After a site had been selected, a local agency was sought to host the station and take care of its maintenance, which would satisfy the following requirements :

- The transmitting beacon and its backup power supply needed to be in a room with moderate temperature and temperature variations, and with continuous ~~mains~~ power ~~supply~~ available.
- The antenna had to be installed outside with a clear sky view above 10 degree elevation, on a structure that would allow the use of the antenna supports – guyed tower or wall side mount – available at that time.
- Occasio

No, "available at that time" doesn't apply to "10 degree elevation", but to "antenna supports". I have changed the order of words at the end of the sentence to make things clearer.

adjustm

- Frequen

could not be avoided, a temporary interruption of the DORIS transmissions, either manual or automatic, could be accepted. The receiving systems that are likely to be affected by the DORIS signal are:
  - VLBI antennas: such interference, if it exists , may be avoided by having a physical signal obstruction between both antennas. Nevertheless there is one case (Kauai) where both antennas are inter-visible and no interference have been noted, so this issue deserves further investigation as its better understanding might open up new opportunities for DORIS-VLBI co-locations.
  - Upper atmosphere soundings carried out by most meteorological stations: some models of Vaisala receivers – which are used to receive the data transmitted by the radiosondes – are likely to be affected if the DORIS antenna and the radiosonde antenna are very close to each other (less than 30 m or so).
  - The 2 GHz antennas used by the Ariane tracking stations at Kourou, Ascension and Libreville.

In order to check that the prospective host agency would meet the above requirements, a questionnaire was sent which generally resulted in yes/no answers to a few questions, and a variable amount of details about the site layout. This has progressively evolved throughout the network's history, with a deeper and more detailed preliminary survey being conducted as the requirements for antenna stability have become more stringent (see section 7.2).

Once the planned location and host agency were found to be satisfying on the above points, the next step was to negotiate a written agreement signed by IGN and the host agency. Frequency clearance had also to be granted, which was generally handled by the host agency through an application with the relevant national radio

For each DORIS station, a sitelog is made available to the users in the form of a text file, on the IDS web site (http://ids.cls.fr/html/doris/sitelog.html). It contains the following information:

- General site information
- Information about the successive antennas installed at the station
- Information about the successive beacons installed at the station
- List of available IERS co-locations (if any)
- Tide gauge co-location (if any)
- Local geodetic survey results
- Description of the meteorological instruments
- Contacts

Each major evolution of the DORIS network (e.g. new station, antenna change, station removal, etc.) is announced to the DORIS community in the form of a DORISmail (Tavernier et al. 2005).

10.4 The antenna stability evaluation

Now that the network renovation is almost complete, we have tried to assess more precisely the quality of the antenna support at all DORIS sites, in order to define criteria for site quality so as to identify a set of core stations with accurate coordinates that might contribute to the ITRF (International Terrestrial Reference Frame) (IDS 2004).

The best way to actually assess the antenna stability would be to carry out stability surveys on a regular basis. Since this would require human and financial means well beyond those allocated to the maintenance of the DORIS network, other approaches had to be considered:

- An analysis of the structure of the [illegible]
- The results of the antenna centring [illegible] when available.
- A time series stability study based on the statistical analysis of several years of DORIS weekly station coordinates (Le Bail, submitted), that is influenced by several factors among which the antenna stability.

No, UK wording was used throughout the text

- Construction type: marks the way the pillar was constructed (according to IGN's specifications dealt with in section 7.2, or not).
- Ground hardness: bedrock, hard soil or soft soil.
- Height: because even a concrete pillar can be bent by temperature differences between the sunny side and the shady one, and this deformation is in proportion to it height, a concrete pillar should not be too high.

do you insulate the concrete pillar

B.2. Metal tower: we have been using two main tower types in the network: Normand, and Leclerc.

- Tower model: "Leclerc" (32 cm sided, self-supporting) is better than "Normand" (17 cm sided, needs to be guyed if height is more than one metre).
- Height (Leclerc tower): although this kind c

No, we only try to paint it in white when possible. See added sentence at the end of 7.2.1.

- Height (Normand tower): weight=3 for this criterion because the amplitude of an antenna movement (if a guy-wire breaks or becomes loose, which cannot be completely ruled out and actually already happened) increases very much with height.
- No guy-wire (Normand tower): the lack of guying will have between "no influence" (for a half-metre section) and "a lot of influence" for a very high tower.
- Guying quality (Normand tower): good guy-wires have turned out to be very efficient in maintaining a mm-level centring over several years at some sites. Moreover, a bad quality guying will have of course a different influence on antenna stability, depending on the tower's height.

C. *Secondary support:* this is the element below the primary support. It can be either a concrete block in the ground, or a building. If the primary support is a concrete pillar or a metal pipe anchored into the ground, there is no secondary support.

C.1. Concrete block or pad on the ground: same criteria as the concrete pillar.

C.2. Building:

- General structure: here we have marked how stable the building is likely to be, according to the kind of structure and materials used.
- Primary support location with respect to the most stable parts of the building.
- Height of tower base above ground: stability-wise, the lower the building the better. Nevertheless as the influence of this parameter is difficult to evaluate (presumably less important than, and highly dependent on the building's structure and the location of the antenna), it was assigned a very small weight.

D. Whole site / geological stability: little can be done as far as this criterion is concerned, other than choosing another site. For lack of detailed information, this was set to 2 for most stations, and the weight was set to 1, so that it would have little influence anyway on the result of the assessment. Nevertheless, this criterion should be properly assessed in the future.

Fig. 30 shows the antennas stability degree at the time of writing, when the renovation of the network is almost complete. If the activity projects for 2006 can be carried to a successful end, the biggest circles on this map should have significantly shrunk by the end of the year.

(Place Fig. 30 around here)

The second approach used in assessing the antenna stability consisted in measuring its eccentricity with respect to the reference ground mark below the antenna, when one was present, on the occasion of an antenna upgrade or move. This was done at 32 out of the 102 antenna positions. The resulting antenna eccentricities are distributed as follows:

- Less than one mm (not measurable) for 6 antennas (including several guyed towers, installed near the end of the "Starec era" dealt with in section 6.2
- Up to 1 cm (more likely resulting from an imperfect centring at the time of the installation, rather than from an antenna movement) for 12 antennas
- 1 to about 3 cm for 9 antennas, where a shift is likely to have occurred, due to poor quality guying
- Two Alcatel antennas had eccentricities between 4 and 6 cm
- The following Starec antennas were affected by corrosion of their base plate, causing a several cm shift of the 2 GHz phase centre: Amsterdam / AMSB (Fig. 17), [illegible] (not mentioned in the ESM file because the code was not changed after the tilt was corrected), and St Helena / HELB (before it was corrected in July 2002)

No correlation can be seen between the antenna stability index on one hand, and the actually measured antenna eccentricity at these sites. But such an eccentricity check was carried out on too small a number of stations to be significant. Moreover, it should be noted that such a centring check only allows to survey the stability of the antenna reference point with respect to the mark at the base of the antenna. It doesn't allow detection of

- Another gap in the western tropical part of the northern Pacific Ocean, which has always existed, was made worse by the removal of the Guam station. A new replacement site at Tarawa, Republic of Kiribati, is likely to be installed in 2006.
- Although the Kauai station has a central location in the northern Pacific Ocean that allows good quality coverage, the network's robustness is not sufficient in this area since a failure of this station means that a significant part of the orbit will no longer be tracked. Additional stations, one north and one south of Kauai would be highly desirable, but IGN's efforts over several years to bring these difficult projects to fruition have failed so far. Sakhalinsk is also somewhat isolated and would be well off being backed up by an additional station south of Japan.
- Less striking but nevertheless improvable robustness wise, the removal of Arlit left a less densely covered area over North Africa, where a failure of Libreville leads to a gap of the orbit coverage for the lowest satellites. The planned installation of a station at Tamanrasset (Algeria) would slightly improve the robustness while adding one more GPS (and maybe SLR) co-location.

(Place Fig. 37 around here)

As far as the co-locations with other techniques are concerned, DORIS-IGS co-locations are in sufficient number. Nevertheless, adding a few more would do no harm and could be achieved without any modification of the DORIS network, by simply including existing permanent GPS stations in the IGS network (e.g. Rothera, Port Moresby, Futuna). But more DORIS-SLR co-locations, and still more DORIS-VLBI co-locations should def

Was added following another reviewer's request. I agree to remove it and did so, but will let the Editor make the final choice.

200 … s

experienced at a few sites, but this is not systematic and this issue deserves to be investigated ~~in deepness.~~ In regards to the DORIS-SLR co-locations, Fig. 36 shows that there is a huge area between Metsähovi, Hartebeesthoek and Jiufeng where no ~~such~~ co-location is present. This gap could be partially filled by installing a DORIS station, and accurately t

Such refers to "SLR-DORIS". There are co-locations in this area, but not with SLR.

results.

Equipment-wise, a problem was recently detected on the connection between the beacon and the antenna, at some sites using the concrete pillar design. Because of the short clearance between the top of the pillar and the base of the antenna, and the stiffness of the antenna cable, a N-type bent adaptor must be used to connect the cable to the antenna in such layouts. As this adapter is not designed for outside use, especially in the very harsh conditions encountered at some DORIS sites, its corrosion may cause a loss of transmitted power.

As regards the antenna stability control, the stability assessment presented in this paper, although more refined than the first approach used, cannot pretend to replace an actual measurement through repeated footprint surveys.

Lastly, it should be noted that a sometimes insufficient tracking of the DORIS on-board instruments, was seldom due to the network design and management, although some host agency closures have caused long data gaps until a replacement solution was implemented. The main reason for DORIS data loss was essentially the significant failure rate of the ground equipment. Administrative and customs procedures delaying equipment changes, and seasonal access constraints contributed to make out of order periods longer, while absence of data distribution by CNES at the beginning of the operation of a new station, and during the first three years of the system's operation also had a large impact on the lack of data. Despite evolution of the transmitting beacons, many equipment failures, added to long repair times, have caused several month data interruption at many sites, and shorter but repeated ones at other places. Nevertheless, the recent massive deployment of retrofitted third generation beacons lets us feel the first stirrings of hope for a significant improvement of the operation ratio.

Maybe. I've already been optimistic when the second generation beacon showed up, then again after the definition of the third gen one.
Let's hope I'll be right this time...

The DORIS stations at Dionysos, Kourou, Toulouse, Socorro and Krasnoyarsk still have to be renovated, and this should hopefully happen in 2006. The last two remaining Alcatel antennas in the network – Dionysos and Toulouse – will then have been replaced with Starec ones.

A new station should be installed at Rikitea (Polynesia), which will eventually replace the one at Rapa. Moreover, new stations are in project at Tarawa and Kiritimati (Republic of Kiribati), Adak (Aleutian Islands),

I intentionnally used the very vague word "projects" as I didn't want to give more details about very uncertain plans.

Apart from these projects, a further densification of the network is not currently necessary from the orbit determination point of view. Nevertheless, the deployment of the next generation DORIS receivers, which will have more than two channels, will make easier to add of more stations in the network, either following proposals made in the framework of the IDS or as permanent stations.

(Place Fig. 38 around here)

Equipment-wise, the deployment of the third generation beacons will continue, until all stations are equipped with this kind of beacons, except a few ones where power supply issues impose the use of less consuming second generation ones. There are currently no plans for a fourth generation beacon. As regards the antenna support design, a new support is being designed to allow more clearance below the antenna when installed on a concrete pillar, hence avoiding the use of corrosion-prone bent adapters. Ideally, this new device will have to be designed so that it can installed over the existing one by host agency staff with no geodetic skills, while retaining the initial centring of the antenna.

UK wording

In order to provide a reliable long-term stability control for the antenna, control geodetic markers should be installed near the antenna (Geodetic Survey Division 1995) and footprint surveys be repeatedly carried out.

13. Conclusion

The quality, density and homogeneity of the DORIS network have continuously improved throughout its 20 year evolution. With 56 stations equally distributed around the globe, the network guarantees an excellent orbit coverage for the DORIS-equipped satellites, usually more than 80 % for Envisat and 95 % for Jason-1 (Jayles et al submitted), thus playing a key role in the success of the DORIS system. Such a density makes the DORIS network an essential contributor to the realisation of the ITRS on one hand, both by making the IERS network denser and through the co-locations available at 2 DORIS stations out of 3, and to the sea level monitoring on the other hand, through co-locations with tide gauges available at one third of the stations. Thanks to the general renovation process that was carried out over six years on the network, almost all antenna supports should ensure from now on excellent long-term stability of the antenna reference point. Moreover, the massive deployment of third generation beacons gives us hope of a 90 to 95 % operating rate.

Managing the DORIS network has been a very long-term task for IGN, requiring a lot of patience to bring projects to a successful end. We sometimes had to cast doubt over formerly adopted procedures, in order to adapt