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Title: 20 years of evolution for the DORIS permanent network from its initial deployment to its renovation

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Editor: P. Willis

Reviewer: G. Tavernier

General remarks:

In my mind, the paper is to long. Chapter 10.4 might be removed (see below) and some elements could be transferred in the electronic supplement (see my comments in the review).

Abbreviations: the standard should be to introduce them once, and then use the abbreviation throughout the text (IERS, IGS, SLR, VLBI…). The rule might be different for the abstract, in the sense that no abbreviations are allowed there

The author often complains about the significant failure rate of the successive generations of equipment. Failures may be related to defective equipments but also the the local environment (power shortage, moisture, temperature…):

- **how significant is the failure rate, do you have statistics on MTBF (Mean Time Between Failures)?**
- **Did you assess the impact of the local environment on failure rate?**

There are many other reasons for stations unavailability: what about transport delays and hazards, custom and administrative proceedings, local problems such as power supply, communication difficulties, reaction delays…

Chapter 10.4 The antenna stability evaluation might be removed:

Is this new evaluation really necessary? It has the same weakness as the previous one, and doesn't seem to be validated when looking for correlations with actually measured antenna eccentricity on some sites (see page 26). As mentioned in paragraph 7.1: "the actual stability of an antenna can only be properly assessed by surveying it at different epochs with respect to a stable reference mark" and reminded here: "The best way to actually assess the antenna stability would be to carry out stability surveys on a regular basis."

Page 1

Author : Hervé Fagard

As mentioned in the abstract and introduction, IGN has taken care of the deployment of the DORIS ground network and is also in charge of its operational maintenance. This major contribution to the DORIS system is achieved by a whole team. As far as I know Hervé Fagard usually deals with new

sites and it's hard to believe that the members of his team in charge of the operational maintenance of the network did not contribute to this very interesting paper.

Page 2

Abstract

An intensive activity on account of a significant failure rate of the successive generations of equipment: see general remark

a very good coverage rate of the satellites orbits --> a very good coverage ratio of the satellites orbits.

Through a large number of well-distributed co-locations with the IGS, SLR and VLBI networks : either IGS, ILRS and IVS or GPS, SLR and VLBI + general remark on abbreviations

and contribution to the IERS frame --> and contribution to the IERS reference frame.

Page 3

Introduction

The realisation of the DORIS system was decided jointly in the early eighties by the French space agency (CNES: Centre National d'Études Spatiales), the French national mapping agency (IGN-F: Institut Géographique National – France) and a research group in the field of space geodesy (GRGS: Groupe de Recherche en Géodésie Spatiale): what is the purpose of the DORIS system? What are its main features? What are its components ? Which requirements and accuracy? Possible reference: paper by Jayles, Nhun Fat and Tourain, same issue (DORIS: SYSTEM DESCRIPTION AND CONTROL OF THE SIGNAL INTEGRITY).

Because of its experience in the field of the installation of geodetic networks --> Because of its experience installating geodetic networks,

as evenly distributed as possible around the globe --> as evenly distributed as possible all over the globe

it was estimated that the network should be made of approximately 50 stations, as evenly distributed as possible around the globe: this initial requirement only applied for TOPEX/POSEIDON launch in order to contribute to the gravity model improvement (the main error source for orbit determination at that time). Once the gravity model would have been improved, the network might have decreased. As a matter of fact, the success and achievements of the TOPEX/POSEIDON led to new requirements. It was then decided to maintain this network and even to improved and increase it.

In this paper we will be relating the genesis of this unique network, and its various evolutions over about 20 years. --> In this paper we will relate the genesis of this unique network, and its various evolutions over two decades.

we will go in detail through the history --> we will scrutinize the history

have been improving over the years. --> have steadily improved over the years.

Page 4

and the determination of geocentric a priori coordinates --> and the determination of a priori geocentric coordinates

Colocation

with other IERS space geodesy techniques: IERS stands for International Earth rotation and Reference frame Service (see general remark on abbreviations)

with other space geodesy technique networks.--> with other space geodesy techniques networks.

2.2 Selection of a host agency

After a site had been a priori selected --> After a site had been identified

with mains power supply available --> with main power supply available?

Page 5

as well as sending out of order equipment --> as well as sending back out of order equipment

with existing receivers in the area --> with existing receivers in the same area

the solution generally consists of --> the solution generally consists in

Upper air soundings --> Upper atmosphere soundings?

such interference occur only if the DORIS antenna --> such interference only occurs if the DORIS antenna

This negotiation stage generally took several months --> This negotiation stage generally lasted several months

took up to two or three years in succeeding --> went on two or three years before succeeding

Page 6

3. Identification of the DORIS site and points

where several successive DORIS points may have been present: not clear --> where there may be several successive DORIS points?

an archipelago made ten or so islands --> an archipelago made up of ten or so islands

Therefore a more accurate name (Santa Cruz, i.e. the name of the island) was chosen when a new station was installed in March 2005, in order to avoid confusion with the first station installed at Sán Cristobal island, inaccurately named “Galapagos”.

The example is rather unjudicious as the same name was given to at least 30 towns (1 in Argentina, 2 in Azores, 1 in Bolivia, 5 in Brazil, 2 in Canary Islands, 2 in Cuba, 1 in California, 1 in Chile, 3 in Mexico, 1 in Peru, 5 in Philippines, 1 in San Jose, 2 in Santo Domingo, 2 in Spain, 1 in Venezuela), 3 other islands (Brazil, California, Melanesia), 2 rivers (Argentina, Cuba), 2 mountains (California, Guatemala) and even one airport (India). Is Santa Cruz really more accurate?

A DOMES number: what is the meaning of DOMES?

Page 7

The very first station at Reykjavik, equipped with an Alcatel antenna, was “REYA”: when?

After the Alcatel antenna was replaced with a Starec on the same tower, it was “REYB”: when?

There have been a few exceptions to these rules --> There are a few exceptions to these rules

“Koke’e Park” --> “Kokee Park”?

SPI derives from the initial site name “Spitzberg” (a 39000 km2 island) which was later changed to the more accurate site name “Ny-Ålesund”: this is also the name used for VLBI and GPS stations co-located on the same site.

A summary of all DORIS antenna acronyms with start and end date for each occupation is provided in theElectronic Supplementary Material of this paper: further information is available in Site Logs on the IDS web site (see chapter 10.3)

Page 8

4. Summary of the network's evolution

Tristan da Cunha (code TRIA): code or acronym?

the first DORIS-equipped receiver (SPOT-2) --> the first DORIS-equipped satellite (SPOT-2)

The deployment of the third generation beacons started in 2002 --> 2001 (Toulouse Master Beacon)

5.1 Description of the equipment

It could be programmed through an integrated man-machine interface --> It is programmed through an integrated man-machine interface

Page 9

consisting of a square horizontal plate welded to a vertical tube --> consisting of a horizontal square plate welded on a vertical tube

A weather station (figure 4) measuring temperature, pressure and humidity: which accuracy?

can be used to correct for atmospheric propagation delays --> can be used to correct atmospheric propagation delays?

5.2 Alcatel antenna layouts

a standard set of antenna supporting devices was sent --> a standard set of antenna supporting devices was usually sent to new sites

Page 10

At a few sites where the antenna was installed on a roof, a clear sky view allowed to use only one tower section --> On a few sites where the antenna was installed on a roof, an open view allowed to use a single tower section

Such a control mark was destined to be used --> Such a control mark would be used

Other designs have been used more rarely --> Other designs have been more seldom used

the recent geodetic results obtained by the DORIS system --> the recent geodetic results obtained with the DORIS system

Page 11

6. The network densification

either following beacons failures or damages --> following either beacons failures or damages

A second generation beacon was installed at a few sites --> Second generation beacons were installed on a few sites

but was never deployed at a large scale --> but was never deployed on a large scale a maximum of 14 units have been operating simultaneously in the network --> a maximum of 14 units were operated simultaneously in the network

6.1 Description of the second generation equipment

The new antenna model (Figure 11): Figure 11 only shows the bottom of the antenna. A picture of a whole antenna would be more appropriate

it catches the wind far less --> it much less sensitive to wind

and causing a significant antenna tilt --> thus causing a significant antenna tilt

Page 12

the internal one on the first generation beacons has been the cause of most failures --> the internal one on the first generation beacons was the cause of most failures

The meteorological station associated with the second generation beacon had the same functionalities as the first model: which accuracy?

they use should be as limited as possible --> their use should be as limited as possible.

Very few such units have been deployed --> Very few such units were deployed

Page 13

6.2 Starec antenna layouts

(Cibinong/CIBB, Rio Grande/RIOB (Figure 14),: parenthesis within parenthesis --> (Cibinong/CIBB, Rio Grande/RIOB - Figure 14 -,

when imposed by nearby signal obstructions --> in order to avoid signal obstructions

7 THE RENOVATION ERA

for the realisation of the IERS Terrestrial Reference System --> for the realisation of the IERS International Terrestrial Reference Frame

Such a policy has been applied until the end of the 90's --> Such a policy was applied until the end of the 90's

Such a policy has been applied until the end of the 90's, with no on-site intervention motivated only by the need for an antenna stability improvement during this period. Confused sentence

Guy-wires were still used to fasten antenna supporting towers, although they were installed with more care --> Guy-wires were still used to fasten antenna supporting towers, but they were installed with more care

Page 14

7.1 Network preliminary review

Such an evaluation --> This evaluation

A more refined stability assessment will be presented in chapter 10.4.: I think that the same restriction apply to this new assessment, thus limiting its interest.

Page 15

7.2.2 Design 1: concrete pillar

built according to “geodetic” specification, who take into account the nature of the ground. --> built according to “geodetic” specifications, which take the nature of the ground into account.

What about the use of bent connectors? Extra connections in the sometimes very corrosive open air can lead to contact problems, especially with “laboratory” connectors (not designed to be used outdoors). Due to constraints, the connectors might break, requiring the antenna to be replaced. These connectors turned to be the cause of some antennae failures requiring their replacement (1 confirmed, 3 under investigation)

According to lessons learnt, why not use a one meter lattice tower over the pillar:

- **to avoid the use of a bent connector**
- **to minimize connections and corrosion opportunities**
- **to improve the “clear view”**
- **to minimize multi-path effects (reflexion on the ground)**

Page 16

7.2.3 Design 2: self-supporting metal tower

One advantage of this kind of support is that it allows a direct cable connexion, avoiding the use of a bent connector

Page 17

7.2.4 Design 3: antenna on a building

in order to achieve as good as possible a long term stability --> in order to achieve the best possible long term stability

Using only one section of a 32 cm sided tower (figure 24), or a half-metre 17 cm sided one (figure 26) – which has the additional advantage of fitting on narrow concrete beams – guarantees an optimal rigidity of the support: are these two supports equivalent on the stability point of view?

Page 18

7.3 The third generation beacons

also has a new “Restart” operating mode allowing its signal to be received even if the time is not properly set: it is not even necessary to set the time when starting a third generation beacon. The “Restart” operating mode allows to monitor the beacon time and frequency without disturbing the receivers, until proper correction are performed upon request.

The weather station (Figure 24) is a Vaisala PTU200 unit: which accuracy?

7.4 The progress of the renovation

During this six year period the following evolutions have been taking place --> During this six year period the following evolutions took place

(at least 3 per year, and up to 10 in one year) --> (between 3 and 10 per year)

8 new stations were installed as a replacement for existing ones which have been closed --> 8 new stations were installed as a replacement for existing ones which were closed

2 stations have been removed and not yet replaced --> 2 stations were removed

The renovation turned out to be much longer … to a successful conclusion. This last paragraph is not very clear, is it really useful.“The renovation was a long and complex process, with sometimes more than one year for a renovation and more than 3 years for a new installation” would be clearer and more simple.

8. THE IDS NETWORK AUGMENTATIONS --> “augmentations”? not very clear

Page 19

with varied scientific objectives and for varied durations. --> with various scientific objectives and for varied durations.

The following experiments have been carried out to date --> The following experiments were carried out to date

on the Sorsdal glacier, Antarctica, by operating a DORIS station for about three months twice, during the austral summers 2002-2003 and 2003-2004. --> I think that it was a few weeks in December 2001-January 2002 (Sorsdal), January 2003 (Lambert) and January 2004 (Sorsdal). Possible reference: paper by Valette, Govind and Lemoine, same issue

It was removed in January 2004 after producing little data, due to interference to the VLBI on one hand, and an equipment failure on the other hand: to be accurate, the DORIS beacon was often turned off (almost every day) to avoid interference with the VLBI. The stand-by mode should have been used instead to keep the Ultra Stable Oscillator “warm”. Moreover, it was operated in shifted frequencies to avoid jamming with the nearby DORIS stations and at that time, Jason-1 was the only satellite able to perform measurements on such a station (today, SPOT-5 and ENVISAT could also perform such measurements).

but a retrofitted third generation is on its way at the time of writing and should be installed in February 2006. --> but a retrofitted third generation was installed in February 2006.

Because of a failure of the second generation beacon shortly after its installation: as far as I know, strong winds (up to 200 km), a very dry climate and the nonconducting soil (lack of effective ground) produce high levels of static electricity in antennas, cables, leads, etc. and in many times it damaged electronic instruments connected to them on this site. People in Belgrano II noticed that when touching the PC terminal or Beacon, it produced a little electrostatic discharge between their finger and the beacon’s chassis.

9. THE NETWORK MAINTENANCE

9.1 Maintenance running

Page 20

IGN-F has also been in charge of its maintenance --> IGN-F is also in charge of its maintenance

Remark: SSALTO, the multi-missions orbitography and altimetry center is a facility devoted to the DORIS system and to altimetry missions control and processing. Located in CNES, Toulouse, France, it is in charge of station network monitoring, science telemetry acquisition and pre-processing, technological archiving, precise orbit determination, station precise positioning, DORIS integrity control. The network is monitored by the DORIS integrity team which associates operators, DORIS experts and the network maintenance team. Possible reference: paper by Jayles, Nhun Fat and Tourain, same issue (DORIS: SYSTEM DESCRIPTION AND CONTROL OF THE SIGNAL INTEGRITY).

An anomaly is detected by the DORIS control centre --> An anomaly is detected by the DORIS integrity team

The DORIS control centre sends – for each anomaly detected —-> the DORIS integrity team sends – for each detected anomaly –

an intervention request to IGN's maintenance unit --> an intervention request to IGN's maintenance team

The host agency performs the requested operation, and reports to IGN/SIMB, which then reports back to the DORIS control centre. --> The host agency performs the requested operation, and reports to IGN/SIMB, which then reports back to the DORIS integrity team.

9.2 Maintenance statistics

The proportion of emitting beacons in the network averages to about 85 %, with lows at 80 % and highs reaching 95 %: to which time span do these figures refer? The current figure, considered as relatively high is 85% (maximum, this year is 89%), and minimum was 73% last year.

Because of very long repairing delays and frequent shortages of spare units, a few stations have remained down for several months before they could be replaced: long repairing delays and frequent shortages of spare units are not the only reason. Administrative and custom steps, transport delays and hazards, seasonal constraints also have a deep impact on station availability (beacons are available for months to be installed in Russia and we may still have several months to wait).

before they could be replaced --> before equipment could be replaced

This rate nevertheless allows the global coverage rate --> This rate nevertheless allows the global coverage ratio

This coverage rate --> This coverage ratio

for high altitude satellites like TOPEX-Poseidon and Jason-1 (both at 1330 km altitude): 1330 km is high for a LEO satellite, but it is still a LEO (Low Earth Orbit) satellite. GPS (20000km) and geostationary satellites (36000 km) are much higher.

this model did not turn out to be more reliable than the first generation: some first generation beacons are now 20 years old and still working. Were they really not reliable, taking into account transport and local conditions on some sites.

Page 21

In 2005 a new problem (power supply defect creating spurious in the signal) was detected, which will require the replacement of the remaining units by third generation beacons --> which could require the replacement of the remaining units by third generation beacons. This problem only affected 2 out of 9 second generation beacons until now. The power supply could theoretically be repaired, but as there is no more maintenance for this equipment, we have to replace it by a third generation beacon when there is a problem.

IGN's maintenance unit --> IGN's maintenance team

Exchange of the beacon by a spare sent by IGN: IGN usually leans on CNES expedition and custom service for such sendings.

to avoid interference to other receiving systems --> to avoid interference with other receiving systems

Ascension and Libreville -> Kourou, Ascension and Libreville

Page 22

have a special status as they are equipped with "master beacons" used for the programming of the on-board instruments: what is a master beacon? Explanation or reference: paper by Jayles, Nhun Fat and Tourain, same issue (DORIS: SYSTEM DESCRIPTION AND CONTROL OF THE SIGNAL INTEGRITY)

Other (a telecommunication station): 1 station --> Telecommunication station: 1 station.

Page 23

10.4 The antenna stability evaluation

"in the frame of the definition of criteria for site quality aiming at identifying a set of core stations with accurate coordinates contributing to the ITRF (IDS 2004)":

- **the IDS 2004 recommendation was "An IDS Working Group should define criteria for site quality (quality of equipment, reference point stability, reliability of power supply, quality of station coordinates time series…) in order to identify a set of reference stations with accurate coordinates contributing to ITRF. The Working Group will also maintain a list of stations (DORIS permanent network, IDS campaigns) that contribute to the IDS."**
- **The aim was to determine which station should contribute to ITRF and which should not and the quality of the antenna support is one criterium among other (see below).**
- **On the stability point of view, a revised evaluation similar to the preliminary review would be clearer and sufficient.**
- **Moreover, lessons learnt on some sites may modify part of your analysis.**

"A stability study based on the statistical analysis of several years of DORIS weekly station coordinates": this is not an antenna stability study. You are mixing basic elements related to the quality of the antenna support with an end-user product (weekly station coordinates) analysis, the quality of which depends on many other elements (masks, radio-frequency jamming, ionospheric scintilliation, site location and stability, operating rate and performance of the system…).

Global site quality assessment should include different distinctive aspects:

- **antenna stability**
- **maintenance**
- **contribution to the DORIS system (geographical orbit covering, redundancy…)**
- **geodetic and tide gauges co-locations**
- **contribution to POD**
- **station coordinates times series**
- **statistical analysis of products**

Page 24

Figure 31 shows the result of such an assessment, for the same network as on figure 16, but using this more detailed and less subjective approach: the new figure, with too many "values" (11 instead of 4) difficult to distinguish is rather confusing. For instance, is MORA better or worse than KERB ?

As the new assessment has the same weakness as the previous (no stability surveys on a regular basis), was it worth the confusion?

Page 25

the amount of an antenna move --> the amplitude of an antenna move

Page 26

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: the site geological stability should be a very important criterion. Either it is too difficult to assess and it should be removed, or it has to be assessed. What is your position and what are your future plans?

Figure 32 shows the antennas stability degree at the time of writing: same comment as figure 31 page 24. An update of figure 16 would have been more convincing for me.

0 mm (perfect centring): in the real world, nothing is perfect. I would prefer either "non measurable" or "less than n mm"

No correlation can be seen between the antenna stability index on one hand, and the actually measured antenna eccentricity at these sites: so was is really useful and is it worth keeping it.

Page 27

The third approach dealt with in (Le Bail submitted) assesses the actual antenna instability: I do not agree (see my comments on page 23).

Page 28

11.2 Surveying a DORIS antenna

in most cases part of the IDS network --> in most cases part of the IGS network?

Page 29

11.3 Determination of a priori coordinates

for the realisation of the IERS terrestrial reference frame --> for the realisation of the IERS International Terrestrial Reference Frame

Page 30

11.4 Co-locations with other IERS techniques

Among these, some are 3 technique co-location sites--> Among these, some are 3 techniques co-location sites

for which the inter-technique distance is less than 10 km: how was this value defined?

Page 31

11.5 Internal DORIS co-locations

where the distance between two successive antenna locations are less than 10 km --> where the distance between two successive antenna locations is less than 10 km.

11.6 Co-locations with tide gauges

the possibility to add more such co-locations was taking into account --> the possibility to add more such co-locations was taken into account

projects for new stations in the Pacific Ocean (Tarawa, Kiritimati, and Adak): the Adak site would be nice but it might be difficult to find a suitable host agency

Page 32

12. PLANNED EVOLUTIONS

12.1 Strengths and weaknesses of the DORIS network

Point 2: "It has practically the right number of stations to meet its primary objectives": strange statement. Is this point really "speaking" and useful?

The PRARE network (Massmann et al. 1997), which initially aimed at achieving the same objectives at DORIS, has 10 stations operating: as far as I know, there are not so many PRARE stations still operating. Only 2? Please check

Points 3 (It makes the IERS network denser) and 4 (Unlike other IERS techniques) proceed from point 1. They should illustrate point 1 instead of appearing as specific strengths.

Point 5: Its centralised management by IGN --> Its centralised management by IGN and CNES

the DORIS maintenance unit --> the DORIS maintenance team

to detect serial problems and take the necessary corrective actions --> to detect recurrent problems and undertake the necessary corrective actions.

Page 33

will remain impossible to fill for lack of islands --> will remain impossible to fill owing to the lack of islands

Another gap in the Eastern tropical part of the Northern Pacific Ocean --> Another gap in the Western tropical part of the Northern Pacific Ocean?

an additional station South of Japan: an alternative option in that area could be the Kouriles Islands where there was a DORIS station in the past. In both case, there are jamming risks with other nearby DORIS stations, which should be carefully assessed before considering adding an new station. Moreover extrathird generation might not be available in a near future for new station.

The planned installation of a station at Tamanrasset (Algeria) would significantly improve the robustness while adding one more GPS (and maybe SLR) co-location.while adding one more GPS (and maybe SLR) co-location: currently no SLR station on this site. Possibly a short campaign with a mobile SLR later (nothing sure right now). Moreover, accurate simulations have shown that this is not a critical weakness and that a new station there would only slightly improve the network coverage and robustness.

this issue deserves to be investigated --> this issue deserves to be investigated in deepness

there is a huge area between Metsähovi, Hartebeesthoek and Jiufeng where no such co-location is present: although it is still interesting to add new SLR/DORIS co-locations, "huge area" might be a little exaggerated

The main reason for DORIS data loss has essentially been the significant failure rate of the ground equipment: see general remark

Page 34

12.2 Evolution plans and proposals

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), Tamanrasset (Algeria) and Riyad (Saudi Arabia). Figure 40 shows the location of these planned new stations: already mentioned in 12.1 Strengths and weaknesses of the DORIS network

When starting the "renovation era" at the end of 1999, new accuracy requirements had to be assessed and taken into account and lessons learnt entailed corrective actions. More than 6 years later, what about the current requirements and lessons learnt on the occasion of this major renovation activity?

Possible issues:

- **new design for the support (See my comments on page 15 7.2.2 Design 1: concrete pillar)**
- **use of "laboratory" bent connectors**
- **multipath effects**
- **clear view constraint: 10 degrees might not be sufficient today as some new instruments are starting measurements with a 8 degrees elevation**
- **way to check the clear view: which reference height? Use of a force-centred adaptator on the antenna supporting plate for an instrument to assess masks and to take "panoramic" pictures**
- **site geological stability assessment**

In spite of the overall good quality of the DORIS network and owing to the continuously improving scientific results achieved with it, a more prospective analysis would be very interesting here.

13. CONCLUSION

usually more than 85 % for the altimetry satellites: more than 80% for ENVISAT and 95% for Jason-1. Possible reference: paper by Jayles, Nhun Fat and Tourain, same issue (DORIS: SYSTEM DESCRIPTION AND CONTROL OF THE SIGNAL INTEGRITY)

Page 35

Moreover, the massive deployment of third generation beacons gives us hope of a near 100 % operating rate: this might be a nice utopia. Even if the beacons tend to be more reliable, some failures will still happen and local environment and constraints will prevent from reaching this rate. A more realistic target should be 90% as a mean value and up to 95%.

By agreeing to criticize ourselves we allowed the network quality to progress significantly: the point is not to criticize. IGN did a great job deploying the network, maintaining and improving it. The requirements were globally fulfilled… but these requirements constantly evolve (see my remark about TOPEX/POSEIDON in the introduction). What is important is to assess the requirements and to analyse lessons learnt in order to keep improving the network quality (availability, antennae stability…). This approach was requisite in 1999 and it still is today (don't use a past tense).

under the supervision of the International DORIS Service --> in the framework of the International DORIS Service. The IDS doesn't supervise the DORIS network as CNES also has commitments to fulfil for various missions. As far as I know, IGS doesn't supervise the GPS constellation.

14. ACKNOWLEDGEMENTS

We also wish to thank the developers of the Generic Mapping Tools software (Wessel and Smith 1998), which was used to plot all maps in this paper, as well as for the continuous management of the network's evolutions: shouldn't this kind of statement be in the text rather than in the acknowledgements?

Page 36

References

Please add paper by Jayles, Nhun Fat and Tourain, same issue (DORIS: SYSTEM DESCRIPTION AND CONTROL OF THE SIGNAL INTEGRITY).

Some DOIs are missing

URL could be indicated for non published references

Page 40

Figure 1: caption Station upgrade or moving → caption Stations upgrade or moving

Page 41

Figure 4: which station? Rothera?

Page 42

Figure 11: which station?

Page 45

Figures 20, 21 and 22: depending on the final size of the figures in the article, part of the text may be hard to read (font size).

Page 46

Figure 25: it's hard to find the antenna in this picture. The picture was apparently shot "from above". How high? Is the requirement for a clear view above 10 degrees fulfilled?

Page 47

Figure 29: and Lambert? (January 2003)

Page 48

Figure 30: pictures of SPOT-5 instead of SPOT-2 and Jason-1 instead of TOPEX/POSEIDON would be more up to date. The "DORIS Control Center" should be split in two different component: the Satellite Control Center (antenna: one for each satellite) and SSALTO, the multi-missions orbitography and altimetry center. IGN/SIMB should be part of the DORIS integrity team (see my remark page 20). Exchanges between SSALTO and the DORIS integrity team are two-way and more sophisticated (see paper by Jayles, Nhun Fat and Tourain, same issue DORIS: SYSTEM DESCRIPTION AND CONTROL OF THE SIGNAL INTEGRITY).

Figure 31: the different colors and sizes might be difficult to distinguish in a black and white and possibly smaller picture in the final version of the article.

Page 49

Figure 32: the different colors and sizes might be difficult to distinguish in a black and white and possibly smaller picture in the final version of the article.

Figure 33: where is the 400MHz phase center of the Alcatel antenna?

Page 50

Figures 34 and 35: are they really useful?

Figure 36: : the different colors might be difficult to distinguish in a black and white and picture. The circles with sectors should be bigger.