accidental failures into account.

On the whole, the feedback on certain stations in the current network subjected to deliberate switch to stand-by (radiosoundings, VLBI) is negative : one-way switch to stand-by, return to transmission overlooked, difficulties in managing the network (deliberate switch to stand-by or failure?) …

EX. I_50	**Sites requiring a deliberate switch to stand-by are prohibited.**

In addition, the use of timers to inhibit transmission from the beacon at set times is also prohibited (possible non-restart after an extended power failure, change of time to be taken into account, long-term disturbances, network configuration control increasingly complex).

EX. I_60	**The use of a timer for automatic switch to stand-by is prohibited.**

In case of co-location with a VLBI or radiosounding station, it will be possible to use a local mask, a sufficient distance and/or demonstrate the fact that no interference is generated by DORIS (neither the VLBI, which are receivers, nor the radiosounding receivers are liable to create interferences with the DORIS signal).

Regarding stations co-located with an Ariane telemetry station, waivers may be granted provided the interruptions take up less than 0.2% of the time, and are incorporated into the approved operational procedures.

7.2.3 TRANSMISSION AUTHORIZATION

A transmission authorization is strictly mandatory for each DORIS site. Depending on the country, it can come in various forms, but must at least include confirmation in writing from the host organization that this authorization has been obtained.

EX. I_70	**A transmission authorization from the cognizant authority in the host country is indispensable prior to installation of the equipment on site.**

If this authorization is submitted to a duration limitation (x years), it must be re-obtained before its end-of-validity date.

7.2.4 AGREEMENT

A written tripartite agreement between host agency, IGN and CNES is necessary for each DORIS site. It must be signed before Doris site installation.

EX. I_75	**A written agreement between host agency, IGN and CNES is necessary for every DORIS site.**

A generic model has been designed and is proposed to each host agency. Its form may be adapted depending on the host agency.

If this agreement is submitted to a duration limitation (x years), it must be rediscussed and resigned before its end-of-validity date.

7.2.5 ELECTRICAL POWER SUPPLY

Dependability of electric current (average/max. duration and frequency of power failures).

EX. I_80	**Maximum duration of power failures ≤ one hour.**
EX. I_90	**Maximum frequency of power failures = one per day.**

And since a one-hour power failure per day would not be acceptable :

EX. I_270	**Monthly total of power failures < 6 hours.**

The project might be more demanding with regard to a Time Beacon.

Electric current characteristics :

EX. I_100	**100 VAC to 264 VAC voltage.**
EX. I_110	**Mains frequency 48 to 66 Hz.**
EX. I_260	**Minimum rating of the circuit-breaker/fuse on the power supply line equal to at least 10 amps**

In case of low voltage (< 100 VAC), waivers can be accepted : between 90 and 100 VAC a 3rd generation beacon will remain usable. If not, an external regulator can be considered.

7.2.6 BEACON ROOM

7.2.6.1 Temperatures

Min./max. operating temperatures, short-term variations in temperature in the beacon room :

	Operating temperature range		Maximum thermal gradient
	Min. T°	Max. T°	
Beacon electronic unit including charger box	0 °C	+ 45 °C	10 °C/hour
Battery	0 °C	+ 40 °C	10 °C/hour
Antenna, weather station and external cables	-30 °C	+ 60 °C	N/A

EX. I_120	**The thermal operating conditions must be in accordance with the table above.**

The maximum thermal gradient of 10°C/hour mostly concerns the beacon room (OUS performance).

7.2.6.2 Beacon environment

The following requirement is an application of the precaution principle. At this stage, there is no justification file for the distances mentioned below.

EX. I_370	**No DORIS beacon must be installed in a location subjected to vibrations (OUS and electronic unit vibrations).**

In particular, installation of the beacon shall be avoided in the vicinity of a compressor, a central air-conditioning unit or any other heavy, vibration-generating equipment: if the minimum distance is below or equal to 50 m, the disruptive object shall be mentioned and described in the installation file.

In such a case, distance is only one among many other factors involved (dimensions of the installation, damping, structure of the building): vibration measurements will have to be made.

Waivers will be reviewed on a case-by-case basis.

7.2.6.3 Cleanliness conditions of the beacon room

The reason for this requirement is the feedback on the SAL beacon.

EX. I_290	**The room where the beacon is to be stored must present cleanliness conditions TBD.**

In particular, no excessive amount of dust, and no animal droppings (in the case of SAL, these were mouse droppings).

7.2.6.4 Environment conditions in the beacon room

The reason for this requirement is the feedback on the ASCENSION beacon for instance (blowing hole).

EX. I_295	**Avoid too much corrosive moods as much as possible.**

In particular, excessive marine humidity may lead to beacon or damage.

Of course, it is not always possible to avoid such conditions (colocations with tide gauges). Waivers may be accepted on a case-by-case basis.

7.2.7 ANTENNA ENVIRONMENT

7.2.7.1 Environment conditions around the antenna

The reason for this requirement is the feedback on the ASCENSION beacon for instance (blowing hole).

EX. I_295 bis	**Avoid too much corrosive moods as much as possible.**

In particular, excessive marine humidity may lead to antenna damage.

Of course, it is not always possible to avoid such conditions (colocations with tide gauges). Waivers may be accepted on a case-by-case basis.

7.2.7.2 Build-up of snow at the foot of the antenna

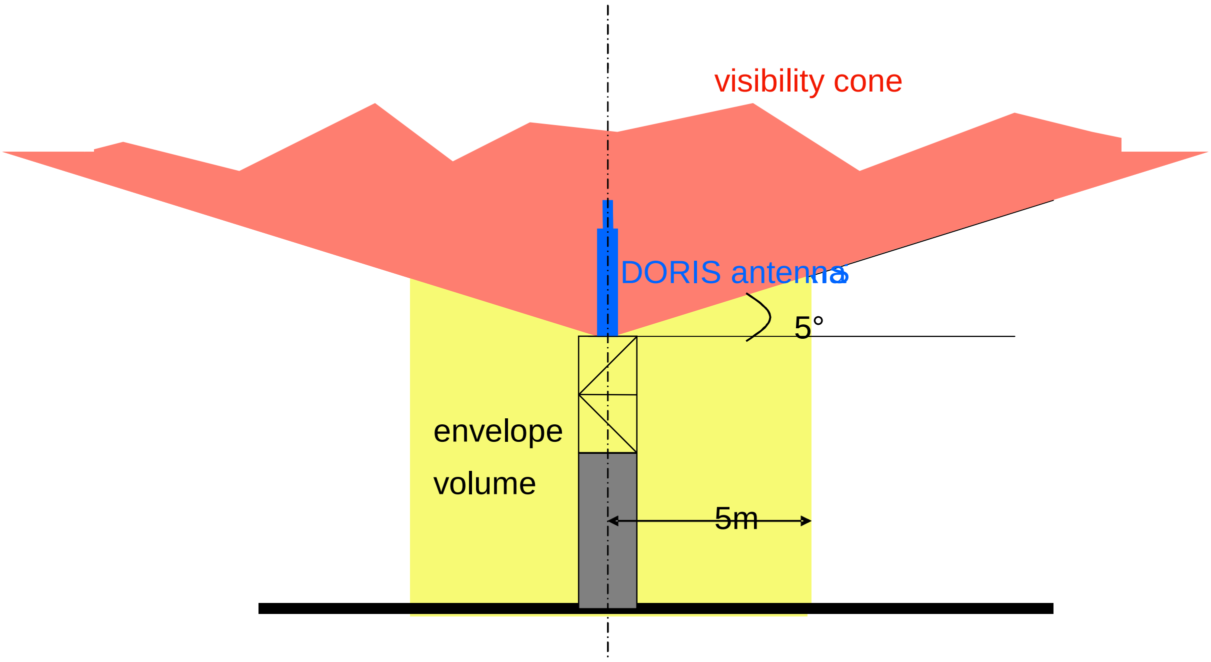
In the case of an antenna support including a concrete pillar, it will be prohibited to fasten the antenna too close to the wider flat base, which is what the pillar is, and on which snow is liable to build up. This build-up would cause a change in impedance on the 400 MHz power supply circuit, preventing proper radiation from the antenna. Moreover, in the long term, this stagnant humidity results in corrosion of the connectors.

EX. I_140	**For a region whose snow cover height reaches H centimetres at least one day a year, in the case of an antenna support including a concrete pillar, a metallic structure H centimetres high minimum is mandatory, to keep the foot of the antenna away from the top of the pillar (on which snow is liable to build up).**

A requirement for waterproofing of the antennas is not possible (see SALP System Point report dated 30/10/2008).

7.2.7.3 Antenna clearance

It will be ascertained on the first visit on a site that the above requirements are met.



7.2.7.4 Visibility cone

7.2.7.4.1 Definition of the visibility cone

The visibility cone of DORIS station antennas contains all the station – DORIS instrument-carrying satellite directions for which significant DORIS measurements must be made with no alteration due to the antenna environment. This revolution cone around the axis of the antenna rests upon the base of the antenna (its tip is therefore located four millimetres below the antenna laying plane).

7.2.7.4.2 Limit of the visibility cone

The visibility cone is defined by an angle 170° at the apex, which corresponds to an elevation of 5°, in order to comply with the DORIS missions in low orbit and bring low site measurements to positioning applications. A justification file for this value will be found in DORIS Performance Group report RD11.

The value which was specified in the beacon installation instructions 2.0 (i.e. 10°) must therefore be considered as obsolete.

7.2.7.4.3 Requirements within the visibility cone

Nothing must stand in the visibility cone, whether it is :

- A large mask : building, rock
- active elements : other transmitting antennas, power lines
- passive elements : wires, poles
- opaque elements : plate, wall
- relatively transparent elements (from an RF point of view) : trees, mesh, passive metallic structures

Unwanted effects to be avoided are :

- Stray radiations from metallic structures “reverberated on” by electromagnetic radiations from the DORIS antenna, affecting DORIS measurements (see RD 9 and Performances Group Study 28/03/2007).
- Masking effects from all the elements above, whether metallic or not, causing DORIS measurements to be lost or degraded.

In particular, avoid installing the beacon at the end of an airport runway, distance to be greater than 5 km TBC.),

The temporary presence of moving objects, such as infrequent flights of aircraft or birds, is tolerated.

EX. I_150	**Nothing must stand within the visibility cone, apart from the antenna itself.**

If this requirement cannot be met, the objects are to be listed in detail : record of masks, dimensions, nature, distance to objects, for analysis and waiver if need be.

7.2.7.5 Envelope volume

7.2.7.5.1 Definition of the envelope volume

This is the cylindrical volume whose axis is the same as that of the antenna.

7.2.7.5.2 Limit of the envelope volume

The radius of the envelope volume is set at 5m, which makes it possible to bring any phase error due to an unwanted isotropic secondary emission (does not cover specular reflection) down to less than 1° (i.e. less than 0.5mm apparent variation in the phase centre).

One particular purpose of this envelope volume is to prevent any multi-paths. This phenomenon has notably been studied in document DR9, as well as in the DORIS Performances Group (see RD11) and in CAVE orbito. The phenomenon has been observed on the DORIS antenna installation in Fairbanks (Alaska), see RD12.

7.2.7.5.3 Requirement in the envelope volume

No metallic object must be located within this volume, except for the DORIS antenna support. This requirement also applies to the surface supporting the antenna mast : the installation of an antenna above a corrugated iron roof or a slab covered by a metal-plated protection is prohibited.

EX. I_160	**No metallic object must be located within the envelope volume (except for the DORIS antenna nominal support).**

The presence of corrugated iron sheets, which are strongly suspected of generating noise on DORIS measurements, in Reykjavik and Papeete in particular, is prohibited (see Performance Group Report dated 26/09/2007).

If this requirement cannot be met, the objects are to be listed in detail : dimensions, nature, position of objects for analysis and waiver if need be.

7.2.7.5.4 Planned installations of other antennas on a DORIS site

It must be ascertained, during the first visit on a site, that no antenna installation project is in progress which might eventually conflict with requirements I_150 and I_160 above.

EX. I_165	**No antenna installation project (known at the date of drafting of the file) conflicting with requirements I_150 and I_160.** **Moreover, to maintain this point over time, the host organization must be made aware of the need to inform both the SIRS and the SMOS in case of planned installation during the site operation period.**

A special clause must be provided for in the memorandum of understanding or the SIO, requesting the host organization to inform both the SIRS and the SMOS of any planned modification to the nearby environment conflicting with requirements I_150 or I_160.

7.3 IN THE ABSENCE OF A MEMORANDUM OF UNDERSTANDING OR SIO WITH THE HOST ORGANIZATION, ORAL OR WRITTEN INFORMATION CAN BE SUFFICIENT. GEODETIC REQUIREMENTS

7.3.1 (LONG-TERM) GEODESIC STABILITY OF THE SITE

This requirement can only be verified immediately on sites where another precise geodesic system is in place.

EX. I_170	**The geodesic stability of the site must be better than 3 millimetres over a ten-year period (apart from plate tectonics).**

In the absence of other geodesic systems, installation on a site suspected to be unstable (even if this cannot be verified) is prohibited.

7.3.2 BUILDING STABILITY

This requirement can only be immediately verified for buildings on which stability measurements have already been made (sites where another precise geodesic system is already in place).

EX. I_173	**In cases where the antenna is to be set up on a building, the stability of this building must be measured and shown to be better than 3 millimetres over a period of more than one year.**

Waivers will be reviewed on a case-by-case basis.

The aim is to take the feedback on installations performed so far into account.

Antenna support refers to the set of components used to fasten the DORIS antenna :

- to the ground (in case of fastening to the ground using a combination of concrete pillar + metallic structure, or with a metallic structure only)

- or to the roof of a building (in case of fastening by means of a metallic pylon on the roof of a building)

A study concerning the height of this support is included in document RD11.

7.3.3 Long-term stability of the support

The purpose of this requirement is to preserve the scientific significance of the station time series.

EX. I_300	**The antenna support must not cause a displacement (from the reference point) of the antenna by more than 3 millimetres on each of the components (vertical, North-South, East-West) in the long-term time domain (periodic with a period longer than one week, or secular drift).**

Particular care must be taken with the examination of thermal expansion/distortion effects during the seasonal period, as well as of elastic distortion due prevailing winds.

7.3.4 Short-term stability of the support

The purpose of this requirement is to limit the WRMS of the station time series.

EX. I_310	**The antenna support must not cause a displacement (from the reference point) of the antenna by more than 3 millimetres on each of the components (vertical, North-South, East-West) in the short-term time domain (period shorter than one week).**

Particular care must be taken with the examination of thermal expansion/distortion effects during the diurnal period, as well as of elastic distortion due to storms.

7.3.5 Point stability

EX. I_176	**The total stability of the point (total contributions from the geodesic stability, possibly from building stability, and from the stability of the antenna support) must be better than 3 millimetres over a period of more than one year.**

For the time being, this requirement cannot be verified without a topometric management system and periodic verification measurements. Temporal series mainly reflect plate tectonics.

Waivers will be reviewed on a case-by-case basis.

7.3.6 Control of the different monumentations of network stations

Although it would be unrealistic to try and eventually unify the monumentations of the DORIS network beacons, it is nonetheless indispensable to control the network configuration, and therefore to limit the number of configurations used.

EX. I_360	**Three standard configurations (compliant with the requirements in this document) shall be defined in a detailed reference document. The configuration selected for each site shall be described. Any departure from this configuration shall be accurately listed.**

Standard configurations are now described in IGN document "DORIS sites Standard Configuration".

Departures shall be recorded in the compliance matrix of the DORIS station.

An example of a Compliance Matrix is given in ANNEX 2.

7.4 EQUIPMENT

7.4.1 ANTENNA TYPE

For renovations or installations of new sites, only the most recent antenna models used for the DORIS network are used, irrespective of the stock status.

EX. I_200	**For renovations or installations of new sites, only the most recent antenna model is used, irrespective of the stock status.**

7.4.2 CONNECTORS RIGHT ANGLE TYPE

Risk of break in impedance, actually experienced on some stations in the current network.

EX. I_210	**The use of connectors right angle type is prohibited at the antenna end and the beacon end.**

As they age, some connectors of this type can adversely affect the proper radiation of the antenna.

7.4.3 CABLES

See also the beacon specification of requirement.

EX. I_220	**The cables bend radius must be greater than 20 cm (margins in relation to 12.5 centimetres in the beacon specification of requirement).**

A departure has deliberately been made with respect to the Beacon Technical Specification to minimize excessively "forceful" preforming (risk of conductor breaking). The reason is that the manufacturer's specification only guarantees continued performance, with no mention of any other effect (aging, humidity…).

EX. I_230	**Cable length = 15 metres for sites fitted out with a 3.0 or 3.1 beacon.**

The purpose of this requirement is to limit on-line losses. A 20m waiver may be accepted provided it is clearly recorded in the station configuration file.

Sites fitted out with a 3.2 or 4.0 beacon may have longer cables (up to 50 meters)

EX. I_320	**The preforming of cables and their fastening on the antenna support must be such that the connectors can be screwed and unscrewed by hand, with no need for a tool.**

The purpose of this requirement is to protect connectors against lateral stresses.

EX. I_330	**The cables must be mechanically fastened to the antenna support, as close as possible to the connectors, without applying any stress.**

The purpose of this requirement is to protect the connectors against the stresses associated with their installation (connectors in the axis = no tangential strain), and with dynamics, and in particular with cable movements caused by the wind (fastening).

7.4.4 MATERIALS USED

Long-term corrosion phenomena have occurred on several network stations.

EX. I_240	**Combinations of incompatible metals are to be avoided in the monumentation.**

(chemical incompatibility observed between plate and antenna support : stainless steel 316L // anodized aluminium incompatibility in hostile environment : humid, mild climate, salt spray)

7.5 RESPONSIVENESS OF THE HOST ORGANIZATION (ACTION REQUESTS AND REPORT)

- Time required to obtain the transmission authorization,
- Customs clearance time,
- average and maximum time for processing an information request
- average and maximum time for processing an action request
- average and maximum time for issue of the action report

EX. I_250	**TBD for the time being**

An Operational Interface Specification with the SALP project will be drafted if possible (TBC.).

8. MANAGEMENT RECOMMENDATIONS

Management of renovations of the different beacons in the network is under SALP project responsibility. It may depend :

- Of other currently undergoing station renovations,
- Of the available mission budget,
- Of the current network status,
- Of the current equipment stock status, etc.

Nevertheless, recommendations may be given here, as a help for DORIS beacon management (see DR14).

In DORIS Performance Groups, every year, Precise Orbit Determination residuals of each beacon are examined. When a degradation of the RMS of one beacon occurs (sudden change in RMS values of a beacon after a certain date wrt RMS before this date), different reactions are possible :

8.1 HUGE RMS SUDDENLY

If RMS values of one beacon suddenly become very high after a certain date :

EX. M_100	If RMS becomes > 1 mm/s (whatever its previous value) => RED : a very fast intervention is required as the degradation is very important.

We have seen in DR14 with Kourou that for such degradations, Precise Orbit Determination doesn't use anymore the measurements.

8.2 SMALL DEGRADATION

When a small degradation of the RMS of one beacon occurs :

EX. M_200	If the degradation (RMS after – RMS before) is < 0.1 mm/s : intervention is not required

It has been shown in DR14 that below 0.1 mm/s, variations could occur without visible consequence. For instance, annual variability of many stations is around that value.

8.3 MEDIUM DEGRADATION

Between both first cases, that is to say if the degradation is higher than 0.1 mm/s but the new RMS remains < 1 mm/s :

EX. M_300	In this case, an intervention is required but according the possibilities left by the current interventions. Priority depends on the value of the RMS degradation : 0.11 mm/s may be slightly delayed if necessary, 0.3 or 0.4 mm/s needs a faster reaction

As an additional point, if the new value of the RMS puts the station in the 25% worst stations in the network :

EX. M_400	If the new value of the RMS puts the station in the 25% worst stations in the network, a higher priority must be given to the reaction.

This kind of additional exigence will benefit the global network improvement, leading to more precise DORIS products in the future.

9. APPLICABILITY OF REQUIREMENTS

The applicability of requirements according to the type of beacons in the DORIS network is given below :

Requirements =>	F_10	F_20	F_30	F_40	F_50	F_60			F_90	F_100	F_110	F_120
B.M.TOULOUSE	X	X	X	X	X	X			X	X		
B.M. KOUROU	X	X	X	X	X	X			X	X		
B.M.H.	X	X	X	X	X	X			X	X		
B.M. PAPEETE	X	X	X	X	X	X			X	X		
Other Future B.M.	X	X	X	X		X			X	X		
Non-Master B.T.						X			X	X		
Other Orbitography Beacons									X	X		
Positioning Beacons												

Requirements =>	F_130	F_140	F_160		F_178	F_181	F_182	F_183	F_185	F_190	F_200
B.M.TOULOUSE		X	X		X	X	X	X	X	X	X
B.M. KOUROU		X	X		X	X	X	X	X	X	X
B.M.H.		X	X		X	X	X	X	X	X	X
B.M. PAPEETE		X	X		X	X	X	X	X	X	X
Other Future B.M.		X	X		X	X	X	X	X	X	X
Non-Master B.T.		X	X		X	X	X	X	X	X	X
Other Orbitography Beacons		X	X		X	X	X	X	X	X	
Positioning Beacons		X	X		X	X	X	X	X		

Requirements =>	O_10	O_11	O_12	O_20			O_50	O_60	O_70		O_80
B.M.TOULOUSE	X			X					X		
B.M. KOUROU	X			X					X		
B.M.H.	X			X							
B.M. PAPEETE	X			X							
Other Future B.M.	X			X							
Non-Master B.T.	X	X	X	X							
Other Orbitography Beacons				X			X	X			
Positioning Beacons				X				X			

Requirements =>	I_10	I_20	I_30	I_40	I_50	I_60	I_70	I_75	I_80	I_90	I_100
B.M.TOULOUSE	X	X	X	X	X	X	X	X	X	X	
B.M. KOUROU	X	X	X	X	X	X	X	X	X	X	
B.M.H.	X	X	X	X	X	X	X	X	X	X	
B.M. PAPEETE	X	X	X	X	X	X	X	X	X	X	
Other Future B.M.	X	X	X	X	X	X	X	X	X	X	
Non-Master B.T.	X	X	X	X	X	X	X	X	X	X	
Other Orbitography Beacons	X	X	X	X	X	X	X	X	X	X	
Positioning Beacons											

Requirements =>	I_110	I_120	I_130	I_140	I_150	I_160	I_165	I_170	I_173	I_176	I_180
B.M.TOULOUSE	X	X	X	X	X	X	X	X	X	X	X
B.M. KOUROU	X	X	X	X	X	X	X	X	X	X	X
B.M.H.	X	X	X	X	X	X	X	X	X	X	X
B.M. PAPEETE	X	X	X	X	X	X	X	X	X	X	X
Other Future B.M.	X	X	X	X	X	X	X	X	X	X	X
Non-Master B.T.	X	X	X	X	X	X	X	X	X	X	X
Other Orbitography Beacons	X	X	X	X	X	X	X	X	X	X	X
Positioning Beacons											

Requirements =>	I_200	I_210	I_220	I_230	I_240	I_250	I_260	I_270	I_275	I_280
B.M.TOULOUSE	X	X	X	X	X	X	X	X	X	X
B.M. KOUROU	X	X	X	X	X	X	X	X	X	X
B.M.H.	X	X	X	X	X	X	X	X	X	X
B.M. PAPEETE	X	X	X	X	X	X	X	X	X	X
Other Future B.M.	X	X	X	X	X	X	X	X	X	X
Non-Master B.T.	X	X	X	X	X	X	X	X	X	X
Other Orbitography Beacons	X	X	X	X	X	X	X	X	X	X
Positioning Beacons										

Requirements =>	I_290	I_295	I_300	I_310	I_320	I_330	I_340	I_350	I_360	I_370		
B.M.TOULOUSE	X	X	X	X	X	X	X	X	X	X		
B.M. KOUROU	X	X	X	X	X	X	X	X	X	X		
B.M.H.	X	X	X	X	X	X	X	X	X	X		
B.M. PAPEETE	X	X	X	X	X	X	X	X	X	X		
Other Future B.M.	X	X	X	X	X	X	X	X	X	X		
Non-Master B.T.	X	X	X	X	X	X	X	X	X	X		
Other Orbitography Beacons	X	X	X	X	X	X	X	X	X	X		
Positioning Beacons		X										

The F_110, F_120, F_130 and O_80 requirements are general and cannot be assigned to one function or another.

Requirements =>	M_100	M_200	M_300	M_400								
B.M.TOULOUSE	X	X	X	X								
B.M. KOUROU	X	X	X	X								
B.M.H.	X	X	X	X								
B.M. PAPEETE	X	X	X	X								
Other Future B.M.	X	X	X	X								
Non-Master B.T.	X	X	X	X								
Other Orbitography Beacons	X	X	X	X								
Positioning Beacons	X	X	X	X								

ANNEX 1 : STABILITY AND EVOLUTIONS OF THE DORIS NETWORK

(text distributed on the I.D.S analysis forum.)

After having discovered corrosion on the antenna of the station in Ascension and further to some discussions related to the usefulness and future of this station, here are some considerations about the evolutions of DORIS network.

Both on a technical and on a scientific point of view, the DORIS network requires long term stability. This long term stability is one of the DORIS network great qualities, and has to be preserved and improved in the next years. This point is clearly stated in several papers in the special DORIS issue of the Journal of Geodesy and other publications, or on the occasion of various meetings involving the scientific users. To only quote the main arguments, let's emphasize on the quality of the DORIS contribution to Ocean observation missions, and to the ITRF.

In principle, each site should comply with system requirements, which should apply to every new station aimed at contributing to the so-called permanent network (requirements are not so strict for temporary scientific experiments). For historical reasons, as some of these requirements were only recently formalized or evolved to match more and more challenging accuracy goals, all current stations do not meet the whole set of requirements. Of course, local constraints may also lead us to waive the principle.

When problems such as frequent unavailability, antenna displacement, high orbit determination residuals or poor station coordinates time series arise on such an existing station, they should be investigated and corrective actions should be undertaken prior to consider a station displacement. Moreover, lessons learnt on such a site could benefit to other stations of the network.

Closing too quickly problematic stations would prevent us from finding explanations (geodetic instability, multi-paths, corrosion, masks) for phenomena which could be encountered on other sites. Lessons learnt are a key factor to define accurate actions to improve the network.

(…)

Christian Jayles with the contributions of Albert Auriol, Nathalie Maléchaux and Cédric Tourain.

ANNEX 2 : EXAMPLE OF A COMPLIANCE MATRIX : ASEB

SYSTEM REQUIREMENTS ON DORIS SITE				
	creation date	15/06/2010		
	validation date	17/05/2011		
ASEB	**Ascension**			
Ident	**Label**	**Compliance**	**Comments**	**Dispensation**
First site examination				
I 10	☑ Coverage contribution ☑ Robustness contribution	VRAI		
I 275	☑ Internal jamming	VRAI		
I 20		VRAI		
Second site examination				
Accessibility	☑ Presence on site			
I 30	☑ Custom clearance time	VRAI		
I 40		VRAI	1 month via RAF (Richard James International, Bristol)	
Stand-by prohibition	☐ Deliberate stand-by			
I 50	☑ Automatic stand-by	FAUX	ESA launches (see SIO SALP-IF-MA-OP-15353-CN)	granted
I 60	☑ Transmission authorization	VRAI		

I 70		VRAI	1995 - but not any document attesting that	
Electrical power supply	☑ Power failure duration			
I 80	☑ Power failure frequency	VRAI	ESA installation cat.3	
I 90	☑ Monthly total of power failure	VRAI		
I 270	☑ Voltage	VRAI		
I 100	☑ Frequency	VRAI	238-243VAC	
I 110	☑ Circuit-breaker/fuse rating	VRAI	50Hz TBC	
I 260		VRAI	15 Amps	
Beacon room	☑ Temperature			
I 120	☑ Vibration	VRAI	18°C < T < 24°C	
I 370	☑ Cleanliness	VRAI		
I 290		VRAI		
Antenna				
I 140	☑ Built-up of snow ☐ Visibility cone	VRAI	N/A	
I 150	☑ Envelope volume	FAUX	obstructions > 5° = 5,3% (mountain eastwards)	granted
I 160	☑ Planned installation projects	VRAI		
I 165		VRAI	specified in SIO SALP-IF-MA-OP-15353-CN	
Stability				
I 170	☐ Geodesic stability ☑ Building stability	FAUX	cf (1)	granted

I 173		VRAI	N/A	
Monumentation				
I 300	☑ Long-term stability ☑ Short-term stability	VRAI	concrete pillar h=1,5m d=0,4m anchoring 1,5m	
I 310	☑ Standard configuration	VRAI		
I 360	☑ Antenna type	VRAI	stainless steel support on concrete pillar	
I 200	☑ Connectors	VRAI		
I 210	☑ Cables bend radius	VRAI		
I 220	☐ Cables length ☑ Lateral stresses	VRAI		
I 230	☑ Cables fastening	FAUX	20m	granted
I 320	☑ Material	VRAI		
I 330	☑ Geodetic tie	VRAI		
I 240	☐ Point stability	VRAI	Inox 316L	
I 350		VRAI		
I 176		FAUX	(1)	
Host agency				
I 250	☑ Responsiveness	VRAI		

(1) Tectonic plate motion according to models:
dN/dt between 8,7 and 12,6 mm/year according to models
dE/dt between -6,2 and -4,0 mm/year according to models
Velocity ITRF2005/DORIS :
dN/dt = 10,7 mm/year
dE/dt = -13,9 mm/year