

DORIS

Generic User Manual

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	DJCS	DJCSA	DJCSB	HY2	HY2C	HY2D					
Model(s)	Consistent with DORIS BDR DGXX-S and DGXX-SEV ; DORIS OBSW from version 4.0										

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CONTROL ELEMENTS

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Summary : The DORIS user manual describes the DORIS global functioning features and implementation. It encompasses the needed information for nominal use of the DORIS instrument on board the satellite.	

DOCUMENT CHANGE RECORDS

The modifications are listed in the Change Record section of the document and identified by change bars in affected sections

Issue	Date	Section	Change description
1.0	18/03/2015	All	Initial Issue
1.1	13/10/2015	12.2.4 and ANNEX A	DM_3059_DRAFT : PATCH IN RAM limitation for V4_xx issues of the DGXX-S software
1.2	08/02/2016		DM 3069 : EEPROM re-write : parag 8.4.15 added
1.3	14/05/2019	15 8.4.13 Annex A 15.8	DM 3244: main changes - Budgets updates regarding DGXX-SEV and SW V5.xx - Restriction for RF interfaces (antenna input) - DORIS_SPECIAL_OPERATIONS updated DM 3264: - TM buffer size
1.4	08/09/20	12.3	DM 3302: a time delay of 90 seconds minimum shall be respected between the sending of a TC DZQS and a TC TMM (or the end of the dump)
1.5	08/06/21	8.4.18	DM3334: additional information regarding the torque tightening procedure for the antenna mounting
1.6	10/03/2026	6.2.2.5 and 6.2.2.6 9	DM 3398: .all DAS mode are defined in DORIS ZQS .adding a column "corrective action" for degraded case

APPLICABLE AND REFERENCE DOCUMENTS

Reference	Document title
CO-SP-D0-EA-16858-CN	AD 1 Generic Definition of DORIS TM packets and TC formats
CO-SP-D112-EA-16443-CN	RD 1 SPECIFICATION DES COMPTE-RENDUS LOGICIELS DORIS

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TBD	RD 2 DORIS receiver Interface Control Document (ICD)
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TBC AND TBD LIST

TBC/TBD	Paragraph	Brief description
TBD		

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ABBREVIATIONS

AD	Applicable Document
AOCS	Attitude and Orbit Control System
BDR	Boîtier DORIS Redondé
BNR	Bus non régulé (Unregulated Bus line)
BOL	Beginning Of Life
CA	Corrective Action
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)
EDAC	Error detection and correction
EEPROM	Electrically-Erasable Programmable Read-Only Memory
EOL	End Of Life
ERS	Earth Remote Sensing
ESA	European Space Agency
EUP	End of UpLoad
GRGS	Groupe de Recherches en Géodésie Spatiale
HK	Housekeeping
HKTM	Housekeeping TeleMetry
ICD	Interface Control Documentation
IGN	Institut Géographique National
IERS	International Earth Rotation Service
I/F	Interface
MB	Master Beacon
MNVR	Non volatile rewritable memory (EEPROM)
MLI	Multi-Layer Insulation
MVR	"Mesure de Vitesse Radiale" (DORIS Receiver Unit)
N/A	Not Applicable
OBC	On Board Computer
OBSW	On Board SoftWare
PDS	Payload Data Segment
POD	Precise Orbit Determination
PPS	Pulse Per Second
RAM	Random Access Memory
RD	Reference Document
RF	Radio Frequency
SALP	Service d'Altimétrie et de Localisation Précise (Service for Altimetry and Precise Positioning)
SET	Single Event Transient
SEU	Single Error Upset
SPA	System Processor for ALtimetry
SSALTO	Segment Sol multi-mission ALTimétrie et Orbitographie (Multi-Mission Ground Segment for Altimetry and Orbitography, at CNES)
STILO	SSALTO DORIS control centre
SW	Software
SWD	Synchronize With Data (1553 command)
TAI	Temps Atomique International
TBC	To Be Confirmed
TBD	To Be Defined
TC	TeleCommand
TDI	Top Datation Interne (Internal Datation Pulse)



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TM	TeleMetry
USO	Ultra Stable Oscillator
UT	Unité de traitement (processing unit)
UTC	Universal Time Coordinated
WC	Worst Case

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1. PURPOSE

This document contains inputs necessary for proper operation of the DORIS Instrument on-board the Project satellite.

2. APPLICABILITY

This document applies internally in the DORIS team to the redaction of the dedicated document for different projects.

This document is applicable to DORIS/Project for launch preparation and in orbit operations.

The use of instrument during AIT phase is specified in Requirements for satellite AIT from integration to Launch Pad.

3. TERMS, DEFINITIONS

The following terms and definitions are used within this document :

DORIS Instrument

The provided material consists in the BDR (Boîtier Doris Redondé), the antenna and their RF links.

DORIS Chains

The BDR consists in 2 Chains USO-Receptor. The connectors of each chain are clearly identified on the BDR.

The inputs of one of these 2 chains are automatically connected to the antenna on a TC DORIS_ON.

Warning : the denomination “chain 1/2” (and “DORIS 1/2”) is a numbering convention used at instrument level and in this document. In the same manner, in this document EEPROMs are called “A/B”. Each chain has an EEPROM A and an EEPROM B.

Operational Limitation

Operational limitations are written against activities or conditions which are expected to cause loss of operating time or temporary loss of data.

Violation will not cause any irreversible damage nor degradation of capabilities.

Operational Constraint

An operational constraint must not be violated unless the trade-off between the activity or condition and risk is acceptable and authorised. Operational Constraints are written against activities or conditions that are expected to cause temporary degradation or disruption in the DORIS mission schedule.

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Operational Restriction

An operational restriction must not be violated. Operational Restrictions are written against activities or conditions that are expected to cause irreversible damage to DORIS.

Primary Power

Power supplied by the Electrical Power System of the satellite up to the points of conversion or conditioning within the instrument shall be defined as primary power (this includes the 28V unregulated power bus).

Secondary Power

Power isolated and converted from the primary power bus shall be defined as secondary power (BDR power feeding).

On-board second

The on-board second is defined as : $1 \text{ sec} = 10^7 / \text{FOUS sec TAI}$, where FOUS is the frequency of the DORIS USO (nominally 10 MHz).

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4. DORIS DESCRIPTION

4.1. THE DORIS SYSTEM

DORIS (Doppler Orbitography and Radio positioning Integrated by Satellite) is a tracking system developed in the early eighties by CNES, with IGN and GRGS collaboration.

This system provides range-rate signal measurements from a dense network of ground-based beacons. These data are processed on ground providing the satellite orbit with a few centimetres accuracy. They are also processed on-board to provide real time satellite positions with accuracy of a few tens of centimetres.

In addition to orbit determination, data are also used to :

- maintain a precise Terrestrial Reference Frame,
- help in the understanding of the dynamics of the solid Earth,
- monitor glaciers, landslides and volcanoes,
- improve the modelling of the Earth gravity field and of the ionosphere.

The DORIS system was originally designed to perform very precise orbit restitution of low-Earth orbiting satellites, in support of the first Poseidon oceanic altimetry experiment on-board the US TOPEX satellite, to provide an orbit altitude reference for radar altimeter data processing.

The DORIS on-board equipment is flying on the numerous Earth observation satellites, since February 1990.

The corresponding DORIS data are processed in the CNES SSALTO multi-mission centre together with altimeters data on altimetry missions. DORIS system operations including the DORIS beacon network and data processing are part of the CNES SALP project undertakings.

4.2. DORIS PRINCIPLE

DORIS is an uplink radiofrequency tracking system based on the Doppler Effect.

Every 10 seconds the receiver on-board measures the Doppler shift of radio-frequency signals continuously transmitted from two frequencies ground beacons : 2.03625 GHz for precise Doppler measurement and 401.25 MHz for propagation delay correction through the ionosphere. Both channels are also used for time-tagging measurements and auxiliary data transmission. The selection of an uplink-only system allows fully automated beacon operation and easy overall system communication links, data being centralized through the satellite and its ground segment to the DORIS data processing centre (SSALTO). This choice is allowed thanks to on board and ground beacons oscillators stability : few 10^{-13} over 10 to 1000 seconds.

The resulting radial velocity values (accuracy of the order of 0.3 mm/s) are used in combination with a dynamic model of the satellite trajectory to perform a precise orbit determination or precise ground beacons positioning.

The results accuracy depends on the orbit altitude, the satellite shape and its attitude motion.

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The time reference for the system is provided by the Time Beacons which are connected to atomic clocks. Time parameters and beacon coordinates are continuously and automatically broadcasted to on board DORIS instruments via Master Beacons.

4.3. DORIS BEACON NETWORK

The orbit determination beacons are deployed on a dense worldwide network. Installation and network maintenance is performed by IGN (French National Geographic Institute).

The DORIS beacon locations are precisely linked to an International reference frame (IERS) to get absolute positioning and long-time series.

Each beacon comprises :

- two transmitters at 2036.25 MHz and 401.25 MHz;
- an ultra-stable oscillator;
- a microprocessor performing the necessary control and management functions, time transmission, housekeeping and failure diagnosis;
- an omni-directional antenna;
- 3 meteorological sensors (for atmospheric pressure, air temperature and relative humidity, needed for the determination of atmospheric propagation delays).

Most of them are orbitography beacons. Today, the network is equipped with beacons which allows to transmit their signals on slightly shifted frequencies with respect to the nominal system frequencies, in order to avoid the Doppler collision risk occurring mostly when using DORIS system from high altitude orbits (MEO, IGSO, GEO) and allows regional number increase of DORIS beacons.

Some of these orbitography beacons are linked with atomic clocks whose time parameters are known and reliable. These beacons are called "Time beacons". They are used as time and frequency references in the system.

Moreover, some of them called "Master beacons" are the links between SSALTO and the on-board package for transmission of DORIS system information (beacon location and time information).

"Customer beacon" may be installed according to customer requirements in order to provide a precise positioning of the beacon. Those customer beacons use the result of high-precision orbit determination as input for the precise determination of the beacon ground positions.

The DORIS network comprises more than fifty beacons hosted by institutes from more than 30 different countries.



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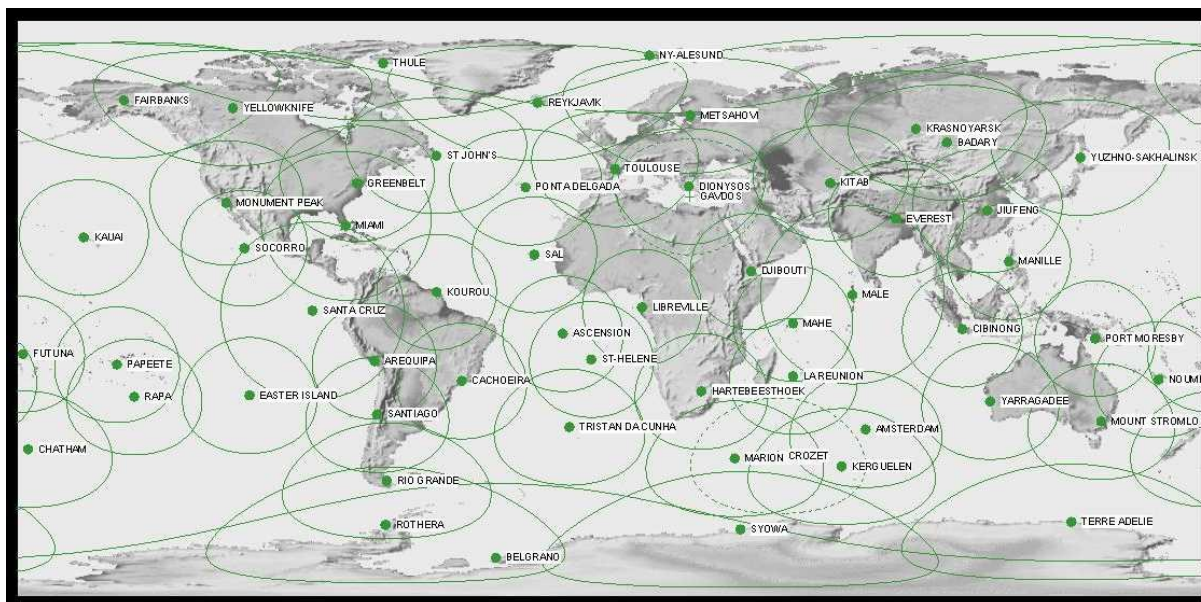
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4.4. FOCUS ON DORIS RECEIVER AUTONOMY

4.4.1. DORIS SELF-INITIALISATION (COLD START)

The DORIS self-initialisation is used in the LEOP phase or after degraded cases in order to reach a routine configuration without ground help and using only information provided by the beacon network.

Self-initialisation consists in the following successive stages :

- Synchronisation of the DORIS BDR TDi internal pulse with the beacons time scale (Si pulse). The beacons time scale is linked to the TAI scale, the sequences therefore enable BDR TDi pulse to be synchronised with the TAI scale.



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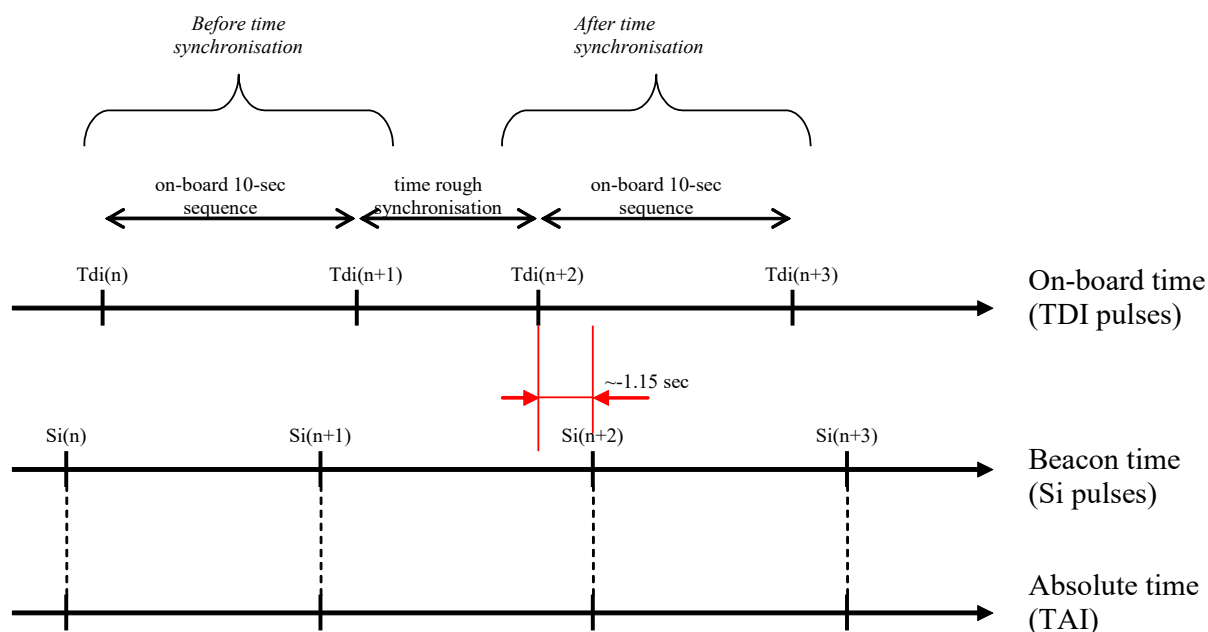
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- Acquisition of the on-board coarse (rounded to 10 seconds) TAI date from third generation beacon (before this stage, the on-board TAI date is running from a default value initiated on the 01/01/2000, 00:00:00).
- Activation of the DIODE navigation function and beginning of the DIODE self-initialisation in order to calculate initial data (positions and velocities) using DORIS measurements. This stage is achieved after the passes-over of at least four beacons, and then the acquisition of a signal transmitted from a time beacon.
- Automatic transition into nominal DORIS MEASUREMENT mode once the previous steps are successfully accomplished.

DORIS self-initialisation is possible assuming the beacon network fulfils the following conditions :

- signal transmission from at least two master beacons for the precise synchronisation of the BDR TDi pulse ; one time beacon is also needed to achieve the navigation convergence,
- signal transmission from at least one 3rd generation beacon for the acquisition of the on-board TAI date,
- signal transmission from at least one master beacon of valid "Broadcast" TCs in order to update the on-board knowledge of the beacon network table,
- signal transmission from at least four different beacons to allow first orbit determination.

The existence of two master beacons is sufficient to fulfil the first three conditions. Currently, there are 4 master beacons in the Doris beacons network, which provide a redundancy and may speed up the self-initialisation process.

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4.4.2. BEACON SIGNAL ACQUISITION

The signals transmitted from the DORIS beacon network and received by the on-board DORIS instrument, have their frequency shifted by the Doppler value.

Those Doppler frequencies depend on the radial velocity in the formula :

$$F_D/F_E = -V_r/C$$

where C is the speed of light, F_D is the Doppler frequency, F_E is the emission frequency, V_r is the radial velocity. F_D is positive at the beginning of the satellite pass.

Therefore, the radial velocity has an opposite sign compared with the Doppler frequency shift.

The DORIS instrument is able to acquire a signal coming from a DORIS beacon in two autonomous ways :

- Nominal case : DIODE navigation function is available : the DORIS instrument uses DIODE prediction in order to lock a beacon signal. Then it is able to track it all over the pass. DIODE assesses the beacon visibility from a geometrical point of view. The beacons are considered visible if their elevation angle is above a predefined value fixed in the DORIS OBSW (5 degrees). The beacon to be tracked is selected using priority criteria and pass continuity considerations.

This case corresponds to an UT MEASUREMENT mode positioned to 'DIODE'.

- Degraded case : DIODE navigation function is not available : the DORIS instrument tries to lock a beacon signal by fast spectral analysis of DORIS RF frequency ranges. The beacon to be tracked is either selected using a higher frequency criteria or by random access. The beacon locking mechanism only functions if the signal level is above -138dBm @ 400MHz and above -134dBm @ 2GHz (Input BDR receiver values). Once a signal from a DORIS beacon is locked, the DORIS instrument is able to track it all over the pass.

This case corresponds to an UT MEASUREMENT mode positioned to 'DAS'.

4.5. DORIS/PROJECT MISSION

The mission of DORIS system on Project is the following :

4.5.1. ON BOARD

- Real time orbit backup determination with respect to inertial frame for satellite orbit control.
- Real time orbit backup determination with respect to terrestrial frame for near real time products.
- Provision of the satellite with a precise 10 MHz reference signal.
- Provision of precise time reference based on international atomic time scale (TAI).
- Provision of precise geodesic data for altimeter open-loop mode.
- Provision of specific navigation data.

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4.5.2. OFF LINE ON GROUND

After storage, downlink and provision of the DORIS raw data to the SSALTO :

- Provision of Precise Orbit Determination (POD) : preliminary and precise orbit.
- Provision of DORIS auxiliary data : USO frequency determination together with the SALP auxiliary data (pole motion, solar activity, MOG2D (see SALP PDGS ICD), GIM ionospheric correction).
- Provision of RINEX files to IDS.
- Provision of on board computed auxiliary data (on-board and beacons USOs frequencies biases and drifts, pole coordinates biases and drifts).

4.6. DORIS/PROJECT SYSTEM

The following chart shows the main components of the system and the principal data exchange.



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Legend :



Component of
DORIS System



Sentinel3 System



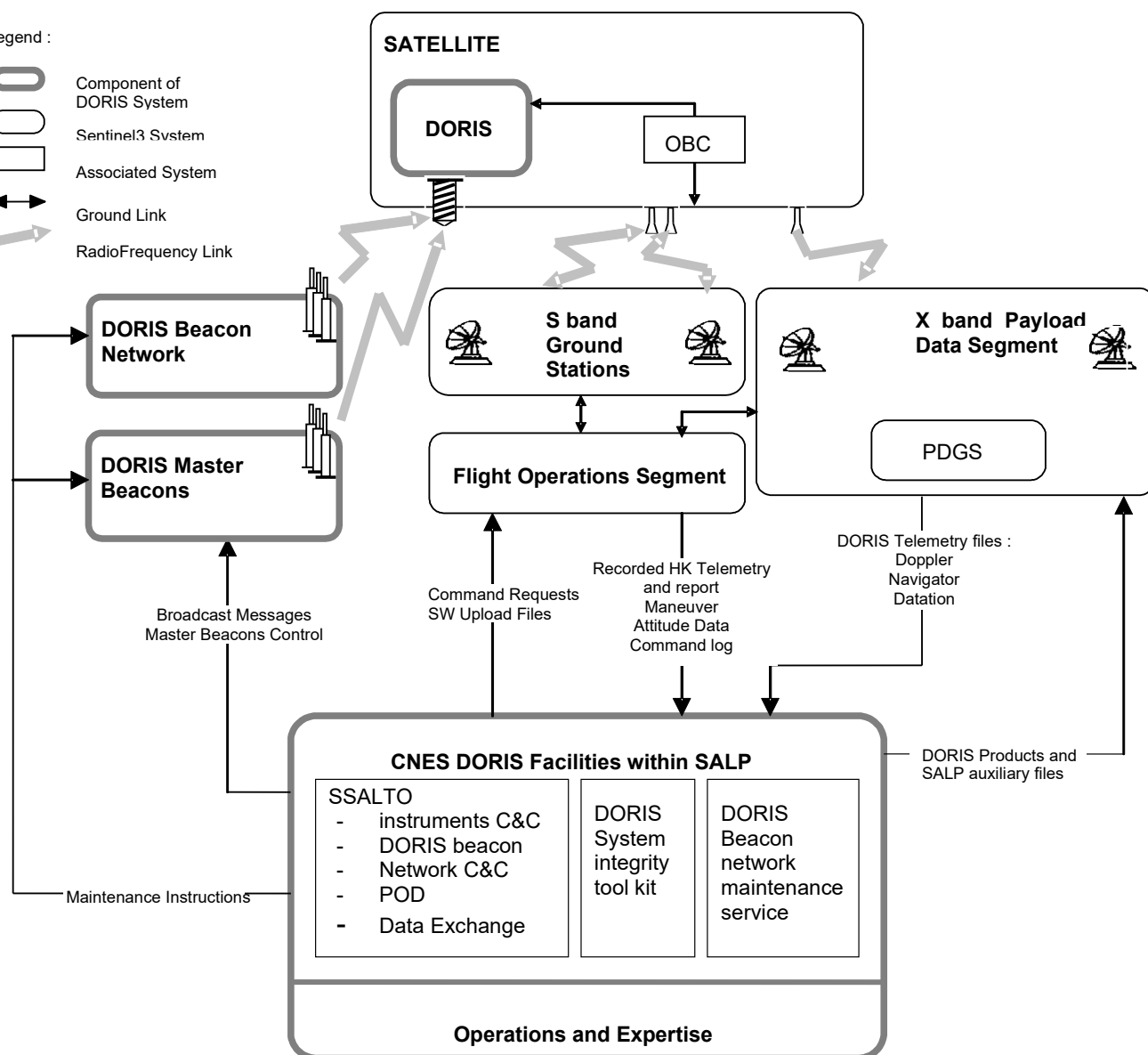
Associated System



Ground Link



RadioFrequency Link



DORIS System Architecture for PROJECT mission operations (example to be updated for the Project)

4.6.1. DORIS INSTRUMENT

The onboard DORIS Instrument comprises:

- a redundant DORIS Box (BDR) including receivers, processing units and ultra-stable crystal oscillators (USO),
- an omni-directional dual-frequency antenna.

The DORIS receivers have the capability to track simultaneously up to seven beacons. The Doppler measurements are stored and downlinked for ground processing.



DORIS BDR

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DORIS antenna

The main characteristics of the DORIS instrument are :

- High precision Doppler measurements :
 - provides elementary velocity measurements with an accuracy better than 0.3mm/s.
- Beacons tracking capability :
 - up to 7 beacons simultaneously (7 dual frequency channels).
- Autonomous operation (Switch ON and forget it !) :
 - Routine high precision measurement mode reached autonomously.
- Power supply :
 - 22 - 37V DC (objective : 42 V),
 - 23 W typical, 26 W at Warm up, less than 2 hours at 20°C, in vacuum condition, for DGXX-S,
 - 27 W typical, 37 W at Warm up, less than 2 hours at 20°C, in vacuum condition, for DGXX-SEV.
- Mechanical :
 - Mass : about 18Kg,
 - Overall dimensions about 400 x 370 x 180 (mm).
- Redundancies :
 - Cold redundancy of Receivers and clocks,
 - Automatic RF antenna switching on active receiver.
- TM/TC I/F :
 - MIL-STD-1553,
 - max TM rate < 4kbits/s (all TM activated),
 - 2 Bi-Level status per chain (power and software status).
- 10 MHz reference signal distribution :
 - 10 MHz distribution for other users (for example to the altimeter),
 - high stability,
 - monitored with an accuracy of 10^{-14} ,
 - Internally cross-strapped.
- On board time tagging capacity :
 - external pulse time tagging capacity or PPS distribution,
 - microsecond accuracy W.r.t. International Atomic Time Scale.

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4.6.2. DORIS/PROJECT GROUND SEGMENT COMPONENTS

4.6.2.1. On CNES side

Within the SALP project the main entities involved in DORIS system operations are:

- The SSALTO mission centre, and in particular three components:
 - SPA : in charge of telemetry pre-processing according to ICD's. SPA is also in charge of DORIS broadcast generation to be uploaded by the master beacons.
 - SD : in charge of the data exchange with internal and external entities.
 - OM : in charge of the precise orbit determination and auxiliary data determination.
- The DORIS beacon network operations and maintenance: operated by CNES and IGN.
- The SALP/DORIS system integrity tool box: in charge of the DORIS system integrity monitoring, operated by CNES, CLS and IGN experts at project level.
- The DORIS on board software maintenance service: in charge of the DORIS SW maintenance.

4.6.2.2. On User Project side

- The Flight Operation Segment (FOS) at FOS where the actual command and control of the DORIS instrument (including contingency operations) and the complete satellite operations will be performed.
- The Payload Data Segment (PDS), where the registered DORIS telemetry data are collected and pre-processed before being retrieved by SSALTO according to ICD's.

5. DORIS INSTRUMENT CONFIGURATION

5.1. PHYSICAL CONFIGURATION

The Doris instrument consists in :

- a Redundant Doris Box (BDR) including the USO,
- an omni directional bi-frequency antenna,
- the RF antenna-BDR link cables (400MHz and 2GHz).



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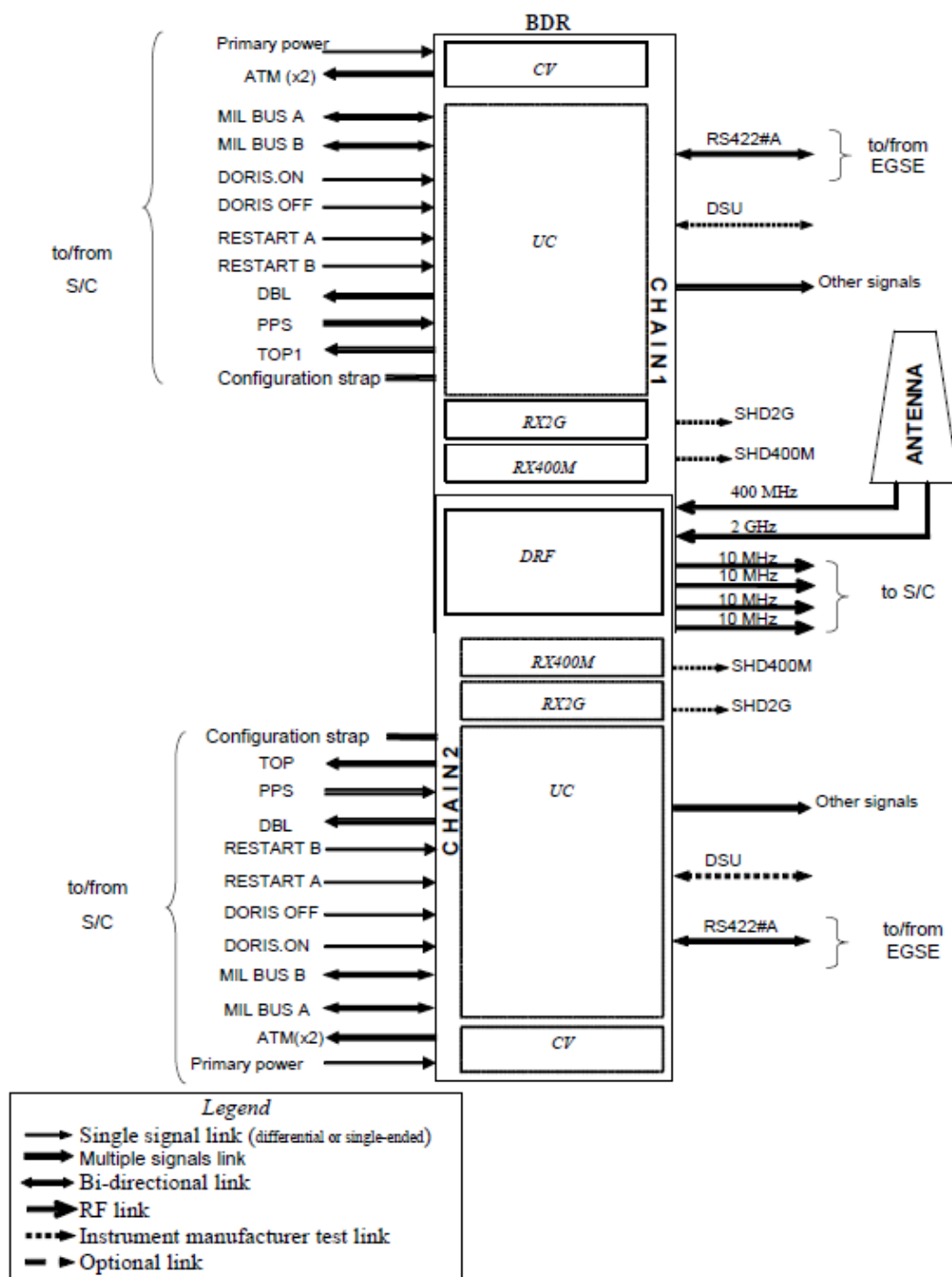


Figure 5.1- DORIS instrument general configuration

The hardware list is reported in the following table:

Name	CI	Serial number		Description
		Satellite A	Satellite B	
BDR	TBD	TBD	TBD	Redundant Doris Box
USO1	TBD	TBD	TBD	Ultra Stable Oscillator for DORIS1
USO2	TBD	TBD	TBD	Ultra Stable Oscillator for DORIS2
Antenna	1835-66	TBD	TBD	DORIS Antenna (400MHz and 2 GHz channels)

CI reports the Configuration Item Number

Table 5-1 DORIS Hardware List

5.2. REDUNDANCY

The BDR includes two identical functional chains in cold redundancy. These 2 chains use a common module (called DRF) in charge of the RF signals distribution. This module DRF contains two USO, each USO being entirely dedicated to one BDR chain (no cross-strapping between USO).

Module DRF comprises also a module which conveys the signals received by the antenna to the active BDR chain.

5.3. SOFTWARE CONFIGURATION

As the resident DORIS SW may be fully changed in EEPROM (see SW Maintenance §12.2), DORIS SW version shall be controlled according to uploaded version.

Current issue of this document is consistent with SW version reported on the front page.

5.4. FUNCTIONAL CONFIGURATION

5.4.1. FUNCTIONAL DESCRIPTION OF DORIS UNITS

The DORIS instrument consists of two redundant chains connected to an antenna.

Each ½ BDR is linked to an Ultra Stable Oscillator (USO), which provides a very stable clock (at a 10 MHz frequency) needed for the Doppler measurements. The BDR makes the 10 MHz clock available for SENTINEL3.

The BDR receives the two RF signals at 400 MHz and 2 GHz, makes measurements using Doppler techniques and computes accurate real time location of the satellite position.

The BDR is powered directly by the satellite Power Bus.

5.4.2. FUNCTIONAL BLOCK DIAGRAM

The functional configuration of the DORIS instrument and its interfaces with the platform are shown below.

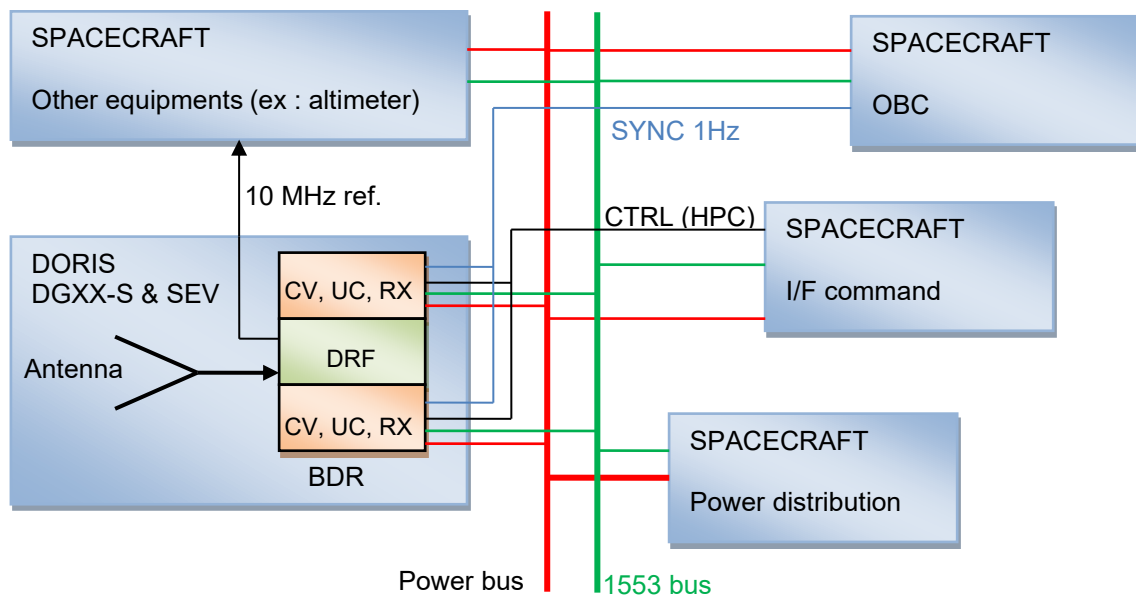


Figure 5.4 DORIS Functional Block Diagram and I/F's to platform

5.4.3. DORIS I/F WITH PLATFORM

The number of functional electrical interfaces provided by the DORIS instrument is given in the following table.
The indicated values show the number of each I/F provided by the individual DORIS units :

Electrical Interface	Signal Name	I/F code	Source	Target	Number of I/F per BDR chain
Command, Control, Status & HK	MIL BUS A and B	MIL	S/C	BDR Chain1	2
				BDR Chain 2	2
Status UC	STATUS.UC	DB	BDR Chain 1	S/C	2
			BDR Chain 2		2
Status Power	STATUS.POWER	DB	BDR Chain 1	S/C	1
			BDR Chain 2		1
DORIS ON command	DORIS.ON	HLC	S/C	BDR Chain 1	1
				BDR Chain 2	1
DORIS OFF command	DORIS.OFF	HLC	S/C	BDR Chain 1	1
				BDR Chain 2	1
1Hz synchronization signal (PPS)	PPS	PPS_PL (SBDL)	S/C	BDR Chain 1	2
				BDR Chain 2	2
1Hz pulse signal	TOP1		BDR Chain 1	Not used	0
			BDR Chain 2		0
DORIS Restart Command EEPROM A	RESTART A	LLC (SBDL)	S/C	BDR Chain 1	1
				BDR Chain 2	1
DORIS Restart Command EEPROM B	RESTART B	LLC (SBDL)	S/C	BDR Chain 1	1
				BDR Chain 2	1
BDR +5V Current Monitor	I.P5V.SAT	ANA	BDR Chain 1	S/C	1
			BDR Chain 2		1
USO +20V Current Monitor	I.OUS.SAT	ANA	BDR Chain 1	S/C	1
			BDR Chain 2		1
10 MHz reference (to satellite)	10 MHz	USO	BDR	S/C	4
Primary Power	BNR.P1 and BNR.P2	DB	S/C	BDR Chain 1	1
				BDR Chain 2	1
Thermistor I/F to BDR (pad for thermistor only)	N/A	TH	BDR Chain 1	S/C	1
			BDR Chain 2		1
Configuration strap	BDR.ADR	-	S/C	BDR Chain 1	1
				BDR Chain 2	1

Table 5.4.3—1 DORIS allocated functional electrical interfaces

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6. INSTRUMENT MODES

6.1. DORIS MODE DESCRIPTION

6.1.1. **MODE OPERATIONS SUMMARY**

Four modes are defined for DORIS : the OFF, START, AUTOINITIALISATION and MEASUREMENT modes.

6.1.2. **DORIS OFF MODE**

In this mode, all the DORIS equipment are off.

In this mode monitoring of DORIS equipment temperatures shall be insured by the OBC (see §13.1).

6.1.3. **DORIS START MODE**

This mode is a transient one from the start of the software to the AUTOINITIALISATION mode. There is no report packet generated for this mode, so this mode is never seen in operation.

During this phase, the 1553 bus coupler is not managed by DORIS OBSW, it is by default in “Master” mode and does not answer to any request that it could receive. The duration for this silent mode is less than 60 seconds.

6.1.4. **DORIS AUTOINITIALISATION MODE**

In AUTOINITIALISATION mode, a BDR chain is powered and the other BDR chain is not powered.

This is a transient mode where DORIS performs a self-test to detect any failure in the EEPROM banks and, if successful, synchronises autonomously its on-board time with the TAI time and insures the initialisation of the navigator.

In this mode, a full monitoring with associated corrective actions is ensured by the OBC (see §13.1).

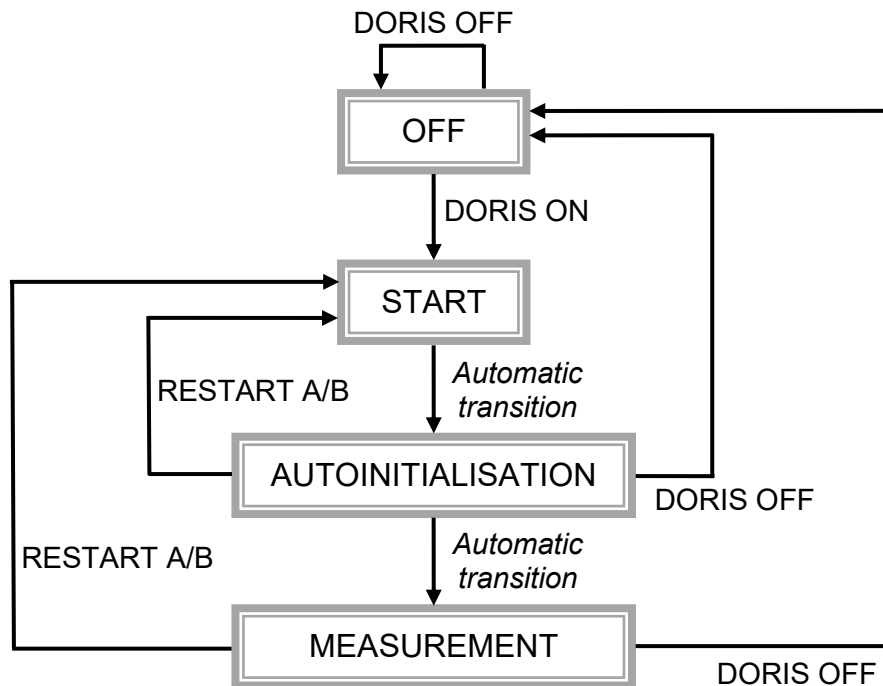
6.1.5. **DORIS MEASUREMENT MODE**

This is the nominal operational mode of DORIS where the instrument is able to fulfil its mission autonomously without receiving any TC, except Manoeuvre TCs (if relevant).

This mode allows uploading a new software version in EEPROM without interrupting the nominal mission.

In this mode, a full monitoring with associated corrective actions is ensured by the OBC (see §13.1).

6.1.6. DORIS MODE TRANSITION



6.1.6.1. Transition to DORIS OFF mode

This transition is triggered as a result of :

1. the reception into the OBC of either a DORIS chain 1 OFF or DORIS chain 2 OFF command,
2. a corrective action issued autonomously by the OBC in case of High Out Of Limit condition on a monitored parameter (temperature or current).

To perform this transition, the OBC opens the power relay of the specified DORIS chain.

The correct execution of the transition may be checked on the BDR power status.

There is no restriction to switch off the DORIS instrument however a 1 minute delay shall be applied before switching on again.

6.1.6.2. Transition to DORIS START mode

This transition is triggered as a result of the reception of either a DORIS chain 1 ON or DORIS chain 2 ON command. In this case, the BDR is switched on, and the on-board SW is transferred from EEPROM A to RAM and starts execution (transition to AUTOINITIALISATION mode).

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This transition can also be triggered by a RESTART A or RESTART B command. In this case, the BDR transfers the on-board SW from EEPROM A or EEPROM B, depending on the RESTART A or B command, starts execution.

6.1.6.3. Transition to DORIS AUTOINITIALISATION mode

This transition is triggered autonomously just after the start execution of the SW in RAM.

6.1.6.4. Transition to DORIS MEASUREMENT mode

This transition is triggered autonomously when the synchronisation of the on-board time and the autoinitialisation of the navigator have been successfully completed.

6.2. DORIS SUB-MODE DESCRIPTION

The DORIS sub-modes define the activity status of certain DORIS software functions. They are reported in the TM report packets defined in AD1.

6.2.1. UT DOPPLER MODE

The “UT Doppler” modes are autonomously managed by DORIS SW.

They are significant only when DORIS mode is AUTOINITIALISATION or MEASUREMENT.

6.2.1.1. SEQUENCE

The phase increment measurement is performed over 7 on-board seconds and starts 3 on-board seconds after the beginning of the 10 second sequence.

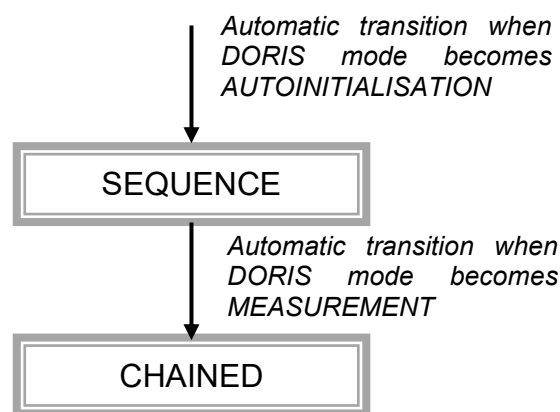
6.2.1.2. CHAINED

The phase increment measurement is performed over 10 on-board seconds and starts at the beginning of the 10 seconds sequence. This sub mode is the nominal one during DORIS MEASUREMENT mode.

6.2.1.3. UT DOPPLER mode transition diagram

The following state diagram is for each UT.

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6.2.2. UT MEASUREMENT MODES

The “UT Measurement” modes indicate for each UT how the measure is performed. These modes are : IDLE, DIODE, DAS Higher frequency, DAS Random. The UT measurement modes are autonomously managed by DORIS SW.

6.2.2.1. IDLE

No measurement is performed by the UT in this mode.

6.2.2.2. DIODE

In this mode, measurements are performed from the beacons selected by DIODE, taking into account the satellite position and the visible beacon locations.

DIODE predicts which beacon will be in visibility next and prepares itself to receive the corresponding beacon frequency (after having calculated the expected Doppler shift from that beacon).

6.2.2.3. DAS Higher frequency DASF

In this mode, DORIS instruments selects the beacons that are in both following cases:

- beacons that offer the higher frequency, based on a spectral analysis of the signals in the Doris frequency bands,
- beacon signals do not match with the beacons already tracked by any UTs in DIODE mode.

6.2.2.4. DAS Random DAST

In this mode, DORIS instruments selects the beacons randomly that are in both following cases:

- beacons that are present on a spectral analysis of the signals in the Doris frequency bands,
- beacon signals do not match with the beacons already tracked by any UTs in DIODE mode.

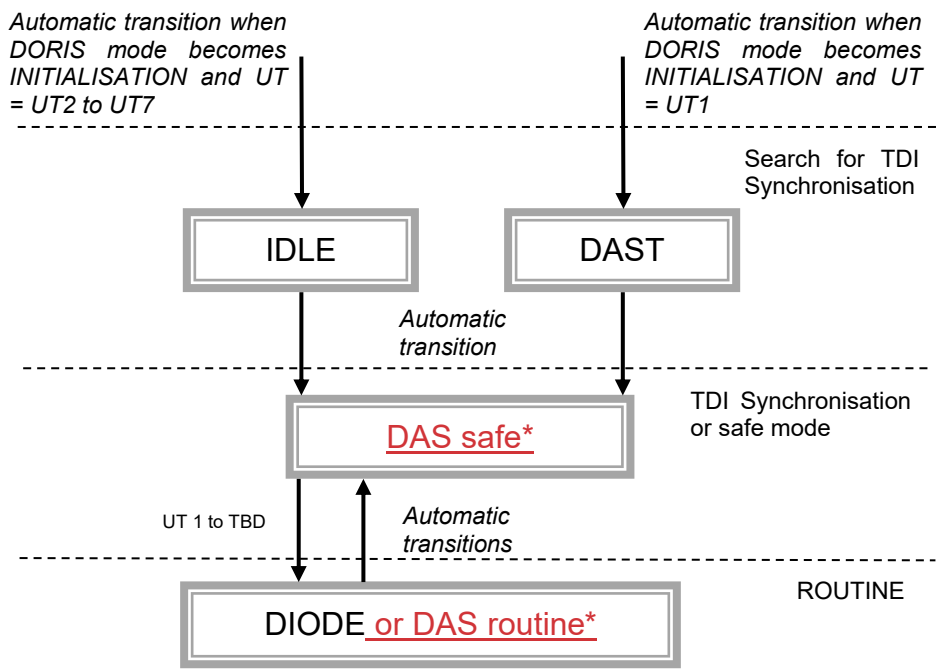
6.2.2.5. ***DAS level DASN***

In this mode, DORIS instruments selects the beacons that are in both following cases:

- beacons that offer the higher level, based on a spectral analysis of the signals in the Doris frequency bands.
- beacon signals do not match with the beacons already tracked by any UTs in DIODE mode.

6.2.2.6. ***UT MEASUREMENT mode transition diagram***

The following state diagram is for each UT.



(*) DAS safe and DAS routine are defined for each UT in the DORIS ZQS among DAS N, DAS T or DAS F.

6.2.2.7. ***UT Configuration according to the various modes***

The measurement mode is usually in a routine configuration, with UT1 to UT "n" in Diode measurement mode (Diode selects the beacons), and UT "n+1" in DAST mode, "n" defined in DORIS ZQS.

When Diode is not able any more to select the beacons, the measurement mode passes in safe configuration. Is this case, UT1 to UT7 are in DAS safe mode, as define in DORIS ZQS.

Configuration

UT Measurement mode



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ROUTINE	UT1 to UT7 : DIODE or DAS routine*
SAFE	UT1 to UT7 : DAS safe*

(*) [DAS safe](#) and [DAS routine](#) are defined for each UT in the DORIS ZQS among DAS N, DAS T or DAS F

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6.2.3. SYNCHRO MODE

This mode is nominally autonomously managed by DORIS SW.

6.2.3.1. AUTHORISED

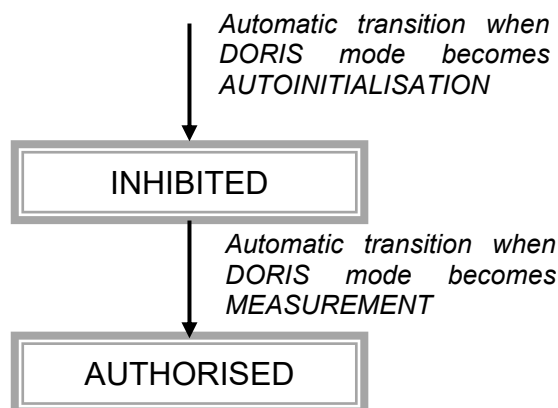
DORIS instrument is allowed to resynchronise its own measurement sequence period on the TAI at the end of each pass over a master beacon (time correction beacon). The sequence period correction is limited to a 10 milliseconds step.

This mode is the nominal one during DORIS MEASUREMENT mode.

6.2.3.2. INHIBITED

DORIS instrument is not allowed to resynchronise its own measurement sequence period.

6.2.3.3. SYNCHRO mode transition diagram



6.2.4. TAI AUTOCORRECTION MODE

This mode is nominally autonomously managed by DORIS SW.

6.2.4.1. AUTHORISED

This mode is reached when DORIS OBSW has acquired a valid TDI synchronisation from the first master beacon (time correction beacon). In this mode, DORIS is authorised to change its own equivalent TAI date (rounded to 10 s) if two different and consecutive beacons have confirmed the same error.

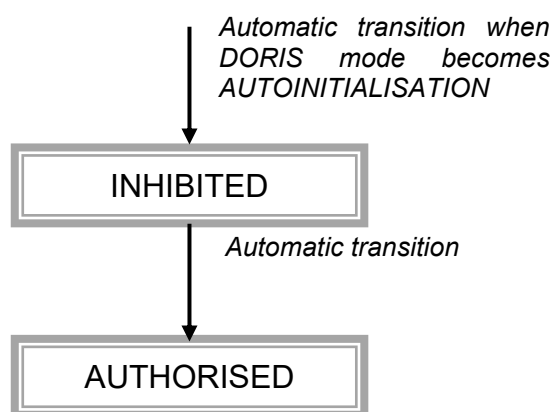
In the case where the TAI date is changed, DIODE is autonomously re-initialised. This event is reported in the TM ROUTINE REPORT packet.

6.2.4.2. INHIBITED

DORIS instrument is not allowed to change its own equivalent TAI date.

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6.2.4.3. *TAI AUTOCORRECTION mode transition diagram*



6.2.5. **UPLOAD MODE**

This mode shall be enabled only while DORIS is in MEASUREMENT mode. This mode has no impact on the mission.

6.2.5.1. **AUTHORISED**

SW Upload is enabled upon reception of the CONFIGURE DORIS TC ARM, see AD1.

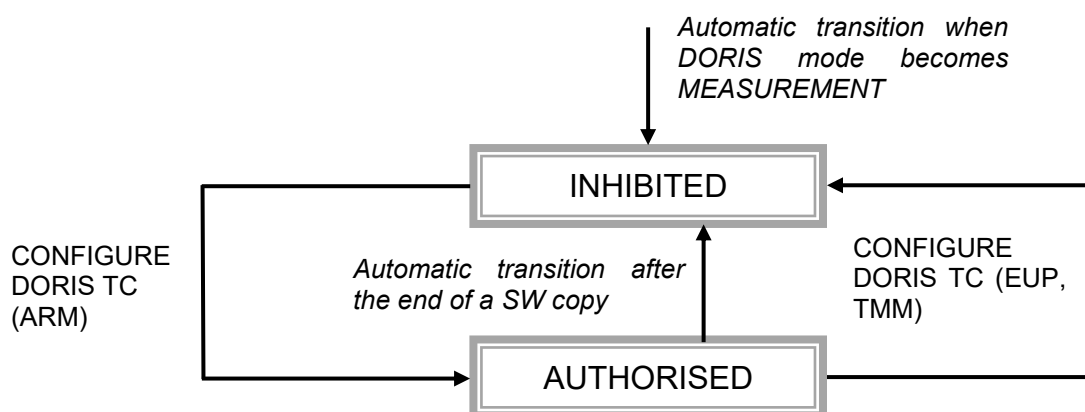
See EEPROMs management in § 12.2 ("SW Maintenance").

6.2.5.2. **INHIBITED**

SW upload is disabled either upon reception of the CONFIGURE DORIS TC EUP, see AD 1, or autonomously at the end of a SW copy from one EEPROM bank to the other one, see TMM TC in AD 1.

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6.2.5.3. **UPLOAD mode transition diagram**



6.2.6. **DIODE MODE**

It is nominally autonomously managed by DORIS SW.

6.2.6.1. **IDLE**

This mode is a transitory mode : it occurs just after a serious anomaly from DIODE, and lasts for 1 sequence.

6.2.6.2. **AUTOINIT**

DIODE is in this mode in the following cases :

1. Just after instrument auto-initialisation following a DORIS ON or RESTART TC.
2. Following a change of DORIS equivalent TAI date, see TAI AUTOCORRECTION mode.
3. In case of divergence.
It is important to note that in such a case, no ground action is required. DIODE will re-converge in an autonomous way.

DORIS starts from a "lost in space" status and tries to predict a first orbit (position and velocity) of the satellite with a rough accuracy using DORIS measurements. In a typical situation, four different passes over beacons are required to achieve this first orbit estimation, which typically lasts for less than 1 hour.

6.2.6.3. **RECOVER**

This mode is entered autonomously in the following cases :

1. after AUTOINIT mode (because computed initial bulletin fits with an internal date which is different to the current date),
In this case, this mode only lasts typically 10 seconds (1 sequence).
2. after a DIODE anomaly.

This RECOVER mode will last until recovering the actual date.

6.2.6.4. ROUTINE

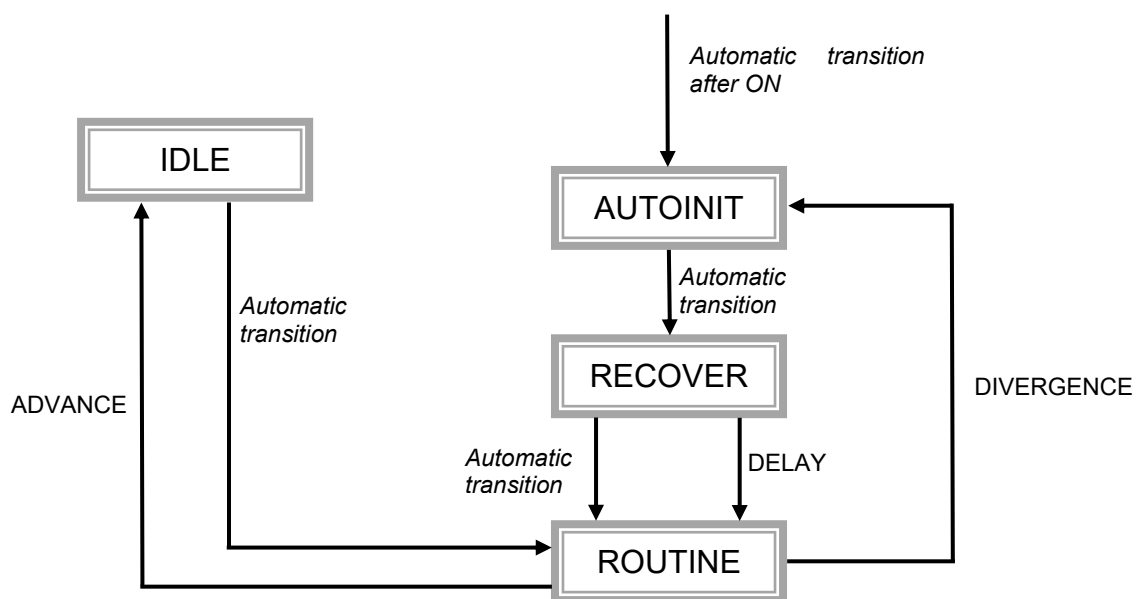
This mode is entered autonomously after RECOVER mode.

In this mode, DIODE SW combines its own extrapolator and the measurements given by DORIS SW (if any) in order to calculate a precise bulletin every ten seconds.

A quality index provided by DIODE gives a good idea of the accuracy of the computed satellite position. When the quality index is under a certain threshold (parameter typically equal to 200 m), DIODE tells DORIS SW that it is confident enough to indicate which beacon to track (and with which corresponding frequency). From this stage, DORIS switches DORIS mode to MEASUREMENT.

During the routine period, DIODE calculates also the precise synchronisation between TAI ground date and TAI on-board date.

6.2.6.5. DIODE mode transition diagram



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7. PERFORMANCES

This chapter reports the main performance requirements/objectives of DORIS at system level.

7.1. PRECISE ORBIT DETERMINATION ON GROUND

Slow time critical :

- objective position on the radial component < TBD cm rms
- required position on the radial component < TBD cm rms

Non time critical :

- objective position on the radial component < TBD cm rms
- required position on the radial component < TBD cm rms

7.2. ON-BOARD ORBIT DETERMINATION REQUIREMENTS

The performance is expressed with respect to ITRF and J2000 reference frames.

7.2.1. ITRF REFERENCE FRAME

The typical figures expected on the Doris Project missions are :

- TBD rms (3 axis-position)
- TBD rms (radial component)

7.2.2. J2000 REFERENCE FRAME

- position on each component < TBD m max

7.2.3. ON-BOARD DATATION

Datation accuracy within the datation packet shall be less than TBD microsec rms.

7.3. DOPPLER MEASUREMENT PERFORMANCE

The following values are expressed in Picinbono variance over 30 triplets.

- Doppler measurement elementary performance shall be better than 0.3 mm/s rms (equivalent to 2 mHz at 2 GHz)
- Pseudo range measurement elementary performance shall be better than 7 μ s on the 400 MHz channel.

7.4. USO STABILITY PERFORMANCE

Due to mechanical relaxation during the warm-up of the DORIS USO, the USO stability performance is changing drastically specially during the first hours of function.

Hereafter some typical figures are given to assess the expected USO performance reliability:

Activation time	$\Delta f/f$ (Short term Stability indicator)
30 mn	10^{-9}
3 h	10^{-12}

Those figures are representative for the DORIS USO during its life expectancy period (See § 8.4.10).

7.5. DORIS SELF INITIALISATION

Depending on the position of the satellite with respect to the DORIS Beacon Network and assuming the satellite is earth pointed, the navigation and datation data may be used after typically 6 hours of initialisation.

7.6. RECOMMENDATIONS ABOUT DORIS NAVIGATION DATA USAGE WITHIN AOCS

Within Satellite AOCS (if used), it is recommended to start using navigation data provided by DORIS only once the navigation quality index has decreased below 100 meters and not to use DORIS data when this navigation quality index is equal to the maximum value (0xFFFF FFFF).

In case of an index equal to 0xFFFF FFFF it is recommended to extrapolate from the last valid navigation packet.

Nota : the DORIS quality index has been designed and validated to be reliable in having a value always bigger than the 3D-error made by the navigation function.

7.7. RECOMMENDATIONS ABOUT DORIS DATATION DATA USAGE

It is recommended to use DORIS datation as soon as the quality index is below 15 ms.

8. OPERATIONS AND CONSTRAINTS

All AIT testing constraints and limitations are described in the document Requirements for satellite AIT from integration to Launch Pad.

8.1. COMMISSIONING AND ROUTINE OPERATIONS FOR DORIS INSTRUMENT

All operations concerning the DORIS instrument are conducted by ESOC and EUMETSAT.

After the satellite launch, there are 2 main phases : the Commissioning and the Routine phases (Figure 8.1-1). The commissioning phase consists in 2 sub-phases: the In-orbit checkout sub-phase and the Performance Verification and POD Parameters Tuning sub-phase.

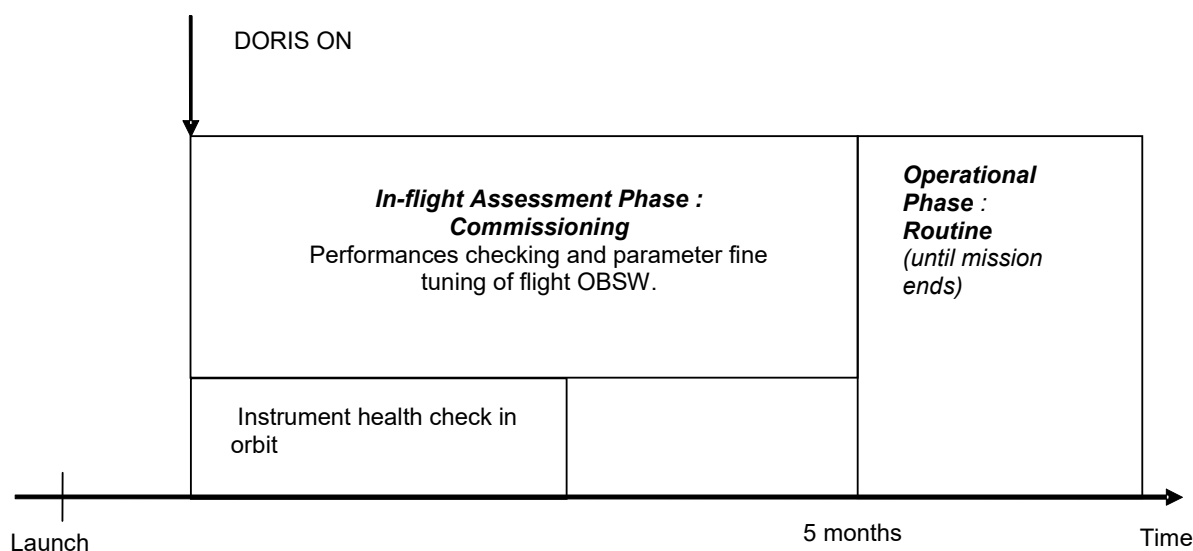


Figure 8.1-1 DORIS Operational phases

The commissioning phase of DORIS is intended to last 5 months ; it will start at DORIS power on and will be made of two parts.

The first period will be dedicated to instrument flight acceptance and to validate the processing algorithms and DORIS products.

During the second part of the commissioning phase, the performances of the DORIS system will be checked against specifications, and the POD parameters will be tuned.

The Routine phase begins at the end of the Commissioning phase. During this phase, preliminary Orbit and Precise Orbit will be determined and validated by SSALTO/POD and then, transmitted to the satellite ground segment if necessary.

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8.2. [LAUNCH, INITIAL SWITCH-ON AND IN-ORBIT CHECK OUT](#)

8.2.1. LAUNCH CAMPAIGN

8.2.1.1. *Red Tag Item List*

The following items of the DORIS Instrument shall be removed before launch :

- antenna test cap,
- handling devices of the BDR.

8.2.1.2. *Green Tag Item List*

Some items are already installed and glued before flight equipment delivery :

- one connector cap on the skin test connector DAM 15P connected to the J2 connector of the BDR chain 1 (test manufacturer),
- one connector cap on the skin test connector DAM 15P connected to the J2 connector of the BDR chain 2 (test manufacturer),
- one 50 ohms load on each SMA connectors J45, J55 of the BDR (4 for both chains).

The following items of the DORIS Instrument shall be installed before launch :

- one connector cap on the skin test connector DAM 15P connected to the J7 connector of the BDR chain 1 (test TM/TC RS422#A),
- one connector cap on the skin test connector DAM 15P connected to the J7 connector of the BDR chain 2 (test TM/TC RS422#A)
- *one 50 ohms load on each 10MHz unused output J20, J21, J22, J23*

8.2.1.3. *Sun trapping and antenna foot MLI*

Special care shall be taken to avoid sun trapping at the antenna foot area to avoid any overheating. This means that MLI shall be compliant with ICD (ref AD) and installed as specified in antenna integration procedure. MLI may be finalized with kapton tape if necessary. In order to avoid any impact on antenna radiation, MLI shall not exceed the base of antenna radiating elements.

A schematic showing how to install the MLI on the antenna foot and pictures from previous antennas mounted on satellites are presented in ANNEX C : Recommendations for the MLI on the antenna.

Pictures of antenna foot will be taken at final step of satellite integration for DORIS team approval.

8.2.2. LAUNCH PHASE

8.2.2.1. *DORIS Launch Phase*

During launch phase, DORIS shall be in OFF mode.

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No special sequence is defined for DORIS during this phase.

No constraints are defined for DORIS except to keep the instrument within the survival temperatures.

8.2.2.2. DORIS Initial Switch-On Phase

No special sequences are defined for DORIS during this phase. For DORIS switch on, see following procedures chapter.

No specific constraints are defined for DORIS except to keep the instrument within the survival temperatures.

It is recommended to switch DORIS ON as soon as possible according to power availability from Satellite : this will allow a fast stabilization of the USO clock, thus increasing the data quality of the altimeter.

8.2.3. INSTRUMENT HEALTH CHECK IN-ORBIT PHASE

A special commanding sequence, defined by CNES, will be used during this phase.

No constraints are defined for DORIS except to keep the instrument within the survival temperatures.

8.3. OPERATIONS AND CONSTRAINTS FOR GROUND INITIATED RECONFIGURATIONS

CONFIGURE DORIS TCs are used to change the DORIS internal modes (see § 14 “Procedures” for use of this command).

UPLOAD PARAMETERS TCs are used to change the on-board software parameters. *[If relevant] Manoeuvre characteristics TC and Killer TC (which is used to delete the manoeuvre characteristics) are under SCC responsibility.*

UPLOAD MEMORY TCs are used to change a block of data or full software at specified addresses on the on-board memory. The new software will be provided by CNES to ESA (see § 14 “Procedures” for use of this command).

8.4. GENERAL RESTRICTIONS, CONSTRAINTS AND LIMITATIONS

8.4.1. GENERAL RESTRICTIONS

DORIS can survive in any situation except if temperature and current are above the survival thresholds. In order to avoid such a situation, these parameters shall be monitored and, in case of out of limit condition, an appropriate corrective action shall be executed (See § 11 “TM Description” for more details).

In addition, the full SW upload is a critical operation which can lead to one of DORIS chain loss. Special attention shall be taken in order to ensure proper operation : a verification of the SW shall be done in the uploaded EEPROM before copying in the other EEPROM (See § 12.2 “SW Maintenance” for more details).

8.4.2. GENERAL CONSTRAINTS

- 1) The DORIS instrument shall remain powered at all times according to Satellite flight policy. In case of power off, the performance of the precise orbit determination will not be guaranteed during the following few days. This is due to a poor USO frequency stability linked to power interruption.

- 2) The DORIS navigation performance cannot be guaranteed in case of satellite manoeuvre and if Doris has not received the corresponding manoeuvre characteristics information. In order to prevent possible DORIS navigator divergence, the characteristics of any foreseen manoeuvre shall be uploaded into DORIS at least 1 minute before the manoeuvre start and assuming DIODE mode is ROUTINE (See the Upload Parameter TC with "Manoeuvre Characteristics"). If the uploaded manoeuvre TC characteristics are representative of the real one, the real time performances will remain nominal during the manoeuvre. This will be verified during commissioning phase.
- 3) The full DORIS performance is not guaranteed when the instrument temperature stands outside the boundaries allowed for operations (see § 8.4.6 "Thermal constraints and restrictions").

Others specific constraints are outlined in annex "Detailed Procedures".

8.4.3. GENERAL LIMITATIONS

- 1) In case of PPS loss for more than 10 seconds, it may be possible that the 11 following datation packets have incorrect time information not reported by the Quality Index.
- 2) In case of bus controller malfunction, only a few packets of DORIS telemetry will be stored in DORIS internal buffers (see § 15.8).
- 3) The OBSW upload during DORIS autoinitialisation phase (DORIS mode = AutoInit) is prohibited. Some operations performed by the computer in this phase are heavy in terms of calculation, as is the upload of a new OBSW. Therefore, an overflowing CPU risk exists in case of trying to carry both tasks at the same time, leading the OBSW to restart automatically. The full SW upload is only allowed when Doris is in Measurement Mode.

8.4.4. SHOCK LIMITS

The Table 8.4—1 presents for the BDR the various shock limits, which apply for an operational restriction, constraint or limitation.

Frequency	Level
100 Hz	40 g
2000 Hz	800 g
10000 Hz	800 g

Table 8.4—1 DORIS Shock Limits

8.4.5. MICRO VIBRATION CONSTRAINTS

The DORIS USO is sensitive in some frequency ranges. At all time, the micro vibration level at the BDR interface shall be less than the levels specified in the following table to sustain the DORIS nominal performances.

Level	Frequency range
0.1 m/s ² peak to peak	500 - 600 Hz
0.1 m/s ² peak to peak	1 kHz - 2 kHz

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0.1 m/s ² peak to peak	3 kHz - 4 kHz
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8.4.6. THERMAL CONSTRAINTS AND RESTRICTIONS

The temperature limits (in °C) for each DORIS unit are defined in Table 8.4-2. These temperature limits are applicable for in-flight operations of the instrument.

UNIT	Chain powered				Chain non powered		SWITCH-ON
	(performances guaranteed)		(performances not guaranteed)				
	MIN	MAX	MIN	MAX	MIN	MAX	MIN
BDR	-15	+40	-20	+60	-40	+65	-20
Antenna	-120	+100	-120	+100	-120	+100	N/A

Table 8.4—2 DORIS thermal limits (in °C)

8.4.7. SUN ILLUMINATION

No specific operational restriction regarding DORIS sun illumination has been identified except sun trapping on the antenna foot (see §8.2.1.3).

8.4.8. OUT-GASSING

No specific operational restriction regarding the DORIS out-gassing has been identified.

8.4.9. CONTAMINATION

USOs included in the BDR are sensitive to helium.

For DGXX and DGXX-S generation (using OUS version NG with Dewar glass) :
BDR shall not be exposed to Helium with a pressure higher than 10mbar in case of environment containing only Helium or containing more than 1% in volume mixed with any other gas (partial pressure 10 mBar at ambient pressure).

For DGXX-SEV generation (using OUS version RK410) :
BDR shall not be exposed to Helium gazing at pressure above 1 bar and during more than 2 hours.

In case of accidental exposure, TAS will have to warn CNES and a DORIS performance test will have to be done to verify the USO integrity.

8.4.10. LIFE LIMITED ITEMS

Relays actuation and EEPROM upload shall be limited as follow :

- DORIS ON/OFF actuation is limited 500 cycles. 1 cycle = 1 OFF + 1 ON (due to USO constraint to guarantee the 10 MHz stability requirement of $\Delta F/F = 2 \cdot 10^{-7}$).
- Software uploading in EEPROM is limited for each of the two banks to 10000 cycles for each chain.

These values are largely above typical values encountered during a nominal DORIS mission.

8.4.11. FIELDS OF VIEW

DORIS antenna has a usable field of view of 125° (62.5° apex angle from the antenna Z axis, 360° circular).

8.4.12. MAGNETIC CLEANLINESS

The constraints linked to the magnetic induction are given in the following table:

Maximum permanent induction (terrestrial field + magnetic field caused by the platform)	5 Gauss
Maximum variation for each axis	+/- 1 Gauss
Maximum slope for each axis	+/- 0.5 Gauss/min over 15min

Table 8.4—3 DORIS Magnetic Cleanliness

The BDR will operate correctly even submitted to a magnetic field up to 1 Gauss sine wave from DC to 10 Hz and is compliant to MIL-STD-462 RS01 up to 120 dBpT from 30 Hz to 50 kHz.

8.4.13. RADIO-FREQUENCY INTERFACES

The beacon signals received by the DORIS antenna on the satellite have the following characteristics :

PARAMETERS	400 MHz LINK	2 GHz LINK
Central frequency	401.25 MHz	2036.25 MHz
Doppler + possible beacon shift	± 18 kHz	± 90 kHz
Modulation	200 bit/s	200 bit/s
Maximum flux received	- 110 dBW/m ²	- 110 dBW/m ²
Receiving band	40 kHz	200 kHz

At the RF input interface for the BDR unit, there shall be no narrow band jammers coming from the satellite or from its TC channel with a level greater than :

- -132 dBm in the 401.25 MHz $\pm$ 50 kHz bandwidth,
- -92 dBm in the 401.25 MHz $\pm$ 1 MHz bandwidth,
- -138 dBm in the 2036.25 MHz $\pm$ 200 kHz bandwidth,
- -98 dBm in the 2036.25 MHz $\pm$ 1 MHz bandwidth,
- -50 dBm elsewhere, (-30 dBm may be accepted after verification by tests on specific frequencies ranges specified by SL prime),

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A maximum of - 15 dBm for all frequencies is imperative, no matter what the satellite's environment, to avoid any irreversible damage.

As far as wide band spurious signals are concerned, the power levels integrated in 25 Hz shall be 13 dB less than these values for the 400 MHz channel and 17 dB for the 2 GHz channel.

8.4.14. REDUNDANT CHAIN POWER ON CONSTRAINT

Simultaneous power ON of both DORIS chains shall be forbidden due to the possibility of strong performance degradation. However, shall this event occur due to wrong operation, bug or SEU, no reliability on life time impact is expected.

8.4.15. LIMITATION ON UPLOAD PARAMETERS TCs

Due to the size of the DORIS buffer, where time tagged Upload Parameter TCs are stored, the number of the TCs (waiting for execution time) shall be limited to 20.

If this limit is exceeded, the latest-in-the-future time tagged TCs are discarded. This is reported in a Routine Report "Software Report" with the Software Report Id field set to 9 ("Buffer TCHD full").

As a result, at the beginning of the DORIS initialisation phase (current date not acquired yet), the DORIS instrument receives from the master beacons several Upload Parameters TCs (2 per 10 seconds) which are stored in the buffer. As this TCs are not processed (execution date in the future), the buffer is saturated after a few sequences, which leads to some TC rejections and Routine Reports "Software Report" with the Software Report Id field set to 9.

Moreover, in routine mission, 2 TCs (whose date is in the past, and which are immediately processed) are typically in the buffer during each pass over a master beacon, which let available room for 18 TCs coming from satellite control centre.

8.4.16. EEPROM RE-WRITE

In order to avoid problems in reading EEPROMS (in case of possible RESTART), it is recommended to re-write all EEPROMS every 10 years.

Before the flight, writing all EEPROMS should be done as late as possible before the launch.

In case of switching to redundant chain or DORIS switch OFF, rewrite of both nominal and redundant EEPROMs should be done.

Three procedures are given in this purpose :

PROC1 : DORIS_SW_COPY (see § ANNEX A: DETAILED PROCEDURES) : Re-write of redundant EEPROM in the nominal chain : very simple operations.

PROC2 : Re-write of nominal EEPROM in the nominal chain : requires a RESTART, and then operate PROC 1.

PROC3 : Re-write of both EEPROM in the redundant chain : complex operation requiring to switch on the redundant chain, then PROC 1 and PROC2.

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8.4.17. VENTING HOLES

Three decompression holes are positioned on the DORIS BDR in the front face :

- approximate diameter : 3 mm
- location : 3 holes on the centre of each side of the DRF module, between the notation 'chain1' and 'chain2'

Special attention should be taken not to tape those holes.

8.4.18. TIGHTENING OF THE ANTENNA FASTENERS

The DORIS antenna is fixed on the mechanical structure using bolts, contact washers and DELRIN washers. Due to the mechanical properties of the DELRIN material, the lesson learned from previous project is that the final torque is achieved after several tightening.

An example of procedure is given hereafter:

T0: 1st tightening to nominal torque

T0+30minutes: 2nd tightening to nominal torque

T0+24h: 3rd tightening to nominal torque

If the fasteners rotated during the last torque tightening, then the fasteners will need to be re-torqued at 24 hour increments.

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9. DEGRADED CASES

Are listed thereafter the non-availability, the non-integrity or non-conformity cases (to a specification or to an expected behaviour) of DORIS data not in an exhaustive manner but rather from a return of experience point of view. This table is coming from the 20 years' experience on DORIS instruments and from system problem troubleshooting (beacon network problems, command-control problem, satellite issue ...). It has been considered that DORIS data would stand for all telemetry data packet types emitted by the DORIS DGXX-S instrument.

The electric failures of the satellite that could induce DORIS status unavailability are not covered in this chapter.

The following naming convention would apply for this table:

- Nav : Navigation packets,
- Dat : Datation packets,
- Dop : Doppler packets.



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N°	Triggering event	Instrument impact	Failure evidence	<u>Corrective action</u>
1.	RESTART unexpected	TM1553 unavailability during restart and OBSW autotest phase (< 1 min) Nav emission from the start (after the restart and OBSW autotest phase) Dat and Nav emission with high values in quality indexes	+ No 1553 TM emission during the re initialisation phase + STATUS.UC set to '1' (during < 60 sec) + Routine Report emission (with DORIS mode change to AutoInit) + Quality Index set to 'FFFF FFFF' for Dat and Nav + date TAI set back to 01/01/2000 date in 1553 TM	After three unexpected restart, execute a restart on the non-active EEP. If another unexpected restart appears, switch OFF nominal chain and switch ON redundant one
2.	Software RESET following an hardware breakdown (double failure, EDAC,...) or following a software bug (ADA exception propagated to main execution loop, µP RESET, etc ...)	Idem 1.	Idem 1. + In the first Routine Report packet following the RESTART the field « MVR Status » encodes an Restart A (resp. B) : bits MS1 set to 01 (resp. 10) * By software : MS2 set to 1 and MS3 set to 0 * By watchdog : MS2 set to 0 and MS3 set to 1	No action at the first occurrence. Idem 1.
3.	Simultaneous RESTART triggered by platform (RESTART A and RESTART B)	Idem 1. No instrument damage (the A or B restart mode depends on pulse phase)	Idem 1. + In the first Routine Report packet following the RESTART the field « MVR Status » encodes the origin bank copied in RAM and then executed (bit MS1 set to '01' for bank A and '10' for bank B)	No action.



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N°	Triggering event	Instrument impact	Failure evidence	<u>Corrective action</u>
4.	PPS duration less than 332 ns	No Dat emitted on the PPS	No Dat on 1553 TM	Ask if it is possible to get another PPS and switch to redundant chain if necessary.
5.	Simultaneous PPS separated by more than 83 ns within the same second	Several Dat can be emitted within the same second	Several Dat may be recuperated on the 1553 bus within the same second	Analyse impact of SALP product. Decide with the project if it is possible to get another PPS and switch to redundant chain if necessary.
6.	Short-circuit TRUE and COMP of the RESTART and threshold triggers on '0' on 26C32 receptor < 20 mV	Permanent reset of UC card → μP in HALT mode	+ No answer to the DORIS sub address on 1553 bus: no DORIS TM recuperation. + STATUS.UC set to '1' permanently	Switch OFF nominal chain and switch ON redundant one
7.	No PPS pulse	- Unless PPS pulse : No Dat, - If missing for more than 10s : Dat non integrity during several seconds (max 10s) when PPS pulse reappears	No Dat	Idem 4.



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N°	Triggering event	Instrument impact	Failure evidence	<u>Corrective action</u>
8.	No TM recuperation on 1553 bus	Buffer Overflow risk → Older packets loss + Anomaly Report emission (in case of buffer overflow)	Anomaly Report reported in the TM, when 1553 recuperation restarts nominally, if buffer overflow during the service interruption.	Ask if 1553 bus works nominally with other instruments. If yes, ask if altimeter receive Doris navigation packet. If yes, wait and analyse; - if not, execute a restart on the non-active EEP (ZQS up to date) - if no effect, execute a SWITCH-OFF/SWITCH-ON. - if no effect, switch on redundant chain.
9.	Incomplete TM packet recuperation on the 1553 with correct acknowledgement (Status Word OK)	Lost packet + 'Software Report' Routine Report Packet emission with Event_ID = 3	One 'Software Report' Routine Report Packet with Event_ID = 3 is fetched	Compare band S and band X data (reports). Ask if a similar problem is encountered on other instruments.
10.	Fix frequency jammer discovered on board the satellite	No Doppler measurement within the jammed range – permanently or not. Possible side effect : Dat and Nav quality deterioration.	Visible deterioration of Dat and Nav quality indexes.	Check with satellite experts if something could be done.



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N°	Triggering event	Instrument impact	Failure evidence	<u>Corrective action</u>
<u>11.</u>	Upload Parameter Stack overflow following the sending of more than 20 Upload Parameters TC with an execution date in the future	+ Loss of the Upload Parameter TC whose execution date is the furthest in the future + Routine Report Packet emission of type 'Software report' with Event_ID = 3 and DORIS Software report field = 9	Reception of a 'Software report' Routine Report Packet with Event_ID = 3 and DORIS Software report field = 9 (Remark : During Instrument AutoInitialisation phase, it is possible to receive Routine Report Packets of this type without reporting any malfunction).	<u>No action.</u> <u>Recommendation for operation : verify that there is no more than 15 Upload Parameter TCs time tagged in the future.</u>
<u>12.</u>	Ground segment wrong TC sending	+ Possible side effect : Dat and Nav quality deterioration + Dop packet number reduction	Visible deterioration of Dat and Nav quality indexes	<u>Satellite Control Center has to discuss with Doris expert to analyze the situation and send eventually a corrective TC.</u>
<u>13.</u>	TC content deterioration received onboard (TC non-compliant with the DORIS TM/TC Packets definition)	1. No effect (unexpected TC behaviour) 2. Emission of a Routine Report Packet of Software Report type 3. TC Rejection with one Anomaly Report Packet emission	1. No effect (unexpected TC behaviour) 2. Reception of a Routine Report Packet of Software Report type 3. Anomaly Report Packet reception	<u>Satellite Control Center has to discuss with Doris expert to analyze the situation and to provide the content of the TC sent</u>
<u>14.</u>	DORIS use of non-compliant beacons	Nav, Dop and Dat deterioration going up to TAI date reinitialisation and/or DIODE reinitialisation.	Deterioration of all quality indexes	<u>Doris expert to analyze root cause. No action.</u>



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N°	Triggering event	Instrument impact	Failure evidence	<u>Corrective action</u>
15.	Logical components upset (the double failure EDAC has been already treated in 2.)	+ Deterioration, non-integrity or TM unavailability + To limit the apparition of such an upset, several measures have been taken : EDAC use for the μ P RAM, hardened compounds use for TETRA ASIC, scrubbing cyclic process addition for microcode TETRA ASIC RAM...	TM content non integrity, deterioration or TM unavailability Remark : False alarm risk urges to confirm the problem detection before any action could be carried out.	Doris expert to analyze root cause. Satellite Control Center has to discuss with Doris expert: Restart on the same bank Restart on the other bank Restart on the redundant chain
16.	UPSET in analogic components	+ Deterioration, non-integrity or TM unavailability + To limit the apparition of such an upset, robustness has been added for specific TC (RESTART and PPS management)	Idem 15.	Idem 15.
17.	Wrong Date in SC_TIME TC	+ Incorrect date is copied in the 1553 TM headers + No date control for this date by DORIS	Detection by Doris Integrity survey tool	Doris expert to analyze root cause. No action.
18.	Incorrect TC Attitude content	Precision Deterioration for Nav (N/A Sentinel3)	Visible deterioration of Nav quality indexes (N/A Sentinel3)	Doris expert to analyze root cause. No action.
19.	Incorrect TC length (on board TC or ground TC)	TC rejection by bus 1553 controller : SWD (Synchronise With Data) « MESSAGE ERROR » bit set to '1'	1553 fetch of a 'Synchronise With Data' packet with the « MESSAGE ERROR » bit set to '1'	To discuss with Satellite Control Center to send eventually a corrective TC.
20.	Doris reception deterioration	Mission potential deterioration	Visible decrease of expected reception power (on one or both frequencies)	Doris expert to analyze root cause. No action. In AIT, check the RF cables

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N°	Triggering event	Instrument impact	Failure evidence	<u>Corrective action</u>
21.	Antenna switch failure (DRF level)	Either loss of one of the two chain or complete loss of the instrument	No Dop presence	Use the working chain
22.	Failure of one of both EEPROM bank (UC level)	- If 1 bank only impacted : redundancy loss at EEPROM level - If both banks impacted : complete chain loss	Idem 1. periodically (Impossibility of copy impacted bank copy in RAM for execution purpose). If 1 bank only is impacted, a simple RESTART command sending will manage to restart the LV program properly from the left bank.	Doris expert to analyze root cause.
23.	µP failure (UC level)	Worst case : complete chain loss	Idem 6.	Idem 6.

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10. COMMAND AND CONTROL

This chapter describes the means to control the DORIS instrument.

The DORIS instrument is a “packet terminal” instrument type as far as TM is concerned. Its TM is conform with CCSDS packet standards (cf. AD 1)

Nominally, DORIS instrument only requires a Switch ON Command and TC Manoeuvres if relevant. Its internal status handling is completely autonomous and the pieces of information needed on the active beacon network are radio broadcasted by the master beacons from the ground.

In case of system trapping, a discrete “Restart” command can be issued to restart the OBSW either from the EEPROM bank A or B (EEPROM banks are redundant in each of both chain).

The OBSW can be modified and uploaded on board in RAM partially or in any available EEPROM partially or in totality without interrupting the mission. In case of software modification in EEPROM, the use of the new OBSW and the reset of the flying instrument will only be effective after a RESTART command being carried out on the modified bank.

All commanding to DORIS on-board will be uploaded using the satellite control centre link.

The satellite OBC does not execute the command or route the TC to Doris when Packet_error_control field is incorrect.

The automatic and continuous transmission of DORIS beacon network characteristics applicable to all in-flight DORIS instruments via the master beacons is under CNES full control and is not addressed in this document.

10.1. COMMAND SUMMARY

A complete list of commands, usable by DORIS, is presented in hereafter table *Table 10.1—1 COMMAND List*.

The meaning of columns stands as follows :

- the constraint column lists the conditions, mode dependency and / or requirements for command initialization, command execution and conditions for command completion.
- the “ack” column describes how the correct COMMAND execution can be verified.
(for DORIS the specified parameters shall be within provided boundaries as specified in section 13.1)
- the function table column describes event sequence after command reception, e.g. events after command reception or the effect of the command.
- the COMMAND execution time consumption column gives the time required to process the COMMAND completely, i.e. until the required state of the instrument is reached.

COMMAND Name	Length (bytes)	Constraints	Ack	Function	Execution time [s]
DORIS1 OFF	N/A	None	(1)	Performs a transition Chain 1 to OFF mode.	1
DORIS2 OFF	N/A	None	(1)	Performs a transition Chain 2 to OFF mode.	1
DORIS1 ON	N/A	Provided Chain 2 OFF and units temperature above minimum switch on temperature	(1)	Performs a transition Chain 1 to ON mode.	1
DORIS2 ON	N/A	Provided Chain 1 OFF and units temperature above minimum switch on temperature	(1)	Performs a transition Chain 2 to ON mode.	1
Restart 1A	N/A	Do not use during an upload sequence in EEPROM A	(2)	Restarts the DORIS processor Chain 1 using EEPROM A.	60
Restart 1B	N/A	Do not use during an upload sequence in EEPROM B	(2)	Restarts the DORIS processor Chain 1 using EEPROM B.	60
Restart 2A	N/A	Do not use during an upload sequence in EEPROM A	(2)	Restarts the DORIS processor Chain 2 using EEPROM A.	60
Restart 2B	N/A	Do not use during an upload sequence in EEPROM B	(2)	Restarts the DORIS processor Chain 2 using EEPROM B.	60
Configure DORIS	2	None	(3)	Change upload (ARM, EUP, TMM) and/or generate an acknowledgement routine report (NOP)	<20
Test	26	None	(3)	Activate test TM or test configurations.	<20
Upload Memory	64	(4)	(4)	Load a block of data or SW at a specified memory address.	(4)
TC time broadcast	10	None	(5)	PPS date emission towards DORIS	1
Upload Parameter	64	None	(3)	Modify on-board parameters	<20

- (1) Power status check in HK TM
- (2) 'UC Status' set to '1' check and 'MVR Status' field set to the correct copied bank in RAM and executed in the Report packet (bit MS1 set to '0' for bank A and '1' for bank B) in HK TM
- (3) Check Report packet Acknowledgment
- (4) For RAM upload with acknowledgment : no constraints; Check Report packet Acknowledgment; duration < 20s
For EEPROM upload without acknowledgment : Constraint is that UPLOAD mode shall be authorized; Once UPLOAD finished, uploaded TC number shall be checked against emitted TC number; Maximum rate is 40 TC per 10s
- (5) Non acknowledged TC

Table 10.1—2 COMMAND List

10.2. COMMAND DESCRIPTION AND SCHEDULING REQUIREMENTS

The command execution shall be made according to the constraints specified in [Table 10.1—2 COMMAND List](#).

The command characteristics are described in AD 1.

10.2.1. DORIS OFF COMMAND

The DORIS OFF command initiates a transition to the DORIS OFF mode on the specified Chain.

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10.2.2. DORIS ON COMMAND

The DORIS ON command initiates a transition to the DORIS START mode, then to the DORIS AUTOINITIALISATION mode on the specified Chain.

The BDR transfers the on-board software from EEPROM A to RAM, starts execution and generates its nominal telemetry.

10.2.3. RESTART COMMAND

This command restarts the processor of the specified Chain.

The BDR processor will then start running using the software stored in the specified EEPROM bank (A or B according to the RESTART A or RESTART B TC).

10.2.4. CONFIGURE DORIS COMMAND

This command is used to configure the DORIS instrument :

- For SW maintenance : ARM, EUP and TMM TC.
- To check the TM/TC link : NOP TC.

A complete description of these Commands is reported in AD 1.

The Maximum rate of sending of TC is 1 TC per 10 seconds.

10.2.5. TEST COMMAND

This command activates a specific Test Telemetry or a specific test configuration.

The only TEST commands used in operation are :

- The MASR command (jamming during commissioning),
- The DZQS command (ZQS Dump in the frame of software maintenance),
- The ADG command (generation of auxiliary data).

Before any test command sending special care shall be taken to check any other TEST TM is received. The three different test TM productions are piloted with those three commands and it is requested that only one shall be active at a time. It is a user duty to take responsibility for this requirement.

Any active TEST TM production shall be stopped manually before any other shall be requested.

A complete description of this Command is reported in AD 1. The Maximum rate of sending of TC is 1 TC per 10 seconds.

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10.2.6. UPLOAD MEMORY COMMAND

This command uploads data either in RAM or in EEPROM and may be executed with or without acknowledgement.

In case of a full software or full ZQS upload in EEPROM, the corresponding UPLOAD MEMORY commands shall be sent to DORIS with the ACK field set to 4 (without acknowledgment). The maximum rate is 40 TC per 10 seconds.

In any other cases (patch in RAM or in EEPROM), the corresponding UPLOAD MEMORY commands shall be sent to DORIS with the ACK field set to 3 (with acknowledgment). The maximum rate is 1 TC per 20 seconds.

A complete description of this Command is reported in AD 1.

10.2.7. UPLOAD PARAMETER COMMAND

This command uploads a set of parameters in the DORIS on-board database. It is used to provide the characteristics of a foreseen satellite manoeuvre.

A complete description of this Command is reported in AD 1.

The Maximum rate of sending of TC is 1 TC per 10 seconds.

Nota : not implemented from the version 5 of the OBSW.

11. TM DESCRIPTION

DORIS TM packets are described in AD 1.

The DORIS TM packets may contain several dates. In order not to be confused, hereafter is provided an exhaustive list of all date formats related to DORIS instrument :

- Packet Time : date of packet generation expressed according to satellite time policy (see AD 1).
- Date_TAI : TAI time relevant to the TM data.
For instance the position and velocity data within a navigator packet are consistent with Date_TAI and not with Packet time.
- Date TOUS : time at start of 10 seconds sequence relevant to the data acquisition, expressed in DORIS internal on board time scale.

11.1. DORIS REPORT TM AND SATELLITE HKTM DESCRIPTION

11.1.1. REPORT PACKET

This packet contains all necessary information for DORIS housekeeping monitoring.

Information contained in the report packet is collected within the 10 seconds following the date reported in the packet Date_TAI field.

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11.1.1.1. Routine Report Packet

Generation and content of Routine Report Packet are described in AD 1.

It may relate to specific situations of DORIS or DIODE SW (DORIS and DIODE Software Report); the DORIS SW will autonomously manage such situations without any external actions from satellite OBC or ground.

DORIS generates at least one Routine Report Packet every 30 minutes. For troubleshooting purposes, this 30 minutes delay may be modified by a specific Upload Memory TC.

If several events occurred within a 10 second sequence, only one Routine Report Packet is generated in this sequence, with its Event_ID corresponding to the higher rank as below :

Rank	Event	Event_ID
6	Acknowledgement of TC,	00000002H
5	Doris Software Report	00000003H
4	Diode Software Report	00000004H
3	Time correction	00000006H
2	Change of the Instrument Mode	00000001H
1	Periodic generation	00000007H

DORIS and DIODE Software report Index field description is given for information in Annex B.

The table below gives the description of the "Doris_Software_Report" field; it is formed of 5x2bytes words:

byte1 – byte2	Current Software Report code	See SOFTWARE REPORT CODES Ann. B
byte3 – byte4	S8 S7 S6 S5 S4 S3 S2 S1 SW_STATUS	S1 to S8: only used by manufacturer SW_STATUS: (reason of software restart) 0000H => switch on or commanded restart 0001H => watchdog trigger 0002H => ADA exception 0003H => hardware issue
byte5 – byte6	Last Software Report code	See SOFTWARE REPORT CODES Ann. B
byte7 – byte8	Next to last Software Report code	See SOFTWARE REPORT CODES Ann. B
byte9–byte10	Previous to next to last Software Report code	See SOFTWARE REPORT CODES Ann. B

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11.1.1.2. Anomaly Report Packet

The Anomaly Report Packet reports any detected anomaly requiring a corrective action from the ground (see §13). An Anomaly event is reported in the Anomaly Report packet once and only once.

In the case of multiple anomalies during the internal 10 seconds sequence, DORIS generates a single Anomaly Report Packet relevant to this sequence.

It should be noted that the first Anomaly Report packet eventually generated just after a Restart or a Switch ON has a null packet time even though the satellite time is initialized.

Remark : one routine report and one anomaly report may be generated in the same 10s sequence.

11.1.2. SATELLITE HOUSEKEEPING DATA

The following DORIS analogue and status data are directly acquired by the satellite OBC to monitor the health and proper functioning of DORIS.

Parameters	TM Type	Unit	Comment
Status power chain1(W.r.t ICD ref A.D.)	Bi-level	N/A	
Status power chain2 (W.r.t ICD ref A.D.))	Bi-level	N/A	
Status UC chain1(W.r.t ICD ref A.D.))	Bi-level	N/A	
Status UC chain2 (W.r.t ICD ref A.D.))	Bi-level	N/A	
ATM.IOUS.SAT chain1 (W.r.t ICD ref A.D.))	Analogue	mA	20 V USO current chain1
ATM.IOUS.SAT chain2 (W.r.t ICD ref A.D.))	Analogue	mA	20 V USO current chain2
ATM.IP.5V chain1 (W.r.t ICD ref A.D.))	Analogue	A	BDR 5 V current chain1
ATM.IP.5V chain2 (W.r.t ICD ref A.D.))	Analogue	A	BDR 5 V current chain 2
TBD satellite prime	Analogue	A	DORIS primary current chain 1
TBD satellite prime	Analogue	A	DORIS primary current chain 2
BDR temperature	Analogue	°C	Thermistor line

Table 11.1—1 DORIS HK data

11.2. SCIENCE TM

A complete description of the science TM Packets is reported in AD 1

11.2.1. DOPPLER PACKET

The Doppler Packet contains DORIS measurements (Doppler, phases, pseudo range, beacon messages) done on each of the Processing Units during the 10s sequence.

In routine mode, when at least one beacon is tracked, DORIS generates one Doppler Packet every 10 seconds. With seven UTs per BDR chain, it is possible to generate 3 Doppler Packet maximum per 10 seconds.

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11.2.2. NAVIGATOR PACKET J2000 OR GEODESIC OR ITRF

The Navigator Packet contains DORIS navigation data computed in real-time. DORIS generates one Navigator Packet of each type every 10 seconds.

The position and velocity data within a navigator packet are consistent with Date_TAI included in the packet. They are however only significant when DIODE mode is ROUTINE. When quality index is set to FFFF FFFF, the bulletin shall be considered as invalid.

On board Satellite, the 3 different navigation packets (ITRF, J2000 and Geodetic) are provided. The reference surface for the geodetic bulletin is the ellipsoid surface WGS84.

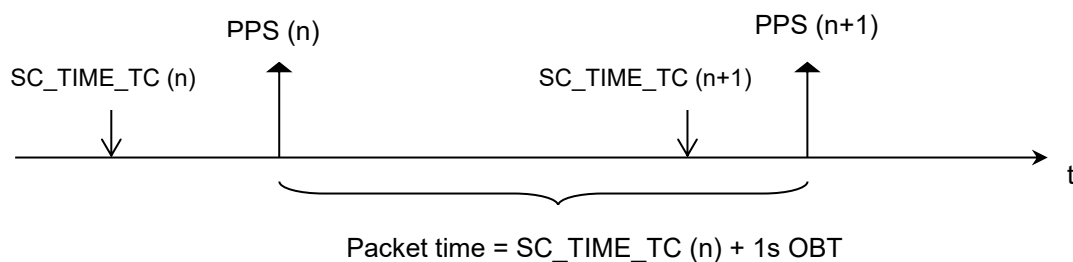
11.2.3. DATATION PACKET

The Datation Packet contains Datation data relevant to the last PPS pulse received by DORIS expressed in TAI reference scale.

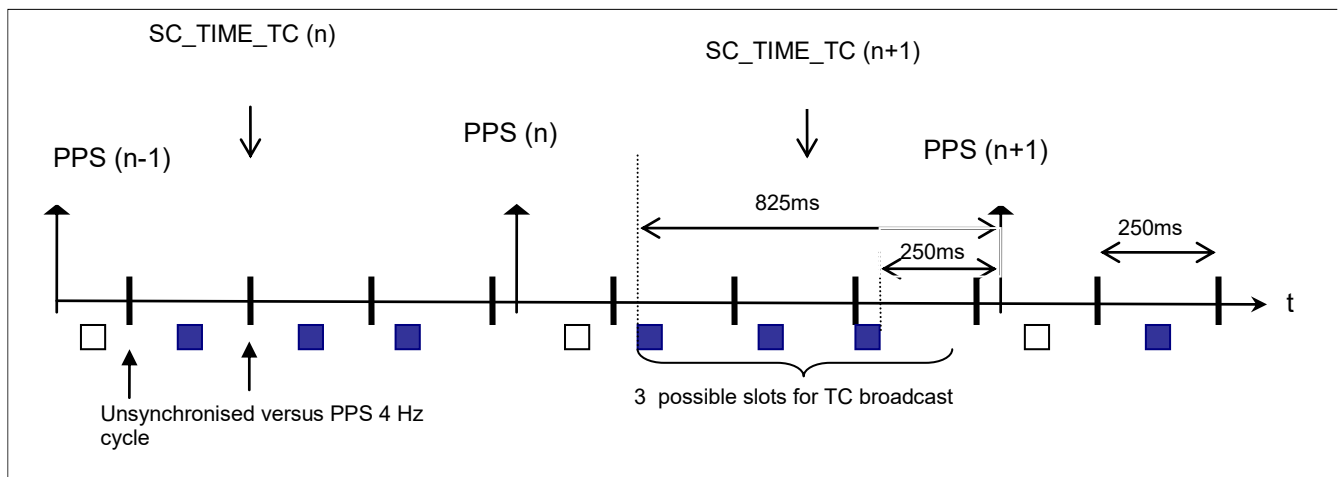
When quality index is set to 0xFFFF FFFF, the bulletin shall be considered as invalid.

DORIS generates one Datation Packet every time it receives a PPS pulse.

The datation policy on board Satellite is as following (see AD 1) *depending on mission* :



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11.2.4. ATTITUDE PACKET (IF ANY)

This packet contains the copy of the TC attitude (Quaternion) transmit by the Platform.

Nota : the delivery of this packet may be inhibited for confidentiality reasons in routine operations. It can be enabled for commissioning, testing or troubleshooting,

11.2.5. TEST PACKET

The Test Packet contains test data. Except Auxiliary Data Packet which may be routinely downlinked, these test data may solely be generated for troubleshooting or expertise.

These packets are generated upon reception of the corresponding enabling TC (see AD 1).

Any test TM type shall be manually stopped before a request for a new one shall be executed. At any time only one test TM type shall be received.

11.2.5.1. Dump Packets

During ground operations on Test TC DZQS, it is possible to generate dumps of the on-board quasi static zone (RAM or EEPROM) at a rate of up to 8 packets every 10 seconds. In this case, due to traffic regulation on the TM link, no other Test TM shall be activated.

11.2.5.2. Jamming Packets

The Jamming Packet contains DORIS RF signal characteristics as received in the DORIS instrument reception bands. These RF signals include the transmitted signals received by all the DORIS beacons in visibility.

When the Jamming TM is activated (on Test TC MASR), DORIS generates 2 Jamming Packets maximum every 10 seconds.

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11.2.5.3. Other tests Packets

11.2.5.3.1. Auxiliary Data Packets

Auxiliary Data Packets contain :

- Navigator engineering data
 - Current filter status
 - Autonomous programming authorization flag
 - Rejection counter : counter of valid measurements rejected by DIODE (detection of divergence beginning)
 - Last upload parameter TC processed by DIODE (manoeuver characteristics)

If two upload parameters TC are processed during the same sequence, one is copied here, while the other is kept in memory, to be copied at the following sequence.
- Science specific data
 - Real time Earth rotation pole coordinates estimation
 - Drag and Hill accelerations
 - On board and ground clocks frequency estimation

When the Auxiliary Data TM is activated (on Test TC ADG), DORIS generates one Auxiliary Data Packet every 10s. In this case, due to traffic regulation on the TM link, no other Test TM shall be activated. Auxiliary data packet production shall be stopped manually with TC ADG before dump or jamming sequence can be activated.

11.2.5.3.2. Manufacturer test Packets

Manufacturer tests packets may be activated for trouble shooting purpose (only used by DORIS manufacturer).

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12. SOFTWARE

The DORIS software is generic for all missions. Before using it on a dedicated mission, it is fully validated in the frame of this mission with the appropriated parameters.

12.1. MEMORY MAPPING

The software is able to address different zones.

The OBSW is organized in four main parts :

- the code,
- the DORIS ZQS,
- the DIODE ZQS,
- the System ZQS.

The 3 ZQS are copied from EEPROM to RAM upon OBSW start. The system ZQS which mainly contains DORIS beacon network data is permanently updated in RAM when the instrument is flying over the master beacons by means of broadcast uploads. The DIODE and DORIS ZQS may be updated if necessary by means of upload memory TC either in RAM or EEPROM.

The main memory areas are described in the table below :

Memory type	Start address	End address
Lower EEPROM bank (1)	0000 0000 H	001F FFFF H
Upper EEPROM bank (1)	0020 0000 H	003F FFFF H
RAM (total)	4000 0000 H	407F FFFF H
RAM (ZQS)	405F C800 H	4060 0000 H

- (1) The lower EEPROM bank is always the bank from where the SW has previously been downloaded to RAM following a DORIS ON or RESTART TC. The upper bank is the other one :
- a. Lower bank = bank A and upper bank = bank B after DORIS ON or RESTART A command
 - b. Lower bank = bank B and upper bank = bank A after RESTART B command

12.2. SOFTWARE MAINTENANCE

The OBSW can be modified in 4 ways:

- full SW zone (code or DORIS ZQS, or DIODE ZQS, or System ZQS) upload in one of the two EEPROM of the active BDR chain,
- patch upload in one of the two EEPROM of the active BDR chain, in any of the following SW zone (code or DORIS ZQS, or DIODE ZQS, or System ZQS),

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- copy of the lower MNVR EEPROM memory bank into the upper MNVR EEPROM memory bank,
- patch upload of any of the current ZQS (DORIS, DIODE, SYSTEM) in RAM.

In all cases, a detailed procedure is provided in Annex A. All the OBSW part version index (CODE, ZQS DORIS, ZQS DIODE, ZQS SYSTEM in RAM and in EEPROM) are defined in Routine Report packets.

12.2.1. FULL SOFTWARE ZONE UPLOAD IN EEPROM

A full Software zone UPLOAD procedure shall be used when a new OBSW version is required. Modifications will not be lost upon switch off or Restart.

The full SoftWare UPLOAD may be done without mission interruption. The SoftWare is loaded into the upper EEPROM bank (ie the non-selected bank at Switch ON or Restart) during several hours or days. However to activate the new uploaded SoftWare, the DORIS mission needs to be interrupted to restart with the EEPROM bank where the new SoftWare has been uploaded. In this case :

- The clock reference frequency delivery is not interrupted
- The DORIS routine measurements may be interrupted a couple of hours
- The DORIS navigation and precise time tagging may be interrupted a couple of hours more depending on initialisation phase duration as per first Switch ON of the instrument (see 4.4.1)

The full SoftWare UPLOAD is performed using Upload Memory TCs which are mandatory without acknowledgement.

Remark : one NOP TC may be sent between groups of N Upload Memory TC in order to check in Routine Report acknowledging the NOP TC that previous N TCs have been uploaded on board correctly.

The EUP TC configuration sent at the end of the UPLOAD procedure shall be set to the right configuration :

- Bit 12 set to 1 if code zone is uploaded
- Bit 13 set to 1 if DORIS ZQS is uploaded
- Bit 14 set to 1 if DIODE ZQS is uploaded
- Bit 15 set to 1 if SYSTEM ZQS is uploaded

Remark: If set all to zero the 4 configuration bits of the TC EUP will cancel the whole upload procedure and switch the Upload mode into inhibited.

On board DORIS, both EEPROMs shall always contain the same SW version, except during the new SW upload and before copying (see below). The update of the SW shall be done in several steps. The upload approach will depend on how DORIS was previously started up.

Case a) DORIS started from normal switch ON or from RESTART A :

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- 1) The new SW is uploaded in EEPROM B. This SW upload is performed without interruption of the mission (see procedure DORIS_SW_UPLOAD in §14).
- 2) The procedure DORIS_RESTART is applied using RESTART B.
- 3) The uploaded SW is then validated in flight by successful initialisation and verification that all DORIS missions (navigation, datation, Doppler measurements) are fulfilled. The upload function of the new software is also validated.
- 4) If step 3 is successful then the uploaded SW is copied from EEPROM B to EEPROM A.
If step 3 is not successful then RESTART on EEPROM A and copy the previous SW from EEPROM A to EEPROM B.
(see procedure DORIS_SW_COPY in §14).

Case b) DORIS started from RESTART B :

- 1) The new SW is uploaded in EEPROM A. This SW upload is performed without interruption of the mission (see procedure DORIS_SW_UPLOAD in §14).
- 2) The procedure DORIS RESTART is applied using RESTART A.
- 3) The uploaded SW is then validated in flight by successful initialisation and verification that all DORIS missions (navigation, datation, Doppler measurements) are fulfilled. The upload function of the new software is also validated.
- 4) If step 3 is successful then the uploaded SW is copied from EEPROM A to EEPROM B.
If step 3 is not successful then RESTART on EEPROM B and copy the previous SW from EEPROM B to EEPROM A.
(see procedure DORIS_SW_COPY in §14)

Execution Time :

The Upload S/W Duration is presented in the Chapter "UPLINK COMMAND budget". The duration for recopying the bank EEPROM on the other stands between 10 minutes and 1 hour after several thousands of cycles of erase.

12.2.2. PATCH IN EEPROM

The blocks of data Upload are performed using the DORIS_Patch_EEPROM procedure (see § ANNEX A: DETAILED PROCEDURES) based upon Upload Memory TCs with acknowledgement.

These modifications will only be available after the next Restart from the modified EEPROM bank.

The EUP TC sent at the end of the UPLOAD procedure is set to the right configuration : Bit 12, 13, 14 and 15 set to 0.

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12.2.3. EEPROM COPY

This copy occurs from the lower EEPROM towards the upper EEPROM. The copy direction is always from the EEPROM selected by the last switch-on or restart command towards the other.

The copy procedure DORIS_SW_COPY is presented in § ANNEX A: DETAILED PROCEDURES.

12.2.4. PATCH IN RAM

This patch upload is done in RAM and may be used when a few parameters only have to be changed temporarily. These modifications will be lost upon switch-off or Restart.

Patch may be done without mission interruption assuming that the current instruction in the running code is not affected by the patch.

The ZQS data block uploads are performed using the DORIS_PATCH_RAM procedure (see § ANNEX A: DETAILED PROCEDURES) based upon Upload Memory TCs mandatory with acknowledgement.

Patches in RAM are allowed in the memory area used by the OBSW. Otherwise, the BDR would perform immediately an automatic Restart.

Note that, as per software configuration convention (see AD 1), each time the RAM is modified, the minus version index of the corresponding zone shall be incremented.

WARNING : for issues v4.xx of DGXX-S software, the following series of PATCHES in the DIODE ZQS :

EXTRA-FINE AUTHORIZED

EXTRA-FINE FORBIDDEN

EXTRA-FINE AUTHORIZED

is not allowed without a RESTART, because it could lead to a software malfunction.

Indeed, Time/Frequency information over Time Beacons that have been stored by the software during the first 'authorized' period, are not resetted when the second 'authorized' period starts. So there is a risk for the software to use together both old information (first period) and recent information (second period). If the time interval between both 'AUTHORIZED' periods is long, this can lead the software to erroneous computation for Time/Beacons characteristics, and possibly strong navigation perturbations may follow.

Pole coordinates and standard beacon information may be strongly perturbed in the same way.

Consequently, if a patch EXTRA-FINE AUTHORIZED is wanted, it is necessary to verify if, since the last "RESTART" command, the software has already been AUTHORIZED before. In this case, a RESTART" command is required before the PATCH EXTRA-FINE AUTHORIZED is performed.

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12.3. MEMORY DUMP

Only the ZQS may be dumped.

Memory dump TM may be used to verify either memory uploading in RAM, in Upper bank of EEPROM or in Lower bank of EEPROM according to TC MEMORY DUMP request (see AD 1).

Note : several parameters (listed below) in ZQS System and DIODE in RAM may be changed by Broadcast Uploads (that are sent to the whole DORIS constellation) without change of their configuration control parameters (date, version, checksum). Operators must keep this in mind when they are checking a DUMP of a RAM ZQS.

ZQS DIODE : parameter TAI-UTC

ZQS SYSTEM : every parameter in the Beacon Characteristic table

Warning : a TC ARM shall not be sent while a dump is going on. After sending a TC DZQS, a minimum time delay of 90 seconds shall be respected before sending a TC ARM (or the time for the dump completion –dump packets emission ended).

12.4. SINGLE EVENT UPSET MANAGEMENT

A scrubbing procedure is implemented on board DORIS. This procedure reads and rewrites 1024 bytes of RAM every 10 seconds. Only the RAM blocks taken by the SW are processed. The scrubbing cycle for complete RAM would take less than 12 hours.

Thanks to the scrubbing task, the multiple errors risks are limited to 1 every 91 years. This case should occur; the process interruption will lead to a SW autonomous Restart.

In a single error case detected by the EDAC, N_Upset counter is incremented. This counter value is reported to the ground by the routine report packets.

Remark : The interrupt generated by the EDAC in case of single error is permanently masked. The single error detection is ensured by exploiting the Pending Interrupts of the processor during scrubbing.
In case of single error encountered during routine SW execution (i.e. scrubbing routine out of RAM boundary reading), a volatile corrected data is delivered to the processor by the EDAC but not physically corrected and stored in RAM and the N_Upset counter is not incremented. This prevents false count from the counter.

12.5. SW AUTOTEST

The DORIS SW performs autotests of its EEPROMs by doing checksum calculations of the memory blocks used by SW.

A SW autotest is performed on the Low EEPROM bank during BDR initialisation, just after a DORIS ON or a Restart.

It is also performed on the High EEPROM bank at the end of a full SW upload (after a TC EUP) or a SW copy (autonomously after the end of the copying).

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If a SW autotest is KO then an Anomaly Report Packet is sent. The SW may continue to run nominally depending on the anomaly location (see §13.3). The Anomaly Report Packet Event_ID field will identify the failure location (CODE, ZQS DORIS, ZQS DIODE, ZQS SYSTEM).

Software autotest of the upper EEPROM may be forced by using an ARM configure TC followed by an EUP configure TC with configuration bits 12 to 15 set to 0.

13. ROUTINE MONITORING AND ERROR HANDLING

13.1. HK TELEMETRY CRITERIAS

The list of on-board monitored parameters is given in Table 13.1—1, with the following definitions :

- Parameters : name of monitored parameters as defined in AD 1,
- Engineering unit,
- TM Type : Type of TM (Analogue or binary level status),
- Lower/Upper limits : Nominal range of the parameter,
- DORIS ON/OFF condition : DORIS power condition (ON or OFF) when monitoring is required,
- Occurrence : when applicable, consecutive occurrence number of an “Out of limit condition” reach for activation of a corrective action,
- Duration : when applicable, lapse of time for manual corrective action on an “Out of limit condition” reach.

Parameters.	Eng Unit	TM Type	Lower Limit (dec)	Upper Limit (dec)	DORIS ON/OFF condition	Occurrence	Duration (sec)	Recommended corrective action
Primary DORIS CURRENT chain1 or chain2	mA	Analogue	400	3000	ON	N/A	N/A	None assuming current limitation from satellite
DORIS_voltage (main bus)	V	Analogue	22	38	ON	N/A	N/A	None assuming maximum voltage controlled by power system
ATM.IOUS.SAT Chain1 or 2	mA	Analogue	30	300	ON	N/A	N/A	None since protection by internal current limitation
ATM.IP.5V Chain 1 or 2	A	Analogue	0.5	2	ON	N/A	N/A	None since protection by internal current limitation
Primary DORIS CURRENT chain1 or chain2	mA	Analogue	N/A	5	OFF (1)	3	N/A	Send OFF command
DORIS_voltage (main bus)	V	Analogue	N/A	2	OFF (1)	3	N/A	Send OFF command
ATM.IOUS.SAT Chain1 or 2	A	Analogue	N/A	0.002	OFF (1)	3	N/A	Send OFF command
ATM.IP.5V Chain 1 or 2	A	Analogue	N/A	0.01	OFF (1)	3	N/A	Send OFF command

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Parameters.	Eng Unit	TM Type	Lower Limit (dec)	Upper Limit (dec)	DORIS ON/OFF condition	Occurrence	Duration (sec)	Recommended corrective action
BDR temperature	°C	Analogue	-20 (3)	60 (3)	ON	3	N/A	Above upper limit : switch off DORIS
BDR temperature	°C	Analogue	-20 (3)	60 (3)	OFF	3	N/A	Above upper limit or beyond lower limit : switch on DORIS not allowed until correct range is reached
Status UC Chain 1 or chain2	N/A	Numeric	0	0 (2)	ON	N/A	60	If the Status. UC is greater than 0 for more than 60 seconds, issue a RESTART A TC of the active DORIS chain. In case that RESTART A TC is not successful, then send RESTART B TC If RESTART B is not successful, then switch OFF DORIS active chain and switch ON DORIS redundant chain. Note : this recommendation assumes the same SW version in EEPROM A and B of the active DORIS chain.
Status Power	N/A	Numeric	1	1	ON	3	N/A	Send ON command
Status Power	N/A	numeric	0	0	OFF	3	N/A	Send OFF command

- (1) : used for OFF status verification in complement of relay status. Due to the internal capacitors discharge, the values are beyond the specified upper limit 1 minute after switch OFF.
- (2) : this status is nominally set to 0, except during a maximum of 60 seconds at BDR power-on or restart.
- (3) : the performances are guaranteed between -15° and 40° (see §8.4.6).

Table 13.1—1 HK Telemetry monitoring criteria

13.2. ROUTINE REPORT OCCURRENCE

The Routine report packets are generated periodically every 30 mns but also on Software events.

The Event_ID value is inferior to 8000H.

The asynchronous packets are generated on the following Software Events :

- TC acknowledgement (1)
- DORIS Software Report cf. § ANNEX B : SOFTWARE REPORT CODES
- DIODE Software Report cf. § ANNEX B : SOFTWARE REPORT CODES

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- Time correction
- Instrument mode change

Those packets are useful for instrument supervision under nominal or exceptional conditions without any ground actions needed (see also 11.1.1.1).

- (1) In case of correct reception and execution of any TC except for the following :
- Upload memory w/o acknowledgement,
 - SC_time,
 - Broadcasted data via MB.

For some projects, after the TAI Date setting of the BDR, it can occur up to 6 DIODE SW report with code 0x001. It is due to the 20 TCHD stack being full up with current time TC (ex. : TC SAP for SWOT) meanwhile the BDR has a date in 2000. Then when the TAI date is set, the BDR tries to execute the 20 TC 3 by 3 (TC due date in the past). Afterwards the BDR reenter a nominal state (non transient mode).

13.3. ANOMALY REPORT OCCURRENCE

This kind of packet is generated when ground action is requested.

Within DORIS internal 10s sequence, only one packet is generated even in case of multiple anomalies.

The Event ID values are over 7FFFFH.

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Anomaly_Event_ID	Detected anomaly (EVENT_ID)	Corrective action
00008006H	Illegal Command_parameter	Correct TC and re send it
00008007H	TC rejected : Parameter invalid or unauthorised TC	Check TC format and content and check TC compatibility with current mode
00008009H	1553 protocol violation (critical Software Report) Inconsistent length of TC packet or unidentified TC or TC cancelled by SMU	Check 1553 link and re-send TC
0000800AH	Illegal TC via Master Beacon	Inform CNES
0000801XH	SW autotest KO. With the different bits of X coded as following : Bit 12=1 : Failure affecting the OBSW code Bit 13=1 : Failure affecting the DORIS ZQS Bit 14=1 : Failure affecting the DIODE ZQS Bit 15=1 : Failure affecting the SYSTEM ZQS	SW failure may fall into two different cases : 1. SW is still running properly (only non-critical data corrupted), then corrective action is not urgent 2. SW is trapped, then Status.UC is set greater than 0, and then the corrective action as per table 13.1 shall be executed urgently.

Table 13.3—1 – Ground action in case of Anomaly Report detection

13.4. [COMMAND VERIFICATION BY GROUND CONTROL CENTER](#)

The command execution verification is specified in the procedures hereafter.

13.5. [AUTOMATIC RESTART](#)

Several cases may cause an automatic restart of the onboard S/W :

- Multiple memory errors detected by EDAC,
- Hardware exception,
- ADA exception not handled by the OBSW.

Under those circumstances, the first routine report packet following the restart will contain the field “MS2” of “MVR_status” set to the logical value ‘1’.

The release of the watchdog (Software reaction time too long; infinite loop ...) may also cause a restart. In this case, the first routine report packet following the restart will contain the field “MS3” of “MVR_Status” set to the logical value ‘1’.

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14. PROCEDURES

The DORIS operation procedures are listed in the following table.

Three different uses of DORIS TC's and procedures are identified in this table : nominal, emergency and special.

Nominal and emergency cases are self-explanatory.

Special case covers specific verification during commissioning phase, troubleshooting and software maintenance.

Procedure	TC used	Different use		
		Nominal	Emergency	Special
DORIS_ON	DORIS ON (1/2)	X		
DORIS_OFF	DORIS OFF (1/2)		X	
DORIS_RESTART	Restart (1/2) (A/B)		X	X (1)
DORIS_TMTC_CHECK	Configure DORIS TC : NOP			X(2)
DORIS_UPLOAD_MANOEUVRE (if any)	Upload parameter TC : manoeuvre characteristics	X		
DORIS_DELETE_MANOEUVRE (if any)	Upload parameter TC: Killer		X	
DORIS_SPECIAL_OPERATION	Test TC : MASR, DZQS, ADG			X
DORIS_FULL_SOFTWARE_ZONE_UPLOAD_EEPROM	Upload memory Configure DORIS TC : ARM, EUP			X(1)
DORIS_PATCH_EEPROM	Upload memory Configure DORIS TC: ARM, EUP			X(1)
DORIS_PATCH_RAM	Upload memory			X(1)

Procedure	TC used	Different use		
		Nominal	Emergency	Special
DORIS_SW_COPY	Configure DORIS TC: ARM, TMM			X(1)

- (1) used for on board SW management
- (2) NOP is not needed in nominal use as far as DORIS is concerned; TC may be sent to check TM-TC link for troubleshooting or to start the emission of a Routine Report

Table 14-1 DORIS operation procedures

See detailed procedures in Annex A.

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15. BUDGETS

15.1. MASS BUDGET

The overall mass of DORIS instrument including all units except the MLI, the harness and bolts is 20 kg.

The following tables report the mechanical characteristics for each of the DORIS units. Drawings can be found within ICD ref. RD 2) The given values are specified w.r.t. the reference coordinate system and the reference point defined in the drawings.

Unit	Dimensions (mm)		
	x	y	z
BDR	388	366	172.5
Antenna	160	160	427.6

Table 15.1—1: Mechanical Budgets – Dimensions

Unit	Qty	Mass	Uncer- tainty	Center of Mass Location (mm)			
		kg	%	x	y	z	Uncertainty
BDR	1	17.7	± 5	179.4	167.9	76.4	± 2%
Antenna	1	2 (without washers)	+/- 1	0 ± 1	0 ± 1	-108 ± 5	± 1%

Table 15.1—2: Mechanical Budgets – Mass and CoM location

Unit	Moment of Inertia (g.m ²)			
	I _{xx}	I _{yy}	I _{zz}	Uncertainty
BDR	198	248	348	± 2 %
Antenna	23.45	23.45	3.9	± 10 % for X and Y ± 15 % for Z

Table 15.1—3: Mechanical Budgets – Mol

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Unit	Moment of Inertia (g.m ²)			
	I _{xy}	I _{xz}	I _{yz}	Uncertainty
All	< 1			-

Table 15.1—4: Mechanical Budgets – Off axis Mol

15.2. NOMINAL OPERATION POWER PROFILE

The next table shows the routine operations power profile, taking into account the converter losses. The power profile remains constant during the orbit lifetime excepted for a limited period following the switch on.

Phase of operation (1)	Typical Power Demand BOL	Worst case Power Demand EOL
USO warm up after switch on (< 1 hour)	26W	29W
Routine @ ambient pressure, + 30°C	22.5W	
Routine @ vacuum, + 30°C	22.5W	25.5W

(1) : USO power can vary between 0.7 W and 4.5 W depending on case temperature, pressure and internal oven stabilization

Table 15.2—1: Routine operations power profile – DGXX-S

Phase of operation (1)	Typical Power Demand BOL	Worst case Power Demand EOL
USO warm up after switch on (< 1 hour) @ vacuum, -15 to +40°C	37.22W	38.54W
Routine @ ambient pressure, + 20°C	30.61W	
Routine @ vacuum, + 20°C	26.39W	27.71W

(1) : USO power can vary between 0.9 W and 8 W depending on case temperature, pressure and internal oven stabilization

Table 15.2—2: Routine operations power profile – DGXX-SEV

Remarks:

Peak power / Average power < 1.05

Power demand is nearly independent from primary voltage, however worst case data is defined for a minimum voltage of 22V, maximum is reached at 37V and typical data is defined for nominal voltage (34V).

WC EOL power demand for BDR OFF is lower than 1W.

15.3. THERMAL DISSIPATION

The thermal dissipation for each unit in some possible instrument switch states is listed in the next table.

	ON		OFF
Unit	Warm Up EOL	Routine (vacuum, +40°C)	
BDR	31 W	22.5 W	< 1 W (1)
ANT	0	0	0

(1): residual dissipation due to 1553 bus signals and primary circuits

Table 15.3—1 Thermal Dissipation (Watts) – DGXX-S

	ON		OFF
Unit	Warm Up EOL	Routine (vacuum, +40°C)	
BDR	43 W	25.3 W	< 1 W (1)
ANT	0	0	0

(1): residual dissipation due to 1553 bus signals and primary circuits

Table 15.3—2 Thermal Dissipation (Watts) – DGXX-SEV

15.4. PROCESSOR LOADS

The DORIS processor loads is given in the table below according to DORIS/DIODE modes and SW activity.

DORIS mode	DIODE mode	SW activity	Load
AUTO INITIALISATION	AUTO INITIALISATION	N/A	5 %
	AUTO INITIALISATION	First orbit determination	10%
	RECOVER	N/A	55%
	ROUTINE	Depending on number of beacons processed	20 to 45%
MEASUREMENT	ROUTINE	Without software upload, depending on number of beacons processed	20 to 45%
		With software upload	< 65 %

Table 15.4—1 Processor Loads versus DORIS/DIODE modes

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15.5. MEMORY BUDGET

The RAM and EEPROMs loads for DORIS are given in the tables below.

Unit	Memory	Memory Load
RAM code / data	80 Mbits *	74 %
Lower EEPROM bank	2 Mo	78 %
Upper EEPROM bank	2 Mo	78 %

Table 15.5—1: DORIS memory loads (LV v4.x)

* Organized in 2 Mwords of 40 bits, including EDAC, copy of software (2Mo), working zone (2Mo) and upload buffer (2Mo).

Unit	Memory	Memory Load
RAM code / data	8 Mbytes	81 %
Lower EEPROM bank	2 Mbytes	63 %
Upper EEPROM bank	2 Mbytes	63 %

Table 15.5—2: DORIS memory loads (LV v5.x)

Number of lines of code of the software Doris (v5.x) :

- 40329 lines of code,
- 12301 lines of comment.

15.6. UPLINK COMMAND BUDGET

During routine operations, the only TCs sent by satellite control centre are relative to satellite manoeuvre when an UPLOAD PARAMETER TC (see §UPLOAD_MANOEUVRE procedure) shall be uploaded.

During special operations the maximum uplink rate will be reached during on-board software upload.

Duration assessment for a full SW uploaded in EEPROM :

SW volume (program + constant) $\approx$ 1.56 Mbytes

Upload packet number = $1.56 \text{ Mbytes} \times 1024^2 / 56$ (or 206 depending on protocol) useful bytes $\approx$ 30000 (or 7500 depending on protocol) TC Upload memory

The maximum allowed upload rate by DORIS is 40 (or 10 depending on protocol) TC Upload memory per 10 s.

Assuming the uplink channel is consistent with this maximum rate (around 2kbts/s), the full SW upload duration will be $\approx$ about 2 hours therefore less than 15 passes assuming a useful pass duration of 8 minutes.

15.7. TM DATA RATE

The amount of TM data defined for routine operations and during dump memory is listed in the table below.

Packet	Mean data rate (routine operation)		Max data rate (dump)*	
	frequency	bits/s	frequency	bits/s
Routine report	1 every 30mn	0.57	1 every 10s	102.4
Anomaly report			1 every 10s	102.4
Doppler	up to 3 every 10s average 1.5	307.20	3 every 10s	614.40
Datation	1 every 1s	288.00	1 every 1s	288.00
Navigation (ITRF, J2000, geo)	3 every 10s	153.60	3 every 10s	153.60
Auxiliary Data	1 every 10s	204.8	N/A	
Dump			8 every 10s	1638.40
Attitude if any	1 every 1s	416	1 every 1s	416
Total		TBD		TBD

Table 15.7—1: HK TM data rate

(*) It is assumed that only one type of test TM is activated at a time i.e., when Dump TM is activated, no other test or jamming TM shall be activated (managed by Ground operations). When the jamming is activated, DORIS generates up to 2 Jamming Packets (256 bytes each) every 10 seconds depending on the jamming mode activated.

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15.8. DORIS TM BUFFER SIZE

To be robust to temporary non 1553 DORIS packet peeking, a memory buffer is implemented to overcome this problem on DORIS side. Those packets are generated but not yet transmitted. The typical buffer size is given hereafter, its justification is in the "DOSSIER DE JUSTIFICATION DU PARAMETRAGE DORIS-DIODE DGXX-S":

Packet type	N*	1553 sub-addresses
Doppler packet	4 (TBC)	TBD
Navigator J2000 packet	4 (TBC)	TBD
Navigator GEOD packet	4 (TBC)	TBD
Navigator ITRF packet	4 (TBC)	TBD
Datation packet	7 (TBC)	TBD
Routine report packet	2 (TBC)	TBD
Anomaly report packet	2 (TBC)	TBD
Jamming packet	4 (TBC)	TBD
Dump packet	4 (TBC)	TBD
Other test packet	4 (TBC)	TBD
<i>Attitude packet if any</i>	4 (TBC)	TBD

This buffer is managed as a FIFO (First In First Out). If the buffer is saturated, then the older packets are lost.

* N is the buffer size in terms of number of packets.

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ANNEX A: DETAILED PROCEDURES

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DORIS_ON [1/2]				
Objective: transition from DORIS OFF to DORIS AUTOINITIALISATION mode for BDR Chain [1/2]				
Remarks: - the DORIS internal static switch has no memory; if the primary power supply falls down, after resuming the power supply, the procedure DORIS_ON is needed once again. - the “Approx Time” column gives the minimum relative delay with respect to the previous step. - Delay necessary for booting BDR is specified unless 60s. For LV5, measurements show that the first report (TOUS=10) occurs after around 25s after reception of TC ON; 40s value is used in procedures but could be minimize to get a better approximation of 1553 bus inactivity.				
Requisite		BDR temperature of Chain [1/2] higher than switch-on temperature (see §8.4.6) DORIS chain [2/1] OFF		
Step	Approx Time	Action / Event	Check	Comment
1	0 s	Send TC DORIS [1/2] ON	UC STATUS default < 1min	
2a	+ 40 s	Receive Satellite HK TM	Status Power = ON DORIS currents between lower and upper limits (see §13.1)	
2b		Receive Routine report packet	Event_ID = Periodic = 7 DORIS mode = Autoinit = 2 No anomaly	
3a	+ 50 s	Receive Routine report packet	Event_ID = Mode change = 1 (UT1 measurement mode : idle to DAS rand) DORIS mode = Autoinit = 2 No anomaly	

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3b		Receive Datation packets	One packet every second	Date starts from 01/01/2000 with IQ = FFFF FFFF
3c		Receive Navigation packets	Dummy packet every ten seconds	Date starts from 01/01/2000, position and velocity values are set to 0 and IQ = FFFF FFFF

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DORIS_OFF [1/2]				
Objective : transition to DORIS OFF for chain [1/2]				
Remarks : the "Approx Time" column gives the minimum relative delay with respect to the previous step				
Requisite		None		
Step	Approx Time	Action / Event	Check	Comment
1	0 s	Send TC NOP		
2	+10 s	Receive Routine report packet	Event_ID = TC acknowledgement = 2 Last_Command = NOP = 0xA5A5 No anomaly	
3	+10 s	Send TC DORIS [1/2]OFF		
4	+ 10 s	Receive Satellite HK TM	Power_status = OFF DORIS currents below upper limits (see §13.1)	

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DORIS_UPLOAD_MANEUVER (if any)				
This procedure is applicable only for satellites using upload parameter TC to manage manoeuvres				
Objective: to inform DORIS about a foreseen manoeuvre				
Constraints:				
1. This procedure shall be applied for each thrust event. Separate thrust events shall be considered if the interruption between thrust is larger than 10 s.				
2. The UPLOAD PARAMETER TC shall be uploaded at least 1 minute before the beginning of the manoeuvre, and assuming DIODE mode is ROUTINE.				
Remark : the “Approx Time” column gives the minimum relative delay with respect to the previous step				
Requisite		Manoeuvre shall be executed assuming DIODE mode is ROUTINE		
Step	Time	Action / Event	Check	Comment
0	N/A	Fill in parameters within TC packet Julian_Day and Seconds: Starting time of thrust rounded to the preceding 10 s Thrust_sequence_number: Thrust duration rounded to the upper 10 s then divided by 10. (Example : thrust duration = 61 sec gives thrust_sequence_number = 7) Radial, Along track, Cross track_acceleration: Foreseen acceleration in the local orbital reference frame : - radial direction is from the centre of the Earth to CoG of satellite - cross track direction is direct normal to orbit plane - Along track direction is crossproduct of cross track direction by radial direction (the along track direction is close to the velocity direction) The three acceleration parameters shall be defined as the ratio, on each axis, of the delta velocity and the rounded thrust duration in seconds (thrust_sequence_number * 10). The computed value shall be rounded to the closest 10 ⁻⁶ m/s ² value.		
		short maneuvers (duration shorter than 1 hour)	long maneuvers (duration longer than 1 hour)	

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		Radial, Along track, Crosstrack acceleration_model_sigma:	The three acceleration_model_sigma shall be <u>set to the same value</u> defined as 10 per cent of the square root of the Thrust_sequence_number multiplied by the root sum square (norm) of the acceleration vector. The computed value shall be rounded to the closest 10^{-5} m/s² value. In case the computed value is equal to zero the final value shall be set to 1.	The three acceleration_model_sigma shall be <u>set to the same value</u> defined as 10 per cent of root sum square (norm) of the acceleration vector. The computed value shall be rounded to the closest 10^{-5} m/s² value. In case the computed value is equal to zero the final value shall be set to 1.
		Adj:	0	1
		Ratio:	3* * This figure represents an off modulation ratio of 15% which is applicable in any case for short manoeuvres	0
		Radial, Along track, Crosstrack acceleration_initial_sigma:	The three acceleration_initial_sigma shall be set to 0 (this field are not used for short maneuvers).	The three acceleration_initial_sigma shall be set to the corresponding acceleration absolute value (i.e. radial, along track or cross track) multiplied by 3. The computed value shall be rounded to the closest 10^{-5} m/s² value. In case the computed value is equal to zero the final value shall be set to 1.
		See examples hereafter.		
1	Latest 1 mn prior to thrust	Send UPLOAD PARAMETER TC: MANOEUVER CHARACTERISTICS		

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2	10 s later	Receive a Routine report packet	Event_ID = TC acknowledgement = 2 Last_Command = Upload = D002 H Total_Upload_OK incremented by 1 No anomaly	
3		Execution of maneuver by Satellite		

Example 1: the thrust is on Julian day 1674; it begins at 5:30:12 and lasts 391 seconds, with an along track delta velocity about 0.05 m/s. This is a **short** manoeuvre.

	Eng	Raw (dec)
Julian_Day	1674 j	1674
Seconds	19810 sec	1981
Thrust_sequence_number	400 sec	40
Radial acceleration	0 m/s ²	0
Along track acceleration	$0.05/400 = 0.000125 \text{ m/s}^2$	125
Cross track acceleration	0 m/s ²	0
Radial acceleration_model_sigma	$10\% * \text{sqrt}(40) * 0.000125 = 0.000079 \text{ m/s}^2$	8
Along track acceleration_model_sigma	0.000079 m/s ²	8
Cross track acceleration_model_sigma	0.000079 m/s ²	8
Adj	no	0
ratio	-	3
Radial acceleration_initial_sigma	N/A	0
Along track acceleration_initial_sigma	N/A	0
Cross track acceleration_initial_sigma	N/A	0

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Example 2: the thrust is on Julian day 1674; it begins at 21:00:08 and lasts 4108 seconds, with a radial delta velocity about 0.4 m/s, and an along track delta velocity about 0.8 m/s. This is a **long** manoeuvre.

	Eng	Raw (dec)
Julian_Day	1674 j	1674
Seconds	75610 sec	7561
Thrust_sequence_number	4110 sec	411
Radial acceleration	$0.4/4110 = 0.0000973 \text{ m/s}^2$	97
Along track acceleration	$0.8/4110 = 0.0001946 \text{ m/s}^2$	195
Cross track acceleration	0 m/s ²	0
Radial acceleration_model_sigma	$10\% * \text{sqrt}(0.0000973^2 + 0.0001946^2) = 0.0000218 \text{ m/s}^2$	2
Along track acceleration_model_sigma	0.0000218 m/s ²	2
Cross track acceleration_model_sigma	0.0000218 m/s ²	2
Adj	yes	1
ratio	-	0
Radial acceleration_initial_sigma	$3 * 0.0000973 = 0.000292 \text{ m/s}^2$	29
Along track acceleration_initial_sigma	$3 * 0.0001946 = 0.000584 \text{ m/s}^2$	58
Cross track acceleration_initial_sigma	0	1

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DORIS_DELETE_MANOEUVER (if any)

This procedure is applicable only for satellites using upload parameter TC to manage manoeuvres

Objective: to delete already uploaded manoeuvre TC's on board DORIS.

This procedure may be used in one of the following situations:

1. The planned manoeuvre has been cancelled.
2. The planned manoeuvre characteristics have changed; in this case this procedure shall be used before uploading the new characteristics.
3. Erroneous manoeuvre characteristics have been uploaded; in this case this procedure shall be used before uploading the new characteristics.

Constraints :

1. This procedure will only delete UPLOAD PARAMETERS TC's whose execution time is not yet elapsed.
2. The DELETE_MANOEUVER TC shall be uploaded at least 20 s before the beginning of the manoeuvre; the DELETE_MANOEUVER will be ineffective if the manoeuvre has already started.

Remark : the "Approx Time" column gives the minimum relative delay with respect to the previous step

Requisite		None		
Step	Time	Action / Event	Check	Comment
1	Latest 20 s prior to thrust	Send UPLOAD PARAMETER TC: TCHD Killer		
2	10 s later	Receive Routine report packet	Event_ID = TC acknowledgement = 2 Last_Command = Upload parameter TC = 0xD005 Total_Upload_OK incremented by 1 No anomaly	

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DORIS_RESTART

Objective : Restart DORIS processor and run SW stored in the EEPROM bank A or B. This procedure may be used in one of the following situations :

1. for emergency : if the DORIS SW is hung (Status_UC is set at 1 for more than 60 seconds),
2. for SW maintenance.

Constraints : not to be used during SW upload.

Remarks:

1. The procedure will stop temporarily the DORIS mission.
2. The “Approx Time” column gives the minimum relative delay with respect to the previous step.

Requisite		None		
Step	Approx Time	Action / Event	Check	Comment
1	0 s	Send TC NOP		
2	+10 s	Receive Routine report packet	Event_ID = TC acknowledgement = 2 Last_Command = NOP = 0xA5A5 No anomaly	
3	+10 s	Send TC RESTART[1/2][A/B]	UC STATUS default < 1min	[1/2] : depending on active chain [A/B] : • emergency case: see table in § 13.1 “HK Telemetry Monitoring Criteria” • SW maintenance case: see § 12.2 “SW Maintenance”

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4	+40s	Receive Routine report packet	Event_ID = Periodic = 7 DORIS mode = Autoinit = 2 No anomaly Check correct Version Indexes : SW_Issue ZQS_Doris_Issue_RAM ZQS_Diode_Issue_RAM ZQS_Systeme_Issue_RAM	In case of SW Maintenance, check that reported SW version indexes are the correct ones.
5a	+ 50 s	Receive Routine report packet	Event_ID = Mode change = 1 (UT1 measurement mode : idle to DAS rand) DORIS mode = Autoinit = 2 No anomaly	
5b		Receive Datation packets	One packet every second	Date starts from 01/01/2000 with IQ = 0xFFFF FFFF
5c		Receive Navigation packets	Dummy packet every ten seconds	Date starts from 01/01/2000, values are set to 0 and IQ = 0xFFFF FFFF

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DORIS_TMTC_CHECK

Objective : to check the TMTC link

Constraint : none.

Remark : the “Approx Time” column gives the minimum relative delay with respect to the previous step.

Step	Approx Time	Action / Event	Check	Comment
1	0 s	Send TC NOP		
2	+10 s	Receive Routine report packet	Event_ID = TC acknowledgement = 2 Last_Command = NOP = 0xA5A5 No anomaly	

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DORIS_SPECIAL_OPERATIONS

Objective: perform a special operation based on Test TC: DZQS, MASR or ADG. This procedure can be executed for requesting a complete ZQS DUMP, executing a stop/start command of Jamming packets production, a stop/start command of Auxiliary Data packets production.

Constraints : ① the detailed procedure will be defined and agreed a few days before execution.

② no other Test TM type shall be generated before this procedure execution. For ex: in case of Dump command request, if Auxiliary Data TM is already active, a manual TC disabling this TM shall be sent before the TC DZQS activating the dump.

Remarks:

1. The present procedure just provides guidelines.
2. The TCs shall be generated by Satellite Control Centre, according to previously agreed procedures.
3. The “Approx Time” column gives the minimum relative delay with respect to the previous step.

Requisite		DORIS ON		
Step	Time	Action / Event	Check	Comment
1	0 s	Send Test TC XXXX		XXXX = TEST (MASR, DZQS, ADG) with appropriate parameters. Depending on detailed procedure.
2	+10 s	Receive Routine report packet	Event_ID = TC acknowledgement = 2 Last_Command = TC XXXX No anomaly	
3a	+10 s	Receive Routine report packet	Event_ID = Change mode = 1	For TC MASR and ADG only
3b	+10 s	Test packet	Generation or no more generation of test packets depending of TC parameters (activation / stop)	If activation of TC, every 10 seconds: 8 test packets containing the dumped values (during around 90s) or 2 jamming packet or one auxiliary data packet

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4	+10 s	Run again this procedure if another TC has to be sent		

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DORIS_FULL_SOFTWARE_ZONE_UPLOAD_EEPROM

Objective : Upload of full on-board software in EEPROM bank [A/B] (see § 12.2 “Software Maintenance”).

Constraint : DORIS is in MEASUREMENT Mode.

Remarks :

1. This procedure shall be repeated 4 times in case of full software upload including the 3 ZQS.
2. The “Approx Time” column gives the minimum relative delay with respect to the previous step.
3. Upload may be interrupted to take into account the different satellite/ground stations contact periods.
4. In case of TC upload failure during a ground station contact period, TCs may be uploaded again since there is no impact within DORIS to receive the same TC once again. However each TC shall be uploaded at least once.
5. After complete and successful upload, DORIS_RESTART procedure has to be executed in order to activate the uploaded new SW.

Requisite		DORIS ON		
Step	Approx Time	Action / Event	Check	Comment
1	0 s	Send TC ARM		
2	+10 s	Receive routine report packet	Event_ID = TC acknowledgement = 2 Last_Command = TC ARM = 0x8400 No anomaly	
3	+20 to 50 s	Receive routine report packet	Event_ID = Mode change = 1 Upload EEPROM mode = 1 = Authorized MVR_Status = 0x20 / 0x40 Record Total_Upload_OK, Total_Upload_KO, Total_TC_OK and Total_TC_KO field values	MVR_Status = 0x20 if last restart was from bank A 0x40 if last restart was from bank B

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4a 4b ...	+10 s	Send the 'N' TC Upload memory corresponding to the full software zone. N is the number of TC needed to upload the full zone. This number is given in the header of the provided file containing the software zone to be uploaded.	No TC acknowledgment mandatory	Total duration : see § 15.6 "Uplink command budget" Provided file: either LOGICIEL_DORIS_CODGXXS_XXY Y_aabb_MEM.TCH, or ZQS_DORIS#_SatelliteName_ccdd_ MEM.TCH or ZQS_DIODE_SatelliteName_eeff_ME M.TCH or ZQS_SYSTHEME_SatelliteName_gghh_ MEM.TCH Max TC rate: 40 TC per 10s
5a 5b ...	Periodically	Some periodic routine report packets may be received (every 30 mn)	Event_ID = Periodic = 7 Check that Total_TC_KO and Total_Upload_KO fields are not incremented	
...	from time to time	Send TC NOP		DORIS_TMTC_CHECK procedure can be run from time to time to check the number of uploaded TC
...			Event_ID = TC acknowledgement = 2 Last_Command = NOP = 0xA5A5 No anomaly Check that Total_TC_KO and Total_Upload_KO fields are not incremented	

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6	+20 s after last Upload Memory TC Unless the 20s delay is respected the complete upload may be failed.	Send TC EUP 0x870X		The EUP TC configuration shall be set to the right configuration. EUP parameter shall be ▪ 8708 if code zone is uploaded ▪ 8704 if DORIS ZQS is uploaded ▪ 8702 if DIODE ZQS is uploaded ▪ 8701 if SYSTEM ZQS is uploaded Remark: If set all to zero the 4 configuration bits of the TC EUP will cancel the whole upload procedure and switch the upload mode into inhibited.
7	+10 s	Receive Routine report packet	Event_ID = TC acknowledgement = 2 Last_Command = TC EUP = 0x870X Total_TC_KO = same value recorded in step 2b Total_upload_OK = value recorded in step 2b +N Total_upload_KO = same value recorded in step 2b	

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8	Between 100 to 1200s depending of zone uploaded	Receive Routine report packet	Event_ID = Mode change = 1 Upload EEPROM mode = 0 = Inhibited No anomaly	In case of failed upload an anomaly report will be received with Event_ID = 0x801X (X depending on the uploaded zone, see step 5) Remark: taking into account the delay, this routine report packet may be received on a subsequent pass.
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DORIS_PATCH_EEPROM				
Objective: Upload of a part of one ZQS data in on-board EEPROM bank [A/B] (see § 12.2 “Software Maintenance”).				
Constraints: none				
Remarks: - The “Approx Time” column gives the minimum relative delay with respect to the previous step. - The modified data will only be available after the next RESTART from the modified EEPROM bank.				
Requisite		DORIS ON		
Step	Approx Time	Action / Event	Check	Comment
1	0 s	Send TC ARM		
2	+10 s	Receive Routine report packet	Event_ID = TC acknowledgement = 2 Last_Command = TC ARM = 0x8400 No anomaly	
3	+20 s	Receive Routine report packet	Event_ID = Mode change = 1 Upload EEPROM mode = 1 = Authorized MVR_Status = 0x20 / 0x40 Record Total_Upload_OK, Total_Upload_KO, Total_TC_OK and Total_TC_KO field values	MVR_Status = 0x20 if last restart was from bank A 0x40 if last restart was from bank B
4	+10 s	Send a TC Upload memory corresponding to the ZQS data (either within DIODE, DORIS or SYSTEM ZQS memory area).	With TC Acknowledgment mandatorily.	Maximum rate: 1 TC packet per 20 s max
5	+10 s	Receive Routine report packet	Event_ID = TC acknowledgement = 2 Last_Command = Upload = 0xD000 Total_Upload_OK incremented by 1 Total_Upload_KO not incremented	

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6a 6b ...	+ 10 s	Go to step 3 in case of another TC upload memory needed to be sent.		
7	+10 s	Send TC EUP 0x8700		
8	+10 s	Receive Routine report packet	Event_ID = TC acknowledgement = 2 Last_Command = TC EUP = 0x8700	
9	+10 s	Receive Routine report packet	Event_ID = Mode change = 1 Upload EEPROM mode = 0 = Inhibited No anomaly	In case of failed upload an anomaly report will be received with Event_ID = 0x801X (X depending on the modified zone)
		A restart on uploaded EEPROM is mandatory to get into account uploaded values		

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DORIS_PATCH_RAM

Objective: Modify code or ZQS data (DIODE, DORIS or SYSTEM) in RAM (see § 12.2 “Software Maintenance”).

Constraints:

1. The patch shall not affect the current instruction in the running code.
2. Patches in RAM are allowed in the memory area used by the OBSW. Unless, the BDR would perform immediately an automatic Restart.
3. Upload mode is inhibited.

Remarks:

1. The “Approx Time” column gives the minimum relative delay with respect to the previous step.
2. Patch will be lost after switch-off or restart.
3. For versions v4.xx of DGXX-S software, if a patch EXTRA-FINE AUTHORIZED is wanted in the DIODE ZQS, it is necessary to verify if, since the last "RESTART" command, the software has already been AUTHORIZED before. In this case, a RESTART" command is required before the PATCH EXTRA-FINE AUTHORIZED is performed. See section 12.2.4.

Requisite		DORIS ON.		
Step	Approx Time	Action / Event	Check	Comment
1	0 s	Send Upload memory TC packet	With TC Ack mandatory	
2	+10 s	Receive Routine report packet	Event_ID = TC acknowledgement = 2 Last_Command = Upload = 0xD000 Total_Upload_OK incremented by 1	
3	+10 s	Go to step 1 in case of other TC to be sent		

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DORIS_SW_COPY				
Objective: Copy the SW from one EEPROM Bank to the other EEPROM Bank (see § 12.2 “SW Maintenance”).				
Constraint: The SW to be copied shall be validated before copy (see § 12.2 “SW Maintenance”).				
Remark: The “Approx Time” column gives the minimum relative delay with respect to the previous step.				
Requisite		DORIS ON.		
Step	Approx Time	Action / Event	Check	Comment
1	0 s	Send TC ARM		
2	+10 s	Receive Routine report packet	Event_ID = TC acknowledgement = 2 Last_Command = TC ARM = 0x8400 No anomaly Check the versions of OBSW and ZQS which will be duplicated on other EEPROM.	
3	+20 s	Receive Routine report packet	Event_ID = Mode change = 1 Upload EEPROM mode = 1 = Authorized MVR_Status = 0x20 / 0x40 Record Total_Upload_OK, Total_Upload_KO, Total_TC_OK and Total_TC_KO field values	MVR_Status = 0x20 if last restart was from bank A 0x40 if last restart was from bank B
4	+10 s	Send TC TMM		
5	+20 s	Receive Routine report packet	Event_ID = TC acknowledgement = 2 Last_Command = TC TMM = 8800H	
6	+1200 s	Receive Routine report packet	Event_ID = Mode change = 1 Upload EEPROM mode = 0 = Inhibited	

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ANNEX B : SOFTWARE REPORT CODES

This list is given as an indication. Some report codes are not relevant on each mission (e.g. attitude CRL). The detailed applicable list can be found in RD 1.

The column "Anomaly report", when filled, indicates that an anomaly report is generated. In this case, the event ID is given.

The columns on the right ranks the anomalies in 3 categories:

- **EXPERT_DORIS** when the software report concerns :
 - the DORIS system (essentially the DORIS beacons),
 - or the DORIS instrument,
 - or the DORIS software development,
 - or the DIODE navigation function.
- **SCC** when the information is suitable for SCC. In those cases, an anomaly report will be generated.
- **SATELLITE ISSUE** when the software report is due to a satellite issue (anomalies on the BUS 1553).

B-1) DORIS SOFTWARE REPORT CODES

Software Report	dec	hex	Anom . Rep.	EXPERT DORIS	SCC	Satellite Issue
PAS_D_ANOMALIE	0	0000				

COMPTE RENDUS POUR LES TC

REJET_TCH_BALISE_SYNCHRO_INVALIDE	1	0001	800A	X	X	
REJET_TCH_BALISE_ENTETE_INVALIDE	2	0002		X		
REJET_TCH_BALISE_ICODE_INVALIDE	3	0003		X		
REJET_TCH_BALISE_BROADCAST_INVALIDE	4	0004	800A	X	X	
REJET_TCHD_DE_CLASSE_INVALIDE (1)	5	0005	8007		X	
REJET_TCHD_DE_TYPE_DORIS_INVALIDE (1)	6	0006	8007		X	
REJET_TCHD_DE_SORTE_INVALIDE (1)	7	0007	8007		X	
REJET_TCHD_TUEUR_INVALIDE (1)	8	0008	8007		X	
TABLE_TCHD_PLEINE	9	0009		X		
EXCEPTION_DANS_REALISER_TELECHAR GEMENTS_VOIE_SATELLITE	10	000A		X		
EXCEPTION_DANS_REALISER_TELECHAR GEMENTS_VOIE_BM	11	000B		X		

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Software Report	dec	hex	Anom . Rep.	EXPERT DORIS	SCC	Satellite Issue
EXCEPTION_DANS_REALISER_TELECHAR GEMENTS_VOIE_TEST	12	000C		Ground testing		
EXCEPTION_DANS_EXPLOITER_TCHD_DO RIS	13	000D		X		
EXCEPTION_DANS_TRAITER_BLOC_TCH_B ALISE	14	000E		X		
BALISE_INCONNUE_DANS_TCHD_CORRES PONDANCE_TEMPS	15	000F		X		
TROP_DE_BALISES_DANS_TCHD_COORD ONNEES_BALISES	16	0010		X		
EXCEPTION_DANS_TRAITER_CTRL_DIREC TIVES	17	0011		X		
EXCEPTION_DANS_TRAITER_CTRL_CONFI GURE_TC	18	0012	8007		X	
EXCEPTION_DANS_TRAITER_UPLOAD_PA RAMETERS	19	0013	8007		X	
EXCEPTION_DANS_TRAITER_UPLOAD_ME MORY	20	0014	8007		X	
EXCEPTION_DANS_TRAITER_TEST_TC	21	0015	8007		X	
TRAITER_ATTITUDE_TC	22	0016		X		X
RECEPTION_1553_METTRE_EN_FILE	23	0017		X		
RECEPTION_1553_LIRE_ET_ENLEVER_DE_ LA_FILE	24	0018		X		
TRAITER_TC_TIME	25	0019		X		X
REJET_TCH_BROADCAST PERIME	26	001A		X		
EXCEPTION_DANS_DEPOSER_DONNEES_ ATTITUDE	27	001B		X		X
REJET_TCHD_DE_DATE_INVALIDE	28	001C		X		

**COMPTE RENDUS POUR LA
SURVEILLANCE**

EXCEPTION DANS SURVEILLANCE REALISER	32	0020		X		
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**COMPTE RENDUS POUR LES
INTERRUPTIONS**

EXCEPTION_DANS_TRAITER_L_IT_1553	128	0080		X		
EXCEPTION_DANS_TRAITER_L_IT_TDI	129	0081		X		
EXCEPTION_DANS_TRAITER_L_IT_DATEU R	130	0082		X		
EXCEPTION_DANS_TRAITER_L_IT_T1S	131	0083		X		
IT_TDI_DANS_TRAITEMENTS_PSEUDO_SY NCHRONES	132	0084		X		

**COMPTE RENDUS POUR LES TEMPS OU
DATEUR**

DEFAULT_DE_T1S	160	00A0		X		
DEFAULT_DE_TDI	161	00A1		X		
L_ADDITION_TOUS_TOUS_A_DEBORDEE	162	00A2		X		
L_ADDITION_TOUS_TEMPS_EN_10_MS_A_ DEBORDEE_EN_PLUS	163	00A3		X		
L_ADDITION_TOUS_TEMPS_EN_10_MS_A_ DEBORDEE_EN_MOINS	164	00A4		X		

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Software Report	dec	hex	Anom . Rep.	EXPERT DORIS	SCC	Satellite Issue
DATE_MESURE_DORIS_DECOMMUTE_IN VALIDE	165	00A5		X		
EXCEPTION_DANS_TRAITER_MESURES_T 3	166	00A6		X		
EXCEPTION_DANS_NOMBRE_DE_PAS_DE_ CTA	167	00A7		X		
DATES_TAI_SOL_INCOHERENTES	168	00A8		X		
DATES_TAI_SOL_BORD_DIFFERENTES	169	00A9		X		
DATES_TAI_SOL_SOL_DIFFERENTES	170	00AA		X		

COMPTE RENDUS POUR LA TELEMESURE

EXCEPTION_DANS_PRODUIRE_UN_NAVIG ATOR_PACKET	192	00C0		X		
EXCEPTION_DANS_REACTUALISER_LES_B ULLETINS_DIODE	193	00C1		X		
EXCEPTION_DANS_REACTUALISER_LE_NA VIGATOR_PACKET	194	00C2		X		
EXCEPTION_DANS_REACTUALISER_LE_DA TATION_PACKET	195	00C3		X		
EXCEPTION_DANS_PRODUIRE_UN_DOPPL ER_PACKET	196	00C4		X		
EXCEPTION_DANS_PRODUIRE_UN_JAMMI NG_PACKET	197	00C5		X		
EXCEPTION_DANS_PRODUIRE_UN_BLOC_ TUT	198	00C6		X		
EXCEPTION_DANS_PRODUIRE_UN_REPOR T_PACKET	199	00C7		X		
EXCEPTION_DANS_PRODUIRE_UN_DUMP_ PACKET	200	00C8		X		
EXCEPTION_DANS_DUMPER	201	00C9		X		
EXCEPTION_DANS_EMISSION_1553_EMET TRE	202	00CA		X		
EXCEPTION_DANS_EMISSION_1553_TRAIT ER_LE_SWD	203	00CB		X		
EXCEPTION_DANS_FILES_TEST_TM_TC_D EPOSER	204	00CC		Ground testing		
EXCEPTION_DANS_EMITTRE_LE_PAQUET	205	00CD		X		

COMPTE RENDUS POUR LES UT

EXCEPTION_DANS_UAM_REAFFECTER	224	00E0		X		
EXCEPTION_DANS_UT_ACTUALISER_SUR_ TDI	225	00E1		X		
EXCEPTION_DANS_UT_PREACTUALISER	226	00E2		X		
EXCEPTION_DANS_CALCULER_NUMERO_ BALISE	227	00E3		X		
EXCEPTION_DANS_ACTUALISER_SUR_TDI DONNEES_UAM_BALISE	228	00E4		X		
EXCEPTION_DANS_VALIDITE_MESURE_AC TUALISER_SUR_TDI	229	00E5		X		
EXCEPTION_DANS_DATATION_T3_ACTUAL ISER_SUR_TDI	230	00E6		X		
EXCEPTION_DANS_TEST_COHERENCE_40 0MHZ_2GHZ	231	00E7		X		

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Software Report	dec	hex	Anom . Rep.	EXPERT DORIS	SCC	Satellite Issue
EXCEPTION_DANS_TEST_FREQUENCE_2G HZ_DEMANDEE	232	00E8		X		
CHAMP_TYP_DES_DONNEES_BALISE_INC ONNU	233	00E9		X		
DATE_PRIMAIRE_T3_INCORRECTE	234	00EA		X		
DATE_FINE_T3_INCORRECTE	235	00EB		X		
COMPTEUR_AS3_INCORRECT	236	00EC		X		
MESURES_DE_PHASE_INCORRECTES	237	00ED		X		
ECART_BASES_DE_TEMPS_INCORRECT	238	00EE		X		
EXCEPTION_DANS_DIODE_PREACTUALISE R_LA_BALISE_A_MESURER	239	00EF		X		
EXCEPTION_DANS_ACTUALISER_SUR_TDI DONNEES_BALISE	240	00F0		X		
EXCEPTION_DANS_ACTUALISER_MESSAG E_400_MHZ	241	00F1		X		
EXCEPTION_DANS_DECOMMUTER_MESSA GE	242	00F2		X		
EXCEPTION_DANS_ACTUALISER_TELECHA RGEMENT_400_MHZ	243	00F3		X		
EXCEPTION_DANS_ACTUALISER_MESSAG E_2_GHZ	244	00F4		X		
EXCEPTION_DANS_ACTUALISER_TELECHA RGEMENT_2_GHZ	245	00F5		X		
EXCEPTION_DANS_DATATION_T3_ACTUAL ISER_T3	246	00F6		X		
CHAMP_XY_DES_DONNEES_BALISE_INCO NNU	247	00F7		X		
EXCEPTION_DANS_DEMANDER_AUTOCOR RECTION_TAI	248	00F8		X		
EXCEPTION_DANS_CALCUL_ICCE	249	00F9		X		
EXCEPTION_DANS_PROGRAMMATION_TE ST_REAFFECTER	250	00FA		X		
EXCEPTION_DANS_PROGRAMMATION_PA R_DIODE_REAFFECTER	251	00FB		X		
EXCEPTION_DANS_PROGRAMMATION_PA R_FFT_REAFFECTER	252	00FC		X		
EXCEPTION_DANS_RECEPTEURS_ACTUAL ISER	253	00FD		X		

COMPTE RENDUS POUR DIODE

EXCEPTION_DANS_APPLICATION_DIODE_ DOPPLER_ATTENDU	288	0120		X		
EXCEPTION_DANS_APPLICATION_DIODE_ PREVISIONS_DE_PROGRAMMATION	289	0121		X		
EXCEPTION_DANS_APPLICATION_DIODE_ CORRESPONDANCE_DES_TEMPS	290	0122		X		

COMPTE RENDUS POUR MEMOIRES

EXCEPTION_DANS_AUTOCORRIGER_LA_R AM	320	0140		X		
EXCEPTION_DANS_MNVR_ACTUALISER_E CRITURES	321	0141		X		
AUTOTEST_KO_DANS_TAMPON_RAM	322	0142	801x	X	X	
AUTOTEST_KO_DANS_MNVR_BASSE	323	0143	801x	X	X	
AUTOTEST_KO_DANS_MNVR_HAUTE	324	0144	801x	X	X	

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Software Report	dec	hex	Anom . Rep.	EXPERT DORIS	SCC	Satellite Issue
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COMPTE RENDUS CARTE UC

DEBORDEMENT_EMISSION_TEST_TM_TC	352	0160		Ground testing		
DEBORDEMENT_RECEPTION_TEST_TM_TC	353	0161		Ground testing		
DESYNCHRO_RECEPTION_TEST_TM_TC	354	0162		Ground testing		

COMPTE RENDUS AUTOINITIALISATION

EXCEPTION_DANS_AUTOINIT_ACTUALISER SUR TDI	384	0180		X		
EXCEPTION_DANS_AUTOINIT_TRAITER_SYNCHRO SUR B1	385	0181		X		
EXCEPTION_DANS_AUTOINIT_TRAITER_SYNCHRO_GROSSIERE	386	0182		X		
EXCEPTION_DANS_AUTOINIT_TRAITER_LES MESURES T3	387	0183		X		
EXCEPTION_DANS_AUTOINIT_TRAITER_ATTENTE FIN CT	388	0184		X		
EXCEPTION_DANS_AUTOINIT_TRAITER_CONFIRMATION SYNCHRO SUR B1	389	0185		X		
EXCEPTION_DANS_AUTOINIT_ATTENDRE PREMIERE MESURE T3	390	0186		X		
FIN_DE_TEMPO_SYNCHRO_SUR_B1	391	0187		X		
FIN_DE_TEMPO_SYNCHRO_SUR_B2 ou B3	392	0188		X		
FIN_DE_TEMPO_CONFIRMATION_SYNCHRO SUR B1	393	0189		X		
DELTA_T3_SUR_B2_INVALIDE	394	018A		X		
DELTA_T3_SUR_B1_B2_B3_INVALIDE	395	018B		X		
DEPASSEMENT_SEUIL_MAX_CT_PREDEFINIES	396	018C		X		
MIN_MAX_DELTA_T3_INVALIDE	397	018D		X		

COMPTE RENDUS DU BUS 1553

MAUVAISE_SEQUENCE	416	01A0	8009		X	X
EMISSION_DESYNCHRONISEE	417	01A1	8009		X	X
EXCEPTION_DANS_ANALYSER	418	01A2	8009		X	X
SOUS_ADRESSE_ILLEGALE	419	01A3	8009		X	X
SATURATION_EMISSION	420	01A4	8009		X	X
SATURATION_RECEPTION	421	01A5	8009		X	X
SOUS_ADRESSE_ACQUITTEE_NON_CONFORME	422	01A6	8009		X	X
BLOC_RECU_TROP_LONG	423	01A7	8009		X	X
BLOC_EMIS_TROP_LONG	424	01A8	8009		X	X
RECEPTION_DESYNCHRONISEE	425	01A9	8009		X	X
SOUS_ADRESSE_SWD_NON_CONFORME	426	01AA	8009		X	X

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Software Report	dec	hex	Anom . Rep.	EXPERT DORIS	SCC	Satellite Issue
COMMANDE_SWD_NON_CONFORME	427	01AB	8009		X	X
RECEPTION_ANNULEE	428	01AC	8009		X	X
EMISSION_ANNULEE	429	01AD	8009		X	X

COMPTE RENDUS DE LA FFT

EXCEPTION_DANS_FFT_LIRE_SIGNAUX_A_TRAITER	448	01C0		X		
DEFAULT_D_ECRITURE_DANS_RAM_FFT	449	01C1		X		

B-2) DIODE SOFTWARE REPORT CODES

This information is primarily aimed towards DORIS experts.

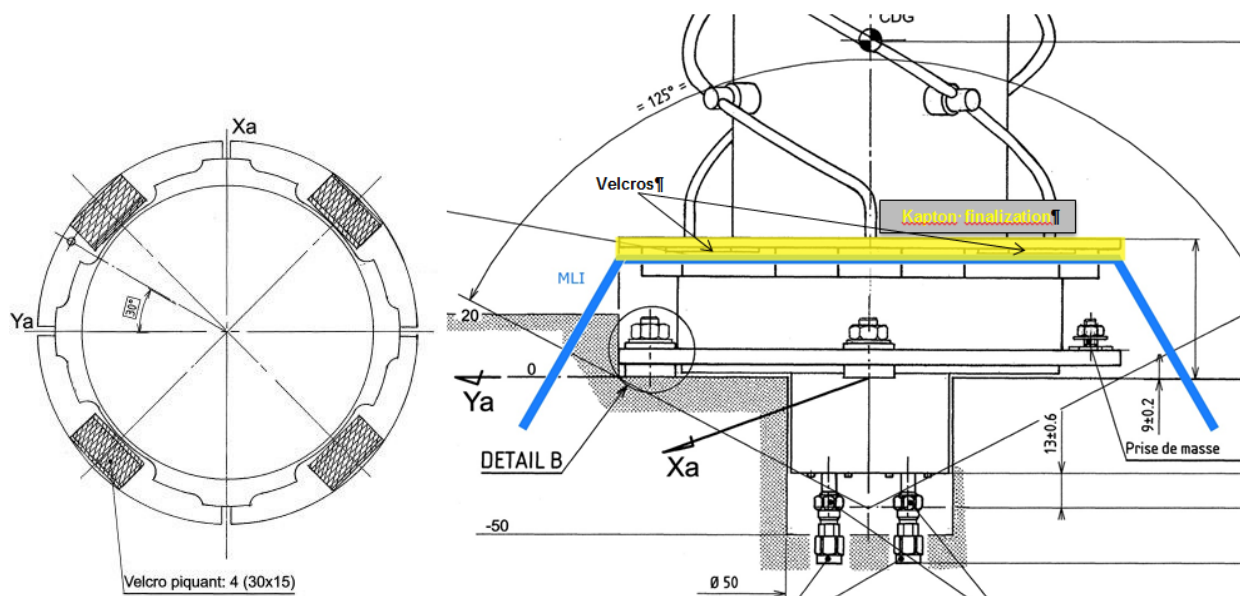
Software Report	dec	hex	Anom . Rep.	EXPERT DORIS	SCC	Satellite Issue
pas d'erreur	0	0000				
TCH	1	0001		X		
Prédiction	2	0002		X		
Extrapolation	3	0003		X		
rattrapage	4	0004		X		
Normal	5	0005		X		
Correction	6	0006		X		
Mesure	7	0007		X		
Autoinitialisation	8	0008		X		
Autoprogrammation	9	0009		X		
Correspondance temps	10	000A		X		
Bulletin estimé	11	000B		X		
prévisions de programmation	12	000C		X		
Passage en mode autonome autorisé	13	000D		X		
Rejet TUC et TU1R	14	000E		X		
Mettre à jour TUC et TU1R	15	000F		X		
Ordre des appels pour TUC et TU1R	16	0010		X		
Doppler Attendu	17	0011		X		
Autres	18	0012		X		
Bulletin estimé J2000	19	0013		X		
Bulletin estimé Géodésique	20	0014		X		
Temps calcul minimal	21	0015		X		
Ecart temps attitude restitution	22	0016		X		
Ecart temps attitude programmation	23	0017		X		X
Bulletin estimé Osculateur	24	0018		X		
Erreur_prise_en compte attitude	25	0019		X		X
PSO estimée	26	001A		X		
Erreur_Rejet_BT	27	001B		X		
Erreur_Réinit_Balise	28	001C		X		

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Software Report	dec	hex	Anom . Rep.	EXPERT DORIS	SCC	Satellite Issue
Erreur_Rejet Dopplers	29	001D		X		
Erreur_Rejet IT3s	30	001E		X		
Erreur_Monitoring_DIODE	31	001F		X		

Erreur dans donnees_attitude.rdv_deposer	254	00FE		X		
Erreur dans donnees_attitude.rdv_fournir	255	00FF		X		

ANNEX C : RECOMMENDATIONS FOR THE MLI ON THE ANTENNA



Notes :

1. 4 Velcros are available under the RF reference plan (upper part of the antenna foot, under radiating elements) of the antenna to maintain the MLI.
2. MLI shall not be positioned on the upper side of the reference plan.
3. Sun trapping shall be limited by positioning the MLI as closely as possible to the lower side of the RF reference plan.





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DIFFUSION LIMITEE DORIS



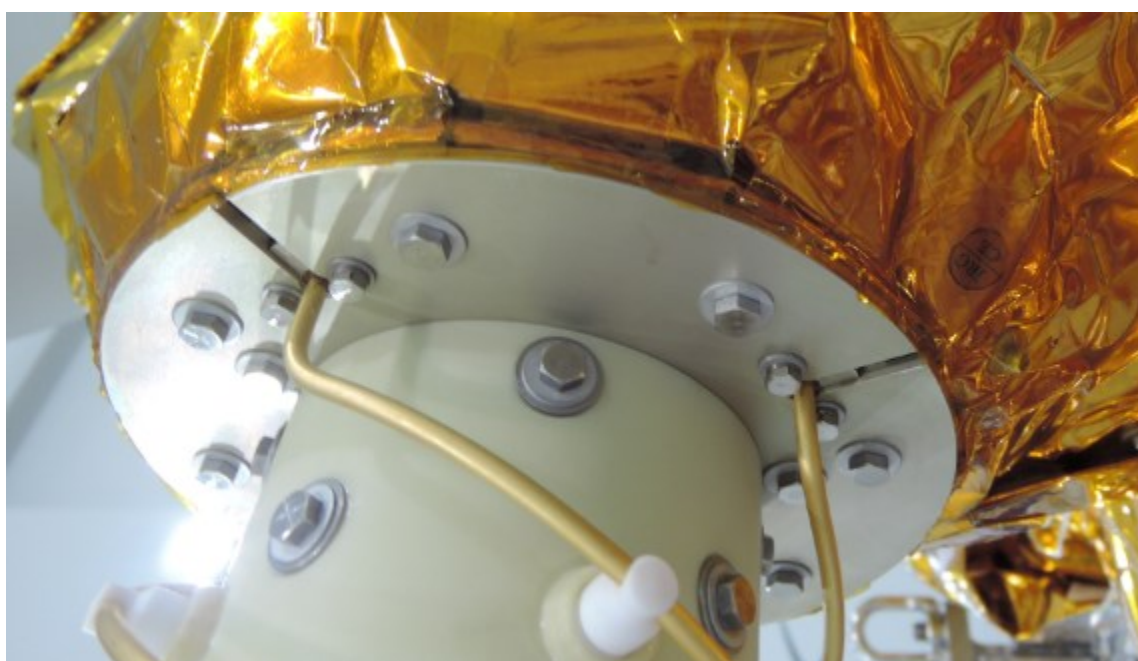
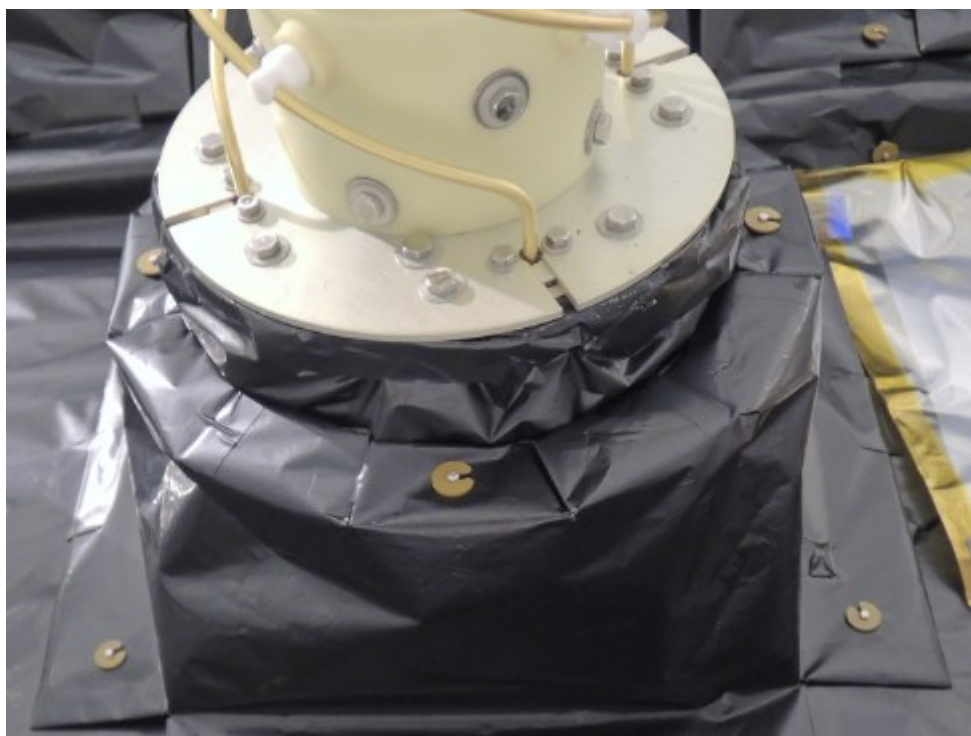
Reference : [CO-MU-D0-OP-16873-CN](#)

Issue : 1.6

Date : 10/03/2026

Page : 109/110

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