

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 1/75
---	--	--

DORIS

Generic Definition of TM Packets and TC Formats

Prepared by :	DORIS TEAM	Date and Signature
Accepted by :	O. DUMOND	Date and Signature Dumon d Olivier Signature numérique de Dumond Olivier Date : 2021.11.26 11:37:01 +01'00'
Approved by :	C. MANFREDI	Date and Signature Manfred i Cecile Signature numérique de Manfredi Cecile Date : 2021.11.26 13:41:23 +01'00'

For Application to	DS4	DS5	DH2A	DH2B	DPP	DJ1	DJ2	DCY2	DOA	D3S	DHY2	DST3
	DJ3	DSW									DOR	SMM
	DGXX-S TBC ; OBSW from DGXX-S V5.0 ; EGSE Linux V3.6.1											

DORIS project internal management :			
Applicable configuration :	NO	Controlled by :	Since :
Applicated configuration :	NO		

• • • • •

PARIS - Les Halles
SIÈGE
2, place Maurice Quentin
75039 Paris Cedex 01
☎ +33 (0)1 44 76 75 00

PARIS - Daumesnil
DIRECTION DES LANCEURS
52, rue Jacques Hillairet
75612 Paris Cedex
☎ +33 (0)1 80 97 71 11

TOULOUSE
CENTRE SPATIAL DE TOULOUSE
18, avenue Édouard Belin
31401 Toulouse Cedex 9
☎ +33 (0)5 61 27 31 31

GUYANE
CENTRE SPATIAL GUYANAIS
BP 726
97387 Kourou Cedex
☎ +594 (0)5 94 33 51 11

RCS Paris B 775 665 912
Siret 775 665 912 000 82
Code APE 731 Z
N° identification :
TVA FR 49 775 665 912

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 2/75
Generic Definition of TM Packets and TC Formats		

CONTROL ELEMENT

Confidentiality : yes	Type : According to distribution list
Key words : TM, TC, telemetry, telecommand, DORIS, packet, format	
Summary : this document defines the format of TM packets and TC formats/packets exchanged via the MIL-STD-1553B data bus interface.	

DOCUMENT CHANGE RECORD

The modifications between issues are listed below.

Issue	Date	Modifications
1.0	04/12/14	Document creation
1.1	13/10/15	DM 3057 : Precision on the convention for quaternions (section 4.10) DM 3060 : Modification of the validity period for the altitude model (section 3.2.4) + correction of a few typos
1.2	22/02/17	Taken into account the following modifications : - DM 3055 : Satellite ID for S3C-S3D (section 3) - DM 3066 : SC_TIME TC format - DM 3067 : precisions concerning OCM (section 4.5) and SAP TC (section 4.6) - DM 3071 : Display chosen channel (section 3.1) - DM 3072 : Applicability to Sentinel 3C and Sentinel 3D - DM 3086 : Add Quality Indexes in the Routine Report (Jason-3 REX) (section 3.4) - DM 3087 : Tracer les erreurs ICCE dans blocs mesures - DM 3090 : Invalid beacon messages set to 0000 in the Doppler packets (section 3.1) - DM 3092 : 1553 TC Time Broadcast address (section 3) - DM 3136 : SWOT Solar Panels Attitude + Label Field Upgrade : Pus version number and Destination_ID correction of a few typos

Generic Definition of TM Packets and TC Formats

1.3	11/09/2018	Taken into account the following modifications : - DM 3236 : Update of the reference documents list ; Removal of the TBC for the RT addresses (section 3) ; Precision about the Quality Index of the KARIN navigator packet (section 3.2.4) ; Removal of the TBC concerning the maneuvers (section 4.5) - DM 3238 : Precision for the OL Reference Frame in the OCM TC (section 4.5); precision about matrix and quaternions notations (section 4.8); conventions deplaced in the beginning of the document
1.4	11/06/2019	DM 3265 : Precision about definitions of Source_data and Data_Size (wording)
1.5	09/11/2021	DM3344 : Precision about quaternions §4.10

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 4/75
Generic Definition of TM Packets and TC Formats		

ABBREVIATIONS

Sigle	Definition
CUC	CCSDS Unsegmented time Code
DGXX-S	DGXX series follow on DORIS instrument (Sentinel3, Jason3, SWOT and Jason-CS)
DIODE	DORIS Immediate Orbit Determination Embedded- Software DORIS Navigation
DORIS	Doppler Orbitography and Radio Positioning Integrated by satellite
EEPROM	Electrically Erasable Programmable Read Only Memory
ICU	Interface Control Unit (if any)
I/F	Interface
PPS	Pulse Per Second
RSAT	Satellite Reference Frame
SAD (or DAS)	Spectrum Analysis Designation (Désignation des UT à partir de l'Analyse Spectrale des bandes Doris)
SC	Space Craft
SCCC	Space Craft Control Center
SMU	Software Management Unit
TAI	International Atomic Time
TU1	Universal Time TU1 used for sidereal time determination
TUC	Universal Time Coordonné
UAM	Acquisition and Measurement Unit: mainly consists of a numerical phase loop processing numerical samples of signals received on one of the DORIS frequency channels , either 400 MHZ or 2GHZ.
UT	Processing Unit : logical unit composed of two UAM, one on the 400 MHZ channel and one on the 2 GHZ channel.

APPLICABLE AND REFERENCE DOCUMENTS

The contents of applicable documents, in their common edition, have to be applied as a supplement to the text of the present document. If an applicable document, listed in the table below, is not called in the text of the present document with detailed application condition, he can be considered to be a reference document for supplementary benefit of information and, because of that, not mandatorily applicable.

Reference	Document title
-----------	----------------

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 5/75
Generic Definition of TM Packets and TC Formats		

CO-IF-D1/B-EA-10823-CN	RD 1 Interface specifications between the DORIS network beacons and the onboard instrument
CO-MU-D0-OP-16873-CN	RD 2 Inputs to Generic User Manual (to be customized)
CO-PL-D0-EA-15414-CN	RD 3 Calibration and Characterization Plan (to be customized)

TBC AND TBD LIST

(in case of no TBC or TBD mention "none" is mandatory in the table here after)

TBC/TBD	Paragraph	Brief description
TBC		To be confirmed

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 6/75
Generic Definition of TM Packets and TC Formats		

CONTENTS

CONTROL ELEMENT.....	2
CONTENTS.....	6
1. PURPOSE AND SCOPE.....	7
2. APPLICATION DOMAIN.....	7
CONVENTIONS	7
3. DESCRIPTION OF DORIS TM PACKET	9
3.1. DESCRIPTION OF DORIS DOPPLER PACKET SPECIFIC FIELDS	14
3.2. DESCRIPTION OF DORIS NAVIGATOR PACKET SPECIFIC FIELDS.....	22
3.2.1. DESCRIPTION OF THE DORIS NAVIGATOR PACKET IN THE ITRF TERRESTRIAL REFERENCE FRAME (NAV_T) SPECIFIC FIELDS	22
3.2.2. DESCRIPTION OF THE DORIS NAVIGATOR PACKET IN THE J2000 INERTIAL REFERENCE FRAME (NAV_I) SPECIFIC FIELDS	24
3.2.3. DESCRIPTION OF THE GEODETIC DORIS NAVIGATOR PACKET (NAV_G) SPECIFIC FIELDS.....	26
3.2.4. DESCRIPTION OF THE DORIS / KARIN NAVIGATOR PACKET (NAV_K) SPECIFIC FIELDS <i>IF ANY</i>	29
3.3. DESCRIPTION OF DORIS DATATION PACKET SPECIFIC FIELDS.....	32
3.4. DESCRIPTION OF DORIS REPORT PACKET SPECIFIC FIELDS	33
3.4.1. ROUTINE REPORT	34
3.4.2. ANOMALY REPORT.....	41
3.5. DESCRIPTION OF DORIS TEST PACKET SPECIFIC FIELDS.....	43
3.5.1. DESCRIPTION OF DORIS JAMMING PACKET TEST DATA.....	44
3.5.2. DESCRIPTION OF DUMP PACKET TEST DATA.....	46
3.5.3. DESCRIPTION OF OTHER TEST PACKETS TEST DATA	47
3.6. DESCRIPTION OF DORIS ATTITUDE PACKETS DATA (IF ANY TC ATTITUDE ON BOARD).....	49
4. DESCRIPTION OF DORIS COMMAND	50
4.1. TC FORMATS	50
4.2. TC PACKETS	51
4.3. CONFIGURE DORIS TC	53
4.3.1. NOP - NO OPERATION.....	53
4.3.2. ARM – SELECT UPLOAD_EEPROM MODE	53
4.3.3. EUP - END OF UPLOAD	54
4.3.4. TMM - COPY EEPROM.....	54
4.4. TEST TC.....	55
4.4.1. TEST TC MASR.....	56
4.4.2. TEST TC DZQS	57
4.4.3. TEST TC ADG	58
4.5. UPLOAD MEMORY TC	58
4.6. OCM TC IF ANY	60
4.7. SAP TC IF ANY	61
4.8. UPLOAD PARAMETERS TC IF ANY	62
4.8.1. MANEUVER CHARACTERISTIC TC	62
4.8.2. DATA KILLER TC	64
4.9. DESCRIPTION OF THE SATELLITE ON BOARD TIME	65
4.10. DESCRIPTION OF THE ATTITUDE TC.....	66
ANNEX 1	69
ANNEX 2	73

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 7/75
Generic Definition of TM Packets and TC Formats		

1. PURPOSE AND SCOPE

The TM/TC exchanges between Doris instrument and the carrier satellite, the satellite ground segment and the DORIS ground segment make use of Source Packets called Doris Packets.

This document defines the formats of the Doris Packets as implemented in the DORIS On Board Software. It is a kind of Software Interface Control Document about high level exchanges on the 1553 MILBus

Depending on the 1553 MIL BUS protocol, TC are defined by CCSDS packets or by formats without CCSDS PUS headers.

This document is generic : as soon as it is customized for a new project, its internal management properties must be changed to :

DORIS project internal management :			
Applicable configuration :	YES	Controlled by : CCM DORIS	Since : First Issue
Applicated configuration :	YES		

2. APPLICATION DOMAIN

This document applies internally in the DORIS team to the redaction of the dedicated document for each specific project.

CONVENTIONS

Note : For all the fields defined in this document :

1. Unless otherwise specified the fields are unsigned Integer,
2. The negative values for signed Integer are coded in "2 complement",
3. All the "Reserved" and "Spare" fields shall be filled with zeros,
4. Unless otherwise specified values are decimal values,
5. Value followed by H means hexadecimal value.

All TM Packets generated by the DORIS instrument have the same structure.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 8/75
Generic Definition of TM Packets and TC Formats		

Generation of optional TM packets depends on specific TCs sent (see TC chapter).

In case of Protocole "PROTEUS", the Main SC SW shall acquire them in specific coupler sub address depending on the TM packet type.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 9/75
Generic Definition of TM Packets and TC Formats		

3. DESCRIPTION OF DORIS TM PACKET

All the Doris TM Packets have the following generic format :

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0-1	PIH					APID										
2-3	3		Source_sequence_count													
4-5	Packet_length=n+13															
6-15	Data field header															
16-17	Satellite_ID								TAI_TUC							
18-(n+17)	packet specific fields (n octets - max 236)															
(n+18)-(n+19)	Packet_error_control															

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 10/75
Generic Definition of TM Packets and TC Formats		

Packet_Identification (2 octets) : This field identifies the different Packet types used by Doris. The Packet_Id starts with 5 bits “Packet Identification Header” (PIH) and ends with APID (11bits). These fields depend on the mission :

The PIH is “X 0 0 0 1” (binary), X depending on project choice

Jason3=1 Sentinel3=0 Jason-CS=0 SWOT=0

The APID definition depending on type of packets is given in the table 3.1.

Depending on project, the APID may be divided into

- *PID field bit 5 to 11*
- *PCAT field bit 12 to 15.*

Table 3.1 : The sub address, type, length of data, and APID are as per following table :

Sub address	TM Packet Type	Data size n (bytes)	Total Packet size (bytes)	PID If any	PCAT If any	Service type (8 bits) If any	Service subtype (8 bits) If any	APID may be different depending on DORIS chain
TBD	Routine Report	108	128	80	TBD	TBD	TBD	TBD
TBD	Anomaly Report (if relevant)	108	128	90	TBD	TBD	TBD	TBD
TBD	J2000 Navigation	44	64	81	TBD	TBD	TBD	TBD
TBD	Geodesical Navigation	44	64	82	TBD	TBD	TBD	TBD
TBD	ITRF Navigation	44	64	83	TBD	TBD	TBD	TBD
TBD	Datation	16	36	84	TBD	TBD	TBD	TBD
TBD	Doppler	236	256	85	TBD	TBD	TBD	TBD
TBD	Test Jamming (on request by TC)	236	256	86	TBD	TBD	TBD	TBD
TBD	Test Dump (on request by TC)	236	256	87	TBD	TBD	TBD	TBD
TBD	Test others (on request by TC)	236	256	88	TBD	TBD	TBD	TBD
TBD	Attitude	32	52	89	TBD	TBD	TBD	TBD
TBD	Specific Navigation Packet if any	44	64		TBD	TBD	TBD	TBD

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 11/75
Generic Definition of TM Packets and TC Formats		

Source_sequence_count (14 bits) : This parameter is dedicated to each packet APID (11 least significant bits of Packet Identification). This parameter shall be set at 0 for the first TM packets for each APID generated by the instrument, at initialization of application software, then, incremented by one at each packet generation of the corresponding APID.

On the TC link, Headers and Packet Error Control are generated by the satellite ground segment according different projects Ground to Satellite policy. They shall be removed by the satellite main on board software or any other device (ICU...) before transmission to DORIS via the 1553 bus. Only Application/Source-data shall be transmitted to the DORIS instrument. Consequently, for the TC part, this document only describes the application/source data of the packets.

The packets are not “segmented” (CCSDS meaning ; the 2 most significant bits of this field are set to “3”).

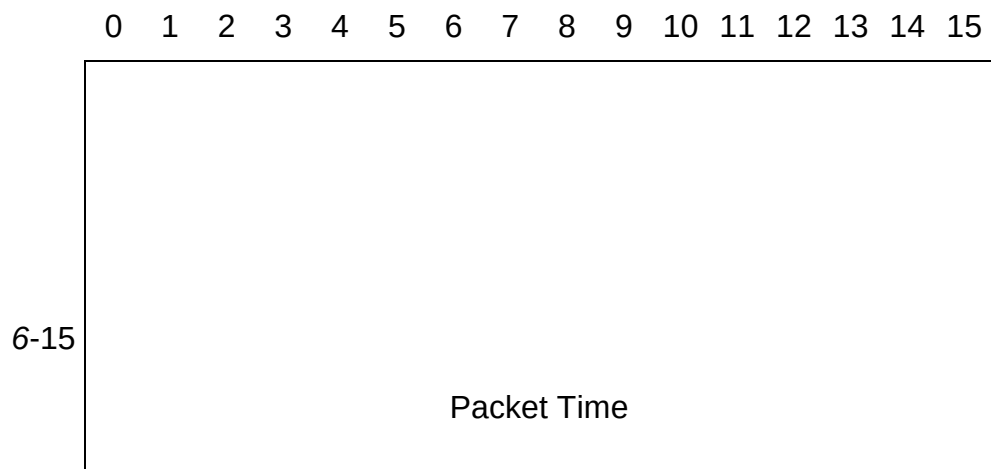
Packet_length (2 octets) : Length in octets of the Data_field_header + Source_data + Packet_error_control fields of the packet minus one octet. It is always an odd number.

The TM Packets may have different lengths but the packets relevant to the same APID shall have the same length.

NB : Source_data = packet specific fields (n) + 2

Data field header (10 octets) : the data field header definition depends on the mission :

In case of “NO PUS” :



In case of PUS :

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 12/75
Generic Definition of TM Packets and TC Formats		

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6-7	0	Pus version number			0 0 0 0				Service packet type							
8-9	Service packet subtype								Destination ID							
10-15	Packet Time															

Pus version number field (3bits) : 001b

Destination ID field (8bits) : 0

The **Packet Time** field will contain the satellite on board time corresponding to the generation of the packet as per satellite on board datation strategy.

- If a *SC_Time TC* is transmitted by the satellite to DORIS (*AltiKa, JASON, Sentinel3, Jason-CS, and SWOT cases*) :

Copy of SC_Time TC (see §4.9 "Description of the satellite on board time"). For the first TM packets generated just after a switch on or a restart of the instrument, this field may be set to "0".

- If no *SC_Time TC* transmitted by the satellite to DORIS (*Pleiades and Cryosat*) :

This field (6 octets) shall contain the TAI time corresponding to the generation of the packet.

The accuracy of the Packet Time shall be better than 1 second.

The Packet Time field shall be compliant to the following:

Day (2 octets): Julian Day starting at 0 on 01/01/2000, LSB=1 day

Millisecond (4 octets): Millisecond in the day, LSB=1 millisecond

Satellite_ID (1 octet) : Identification of the SC TBD

The satellite_ID shall be chosen avoiding reuse of previous codes see CO-SP-D112-EA-16819-CN.

TAI_TUC (1 octet) : bias between TAI and UTC time scales, LSB = 1 sec, counted positively when TAI is in advance w.r.t UTC.

Nota1 : Remote terminal address

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 13/75
Generic Definition of TM Packets and TC Formats		

RT Name	RT Address (decimal)
DORIS chain1	TBD
DORIS chain2	TBD

These addresses are given here for information.
The reference document is : TBD

Nota2 : 1553 TC Time Broadcast address

	1553 TC Time Broadcast Address (decimal)
DORIS chain1	TBD
DORIS chain2	TBD

These addresses are given here for information.
The reference document is TBD

Packet_error_control (2 octets) : This is a CRC on all the words of the packet, from the Packet_Identification field down to the last word of the Source_data area. This parameter shall be used to check possible corruption of the packet during the transmission.

The computation of CRC is defined in ANNEX 2.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 14/75
Generic Definition of TM Packets and TC Formats		

3.1. DESCRIPTION OF DORIS DOPPLER PACKET SPECIFIC FIELDS

The Doppler Packets contain Doppler measurements made by up to 8 processing units (UT).

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
18-27	Date_TAI															
28-33	Date_TOUS															
34-37	Delta_F															
38-41	Delta_T_UAM_2GHz															
42-43	Delta_TDI_400MHZ_TDI_2GHZ															
44-45	Delta_UAM_TDI_400MHZ								Delta_UAM_TDI_2GHZ							
46-51	Spare															
52-53	UT_group								Nb_Meas							
54-119	Meas_1 (if applicable)															
120-185	Meas_2 (if applicable)															
186-251	Meas_3 (if applicable)															
252-253	Spare															

Date_TAI (10 octets) : TAI time of the start of the 10sec sequence (TDI_UC)*, relevant to the Doppler measurement

Day (2 octets) : Julian Day starting at 0 on 01/01/2000 0h00:00, LSB=1 day

Millisecond (4 octets) : millisecond in the day, LSB=1 millisecond,

Microsecond (2 octets) : microsec in the millisec, LSB=1 microsec,

Fraction of microsec (2 octets) : fraction of microsec, LSB=0.1 nanosec.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 15/75
Generic Definition of TM Packets and TC Formats		

Date_TOUS (6 octets) : Doris Date of the start of the 10 seconds sequence (TDI_UC)* relevant to the Doppler measurement (USO reference), $LSB=10^5/USO$ Freq.

Delta_F (4 octets) : Relative bias of the on-board USO frequency (FOUS), with respect to nominal frequency (Fnom), $\Delta_F = (FOUS - F_{nom}) / F_{nom}$; (FOUS) being the real frequency of the Onboard USO at the start of the 10 sec sequence, relevant to the Doppler measurement. Signed Integer, $LSB=10^{-14}$.

Delta_T_UAM_2GHZ (4 octets) : Relative bias of UAM_2GHz of the 10 seconds sequence relevant to the Doppler measurement with respect to the nearest 10 seconds round TAI, increased by 1.15 seconds. Signed Integer, $LSB=0.01$ microsecond,

Delta_TDI_400MHZ_TDI_2GHZ (2 octets) : Delay between the TDI_400MHZ pulse and the TDI_2GHZ pulse. Signed Integer, $LSB=1/36$ microsecond. This delay has a positive value when the TDI_400MHZ pulse signal occurs after the TDI_2GHZ pulse signal,

Delta_UAM_TDI_400MHZ (1 octet) : Delay between the first phase measurement delivered by the 400 MHz UAM and the TDI_400MHZ pulse signal. $LSB=100$ nanoseconds ; this delay is always included between 0 and 4 microseconds,

Delta_UAM_TDI_2GHZ (1 octet) : Delay between the first phase measurement delivered by the 2 GHz UAM and the TDI_2GHZ pulse signal. $LSB=100$ nanoseconds ; this delay is always included between 0 and 4 microseconds,

Spare (6 octets),

UT_group (1 octet) : identifies the group of processing Units (UT) which have performed the measurements reported in the measurements slots of the Doppler Packet.

UT_group = 1 : measurements slots 1 to 3 report measurements from respectively UT1 to UT3.

= 2 : measurements slots 1 to 3 report measurements from respectively UT4 to UT6.

= 3 : measurements slot 1 report measurement from UT7.

When UT_group = 3, the second and third measurements slots are unused and all octets shall be filled with "00"H.

Nb_Meas (1 octet) : Number of significant measurements slots hereafter in the packet (between 1 and 3).

Meas_1 to Meas_3 (66 octets) : Measurements slot#1 to 3 (when applicable ; otherwise the 66 octets of the slot shall be filled with "0000"H),

Generic Definition of TM Packets and TC Formats

* Nota : the TDI_UC pulse is the start of the 10 seconds sequence which is the basic sequence of DORIS software. On DGXX equipments, the TDI_2GHZ pulse signal is also the TDI_UC pulse signal.

The scheme in Figure 1 : description of UC and UAMs sequencing illustrates the definition of some Doppler packet parameters :

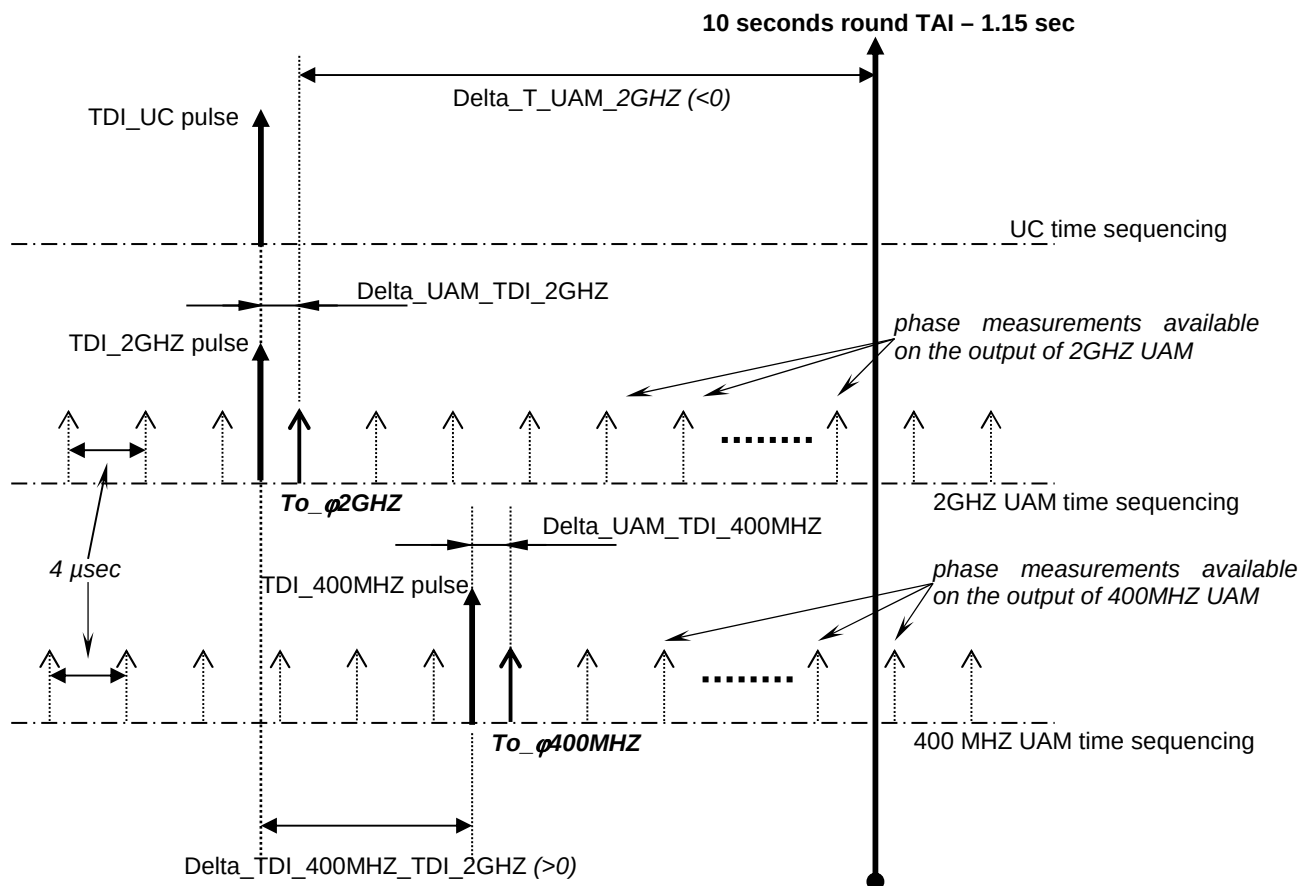


Figure 1 : description of UC and UAMs sequencing

Note that "To_φ2GHZ" (resp. "To_φ400MHZ") corresponds to the precise time when the first phase measurement, just after the TDI_2GHZ pulse (resp. after the TDI_400MHZ pulse), is delivered by the 2GHz UAM (resp 400 MHz UAM). By conception, "To_φ2GHZ" (resp. "To_φ400MHZ") instants are exactly the same for all 2GHz UAM (resp. for all 400 MHz UAM).

Generic Definition of TM Packets and TC Formats

Each measurement slot has the following format :

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0-1	Spare								UT_Num							
2-3	Prog_Beacon															
4-7	Phase_To_400MHZ															
8-11	Phase_T1_400MHZ															
12-15	Phase_T3_400MHZ															
16-19	Delta_Phase_400MHZ															
20-23	T3_datation_400MHZ															
24-31	Beacon_msg_400MHZ															
32-35	Phase_To_2GHZ															
36-39	Phase_T1_2GHZ															
40-43	Phase_T3_2GHZ															
44-47	Delta_Phase_2GHZ															
48-51	T3_datation_2GHZ															
52-59	Beacon_msg_2GHZ															
60-61	Level_400MHZ								Level_2GHZ							
62-63	Measurement_Status															
64-65	Spare															

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 18/75
Generic Definition of TM Packets and TC Formats		

Spare (1 octet)

UT_Num (1 octet) : Processing Unit number, if this value is set to zero, the content of this measurement slot shall not be taken into account,

Prog_Beacon (2 octets) : Beacon number programmed by Diode ; this field is significant only when the UT is in DIODE mode,

Concerning master beacons (see RD 1), two numbers can be used : emission or non-emission. Whatever number is present in the broadcast TCH, the on-board software will assimilate it to emission number. For example, if beacon number 3 (or 387) is present in the broadcast file, the on-board software will assimilate it to beacon number 1 (or 385).

Phase_To_400MHZ (4 octets) : Non ambiguous (modulo $2\pi \times 2^{22}$ radians) value of the phase, measured at $To_{\phi 400MHZ}$ (beginning of measurement sequence), on the signal tracked by the 400 MHZ UAM of considered UT. $LSB = 2\pi/2^{10}$ radian. Note that if phase measurement is not available at $To_{\phi 400MHZ}$, **Phase_To_400MHZ** value is set to zero,

Phase_T1_400MHZ (4 octets) : Non ambiguous (modulo $2\pi \times 2^{22}$ radians) value of the phase, measured at $To_{\phi 400MHZ} + 3 \cdot 10^7 / FOUS$, on the signal tracked by the 400 MHZ UAM of considered UT. $LSB = 2\pi/2^{10}$ radian,

Phase_T3_400MHZ (4 octets) : Non ambiguous (modulo $2\pi \times 2^{22}$ radians) value of the phase, measured when T3 event is detected by the 400 MHZ UAM, on the signal tracked by the 400 MHZ UAM of considered UT. $LSB = 2\pi/2^{10}$ radian. Note that **Phase_T3_400MHZ** is actually measured at T3 event detection + time bias, this time bias value being equal to 5 milliseconds $\pm$ 520 microseconds,

Delta_Phase_400MHZ (4 octets) : Non ambiguous phase increment of the signal tracked by the 400 MHZ UAM of considered UT. Signed Integer, $LSB = 2\pi/2^{10}$ radian. If **Chain_DOP** = 0, **Delta_Phase_400MHZ** corresponds to the phase variation of the tracked signal, between $To_{\phi 400MHZ} + 3 \cdot 10^7 / FOUS$ and $To_{\phi 400MHZ} + 10^8 / FOUS$. If **Chain_DOP** = 1, **Delta_Phase_400MHZ** corresponds to the phase variation of the tracked signal, between $To_{\phi 400MHZ}$ and $To_{\phi 400MHZ} + 10^8 / FOUS$.,

T3_datation_400MHz (4 octets) : datation of T3 event detection with regard to **T1_400MHz** by the 400 MHZ UAM of considered UT. $LSB = 10 / (4 \cdot FOUS)$. Note that if T3 event is not received, or not correctly detected, during the measurement sequence, this field shall be filled with "00"H,

Beacon_msg_400MHZ (8 octets) : beacon message received by the 400 MHZ UAM of considered UT, if this message is VALID ; if not, filled with "00" H. For beacon message description , see RD 1.

The message is VALID if :

- the message is correctly received during the measurement sequence (**AS3**!=0)
- the beacon is not too much desynchronized (value of **T3** <= configurable threshold)

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 19/75
Generic Definition of TM Packets and TC Formats		

Phase_To_2GHZ (4 octets) : Non ambiguous (modulo $2\pi \times 2^{22}$ radians) value of the phase, measured at To_φ2GHZ (beginning of measurement sequence), on the signal tracked by the 2 GHZ UAM of considered UT. LSB = $2\pi/2^{10}$ radian. Note that if phase measurement is not available at To_φ2GHZ, Phase_To_2GHZ value is set to zero,

Phase_T1_2GHZ (4 octets) : Non ambiguous (modulo $2\pi \times 2^{22}$ radians) value of the phase, measured at To_φ2GHZ + $3 \cdot 10^7/\text{FOUS}$, on the signal tracked by the 2 GHZ UAM of considered UT. LSB = $2\pi/2^{10}$ radian,

Phase_T3_2GHZ (4 octets) : Non ambiguous (modulo $2\pi \times 2^{22}$ radians) value of the phase, measured when T3 event is detected by the 2GHZ UAM, on the signal tracked by the 2 GHZ UAM of considered UT. LSB = $2\pi/2^{10}$ radian. Note that Phase_T3_2 GHZ is actually measured at T3 event detection + time bias, this time bias value being equal to 5 milliseconds $\pm$ 520 microseconds,

Delta_Phase_2GHZ (4 octets) : Non ambiguous phase increment of the signal tracked by the 2 GHZ UAM of considered UT. Signed Integer, LSB= $2\pi/2^{10}$ radian. If Chain_DOP = 0, Delta_Phase_2GHZ corresponds to the phase variation of the tracked signal, between To_φ2GHZ + $3 \cdot 10^7/\text{FOUS}$ and To_φ2GHZ + $10^8/\text{FOUS}$. If Chain_DOP = 1, Delta_Phase_2GHZ corresponds to the phase variation of the tracked signal, between To_φ2GHZ and To_φ2GHZ + $10^8/\text{FOUS}$.

T3_datation_2GHZ (4 octets) : datation of T3 event with regard to T1_2GHz detection by the 2 GHZ UAM of considered UT. LSB= $10/(4 \cdot \text{FOUS})$. Note that if T3 event is not received, or not correctly detected, during the measurement sequence, this field shall be filled with "00"H,

Beacon_msg_2GHZ (8 octets) : beacon message received on the 2 GHZ UAM of considered UT, if this message is VALID; if not, filled with "00" H. For beacon message description , see RD 1.

The message is VALID if :

- the message is correctly received during the measurement sequence (AS3/=0)
- the beacon is not too much desynchronized (value of T3 <= configurable threshold)
- the ICCE check result is OK (=0 or =1 see below)

Level_400MHZ (1 octet) : Relative level of the signal tracked by the 400 MHZ UAM of considered UT, with respect to a reference level at -160 dBm, LSB=0.35 dB,

Level_2GHZ (1 octet) : Relative level of the signal tracked by the 2 GHZ UAM of considered UT, with respect to a reference level at -160 dBm, LSB=0.35 dB,

Measurement_Status (2 octets) :

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 20/75
Generic Definition of TM Packets and TC Formats		

Val_DOP_400MHZ (bit 0) : Validity of phase measurements and Doppler measurement (phase increment) on the 400 MHz channel (0=valid, 1=invalid). This status includes :

- the existence of a significant phase measurement in the hardware registers (no software exception during acquisition process)
- a phase measurement has been performed during the sequence ; e.g the lock status of the phase loop all along the sequence (AS1 internal status)
- a consistence with the 2GHz channel Doppler measurement
- a coherence between beacon codes on the 2 channels (see bit7 below).

Val_DOP_2GHZ (bit 1) : Validity of phase measurements and Doppler measurement (phase increment) on the 2 GHz channel (0=valid, 1=invalid). This status includes :

- the existence of a significant phase measurement in the hardware registers (no software exception during acquisition process)
- a phase measurement has been performed during the sequence ; e.g the lock status of the phase loop all along the sequence (AS1 internal status)
- a consistence with the 400MHz channel Doppler measurement
- a coherence between beacon codes on the 2 channels (see bit7 below).

Nota : VAL_DOP_400MHZ = VAL_DOP_2_GHZ

Meas_coherence (bit 2) : Coherence of the Doppler measurements (phase increment) made on the 2 channels (0=coherent, 1=not coherent),

2GHz_prediction (bit 3) : Coherence of the Doppler measurement (phase increment) made on the 2 GHz channel with the predicted one (0=coherent, 1=not coherent), (only significant if the UT is in DIODE mode),

Chain_DOP (bit 4) : Doppler measurement chaining with the previous one (1=chained, 0= sequence),

T3_datation_correct_400MHZ (bit 5) : On board correction of the T3 datation value determined by the 400 MHz UAM of considered UT (0= no correction, 1= correction),

T3_datation_correct_2GHZ (bit 6) : On board Correction of the T3 datation value determined by the 2 GHZ UAM of considered UT (0= no correction, 1= correction),

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 21/75
Generic Definition of TM Packets and TC Formats		

Stereo Measurement (bit 7): Coherence between Beacon codes on the 2 channels (0=coherent, 1=not coherent). "Not coherent" means that :

- the synchronization word of the beacon message has been recognized on both channels (AS3 internal status including the fact that a phase measurement has been performed and reported by AS1)
- the 2GHz message is validated by its CRC
- the both beacon identification codes are valid (consistency of INBAL, ICODEC, IPARB ; see RD1)
- 2GHz and 400MHz beacon identification codes are different.

Chosen channel for beacon message (Bit 8) : channel on which the beacon message was taken (0=400_MHz, 1=2_GHz)

Chosen channel for T3_datation (Bit 9) : channel on which the T3_datation was taken (0=400_MHz, 1=2_GHz)

ICCE result (Bit 10-12) : result of the error control check on the 2 GHz channel :

000 = check result OK => message in the Doppler packet is valid (and no correction occurred).

001 = check result OK with a successful correction => message in the Doppler packet is valid and corrected (a correction occurred).

010 = check detected errors, but failed to correct them (probability $< 10^{-20}$) => message in the Doppler packet is not valid (forced to 0000).

011= check detected too many errors => message in the Doppler packet is not valid (forced to 0000).

100 = check detected errors, but tried to correct them outside the message (algorithm in default) => message in the Doppler packet is not valid (forced to 0000).

111 = check was not made because message was corrupted and the software could not read it (as a consequence, no control check result is available) => message in the Doppler packet is not valid (forced to 0000).

Spare (Bits 13-15)

Spare (2 octets)

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 22/75
Generic Definition of TM Packets and TC Formats		

3.2. DESCRIPTION OF DORIS NAVIGATOR PACKET SPECIFIC FIELDS

3.2.1. DESCRIPTION OF THE DORIS NAVIGATOR PACKET IN THE ITRF TERRESTRIAL REFERENCE FRAME (NAV_T) SPECIFIC FIELDS

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
18-27	Date_TAI															
28-31	Velocity X (ITRF)															
32-35	Velocity Y (ITRF)															
36-39	Velocity Z (ITRF)															
40-43	Position X (ITRF)															
44-47	Position Y (ITRF)															
48-51	Position Z (ITRF)															
52-55	ITRF Quality Index															
56-57	TU1-TUC															
58-59	LSB_X				LSB_Y				LSB_Z				LSB_VX			
60-61	LSB_VY				LSB_VZ				Spare							

This Packet contains one NAV_T Navigator Bulletin. This NAV_T Bulletin gives the position and velocity of the satellite center of mass at the time defined in Date_TAI field, in the ITRF terrestrial reference frame.

The NAV_T Bulletin format shall be compliant to the following :

Date_TAI (10 octets) : TAI date of the bulletin
Format : see Doppler Packet

The Date_TAI field is always a round 10 second TAI time so that the millisecond field is a multiple of 10^4 ; the microsecond and fraction of microsecond fields are set to 0.

The following Velocity and Position fields are defined with respect to the ITRF (International Terrestrial Reference Frame) terrestrial reference frame. The velocities are the components in the ITRF frame, of the relative velocity with respect to the ITRF terrestrial frame.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 23/75
Generic Definition of TM Packets and TC Formats		

Velocity X (4 octets) : Velocity on X axis. Signed Integer, LSB=0.01 mm/sec,

Velocity Y (4 octets) : Velocity on Y axis. Signed Integer, LSB=0.01 mm/sec,

Velocity Z (4 octets) : Velocity on Z axis. Signed Integer, LSB=0.01 mm/sec,

Position X (4 octets) : Position on X axis. Signed Integer, LSB=1 cm,

Position Y (4 octets) : Position on Y axis. Signed Integer, LSB=1 cm,

Position Z (4 octets) : Position on Z axis. Signed Integer, LSB=1 cm,

ITRF Quality Index (4 octets) : Uncertainty of the location in the ITRF reference frame, LSB=1 cm,

If the Quality Index value is equal to "FFFF FFFF" H, the bulletin shall be considered as not valid.

TU1-TUC (2 octets) : Difference between TU1 and TUC, Signed Integer, LSB= 100 microsec.

LSB_X (4 bits = ½ octet): Complementary position on X axis. Signed Integer, LSB=1mm,

LSB_Y (4 bits = ½ octet): Complementary position on Y axis. Signed Integer, LSB=1mm,

LSB_Z (4 bits = ½ octet): Complementary position on Z axis. Signed Integer, LSB=1mm,

LSB_VX (4 bits = ½ octet): Complementary velocity on X axis. Signed Integer, LSB=0.001 mm/sec,

LSB_VY (4 bits = ½ octet): Complementary velocity on Y axis. Signed Integer, LSB=0.001 mm/sec,

LSB_VZ (4 bits = ½ octet): Complementary velocity on Z axis. Signed Integer, LSB=0.001 mm/sec,

Spare (1 octets)

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 24/75
Generic Definition of TM Packets and TC Formats		

3.2.2. DESCRIPTION OF THE DORIS NAVIGATOR PACKET IN THE J2000 INERTIAL REFERENCE FRAME (NAV_I) SPECIFIC FIELDS

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
18-27	Date_TAI															
28-31	Velocity X (J2000)															
32-35	Velocity Y (J2000)															
36-39	Velocity Z (J2000)															
40-43	Position X (J2000)															
44-47	Position Y (J2000)															
48-51	Position Z (J2000)															
52-55	J2000 Quality Index															
56-57	TU1-TUC															
58-61	Spare															

This Packet contains one NAV_I Navigator Bulletin. This NAV_I Bulletin gives the position and velocity of the satellite center of mass at the time defined in Date_TAI field, in the J2000 inertial reference frame.

The NAV_I Bulletin format shall be compliant to the following :

Date_TAI (10 octets) : TAI date of the bulletin
Format : see Doppler Packet

The Date_TAI field is always a round 10 second TAI time so that the millisecond field is a multiple of 10^4 ; the microsecond and fraction of microsecond fields are set to 0.

The following Velocity and Position fields are defined with respect to the J2000 inertial reference frame. The velocities are the components in the J2000 inertial frame, of the inertial J2000 velocity.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 25/75
Generic Definition of TM Packets and TC Formats		

Velocity X (4 octets) : Velocity on X axis. Signed Integer, LSB=0.01 mm/sec,

Velocity Y (4 octets) : Velocity on Y axis. Signed Integer, LSB=0.01 mm/sec,

Velocity Z (4 octets) : Velocity on Z axis. Signed Integer, LSB=0.01 mm/sec,

Position X (4 octets) : Position on X axis. Signed Integer, LSB=1 cm,

Position Y (4 octets) : Position on Y axis. Signed Integer, LSB=1 cm,

Position Z (4 octets) : Position on Z axis. Signed Integer, LSB=1 cm,

J2000 Quality Index (4 octets) : Uncertainty of the location in the J2000 reference frame, LSB=1 cm ; If the Quality Index value is equal to "FFFF FFFF"H, the bulletin shall be considered as not valid.

TU1-TUC (2 octets) : Difference between TU1 and TUC, Signed Integer, LSB= 100 microsec.

Spare (4 octets).

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 26/75
Generic Definition of TM Packets and TC Formats		

3.2.3. DESCRIPTION OF THE GEODETIC DORIS NAVIGATOR PACKET (NAV_G) SPECIFIC FIELDS

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
18-27	Date_TAI															
28-31	Latitude															
32-35	Longitude															
36-39	Altitude															
40-43	Altitude variation rate															
44-47	Orbit number															
48-51	Orbital angular position															
52-55	Geodetic Quality Index															
56-57	TU1-TUC															
58-61	Alt_var_rate_ellipsoid TBC															

This Packet contains one NAV_G Navigator Bulletin. This NAV_G Bulletin gives the position and vertical velocity (altitude variation rate) of the satellite center of mass, at the time defined in Date_TAI field :

- with respect to the Earth surface reference (see RD 3),
- and with respect to the satellite mission orbits reference (mission orbital cycle reference).

The NAV_G Bulletin format shall be compliant to the following :

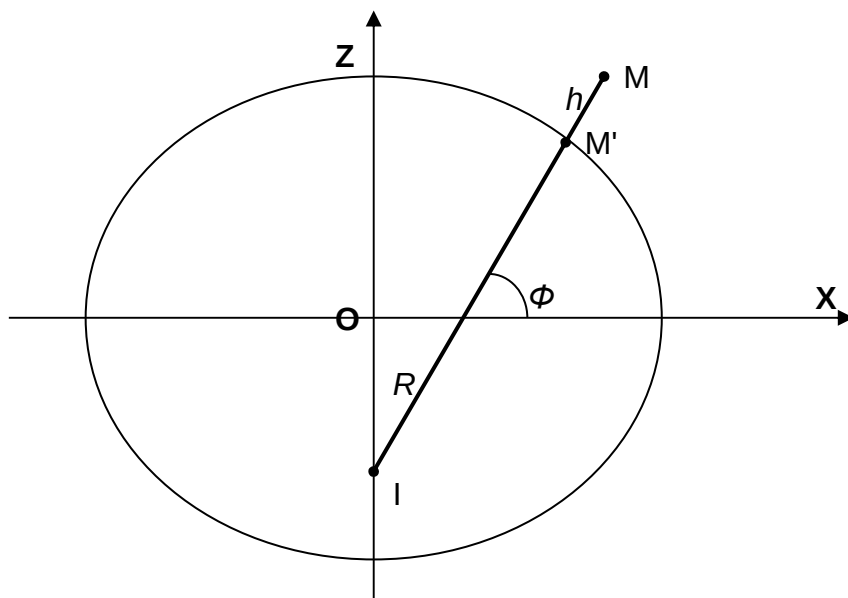
Date_TAI (10 octets) : TAI date of the bulletin

Format : see Doppler Packet

The Date_TAI field is always a round 10 second TAI time so that the millisecond field is a multiple of 10×4 ; the microsecond and fraction of microsecond fields are set to 0.

Latitude (4 octets) : Geodetic Latitude ; Elevation angle between the Equatorial plane and the normal direction to the ellipsoid ; this angle has a positive value when the satellite is above the northern hemisphere. Signed Integer, LSB= 10^{-7} deg,

Generic Definition of TM Packets and TC Formats



Longitude (4 octets) : Angle between the projection in the equatorial plane of the vector “Center of Earth → Satellite” and the Xaxis of the ITRF reference frame ; eastern position corresponds to a positive value of longitude. Signed Integer, LSB= 10^{-7} deg,

Altitude (4 octets) : Unsigned Integer, LSB= 1 cm.

Altitude variation rate (4 octets) : Time derivative of altitude. The altitude variation rate is the component of the relative velocity with respect to the ITRF terrestrial frame, projected on the normal direction to the ellipsoid surface. Signed Integer, LSB=0.01 mm/sec,

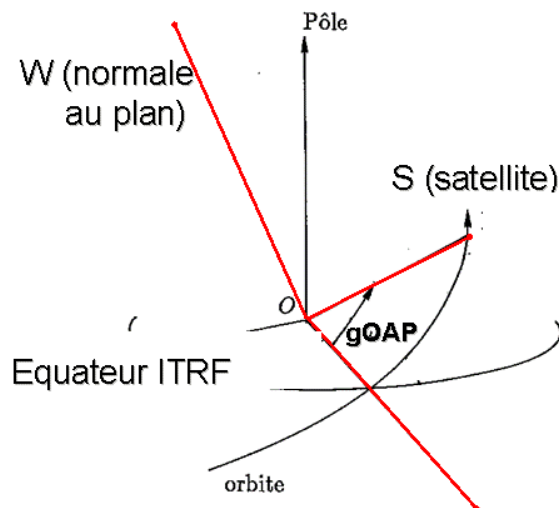
Orbit number (4 octets) : Number of the satellite current orbital revolution in the mission reference orbital cycle ; this number is incremented by “+1” when the satellite crosses the equatorial plane from South to North. Integer, LSB=1. In routine, this number varies between “1” and “total number of revolutions in the cycle”.

Orbital angular position (4 octets) : depending on the users request in ZQS

INERTIAL_OAP = Angle, measured in the orbital plane, between the ascending node position of the orbit and the satellite position. Unsigned Integer, (also named true on-orbit position, exactly equals perigee argument + true anomaly)
LSB= 10^{-7} deg,

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 28/75
Generic Definition of TM Packets and TC Formats		

GEODETTIC_OAP = Angle between the intersection of the true Terrestrial Equator plan (ITRF) and the orbital plane, and the current satellite position. Unsigned Integer, LSB= 10^{-7} deg,



Geodetic Quality Index (4 octets) : same definition as in the NAV_T_packets (section 3.2.1).

TU1-TUC (2 octets) : Difference between TU1 and TUC, Signed Integer, LSB= 100 microsec.

Alt_var_rate_ellipsoid (4 octets) : Time derivative of altitude w.r.t. ellipsoid reference surface. Signed Integer, LSB=0.01 mm/sec

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 29/75
Generic Definition of TM Packets and TC Formats		

3.2.4. DESCRIPTION OF THE DORIS / KARIN NAVIGATOR PACKET (NAV_K) SPECIFIC FIELDS IF ANY

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
18-27	Date_TAI															
28-31	Latitude prediction															
32-35	Longitude prediction															
36-39	Altitude prediction : a parameter															
40-43	Altitude prediction : b parameter															
44-47	Altitude prediction : c parameter															
48-51	Altitude prediction : d parameter															
52-55	Altitude prediction : e parameter															
56-59	KARIN Quality Index															
60-61	Spare															

This Packet contains one DORIS / KARIN Navigator Bulletin. This NAV_K Bulletin gives a prediction for latitude and longitude, at the time defined in Date_TAI field , It also gives parameters of an altitude prediction model of the satellite center of mass with respect to the Earth surface (see RD 3). This model, **computed at [Date_TAI-20s]**, is valid in the [Date_TAI-20s, Date_TAI] time window.

This packet is delivered by DORIS during the 10s sequence including Date_TAI -20sec.

The NAV_K Bulletin format shall be compliant to the following :

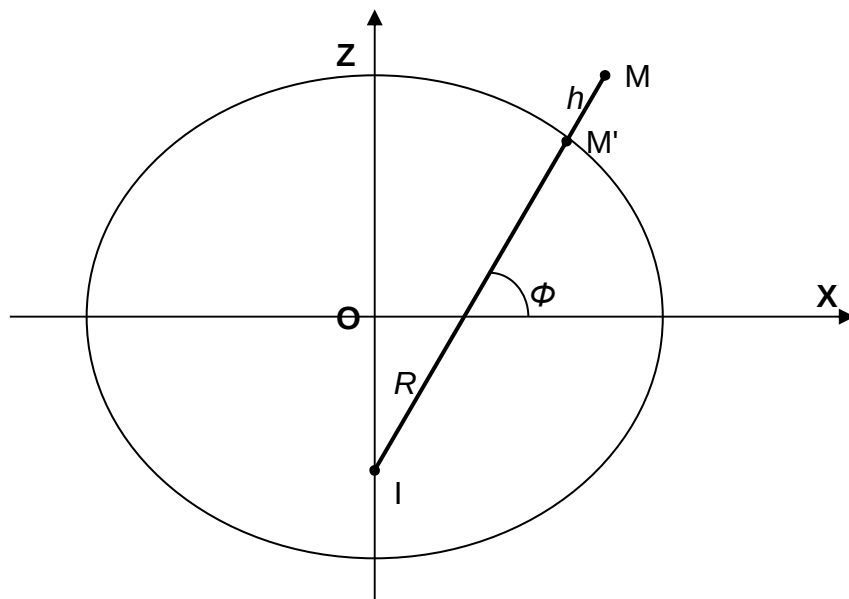
Date_TAI (10 octets) : TAI date of the bulletin

Format : see Doppler Packet

The Date_TAI field is always a round 10 second TAI time so that the millisecond field is a multiple of 10^4 ; the microsecond and fraction of microsecond fields are set to 0.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 30/75
Generic Definition of TM Packets and TC Formats		

Latitude prediction (4 octets) : Geodetic Latitude ; Elevation angle between the Equatorial plane and the normal direction to the ellipsoid ; this angle has a positive value when the satellite is above the northern hemisphere. Signed Integer, LSB= 10^{-7} deg,



Longitude prediction (4 octets) : Angle between the projection in the equatorial plane of the vector « Center of Earth → Satellite » and the Xaxis of the ITRF reference frame ; eastern position corresponds to a positive value of longitude. Signed Integer, LSB= 10^{-7} deg,

Altitude prediction : a parameter (4 octets) : Distance (at DATE_TAI-20sec) between the satellite center of mass and the Earth surface (see RD3). Unsigned Integer, LSB= 0.5 millimeters.

Altitude prediction : b parameter (4 octets) : First time derivative of altitude (at DATE_TAI-20sec). Signed Integer, LSB=2 micrometers/sec.,

Altitude prediction : c parameter (4 octets) : Second time derivative of altitude (at DATE_TAI-20sec). Signed Integer, LSB=2 nanometers/sec².

Altitude prediction : d parameter (4 octets) : Third time derivative of altitude (at DATE_TAI-20sec). Signed Integer, LSB=2 e-12meters/sec³.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 31/75
Generic Definition of TM Packets and TC Formats		

Altitude prediction : e parameter (4 octets) : Fourth time derivative of altitude (at DATE_TAI-20sec). Signed Integer, LSB=2 e-15meters/sec⁴.

KARIN Quality Index (4 octets) : same definition as in the NAV_T_packets (section 3.2.1).

Note : the quality index in the DORIS/KARIN Navigator packet is the copy of that of the ITRF Navigator packet except when the prediction parameters are not in the defined range. In this case, this quality index is equal to "FFFF FFFF"H, the KARIN bulletin shall be considered as not valid.

Spare (2 octets)

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 32/75
Generic Definition of TM Packets and TC Formats		

3.3. DESCRIPTION OF DORIS DATATION PACKET SPECIFIC FIELDS

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
18-27	Date_TAI															
28-31	Datation Quality Index															
32-33	Pulse_counter															

This Packet contains one Datation Bulletin (in TAI time) corresponding to the last Datation Pulse received at the DORIS I/F.

The Datation Bulletin format shall be compliant to the following :

Date_TAI (10 octets) : TAI datation of the datation pulse.

Depending on the satellite on board time policy this date may be incremented by 1 TAI s, or not (this increment is in the DORIS ZQS).

Format : see Doppler Packet

Datation Quality Index (4 octets) : Uncertainty of the datation, LSB=0.1 nanosec.

As an example, if the Quality Index is 12 microsec, it means that the datation is given with an estimated uncertainty of + or - 12 microsec.

If the Quality Index is "FFFF FFFF"H, the datation shall be considered as no valid.

Pulse_counter (2 octets) : Cumulated number of datation pulses. This field shall be set to 0 at initialization of Doris SW then incremented by one at each reception of a Datation pulse.

Depending on existing protocol requirements, this sentence may be added or not :

Nota : The Datation Packet is available only 75 ms after the Datation Pulse reception.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 33/75
Generic Definition of TM Packets and TC Formats		

3.4. DESCRIPTION OF DORIS REPORT PACKET SPECIFIC FIELDS

The Report Packets are used by the ground for monitoring and control of the instrument; depending of the type of on-board events (routine or anomaly), 2 different packets are generated.

Generic Definition of TM Packets and TC Formats

3.4.1. ROUTINE REPORT

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0-15	Generic TM Header															
16-17	Sat_ID and TAI-TUC or Event_ID LSB															
18-19	Event_ID MSB or Sat_ID and TAI-TUC															
20-21	Event_ID LSB or Spare															
22-31	Date_TAI															
32-37	Date_TOUS															
38-41	Delta_F															
42-45	Delta_T_UAM_2GHZ															
46-47	Diode SW report															
48-57	Doris SW report															
58-59	TU1-TUC															
60-61	UT_Doppler_Mode								M1		M2	M3	M4	M5		
62-65	UT_Measurement_Mode															
66-67	Loop_Status															
68-69	Last_Command															
70-71	Spare					M7		M6		TM modes					MA	
72-73	Total_Upload_OK															
74-75	Total_Upload_KO															
76-77	SW_Issue															
78-79	MVR_Status								N_Upset							
80-83	Datation Quality Index															
84-87	ITRF Quality Index															
88-97	Spare															
98-99	Total_TC_OK															
100-101	Total_TC_KO															
102-103	ZQS DORIS issue in EEPROM															
104-105	ZQS DIODE issue in EEPROM															

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 35/75
Generic Definition of TM Packets and TC Formats		

106-107	ZQS System issue in EEPROM
108-109	ZQS DORIS issue in RAM
110-111	ZQS DIODE issue in RAM
112-113	ZQS System issue in RAM
114-125	Spare

This Packet shall report transition, nominal activity or exceptional event which do not require any recovery action. This Packet shall be generated :

a) upon occurrence of one of the following events :

- Change of the Instrument Mode,
- Acknowledgement of TC ,
- Doris SW report,
- Diode SW report,
- Time correction (TDI on board internal sequencing shift).

b) after a predefined period since the last “Periodic Routine Report” (independently of generation of “On event Routine Reports”). This predefined period is set to 30 minutes.

The Packet specific fields shall contain the following :

Octets 0-15 : generic TM Packet header (see §3)

Event_ID (2 or 4 octets, depending on satellite rules) : Event Identifier, indicating the reason of generation of the Report :

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 36/75
Generic Definition of TM Packets and TC Formats		

Event_ID	Event
(0000)0001 H	Change of the Instrument Mode,
(0000)0002 H	Acknowledgement of TC,
(0000)0003 H	Doris SW report,
(0000)0004 H	Diode SW report,
(0000)0006 H	Time correction,
(0000)0007 H	Periodic generation (see section b above).

Date_TAI (10 octets) : TAI time of the start of the 10sec sequence relevant to the occurrence of the Report

Format : see Doppler Packet

Date_TOUS (6 octets) : Doris Date of the start of the 10sec sequence (USO reference), relevant to the occurrence of the report, $LSB=10^5/USO \text{ Freq.}$

Delta_F (4 octets) : Relative bias of the on-board USO frequency (FOUS), with respect to nominal frequency (F_{nom}), $\Delta F = (FOUS - F_{nom})/F_{nom}$; (FOUS) being the real frequency of the Onboard USO at the start of the 10 sec sequence, relevant to the report packet generation. Signed Integer, $LSB=10^{-14}$.

Delta_T_UAM_2GHZ (4 octets) : Relative bias of UAM_2GHz of the 10 seconds sequence relevant to the report packet generation, with respect to the nearest 10 seconds round TAI, increased by 1.15 seconds. Signed Integer, $LSB=0.01 \text{ micro second.}$

Diode SW report (2 octets) : Identifier of the Last Diode SW report, (this SW report does not require any ground action).

Doris SW report (10 octets, arranged in 5 words of 2 octets) : report of last status and history of specific situations encountered by OBSW. This does not require any ground action.

TU1-TUC (2 octets) : Difference between TU1 and TUC, Signed Integer $LSB=100 \text{ microseconds.}$

UT_Doppler_Mode (1 octet) : Doppler mode for all UTs (1 bit per UT)

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 37/75
Generic Definition of TM Packets and TC Formats		

Sequence=0
Chained=1
Bits 0 to 6 : respectively UT1 to 7 Doppler mode
Bit 7 =RESERVED

M1(3 bits) : DORIS mode

Reserved=0,1
Autoinit=2,
Measurement=4,
Spare= 3,5,6,7.

M2 (1 bit) : Synchro mode

Inhibited=0,
Authorized=1.

M3 (1 bit) : TAI Autocorrection Mode

Inhibited=0,
Authorized=1.

M4 (2 bits) : Diode Mode

Idle=0,
Autoinit=1,
Recover=2,
Routine=3.

M5 (1 bit) : UPLOAD_EEPROM Mode

Inhibited=0,
Authorized=1.

UT_Measurement_Mode (4 octets) : Mode of each UT (4 bits per UT) ;

Idle=0,
Diode=2,
Test=3,
DAS Higher level =7,
DAS Higher frequency =8,
DAS Random =9,
Spare= 1,4,5,6,10,11,12,13,14,15,

Octet 60 : Bits 0-3 : UT1 mode,
Bits 4-7 : UT2 mode,
Octets 61 : Bits 0-3 : UT3 mode,

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 38/75
Generic Definition of TM Packets and TC Formats		

Octets 62 : Bits 4-7 : UT4 mode,
Bits 0-3 : UT5 mode,
Bits 4-7 : UT6 mode,
Octets 63 : Bits 0-3 : UT7 mode,
Bits 4-7 : = RESERVED.

Loop_Status (2 octets) : Status of the loops for all UTs (1 bit per UT) :

0=unlocked,
1=locked.

Bit 0 : Loop_Status_UT1_4 : UT1, 400MHz,
Bit 1 : Loop_Status_UT1_2 : UT1, 2GHz,
Bit 2 : Loop_Status_UT2_4 : UT2, 400MHz,
Bit 3 : Loop_Status_UT2_2 : UT2, 2GHz,
.
.
Bit 13 : Loop-status UT7_2 : UT7, 2GHz,
Bit 14 : RESERVED
Bit 15 : RESERVED

Last_Command (2 octets) : Command parameter of the last TC not rejected.

Spare (7bits)

M7 (1 bit) : **(depending on the mission)** N/A, not used

or NAV_K downlink (0=OFF 1= ON)

M6 (1 bit) : Diode function as used by Doris Management sw

Idle=0, (Diode navigation function not used)
Navigation=1 (Diode navigation function called every sequence).

TM Modes (5 bits)

Bit 9 = NAV_T downlink (0=OFF 1= ON)
Bit 10 = NAV_I downlink (0=OFF 1= ON)
Bit 11 = NAV_G downlink (0=OFF 1= ON)
Bit 12 = Doppler downlink (0=OFF 1= ON)
Bit 13 = Attitude downlink (0=OFF 1= ON)

MA : ASR Modes (2 bits)

0 = OFF
1 = 400 MHz
2 = 2 GHz
3 = 400 MHz and 2 GHz

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 39/75
Generic Definition of TM Packets and TC Formats		

Total_Upload_OK (2 octets) : Number of MEMORY UPLOAD TC accepted by Doris since the last switch-on or restart.

Total_Upload_KO (2 octets) : Number of MEMORY UPLOAD TC rejected by Doris since the last switch-on or restart.

SW_Issue (2 octets) : Issue of running "Logiciel_Doris" SW (for example "0200" H means issue 2.00).

MVR_Status (1 octet) : Status of MVR.

Bit	0	1	2	3	4	5	6	7
	0	MS1		MS2	MS3	MS4	MS5	MS6

MS1 : 2 bits

Bit1	Bit2	
0	0	Power ON
0	1	Restart A
1	0	Restart B
1	1	Not used

MS2 : = 0 : default value
= 1 : after a software automatic restart

MS3 : = 0 : default value
= 1 : after watchdog automatic restart

MS4 : = 0 : spare

MS5 : = 0 : upper EEPROM bank power supply off
= 1 : upper EEPROM bank power supply on

MS6 : = 0 : lower EEPROM bank power supply off
= 1 : lower EEPROM bank power supply on

N_Upset (1 octet) : Number of RAM upsets, (modulo 256)

Datation Quality Index (4 octets) : same definition as in the Datation Packet (section 3.3).

ITRF Quality Index (4 octets) : same definition as in the NAV_T_packets (section 3.2.1).

Spare (10 octets)

Total_TC_OK : number of total TC including upload memory TC accepted by DORIS since the last Switch On or restart.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 40/75
Generic Definition of TM Packets and TC Formats		

Total_TC_KO : number of total TC including upload memory TC rejected by DORIS since the last Switch On or restart.

Nota : Master Beacon are broadcasting only DORIS System parameters which are not considered as Memory Uploads TCs.

ZQS DORIS issue in EEPROM (2 octets) : version number of ZQS DORIS in EEPROM.

ZQS DIODE issue in EEPROM (2 octets) : version number of ZQS DIODE in EEPROM.

ZQS System issue in EEPROM (2 octets) : version number of ZQS System in EEPROM.

ZQS DORIS issue in RAM (2 octets) : version number of ZQS DORIS in RAM.

ZQS DIODE issue in RAM (2 octets) : version number of ZQS DIODE in RAM.

ZQS System issue in RAM (2 octets) : version number of ZQS System in RAM.

Nota : those words of 16 bits are divided in two fields, one for the version number, one for the update number.

Examples : version 2.09 : "0209"H ; version 10.12 : "1012"H

Only 1 Routine Report Packet can be generated during a DORIS 10 seconds sequence.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 41/75
Generic Definition of TM Packets and TC Formats		

3.4.2. ANOMALY REPORT

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0-15	Generic TM Header															
16-17	Sat_ID and TAI-TUC or Anomaly_Event_ID LSB															
18-19	Anomaly_Event_ID MSB or Sat_ID and TAI-TUC															
20-21	Anomaly_Event_ID LSB or Spare															
22-125	Idem Routine Report															

This Packet shall be generated upon occurrence of an anomaly requiring any ground or SC action.

The Packet specific fields shall contain the following :

Anomaly_Event_ID (2 or 4 octets depending on satellite rules) : Event Identifier, indicating the reason of generation of the Anomaly:

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 42/75
Generic Definition of TM Packets and TC Formats		

Event_ID	Event
(0000)8000 H	incorrect TC APID not relevant in case non CCSDS TC formats
(0000)8001 H	incorrect TC length not relevant in case non CCSDS TC formats
(0000)8002 H	incorrect TC CRC not relevant in case non CCSDS TC formats
(0000)8006 H	illegal Command_parameter
(0000)8007 H	TC rejected
(0000)8009 H	1553 TC protocol violation leading in TC rejection
(0000)800A H	illegal TC via Master Beacon
(0000)801X H	Software autotest KO Bit 12 = 1 : failure affecting the code Bit 13 = 1 : failure affecting ZQS Bit 14 = 1 : failure affecting ZQS Bit 15 = 1 : failure affecting ZQS DORIS DIODE System

Octets 0-15 : generic TM Packet header (see §3)

Octets 16-21 : see details format above (depending on satellite HKTM policy)

Octets 22-125 : idem Routine Report Packet specific fields ; in this data, the Software reports fields give additional information about the Anomaly.

Note 1 : An anomaly shall be reported by the corresponding Anomaly Report once and once only.

Note 2 : Even in case of multiple anomalies during a Doris 10 seconds sequence, a single Anomaly Report reporting the last risen anomaly shall be generated within this sequence.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 43/75
Generic Definition of TM Packets and TC Formats		

3.5. DESCRIPTION OF DORIS TEST PACKET SPECIFIC FIELDS

This Packet contains one block of test data.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
18-27	Date_TAI															
28-33	Date_TOUS															
34-35	Test_Type															
36-253	Test_data (218 octets)															

Date_TAI (10 octets) : TAI time of the start of the 10sec sequence relevant to the acquisition of test data.

Format : see Doppler Packet

Date_TOUS (6 octets) : Doris Date of the start of the 10 seconds sequence (USO reference) relevant to the acquisition of test data, $LSB=10^{*}5/USO$ Freq.

Test_type (2 octets) : Type of test data.

Test UT 1	: 1	(0001H)
Test UT 2	: 2	(0002H)
Test UT 3	: 3	(0003H)
Test UT 4	: 4	(0004H)
Test UT 5	: 5	(0005H)
Test UT 6	: 6	(0006H)
Test UT 7	: 7	(0007H)
Test Jamming	: 16	(0010H)
Test Dump	: 32	(0020H)
Test Techno.	: 48	(0030H)
Nav. Aux. data	: 64	(0040H)

Test_data (218 octets) : Test data (see detailed description here after)

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 44/75
Generic Definition of TM Packets and TC Formats		

3.5.1. DESCRIPTION OF DORIS JAMMING PACKET TEST DATA

The Jamming Packet is a specific test packet which contains the characteristics of RF signals inside the Doris bandwidth.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
36-37	Jam_type								Spare							
38-39	Jam_measurement_1								Jam_measurement_2							
40-41	Jam_measurement_3								Jam_measurement_4							
37+i – 37+(i+1)	Jam_measurement_i								Jam_measurement_i+1							
252-253	Jam_measurement_215								Jam_measurement_216							

Jam_type (1 octet) : type of Jamming measurement data ; for each type, a fixed number of status and/or levels is defined :

Jam_type=2, Jamming measurement using FFT method on the 400 MHz channel.

Jam_type=3, Jamming measurement using FFT method on the 2 GHz channel.

Jamming measurement data represent 216 levels of received RF signal in the DORIS reception bands.

Jamming measurement_i (1 octet) : mean relative level of received RF signal in the predefined bandwidth centered on the frequency F_i , with respect to the reference level of –160 dBm ; LSB 0.35 dBm.

For Jamming measurement on the 400 MHz channel :

$$\text{Bandwith} = 3 \times (1. \text{E}+03 / 16.384) = 183.1055 \text{ Hz}$$

$$F_i \text{ (Hz)} = [([702 + 3 \times (i-1)] - 1025) \times 125 \text{ E}+03 / 2048] + 401.25 \text{ E}+06$$

$$F1 = 401.25 \text{ E}+06 - 19 \text{ 714.355 Hz}$$

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 45/75
Generic Definition of TM Packets and TC Formats		

$$F_{108} = 401.25 \text{ E}+06 - 122.070 \text{ Hz}$$

$$F_{109} = 401.25 \text{ E}+06 + 61.035 \text{ Hz}$$

$$F_{216} = 401.25 \text{ E}+06 + 19\,653.320 \text{ Hz}$$

For Jamming measurement on the 2GHz channel :

$$\text{Bandwith} = 8 \times (1. \text{ E}+03 / 8.192) = 976.5625 \text{ Hz}$$

$$F_i \text{ (Hz)} = [([164.5 + 8 \times (i-1)] - 1025) \times 250 \text{ E}+03 / 2048] + 2036.25 \text{ E}+06$$

$$F_1 = 2036.25 \text{ E}+06 - 105\,041.504 \text{ Hz}$$

$$F_{108} = 2036.25 \text{ E}+06 - 549.316 \text{ Hz}$$

$$F_{109} = 2036.25 \text{ E}+06 + 427.246 \text{ Hz}$$

$$F_{216} = 2036.25 \text{ E}+06 + 104\,919.434 \text{ Hz}$$

The rate is 0, 1 or 2 jamming packets per sequence depending on MASR TC

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 46/75
Generic Definition of TM Packets and TC Formats		

3.5.2. DESCRIPTION OF DUMP PACKET TEST DATA

Dump TM packets are generated upon reception of a Dump TC (see TC chapter).

Dump packets are specific Test packets (see above) with :

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
36-39	address of the first byte dumped in the packet															
40-41	number of bytes dumped in the packet – 1															
42-253	dumped bytes (max. 212); non-significant bytes will be filled with "0" to provide always a fixed length packet (256 bytes)															

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 47/75
Generic Definition of TM Packets and TC Formats		

3.5.3. DESCRIPTION OF OTHER TEST PACKETS TEST DATA

3.5.3.1. Auxiliary Data Packet

Auxiliary Data TM packets are generated upon reception of an enable auxiliary data generation TC (see TC chapter).

Auxiliary data packets are specific Test packets (see above) with :

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
36-37	Current filter status								Autonomous programming authorization							
38-41	Smoothed Earth Pole Coordinate (U)															
42-43	Smoothed Earth Pole Drift (U)															
44-47	Smoothed Earth Pole Coordinate (V)															
48-49	Smoothed Earth Pole Drift (V)															
50-53	Hill Along-Track (P)															
54-57	Hill Cross-Track (P)															
58-61	Drag															
62-63	Rejection counter															
64-67	On-board Frequency															
68-69	On-board Frequency Drift															
70-71	UT1 beacon number															
72-75	UT1 beacon frequency															
76-77	UT1 beacon frequency drift															
78-85	Same parameters for UT2															
86-125	Same parameters for UT3 to UT7															
126-173	Last TC DIODE															
174-253	Spare															

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 48/75
Generic Definition of TM Packets and TC Formats		

Current filter status (8 bits) : integer

Filtering tuning type :

0 = Coarse perfo

1 = Fine perfo

2 = Xtra-fine perfo

Autonomous programming authorization (8 bits) : integer

The convergence is sufficient to allow autonomous programming of the beacons :

0 = unauthorised

1 = authorised

Smoothed Earth Pole Coordinates (32 bits) : U and V. Signed integer, LSB = $10e^{-6}$ arc sec.

Earth Pole coordinates as estimated by the Pole Specific Filter

Smoothed Earth Pole Drift (16 bits) : U et V. Signed integer, LSB = $10e^{-9}$ arc sec / second

Earth Pole Time Derivative as estimated by the Pole Specific Filter

Hill – p parameter (32 bits) : Along-Track and Cross-Track. Signed integer, LSB = $10e^{-13}$ meter / second²

Filter Estimated Values for Hill empirical acceleration

Drag (32 bits) : signed integer, LSB = $10e^{-13}$ meter / second²

Filter Estimated Values for air drag acceleration

Rejection Counter (16 bits) : integer, LSB = 1

Number of measurements rejected by the filter (innovation > threshold)

On-board Frequency (32 bits) : signed integer, LSB = $10e^{-14}$ $\delta f/f$

Filter estimation for on-board USO frequency bias

On-board Frequency Drift (16 bits) : signed integer, LSB = $10e^{-18}$ $\delta f/f$ / second

Filter estimation for on-board USO frequency drift

Uti beacon number (16 bits) : integer, LSB = 1

Beacon number tracked by UT i (i from 1 to 7)

Uti beacon frequency (32 bits) : signed integer, LSB = $10e^{-14}$ $\delta f/f$

Filter estimation for USO frequency bias for the beacon tracked by UT i (i from 1 to 7)

Uti beacon frequency drift (16 bits) : signed integer, LSB = $10e^{-18}$ $\delta f/f$ / second,

Filter estimation for USO frequency drift for the beacon tracked by UT i (i from 1 to 7)

Last TC DIODE (24 useful words of 16 bits, starting with Upload_ID) : copy of the last TC (manoeuvre or SAP) processed by DIODE Navigation function.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 49/75
Generic Definition of TM Packets and TC Formats		

NOTA : Three words (of 16 bits) are added by the on-board software before copy of OCM or SAP TC, for internal use, which do not appear in sections 4.5 and 4.6 :

Upload_ID (2 octets) : Identifier of the command.

Julian_Day (2 octets) : Julian Day (TAI) of the execution time ; LSB = 1 day ; origin 01/01/2000

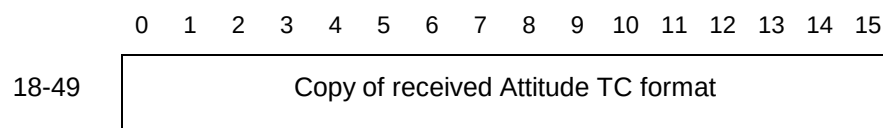
Seconds (2 octets) : Time (TAI) in the day, of the execution time LSB = 10s ; range 0 to 8639

3.5.3.2. *Manufacturer test packets*

Only used by manufacturer.

3.6. DESCRIPTION OF DORIS ATTITUDE PACKETS DATA (IF ANY TC ATTITUDE ON BOARD)

This packet is only generated after reception of a TC attitude sent by the satellite AOCS. It is used to downlink attitude data.



	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 50/75
Generic Definition of TM Packets and TC Formats		

4. DESCRIPTION OF DORIS COMMAND

Doris is able to receive commands packets transmitted on the 1553 bus or discrete commands such as relay commands.

Depending on existing protocol requirements, this paragraph may be added or not :

The DORIS TC are included as variable data field of higher level CCSDS Packets according to Ground to SC I/F requirements. Additional headers and Packet Error Control shall be discarded by the SC main computer in order to transmit to the DORIS instrument the TC formats as specified here after.

Note that the DORIS instrument does not require any time critical or time tagged command. Time tagged data included in optional data of DORIS TC are managed internally by DORIS.

In case of CCSDS TC packets, this sentence shall be added : on TC link, DORIS does not check the correct incrementation of SSC but only reports it in the corresponding report packet.

Depending on protocol, choose §4.1 or §4.2 :

4.1. TC FORMATS

The TC have different formats depending on TC type.

The SC main SW shall transmit each type of DORIS TC to a specific 1553 DORIS sub address as defined in the table here after.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 51/75
Generic Definition of TM Packets and TC Formats		

Sub address (decimal)	TC Type	Data size (bytes)
1	CONFIGURE DORIS	2
2	UPLOAD MEMORY	64
3	UPLOAD PARAMETER (if any, depending on mission)	64
5	TEST	10
16	SC_TIME broadcast (if any, depending on mission)	TBD
29	SC_TIME (if any, depending on mission)	TBD
14	ATTITUDE (if any, depending on mission)	32
13	Solar Array Parameter TC (if any, depending on mission)	18
12	OCM_TC (if any, depending on mission)	24

4.2. TC PACKETS

The TC Packets shall have the general format:

N° octet	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0-1	3					PID=80 (TBC)						Cat=12 (TBC)				
2-3	3		Source_sequence_count													
4-5	Packet_length															
6-7	10H (TBC)								Service Type = 8* (TBC)							
8-9	Service Subtype = 1* (TBC)								Source = 0 (TBC)							
10-11	Function_ID								Activity_ID=0 (TBC)							

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 52/75
Generic Definition of TM Packets and TC Formats		

12-13

Command_parameter
Optional Data
Packet_error_control

(*)These fields are not checked by DORIS instrument

Source sequence count : see DORIS TM packets definition

Packet length : see DORIS TM packets definition

Packet error control : see DORIS TM packets definition

The **Source (1 octet)** indicates the origin of the TC (ground or CDMU) and shall not be checked by Doris.

The TC have different formats depending on TC type.

Sub address (TBC)	TC Type	Packet size (bytes)	Packet lenght	Function _ID (TBC)
16	CONFIGURE DORIS	16	9	1
16	TEST	24	17	2
16	UPLOAD MEMORY	n + 22	n + 15	3
16	UPLOAD PARAMETER	64	57	5
17*	ATTITUDE	48	41	6

(*) this sub address shall be different from the others in order to process attitude TC with appropriate priority. It would be the same issue in case a Time TC would be implemented

Nota : on some satellites, some TC types are not implemented (ex : no Upload Parameter for SWOT mission).

The **Command_parameter (2 octets)** and **Optional Data** area are defined hereafter, according to each TC type.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 53/75
Generic Definition of TM Packets and TC Formats		

4.3. CONFIGURE DORIS TC

The CONFIGURE DORIS TC contains a Command parameter which is a 16 bits command used to force the configuration of the instrument.

4.3.1. NOP - NO OPERATION

This command only generates a Report Packet.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	1	0	0	1	0	1	1	0	1	0	0	1	0	1

NOP Command Parameter = "A5A5"H

4.3.2. ARM – SELECT UPLOAD_EEPROM MODE

This command allows EEPROM uploading (UPLOAD_EEPROM Mode = Authorized).

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

ARM Command Parameter = "8400"H

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 54/75
Generic Definition of TM Packets and TC Formats		

4.3.3. EUP - END of UPLOAD

This command indicates the end of a sequence of UPLOAD MEMORY TCs relevant to on-board software, only in EEPROM (it shall not be send after a software "patch" in RAM) and sets the UPLOAD_EEPROM Mode to inhibited.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	0	0	0	1	1	1	0	0	0	0	0/1	0/1	0/1	0/1

EUP Command Parameter = "870X"H

X = 8, bit 12 = 1 : end of upload of executable software

X = 4, bit 13 = 1 : end of upload of ZQS DORIS data

X = 2, bit 14 = 1 : end of upload of ZQS DIODE data

X = 1, bit 15 = 1 : end of upload of ZQS System data

X = 0, bits 12, 13, 14, 15 = 0 : end of patch in EEPROM (or OBSW maintenance specific operation : see RD 2)

4.3.4. TMM - COPY EEPROM

This command copies the lower EEPROM bank to the upper one assuming that UPLOAD_EEPROM Mode is authorized. At the end of the copy, the UPLOAD_EEPROM Mode is set to inhibited. The lower EEPROM bank is the A or B EEPROM bank depending on RESTART A or B Command previously sent.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

TMM Command Parameter = "8800"H

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 55/75
Generic Definition of TM Packets and TC Formats		

4.4. TEST TC

The Test TC allows activation/inhibition of instrument technological/test configuration.

This TC shall have the following format :

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Command Parameter															
Parameter#1															
Parameter#2															
Parameter#3															
Parameter#4															

The Command parameters define the type of the test.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 56/75
Generic Definition of TM Packets and TC Formats		

4.4.1. TEST TC MASR

This test TC controls the generation of Jamming TM based on FFT processing.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Command Parameter	"0E00"H															
Parameter#1	Start/Stop															
Parameter#2	Channel															
Parameter#3	Reserved															
Parameter#4	Reserved															

Parameter#1 = 0, Stop Jamming TM,

Parameter#1 = 1, Start Jamming TM for Channel defined in Parameter#2

Parameter#2 = 0, Jamming TM for both channels,

Parameter#2 = 1, Jamming TM for 400 MHz channel,

Parameter#2 = 2, Jamming TM for 2 GHz channel.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 57/75
Generic Definition of TM Packets and TC Formats		

4.4.2. TEST TC DZQS

This TC starts the Dump of DORIS SW parameters.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Command Parameter	"2E00"H															
Parameter#1	MS															
Parameter#2	spare															
Parameter#3	spare															
Parameter#4	spare															

MS (2 octets) : Memory Selection :

"0" : Dump of the SW parameters stored in RAM

"1" : Dump of the SW parameters stored in lower bank of EEPROM

"2" : Dump of the SW parameters stored in upper bank of EEPROM

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 58/75
Generic Definition of TM Packets and TC Formats		

4.4.3. TEST TC ADG

This TC controls the generation of auxiliary data test packets.

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Command Parameter	"2400"H
Parameter#1	0000
Parameter#2	Data generation
Parameter#3	spare
Parameter#4	spare

Data generation (2 octets) :

- "0" : Auxiliary data test packets generation disabled
- "1" : Auxiliary data test packets generation enabled

4.5. UPLOAD MEMORY TC

The UPLOAD MEMORY TC is used to upload data or program from a specified address on the on-board memory (RAM or EEPROM).

This command shall have the following format, depending on the protocol :

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

0-1	Command Parameter = "D000"H	
2-5	Start _Address	
6-7	Length (octets)	Ack
8-63	Data	
	(56 octets)	

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 59/75
Generic Definition of TM Packets and TC Formats		

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12-13	Command Parameter = "D000"H															
14-17	Start _Address															
18-19	Length (octets)								Ack							
20- (n+19)	Data n octets (max 206)															

Ack (1 octet) indicates if the TC shall be, or not, acknowledged by a Report Packet :

3 = UPLOAD MEMORY with Acknowledgement, mandatory for software patch

4 = UPLOAD MEMORY without Acknowledgement, mandatory for full software zone upload

The **Start_address** (4 octets) defines the beginning address of the load area. According to its value this address makes reference to the type of memory used (RAM or EEPROM).

The **Length** (1 octet) defines the length, in octets, of the uploaded significant data (dummy "00 00" not taken into account).

The length shall be an even value.

Depending on protocol :

*The **Data field** (56 octets) contains data to upload, filled, if necessary, with dummy zeros.*

or

*The **Data field** contains data to upload.*

Note : The procurement of on-board software shall be made according to ANNEX 1.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 60/75
Generic Definition of TM Packets and TC Formats		

4.6. OCM TC IF ANY

This TC gives the characteristics of the next Orbit Control Maneuver thrust of the satellite. One OCM TC is needed for each thrust, it is considered that only one maneuver is performed in the same slot between two consecutive ticks of 10 seconds TAI .

On board SWOT this TC shall be transmitted to DORIS instrument by the main on board computer at least 30 seconds before the beginning of the thrust.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0-9	thrust_start															
10-11	thrust_duration															
12-15	R_acceleration															
16-19	T_acceleration															
20-23	N_acceleration															

Thrust start (10 octets TBC) : date of the beginning of the thrust in on board time in TAI, CUC format (cf. Time_TC format) including Time status and the 2 spare bytes

Thrust_duration (2 octets) : Thrust duration expressed in seconds, LSB = 0.125 second with range 8192s.

R, T, N_acceleration (4 octets) : Foreseen acceleration, along Radial, Along track, across track axes of orbital local reference frame (TBC). Signed integer, LSB=1 micrometer/s² with range +- 2147m/s².

The orbital local reference frame convention is the following:

- **Radial_direction** : (from Center of Earth to CoG of SC)
- **Along track_direction**: (Cross product of Cross track by Radial direction ; Along track is close to the direction of the SC velocity)
- **Cross track direction**: (Direct normal to orbit plane)

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 61/75
Generic Definition of TM Packets and TC Formats		

4.7. SAP TC IF ANY

This TC gives the Position of the Solar Array.

On board SWOT this TC shall be transmitted to DORIS instrument by the main on board computer every 32 seconds.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0-9	Date															
10-13	SA position for the +X wing															
14-17	SA position for the -X wing															

Date (10 octets) : TAI date of the SA +X and -X wings positions, CUC format (cf Time_TC format), including Time status and spare bytes.

SADM position for the +X wing (4 octets) : angle from $-PI$ to $+PI$, 32 bits signed Integer, Unit rd, $LSB = 1.0 \cdot 10^{-8}$. Zero angle corresponding to wing solar cells orientation vector toward $-Z_{sat}$ (nominally the Radial direction). Positive angle defined when Solar cells orientation vector is toward $+Y_{sat}$ hemisphere.

SADM position for the -X wing (4 octets) : angle from $-PI$ to $+PI$, 32 bits signed Integer, Unit rd, $LSB = 1.0 \cdot 10^{-8}$. Zero angle corresponding to wing solar cells orientation vector toward $-Z_{sat}$ (nominally the Radial direction). Positive angle defined when Solar cells orientation vector is toward $-Y_{sat}$ hemisphere.

Note: Rotation angle is considered in the wing frame and not in the satellite frame, which explains the different sign behavior for +X & -X wings.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 62/75
Generic Definition of TM Packets and TC Formats		

4.8. UPLOAD PARAMETERS TC IF ANY

The UPLOAD PARAMETERS TC is used to update a set of parameters of the on-board SW.

4.8.1. **MANEUVER CHARACTERISTIC TC**

This TC gives the characteristics of the next orbit control thrust of the satellite. One Maneuver Characteristic TC is needed for each thrust.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12-13	CommandParameter = "D002"H															
14-15	Upload_ID="0C04"H															
16-17	Julian_Day															
18-19	Seconds															
20-21	Thrust_sequence number															
22-25	Radial_acceleration															
26-29	Along track_acceleration															
30-33	Cross track_acceleration															
34-35	Radial_acceleration_model_sigma															
36-37	Along track_acceleration_model_sigma															
38-39	Cross track_acceleration_model_sigma															
40-41	Adj	Ratio					Reserved									
42-43	Radial_acceleration_initial_sigma															
44-45	Along track_acceleration_initial_sigma															
46-47	Cross track_acceleration_initial_sigma															
48-61	Reserved															

Upload_ID (2 octets) : Identifier of the command.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 63/75
Generic Definition of TM Packets and TC Formats		

Julian_Day (2 octets) : Julian Day (TAI) of the execution time ; LSB = 1 day ; origin 01/01/2000

Seconds (2 octets) : Time (TAI) in the day, of the execution time LSB = 10s ; range 0 to 8639

The Julian Day/Time shall be computed as indicated in the user manual RD 2.

Thrust_sequence_number (2 octets): Thrust duration expressed in number of sequences of 10 seconds (see user manual RD2).

Radial_acceleration (4 octets) : Foreseen radial acceleration, in local orbital reference frame (from Center of Earth to CoG of SC). Signed integer, LSB=1 micrometer/s².

Along_track_acceleration (4 octets) : Foreseen Along track acceleration, in local orbital reference frame (Cross product of cross tracks by Radial direction ; Along track is close to the SC velocity). Signed integer, LSB=1 micrometer/s².

Cross_track_acceleration (4 octets) : Foreseen Cross track acceleration, in local orbital reference frame (Direct normal to orbit plane). Signed integer, LSB=1 micrometer/s².

The three acceleration parameters shall be computed as specified in the user manual RD 2.

Radial_acceleration_model_sigma (2 octets) : Uncertainty on foreseen radial acceleration. Unsigned Integer, LSB=10⁻⁵ m/s².

Along_track_acceleration_model_sigma (2 octets) : Uncertainty on foreseen Along track acceleration. Unsigned Integer, LSB=10⁻⁵ m/s².

Cross_track_acceleration_model_sigma (2 octets) : Uncertainty on foreseen Cross track acceleration. Unsigned Integer, LSB=10⁻⁵ m/s².

Adj (1 bit) : Thrust value adjustment :
Adj=0, adjustment forbidden,
Adj=1, adjustment authorized.

Ratio (4 bits) : Unsigned integer ; shall be set to 0 or 3 (see RD 2)

Radial_acceleration_initial_sigma (2 octets) : Initial uncertainty on foreseen radial acceleration. Unsigned Integer, LSB=10⁻⁵ m/s².

Along_track_acceleration_initial_sigma (2 octets) : Initial uncertainty on foreseen Along track acceleration. Unsigned Integer, LSB=10⁻⁵ m/s².

Cross_track_acceleration_initial_sigma (2 octets) : Initial uncertainty on foreseen Cross track acceleration. Unsigned Integer, LSB=10⁻⁵ m/s².

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 64/75
Generic Definition of TM Packets and TC Formats		

4.8.2. DATA KILLER TC

This TC allows the cancellation of all TC, not yet executed (Julian day and seconds > current date), already uploaded into Doris.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12-13	Command Parameter = "D005"H															
14-15	Upload_ID="0306"H															
16-17	0000H															
18-19	0000H															
20-21	0200H															
22-61	Reserved															

Upload_ID (2 octets) : Identifier of the command.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 65/75
Generic Definition of TM Packets and TC Formats		

4.9. DESCRIPTION OF THE SATELLITE ON BOARD TIME

Depending on the satellite on board time policy, the following paragraph may be discarded.

The Platform is in charge of the delivery of a precise synchronization pulse each second, so called PPS (pulse per second). Each DORIS functional chain of the DORIS instrument will receive a PPS signal whatever Module, nominal or redundant inside the Spacecraft is ON.

These signals are absolute references, they are phased on round seconds of the on-board time and have an accuracy better than +/- 10 μ s.

The associated dates are delivered to DORIS by the Spacecraft Main Computer via the 1553B data bus by SC_TIME commands described here after depending on the mission.

The instrument is able to receive the SC_TIME TC at a maximum rate of 1 TC every 1 second.

For SC_TIME TC only, the size of the TC is verified by DORIS.

This TC does not include any command parameter.

SC_TIME TC format (TBD octets) : TBD

Each DORIS TM packet, generated between the PPS(n) and PPS (n+1), shall contain in the "Packet Time" field (cf. chapter 3), the copy of the last received SC_TIME TC before PPS (n).

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 66/75
Generic Definition of TM Packets and TC Formats		

4.10. DESCRIPTION OF THE ATTITUDE TC

This TC defines the attitude and the angular velocities of the satellite at a particular time. It is generated on board by the SC and transmitted to DORIS every 1 second.

Depending on protocol, the format is as following :

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0-1	q ₁ of attitude quaternion in J2000 reference frame															
2-3	q ₂ of attitude quaternion in J2000 reference frame															
4-5	q ₃ of attitude quaternion in J2000 reference frame															
6-7	q ₀ of attitude quaternion in J2000 reference frame															
8-19	Date / Spare (format TBD)															
20-23	X angular velocity in J2000 reference frame															
24-27	Y angular velocity in J2000 reference frame															
28-31	Z angular velocity in J2000 reference frame															

(in this case, this TC does not include any COMMAND_PARAMETER)

Generic Definition of TM Packets and TC Formats

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
12-13	Command Parameter = "D001"H															
14-15	q ₁ of attitude quaternion in J2000 reference frame															
16-17	q ₂ of attitude quaternion in J2000 reference frame															
18-19	q ₃ of attitude quaternion in J2000 reference frame															
20-21	q ₀ of attitude quaternion in J2000 reference frame															
22-33	Date / Spare (format TBD)															
34-37	X angular velocity in J2000 reference frame															
38-41	Y angular velocity in J2000 reference frame															
42-45	Z angular velocity in J2000 reference frame															

The attitude quaternion (named $Q = (q_0, q_1, q_2, q_3)$) allows conversion between :

- a vector given by its component in the SATELLITE frame (vector X /RSAT),
- and the same vector given by its component in the J2000 frame (vector X /J2000).

The associated frame change equation is :

$$\begin{pmatrix} 0 \\ \text{vector } X_{/J2000} \end{pmatrix} = Q * \begin{pmatrix} 0 \\ \text{vector } X_{/RSAT} \end{pmatrix} * \bar{Q}$$

Where $\bar{Q} = (q_0, -q_1, -q_2, -q_3)$.

The ageing of the data, due to the delay of delivery of this TC by the satellite to DORIS through the MIL-STD-1553 bus, will not be more than 1 second.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 68/75
Generic Definition of TM Packets and TC Formats		

Attitude quaternion (imaginary part, real part) :

q₁ (2 bytes) : i imaginary part. Signed Integer, LSB = $1/(2^{15} - 1)$

q₂ (2 bytes) : j imaginary part. Signed Integer, LSB = $1/(2^{15} - 1)$

q₃ (2 bytes) : k imaginary part. Signed Integer, LSB = $1/(2^{15} - 1)$

q₀ (2 bytes) : real part. Signed Integer, LSB = $1/(2^{15} - 1)$

(please notice the convention giving in the TC format, q₀, real part, after q₁, q₂ and q₃ imaginary parts).

Time-tagging :

Time data field is TBD depending on the satellite datation policy.

Angular velocities :

X angular velocity (4 bytes): component on the X direction of SATELLITE frame, of the instantaneous rotation vector of RSAT frame with respect to the J2000 reference frame. Signed Integer, LSB = $2.5 \cdot 10^{-9}$ °/s with $\pm 5^\circ/\text{s}$ range.

Y angular velocity (4 bytes): component on the Y direction of SATELLITE frame, of the instantaneous rotation vector of RSAT frame with respect to the J2000 reference frame. Signed Integer, LSB = $2.5 \cdot 10^{-9}$ °/s with $\pm 5^\circ/\text{s}$ range.

Z angular velocity (4 bytes): component on the Z direction of SATELLITE frame, of the instantaneous rotation vector of RSAT frame with respect to the J2000 reference frame. Signed Integer, LSB = $2.5 \cdot 10^{-9}$ °/s with $\pm 5^\circ/\text{s}$ range.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 69/75
Generic Definition of TM Packets and TC Formats		

ANNEX 1

The file format for on-board software upload

The file is a PC compatible ASCII file containing lines less than 80 characters long and allowing an easy display and printout with standard PC tools. It is divided into 4 parts : one file for the DORIS software, and one file for each ZQS, ZQS DORIS, ZQS DIODE and ZQS SYSTEME.

The files may be delivered eventually "zipped" either on a CD-ROM or any other agreed support.

The files name shall be

LOGICIEL_DORIS_CODGXXS_XXYY_aabb_MEM(_CCSDS)(_PATCH)**.TCH* where :

- *XXYY* is the issue *XX.YY* of the LOGICIEL_DORIS software,
- *aabb* is the issue *aa.bb* of the DIODE software included in EEP,
- *MEM* is the type of memory : RAM or EEP (for EEPROM).
- *TCH* is the file name extension.

ZQS_DORIS#_SatelliteName_ccdd_MEM(_CCSDS)(_PATCH)**.TCH* where :

- *#* is 1 or 2, depends on DORIS chain concerned by the ZQS
- *SatelliteName* is TBD
- *ccdd* is the issue *cc.dd* of the ZQS_DORIS issue
- *MEM* is the type of memory : RAM or EEP (for EEPROM).
- *TCH* is the file name extension.

ZQS_DIODE_SatelliteName_eeff_MEM(_CCSDS)(_PATCH)**.TCH* where :

- *SatelliteName* is TBD
- *eeff* is the issue *ee.ff* of the ZQS_DIODE issue
- *MEM* is the type of memory : RAM or EEP (for EEPROM).
- *TCH* is the file name extension.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 70/75
Generic Definition of TM Packets and TC Formats		

ZQS_SYSTHEME_SatelliteName_gghh_MEM(_CCSDS)(_PATCH)**.TCH* where :

- *SatelliteName* is TBD
- *gghh* is the issue *gg.hh* of the *ZQS_SYSTHEME* issue
- *MEM* is the type of memory : RAM or EEP (for EEPROM).
- *TCH* is the file name extension.

The files include a header giving information about the file, the code containing the data to be uploaded and a trailer indicating the end of the file.

1) The header format

The header is a sequence of lines starting with the character "!".

The LOGICIEL_DORIS file header shall include :

- the file name,
- the LOGICIEL_DORIS software issue,
- the Diode software issue,
- the software creation date (dd/mm/yyyy),
- the memory addressed type (RAM or EEPROM),
- the upload type (FULL or PATCH)**,
- the number of Upload Memory TC packets.

The ZQS_DORIS file header shall include :

- the file name,
- chain identifier
- the ZQS_DORIS issue,
- the ZQS_DORIS creation date (dd/mm/yyyy),
- the memory addressed type (RAM or EEPROM),

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 71/75
Generic Definition of TM Packets and TC Formats		

- the upload type (FULL or PATCH)**,
- the number of Upload Memory TC packets.

The ZQS_DIODE file header shall include :

- the file name,
- the ZQS_DIODE issue,
- the ZQS_DIODE creation date (dd/mm/yyyy),
- the memory addressed type (RAM or EEPROM),
- the upload type (FULL or PATCH)**,
- the number of Upload Memory TC packets.

The ZQS_SYSTEME file header shall include:

- the file name,
- the ZQS_SYSTEME issue,
- the ZQS_SYSTEME creation date (dd/mm/yyyy),
- the memory addressed type (RAM or EEPROM),
- the upload type (FULL or PATCH)**,
- the number of Upload Memory TC packets.

2) The upload file Format

The upload file contains a sequence of Upload Memory TC** ; each TC is separated from the following by an empty line (without any blank character).

Each word of the TC is coded in hexadecimal format, as a chain of 4 consecutive ASCII characters (between 0000 and FFFF) and is separated from the following one by a "space" character.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 72/75
Generic Definition of TM Packets and TC Formats		

Depending on the protocol :

In case of 1553 protocol (PROTEUS like) without CCSDS headers in the TCs :

Each TC shall start with the "D000"H sequence. Each TC shall be made of a sequence of two lines of 79 characters (corresponding to 16 words separated by 15 "spaces").

Every TC will contain 56 octets in the data field.

In case of 1553 protocol (CRYOSAT like) with CCSDS headers in the TCs :

Each packet shall start with the CCSDS Header and shall finish with the Packet_error_control field (which shall be computed).

The Source_sequence_count field shall be set to 1 at the first packet then incremented by 1 for each following packet.

Each packet shall be made of a sequence of lines of 79 characters (corresponding to 16 words separated by 15 "spaces"), except for the last line which may be shorter.

3) End of file

The logical end of the file shall be identified by the following line :

! END OF FILE

With single space character between each word.

4) Example

TBD

(*) : depending on the protocol, `_CCSDS` shall be added in the files names

()** :In case of a patch, `_PATCH` shall be added in the files names

The information FULL or PATCH in the header shall be consistent with the Ack field of the TC (see § UPLOAD Memory TC) .

Nota : a) finally the file delivered by the DORIS OBSW maintenance service (SMLD) will be named as specified by the customer.

b) before using it on a dedicated mission, the universal DGXXS OBSW shall be validated in the frame of this mission and with appropriated parameters.

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 73/75
Generic Definition of TM Packets and TC Formats		

ANNEX 2

Algorithm for CRC generation of TM packets

This algorithm, described using C Language, is extracted from document ESA PSS-07-101 - Annex 4.

Crc FUNCTION

The Crc function calculates the CRC for one byte in serial fashion and returns the value of the calculated CRC checksum.

```

unsigned int Crc(Data,Syndrome)
  unsigned char Data;          /* Byte to be encoded */
  unsigned Syndrome;          /* Original CRC Syndrome */
  {
    int i;

    for (i=0; i<8; i++) {
      if (( Data & 0x80)^(( Syndrome & 0x8000) >> 8)) {
        Syndrome = ((Syndrome << 1) ^ 0x1021) & 0xFFFF;
      } else {
        Syndrome = (Syndrome << 1) & 0xFFFF;
      }
      Data = Data << 1;
    }
    return (Syndrome);
  }

```

/* Program to test CRC generation function*/

```

Void main ( )
{

```

Generic Definition of TM Packets and TC Formats

```
unsigned int Chk; /* CRC syndrome */
unsigned char indata[32]; /* Data to be encoded */
int j;
indata[0] = 0x31; indata[1] = 0x23; indata[2] = 0x48; indata[3] = 0x07;
indata[4] = 0x00; indata[5] = 0xEC; indata[6] = 0xD0; indata[7] = 0x37;
Chk = 0xFFFF; /* Reset syndrome to all ones */
for (j=0; j<8; j++) {
    Chk = Crc(indata[j], Chk);
}
printf(" CRC = %x (should be 0)\n", Chk);
}
```

	DIFFUSION LIMITEE DORIS 	Reference : CO-SP-D0-EA-16858-CN Issue : 1.5 Date : November 09th 2021 Page : 75/75
Generic Definition of TM Packets and TC Formats		

DIFFUSION

Diffusion Interne

C. MANFREDI	CNES - DSO/OT/DOR
O. DUMOND	CNES - DSO/OT/DOR
JF.DUTREY	CNES - DSO/OT/DOR
J.M. BENEZETH	LOGIQUAL- DSO/AQ/BA
P.BUZON	CNES - DSO/OT/DOR