

UNCLASSIFIED

PROCUREMENT SPECIFICATION
(or CRITICAL ITEM DEVELOPMENT SPECIFICATION - CIDS)

Prepared for:
CNES and C-MAC

For the
Ultra Stable Oscillator
DORIS DGXX

CONTRACT CNES N° ° 04/1471/01

Prepared by:
THALES SYSTEMES AEROPORTES

DOCUMENTATION

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DOCUMENT FOLLOW UP

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A vertical straight line, at the left of the text, will mark where the modifications take place, excepted between draft versions and successive versions.

APPLICABLE DOCUMENTS

N°	TITLE OF THE DOCUMENT	REFERENCE	VERSION
AD1	EXIGENCES SYSTEME POUR LES OUS BORD DORIS	CO-SP-D12-EA-11677-CN	2.1 du 22/05/2001
AD2	JASON-2 payload design and interface specification (PDIS)	- note 1	Draft 11/09/02
AD3	PLEIADES HR Unit Requirement Document	PLHR.SP.234.T.ASTR	2.4 du 7/01/2004
AD4	C-MAC USO interface drawing	409386	Rev. M
AD5	JASON-2 DORIS Interface Specification	TP3-ASP-SP-0033	3.0 17/02/2006
AD6	Spécification d'interface pour l'accommodation et les essais de DORIS sur PLEIADES HR (IRD)	D3S-IF-D1-EA-11705-CN	3.3 19/10/05
AD7	Justificatif technique de la décomposition de la stabilité en environnement suivant la spécification DORIS DGXX d'approvisionnement de l'OUS	92 987	Ed. 3 8/12/2005
AD8	DORIS DGXX Product Assurance requirements	CO-SP-DI-AP-15063-CN	Iss. 1.0 29/06/2005
AD9	Spécification Technique de Besoin de l'instrument DORIS DGXX	CO-SP-D1-EA-15704-CN	1.0 14/03/2006

Note 1: this document is no longer applicable to the DORIS DGXX contract but has been used as a source for the elaboration of the present document and is still referenced in the text.

REFERENCE DOCUMENTS

The following documents have been used as a source or a guideline for elaboration of the requirements.

N°	TITLE OF THE DOCUMENT	REFERENCE	VERSION
RD1	Spécifications Techniques de Besoin de l'ONG 5 MHz DORIS BORD Futur - modèle MIQ	DTS/AE/TTL/TF/2001-017	1.2 dated 8/02/2001
RD2	Spécifications Techniques des OUS DORIS/SPOT 5 et DORIS/HELIOS II	CO-ST-D12-EA-11677-CN	0.0 dated 9/10/1998
RD3	Deleted	-	-
RD4	CAHIER DES CLAUSES TECHNIQUES PARTICULIERES DU MARCHE N° 714/01/CNES/8672/00 Etude et qualification d'un ONG 5 MHz DORIS futur	DTS/AE/TTL/TF/2001-021	1.0 dated 19/03/2001
RD5	Deleted	-	-
RD6	Test method standard for measurement of electromagnetic interference characteristics	MIL-STD-461	revision: E dated 20/08/1999
RD7	Oscillator, Crystal Controlled, General Specification For	MIL-PRF-55310	revision: D dated 25/03/1998

TBD AND TBC LIST

TBD/TBC	REQU ID.	DESCRIPTION
none		

These TBC and TBD shall be resolved under THALES responsibility before flight model tests.

LIST OF ACRONYMS

AD	:	Applicable Document
AIT	:	Assembly, Integration and Test
BDR	:	Boîtier DORIS Redondé
BOL	:	Beginning Of Life
CIDS	:	Critical Item Development Specification
CNES	:	Centre National d'Etudes Spatiales
DISS	:	DORIS Interface Satellite Simulator
DORIS	:	Détermination d'Orbite et Radio-positionnement Intégrés par Satellite
EOL	:	End Of Life
EQM	:	Engineering and Qualification Model
FM	:	Flight Model
ICD	:	Interface Control Document
PHR	:	Pléiades HR
RD	:	Reference Document
SEB	:	Single Event Burn Out
SEL	:	Single Event Latch up
SET	:	Single Event Transient
TAS	:	THALES Airborne Systems (THALES Systèmes Aéroportés)
USO	:	Ultra-Stable Oscillator
VSWR	:	Voltage Stationary Wave Ratio

DOCUMENT IDENTIFY SHEET

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TABLE OF CONTENTS

1.	DOCUMENT OBJECT	10
2.	DEFINITIONS.....	11
3.	FUNCTIONAL REQUIREMENTS	12
4.	GENERAL ENVIRONMENT REQUIREMENTS	14
5.	EXTREME ENVIRONMENT REQUIREMENTS	19
6.	CONNECTOR REQUIREMENTS.....	20
7.	POWER SUPPLY REQUIREMENTS	21
8.	USO LOAD REQUIREMENTS	24
9.	USO OUTPUT REQUIREMENTS	25
10.	PERFORMANCE REQUIREMENTS	27
11.	MECHANICAL ENVIRONMENT REQUIREMENTS.....	30
12.	MECHANICAL INTERFACES REQUIREMENTS.....	32
13.	MISCELLANEOUS REQUIREMENTS.....	34
14.	EMC REQUIREMENTS.....	36

15. TEST REQUIREMENTS 38

16. RELIABILITY REQUIREMENTS.....45

17. SAFETY REQUIREMENTS.....46

18. QUALITY ASSURANCE REQUIREMENTS 48

19. DELIVERY 49

ANNEX 1 TABLES AND FIGURES.....50

Note:

These requirements are maintained and managed through an Access database.

They are exported to this Word document by a semi automatic process with a Word macro function.

This document version was created by extraction of the database at the following date:

Extraction date: 27/07/2006 08:29:17

1. DOCUMENT OBJECT

Rq. Id: USO_DEF_001 Rq. Source: MODIFIED Rq. version: 1,1
Delay: - Temp.: - Verify: D
Compliance: AD1: Y AD2: NA
 AD3: NA RD1: NA

This document at its current edition is applicable to the procurement of USOs in the frame of the DORIS DGXX contract for JASON2 and PLEIADES.

The USOs provides the critical high stability frequency source for the DORIS instruments.

The following requirements are fully applicable to USO NG 10 MHz direct (recurrent models) and new USO ONG 5 MHz x 2, independently of the satellite affectation (JASON2, PLEIADES).

These requirements are consistent with AD9.

Foreseen non conformances of these different versions (especially radiation and acceleration susceptibility) shall be processed through Non Conformance Requests (NCR). These NCR might be accepted on a case by case basis depending on the mission affectation.

2. DEFINITIONS

Rq.- Id: USO_DEF_006 Rq. Source: CREATED Rq. version: 0,1
Delay: - Temp.: - Verify: D
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

Requirement identification:

All requirements are composed of a header and a requirement text.

The header provides:

- a requirement unique identifier in the form USO_XXX_YYY where XXX defines the theme of the requirement and YYY is a number starting from 000;
- the requirement source field:
 - the source of the requirement (document that contains the original requirement when available)
 - or CREATED key word if the requirement has no link with upper level;
 - or MODIFIED key word if the requirement is derived from a historic requirement (see 'compliance' field);
- the modification index of the requirement (version) with the format x,y where x is the major revision index and y the minor revision index and starting from 0;
- the delay since power On when the requirement becomes applicable (see USO_DEF_003 and USO_DEF_004);
- the temperature range applicable to the requirement when relevant (see USO_DEF_003 and USO_DEF_004);
- the proposed method of verification defined by the following conventions:
 - R/review of design;
 - I/inspection;
 - A/analysis;
 - T/test;
 - D/definition (not be tracked);
- the compliance of the requirement to Applicable or Reference Documents;
 - NA: no similar requirement in the source document;
 - Y: requirement same as source document;
 - Y+: requirement more stringent than in the source document;
 - N: requirement less stringent than the source requirement.

If tables are considered as part of requirement, they are referenced clearly in the text and inserted in annex 1.

3. FUNCTIONAL REQUIREMENTS

Rq.- Id: USO_DEF_003 Rq. Source: MODIFIED Rq. version: 0,1
Delay: - Temp.: - Verify: T + A
Compliance: AD1: Y+ AD2: NA
 AD3: NA RD1: Y+

After Power-On, functional and performance requirements shall be met after no more than the delay associated to each requirement.

Rq.- Id: USO_DEF_004 Rq. Source: MODIFIED Rq. version: 0,1
Delay: - Temp.: - Verify: T + A
Compliance: AD1: Y+ AD2: NA
 AD3: NA RD1: Y+

Functional and performance requirements shall be met in the temperature range associated to each requirement (EXTended or NOMinal).

Rq.- Id: USO_ENV_002 Rq. Source: MODIFIED Rq. version: 0
Delay: - Temp.: - Verify: A
Compliance: AD1: NA AD2: NA
 AD3: Y RD1: Y

The USO required life is:
- ground test: up to 1 year (powered on)
- ground storage: up to 4 years (unpowered)
- flight operation: 5 years
Note: the USO is not powered during launch.

Rq.- Id: USO_FUNC_001 Rq. Source: AD1, RD1 Rq. version: 1
Delay: 2 s Temp.: EXT Verify: T
Compliance: AD1: Y AD2: NA
 AD3: NA RD1: Y

The USO shall provide a pure sine signal at his output interface when powered ON

Rq.- Id: USO_FUNC_003 Rq. Source: CREATED Rq. version: 0,1
Delay: - Temp.: - Verify: A
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

All functional and performance requirements shall be met all along the required life and when the USO is powered ON, unless otherwise stated.

Rq.- Id: USO_ITF_001 Rq. Source: MODIFIED Rq. version: 1
Delay: 2 s Temp.: EXT Verify: T
Compliance: AD1: Y AD2: NA
 AD3: NA RD1: N

The nominal frequency of the USO signal at the output interface shall be 10 MHz.

4. GENERAL ENVIRONMENT REQUIREMENTS

Rq. Id: USO_DEF_002 Rq. Source: RD1 Rq. version: 0,1
Delay: - Temp.: NOM Verify: D
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y

In addition to general environment and interface requirements, the definition of stable environment for further requirements is:

- stabilized temperature +/- 1°C in the range:
 - 20 to +45°C at ambient pressure
 - 20 to +45°C in vacuum,
- relative humidity < 65% at ambient pressure
- power supply slow variations < +/- 1 mV
- 50 ohm load variations less than +/- 1 %.

Rq. Id: USO_DEF_007 Rq. Source: CREATED Rq. version: 0
Delay: - Temp.: - Verify: D
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

The USO is powered OFF during satellite launch, ascent and pyrotechnic deployments.

Rq. Id: USO_ENV_001 Rq. Source: AD1, RD1 Rq. version: 0,2
Delay: - Temp.: - Verify: T + A
Compliance: AD1: Y AD2: NA
 AD3: NA RD1: Y

All functional and performance requirements shall be met under all environment conditions specified hereafter (temperature, vacuum and air pressure, radiation, mechanical, magnetic field, ...) unless otherwise stated.

Rq.- Id:	USO_ENV_004	Rq. Source:	RD1	Rq. version:	0
Delay:	-	Temp.:	NOM	Verify:	D
Compliance:	AD1: NA			AD2:	NA
	AD3: NA			RD1:	Y+

The thermal temperature profile applicable to the medium term frequency stability and time stability tests shall be:

- sinusoidal variation
- amplitude 4°C peak to peak
- period 100 mn
- temperature range -20 to +45 °C under vacuum

Rq.- Id:	USO_ENV_007	Rq. Source:	AD2 + AD3	Rq. version:	0,2
Delay:	-	Temp.:	-	Verify:	A
Compliance:	AD1: NA			AD2:	Y+
	AD3: Y+			RD1:	N

The USO shall withstand the following long term ground storage and AIT conditions without any maintenance:

- AIT: temperature: 10 to 30°C;
- storage -40 to +70°C;
- relative humidity: 20 to 65 %
- pressure: ambient
- total duration: 5 years

Rq.- Id:	USO_ENV_008	Rq. Source:	RD1	Rq. version:	0
Delay:	-	Temp.:	-	Verify:	T + A
Compliance:	AD1: NA			AD2:	NA
	AD3: NA			RD1:	Y (partially)

All functional and performances requirements shall be met in ambient pressure and vacuum conditions unless otherwise stated.

Rq.- Id:	USO_ENV_009	Rq. Source:	RD1	Rq. version:	0,1
Delay:	-	Temp.:	EXT	Verify:	T or A
Compliance:	AD1: NA			AD2:	NA
	AD3: NA			RD1:	Y

The USO shall comply with all functional and performances requirements following long term storage in the conditions defined by USO_ENV_017.

Rq.- Id: USO_ENV_010 Rq. Source: MODIFIED Rq. version: 0
Delay: - Temp.: - Verify: D
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y+

The extended (EXT) temperature range definition applicable to identified requirements is:
-30°C to +65°C under ambient pressure and vacuum.

Rq.- Id: USO_ENV_011 Rq. Source: RD1 Rq. version: 0
Delay: - Temp.: - Verify: D
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y+

The nominal (NOM) temperature range definition applicable to identified requirements is:
-20°C to +45°C under ambient pressure and vacuum.

Rq.- Id: USO_ENV_012 Rq. Source: DA3 Rq. version: 1
Delay: - Temp.: - Verify: T + A
Compliance: AD1: NA AD2: NA
 AD3: Y RD1: NA

The USO shall meet all its functional, performance and safety requirement after up to 1000 ON/OFF cycles (qualification). This shall be demonstrated by a qualification test as defined by USO_TEST_017.
A worst case frequency drift resulting from the ON/OFF cycles shall be estimated and taken into account for the verification of USO_PERF_001.

Rq.- Id: USO_ENV_013 Rq. Source: MODIFIED Rq. version: 0,1
Delay: - Temp.: - Verify: T + A
Compliance: AD1: NA AD2: Y
 AD3: Y RD1: Y

The USO shall meet its functional and performance requirements during exposure to the total radiation dose received during its required operational life. The total dose model is defined in table ENV_013_1 and figure ENV_013_2 (JASON dose profile in annex 1). A safety margin of x2 shall be applied to this model. The USO supplier shall take into account an external shielding equivalent to 4 mm Aluminium and the additional shielding provided by the USO structures to assess the total dose at the component level.
These data are in accordance with AD5 which is the worst case input for radiation dose.

The dose rate profile applicable for the medium term stability requirements USO_PERF_003 and USO_PERF_004 is defined in figure ENV_014 in annex 1.

The USO shall withstand a depressurisation rate of 4200 Pa/sec from ambient pressure down to zero (launch conditions) and a pressurisation rate of 170 Pa/sec from vacuum to ambient pressure (return to ambient pressure in 10 mn min at the end of vacuum tests).

The magnetic field environment applicable for the medium term stability requirements USO_PERF_003 and USO_PERF_004 is defined in figure ENV_023 in annex 1.

The acceleration profile environment applicable for the medium term stability requirements USO_PERF_003 and USO_PERF_004 is defined in figure ENV_024 in annex 1.

Rq.- Id: USO_ENV_104 Rq. Source: CREATED Rq. version: 0
Delay: - Temp.: NOM Verify: D
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

The following thermal environment model shall be taken into account for the estimation of the USO medium term stability:

Teta = Teta0 + Delta_teta sin (2 PI t/T)
with Teta0 = any temperature in the range -20°C to +45°C,
Delta_teta = 2.1 K, T = 100 mn

5. EXTREME ENVIRONMENT REQUIREMENTS

Rq.- Id:	USO_ENV_021	Rq. Source:	RD1	Rq. version:	0
Delay:	-	Temp.:	-	Verify:	A
Compliance:	AD1: NA			AD2:	NA
	AD3: NA			RD1:	Y

The USO shall withstand in non operation (power OFF state), for duration up to one week, the following ground storage temperature:
-40°C to +70°C.

Rq.- Id:	USO_ENV_022	Rq. Source:	RD1	Rq. version:	0,1
Delay:	-	Temp.:	-	Verify:	A
Compliance:	AD1: NA			AD2:	NA
	AD3: NA			RD1:	Y

The USO shall withstand the following extreme humidity conditions in non operation:

- relative humidity: 90% +/- 5%
- duration: 24 h
- temperature: 25°C +/- 5°C

It shall be able to return to normal operation after 2 hours drying.

6. CONNECTOR REQUIREMENTS

Rq.- Id: USO_ITF_012 Rq. Source: RD1 Rq. version: 0
Delay: - Temp.: - Verify: R
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y

The USO shall provide a DAM15P type connector or equivalent for power supply input.

Rq.- Id: USO_ITF_013 Rq. Source: RD1 Rq. version: 0
Delay: - Temp.: - Verify: R
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y

The sub D connector pinout shall be:
- pins 1, 2 and 8: mechanical and electrical ground
- pins 9 and 10: +20V input
- other pins not connected
Note: no TM signal required.

Rq.- Id: USO_ITF_014 Rq. Source: RD1 Rq. version: 0
Delay: - Temp.: - Verify: R
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y

The USO output signal shall be provided through a SMA female connector.

7. POWER SUPPLY REQUIREMENTS

Rq.- Id: USO_DEF_005Rq. Source: CREATEDRq. version: 0,1

Delay: -Temp.: -Verify: D

Compliance: AD1: NAAD2: NAD3: NARD1: NA

All functional and / or performance requirement shall be met with the power supply characteristics defined in the requirements hereafter.

Rq.- Id: USO_ITF_002Rq. Source: CREATEDRq. version: 1

Delay: -Temp.: EXTVerify: A

Compliance: AD1: NAAD2: NAD3: NARD1: NA

The power supply voltage range is: 19.7 V +/- 0,5 V (DC).
This includes the adjustment tolerance at the beginning of life and long term drift.

Rq.- Id: USO_ITF_003Rq. Source: CREATEDRq. version: 0,1

Delay: -Temp.: NOMVerify: D

Compliance: AD1: NAAD2: NAD3: NARD1: NA

The following drift model of the power supply shall be taken into account for the estimation of the USO medium term stability:

- 20V voltage = V0 + a sin (2 Pi t/T)
 - with V0 = 20V +/- 1%,
 - a = 10 mV, T = 100 mn
- (based on worst case analysis)

Rq.- Id: USO_ITF_004	Rq. Source: CREATED	Rq. version: 1
Delay: -	Temp.: EXT	Verify: A
Compliance: AD1: NA		AD2: NA
AD3: NA		RD1: NA

The USO shall be compatible with the following power supply characteristics:

at DORIS switch on, the rise time of the 20V power supply is up to 200 ms (between 10% and 90% of the voltage) and $dV/dt \leq 1000 \text{ V/s}$.

Rq.- Id:	USO_ITF_005	Rq. Source:	MODIFIED	Rq. version:	1
Delay:	2 s	Temp.:	EXT	Verify:	T + A
Compliance:	AD1: NA			AD2: NA	
	AD3: NA			RD1: Y+	

The worst case USO consumption shall be less than 6,0 W (cumulated End of Life drifts + cold start).

Rq.- Id:	USO_ITF_006	Rq. Source:	RD1	Rq. version:	2
Delay:	1 h	Temp.:	-	Verify:	T
Compliance:	AD1: NA			AD2: NA	
	AD3: NA			RD1: Y	

When thermally stabilised, the USO power consumption shall meet the following requirements:

- under vacuum:

-20°C: < 3.5 W

 $+30^{\circ}\text{C}: < 3 \text{ W}$

+50°C: < 1.5 W

- ambient pressure:

-20°C: < 4.0 W

+20°C: < 3 W

+40°C: < 1.5 W

If the USO consumption decreases when temperature rises, it is allowed to test the conformance at a temperature lower than the specified temperature, not exceeding 10°C below the specified temperature.

Rq.- Id: USO_ITF_007

Rq. Source: RD1

Rq. version: 0,1

Delay: -

Temp.: EXT

Verify: T

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: Y (partially)

At power ON, the USO supply current shall comply with the following limits:

- > 10 ms to 50 ms: < 0.7 A
- > 50 ms to 2 hours: < 0.35 A
- > after 2 hours: nominal current

(measurement conditions: MIL-STD-461 rev. E - test setup as method CE102)

Rq.- Id: USO_ITF_008

Rq. Source: RD1

Rq. version: 1

Delay: 2 s

Temp.: NOM

Verify: T (EQM)

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: Y

The total spurious current of the USO in the [30 Hz, 10 MHz] band shall be less than the limits defined by the methods CE101 and CE102 of RD6 (basic curve applicable).

Test setup and measurement method shall be as per methods CE101 and CE102 of RD6 according to the appropriate frequency bands.

Rq.- Id: USO_ITF_031

Rq. Source: RD1

Rq. version: 0,1

Delay: 2 h

Temp.: NOM

Verify: T

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: Y

The USO shall meet its performance requirements with the application of the following spurious conducted emission:

- > 120 dBmicroA from 10 Hz to 12 kHz
- > - 36 dB / decade from 12 kHz to 2 MHz
- > 40 dBmicroA from 2 MHz to 100 MHz
- > input voltage emission limited to 100 mV pp for any frequency below 1 MHz and limited to 50 mV above.

Test conditions are defined by USO_TEST_007.

(Note : the Id. of this requirement has been changed from ENV_003 to ITF_031)

8. USO LOAD REQUIREMENTS

Rq.- Id: USO_ITF_026	Rq. Source: CREATED	Rq. version: 0
Delay: -	Temp.: -	Verify: T
Compliance: AD1: NA		AD2: NA
AD3: NA		RD1: NA

All functional and / or performance requirement shall be met with the following constant load on the USO output:

- nominal load = 50 ohm
- VSWR is equal or less than 1.1 all phase.

Rq.- Id: USO_ITF_126	Rq. Source: CREATED	Rq. version: 0,1
Delay: -	Temp.: -	Verify: D
Compliance: AD1: NA		AD2: NA
AD3: NA		RD1: NA

The following drift model of the USO load shall be taken into account for the estimation of the USO medium term stability:

- > $Z = R0 + r \sin(2 \pi t/T)$
 - > with $R0 = 50 \text{ ohm} \pm 10\%$,
 - > $r = 0,5 \text{ ohm}$, $T = 100 \text{ mn}$
- (based on worst case analysis)
-

9. USO OUTPUT REQUIREMENTS

Rq.- Id:	USO_ITF_027	Rq. Source:	RD1	Rq. version:	1
Delay:	2 s	Temp.:	EXT	Verify:	T + A
Compliance:	AD1: NA			AD2:	NA
	AD3: NA			RD1:	Y

The output level shall always remain in the range [0 dBm , + 3 dBm].

Rq.- Id:	USO_ITF_028	Rq. Source:	RD1	Rq. version:	0,1
Delay:	2 h	Temp.:	EXT	Verify:	T
Compliance:	AD1: NA			AD2:	NA
	AD3: NA			RD1:	Y

The output level stability shall be better than +/-1 dB during the operational life.

Rq.- Id:	USO_ITF_029	Rq. Source:	RD1	Rq. version:	1
Delay:	2 s	Temp.:	EXT	Verify:	T
Compliance:	AD1: NA			AD2:	NA
	AD3: NA			RD1:	Y

The USO output VSWR shall be less than 1,25 (reference 50 Ohm, all phase).

Rq.- Id:	USO_ITF_030	Rq. Source:	MODIFIED	Rq. version:	1
Delay:	2 s	Temp.:	EXT	Verify:	T
Compliance:	AD1: NA			AD2:	NA
	AD3: NA			RD1:	Y+

The spurious signal on the USO output shall be limited to:

- harmonic <= - 40 dBc
- sub harmonic 5 MHz <= -40 dBc
- non harmonic <= - 90 dBc

Rq.- Id: USO_PERF_009 Rq. Source: MODIFIED Rq. version: 0,1
Delay: 2 h Temp.: NOM Verify: T
Compliance: AD1: N AD2: NA
 AD3: NA RD1: N

The single side phase noise spectral density shall comply with:

- * 10 Hz < -120 dBc/Hz
- * 100 Hz < -130 dBc/Hz
- * 1 kHz < -145 dBc/Hz
- * >10 kHz < -145 dBc/Hz

10. PERFORMANCE REQUIREMENTS

Rq.- Id: USO_PERF_001	Rq. Source: AD1	Rq. version: 0
Delay: 2h	Temp.: NOM	Verify: T + A
Compliance: AD1: Y	AD2: NA	
AD3: NA	RD1: Y	

The USO relative frequency bias shall remain in the $\pm 2.10^{-7}$ range all along its required life in the presence of all environment conditions (radiation, thermal, On/Off, aging, ...).

Rq.- Id: USO_PERF_002	Rq. Source: MODIFIED	Rq. version: 0
Delay: 2h	Temp.: NOM	Verify: T
Compliance: AD1: Y+	AD2: NA	
AD3: NA	RD1: N	

The mean value of the sliding Picinbono standard deviations shall be less than 2.10^{-13} (objective: $5 \cdot 10^{-14}$) under the following conditions:

- stable environment as defined per USO_DEF_002,
- test definition as defined per USO_TEST_004.

Rq.- Id: USO_PERF_003	Rq. Source: AD1	Rq. version: 0
Delay: 8h	Temp.: NOM	Verify: T + A
Compliance: AD1: Y	AD2: NA	
AD3: NA	RD1: NA	

The quadratic mean of the medium term frequency slopes shall be less than $7.10^{-14}/mn$ under the following cumulated environment:

- thermal environment as per USO_ENV_104 and USO_TEST_002
- magnetic field as per USO_ENV_023
- acceleration as per USO_ENV_024
- radiation environment as per USO_ENV_014
- load stability as per USO_ITF_126
- power supply stability as per USO_ITF_003

The compliance to this requirement shall be demonstrated by analysis based on the thermal environment test and individual sensitivity tests in accordance to AD7.

Rq.- Id: USO_PERF_004	Rq. Source: AD1	Rq. version: 0
Delay: 8h	Temp.: NOM	Verify: T + A
Compliance: AD1: Y	AD2: NA	
AD3: NA	RD1: N	

99 % of the standard deviations of the residuals shall be less than 1.10-12 (objective 5.10-13) with the same conditions as USO_PERF_003.

Rq.- Id: USO_PERF_005	Rq. Source: AD1	Rq. version: 0,1
Delay: 8h	Temp.: NOM	Verify: T
Compliance: AD1: Y	AD2: NA	
AD3: NA	RD1: Y	

The standard deviation of the USO time residuals with respect to a parabolic drift model fitted over 24 h shall be less than 500 ns.

Frequency measurement shall be taken every 10 s.

Rq.- Id: USO_PERF_006	Rq. Source: RD1	Rq. version: 0
Delay: 40 days	Temp.: NOM	Verify: T + A
Compliance: AD1: NA	AD2: NA	
AD3: NA	RD1: Y (partially)	

After no more than 40 days of continuous power on, the USO relative frequency drift shall be less than 10-10 / day.

Rq.- Id: USO_PERF_007	Rq. Source: RD1	Rq. version: 0,1
Delay: 40 h	Temp.: NOM	Verify: T
Compliance: AD1: NA	AD2: NA	
AD3: NA	RD1: Y	

The relative frequency variation shall be less than +/- 5.10-9 after the following power On/Off cycle (see figure PERF_007 in annex 1):

- more than 40h of operation
- power Off 24 h
- power On 24h

After power on, the USO frequency shall be measured every 10 s and the Allan and Picinbono variance shall be plotted over 24h.

Rq.- Id: USO_PERF_014

Rq. Source: RD1

Rq. version: 0,1

Delay: 2 h

Temp.: NOM

Verify: T

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: Y

For any transition from atmospheric pressure to vacuum or vacuum to atmospheric pressure, the relative frequency variation $|\Delta F / F|$ shall be less than $2 \cdot 10^{-8}$.

Rq.- Id: USO_PERF_016

Rq. Source: RD1

Rq. version: 0,2

Delay: -

Temp.: -

Verify: T

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: Y

The relative frequency variation following vibration and shock tests shall be less than $5 \cdot 10^{-9}$.

Rq.- Id: USO_PERF_102

Rq. Source: CREATED

Rq. version: 0

Delay: 2h

Temp.: NOM

Verify: T

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: NA

99% of the sliding Picinbono standard deviations shall be less than $4 \cdot 10^{-13}$ under the following conditions:

- stable environment as defined per USO_DEF_002,
- test definition as defined per USO_TEST_004,

11. MECHANICAL ENVIRONMENT REQUIREMENTS

Rq.- Id: USO_ENV_016	Rq. Source: MODIFIED	Rq. version: 1,1
Delay: -	Temp.: -	Verify: T
Compliance: AD1: NA		AD2: Y
AD3: Y		RD1: Y

Qualification levels for sinusoidal vibration tests are on 3 axis:

- frequency 5 to 21 Hz: 11 mm peak
- frequency 21 to 100 Hz: 20 g
- sweep rate: 2 oct/min up & down

Rq.- Id: USO_ENV_017	Rq. Source: MODIFIED	Rq. version: 1,1
Delay: -	Temp.: -	Verify: T
Compliance: AD1: NA		AD2: Y
AD3: Y		RD1: NA

Acceptance levels for sinusoidal vibration tests are on 3 axis:

- frequency 5 to 21 Hz: 9 mm
- frequency 21 to 100 Hz: 16 g
- sweep rate: 4 oct/min up & down

Rq.- Id: USO_ENV_018	Rq. Source: RD1	Rq. version: 1,1
Delay: -	Temp.: -	Verify: T
Compliance: AD1: NA		AD2: Y
AD3: Y		RD1: Y

Qualification levels for random vibration tests are on 3 axis:

- > 20 - 100 Hz: +3 dB/oct
- >100 - 400 Hz: 0,7g2/Hz
- > 400 - 2000 Hz: -3 dB/oct
- > duration: 2 minute per axis

Rq.- Id: USO_ENV_019

Rq. Source: RD2

Rq. version: 1,1

Delay: -

Temp.: -

Verify: T

Compliance: AD1: NA

AD2: Y

AD3: Y

RD1: NA

Acceptance levels for random vibration tests are on 3 axis:

- > 20 - 100 Hz: +3 dB/oct
- > 100 - 400 Hz: 0,3 g2/Hz
- > 400 - 2000 Hz: -3 dB/oct
- > duration: 1 minute per axis

Rq.- Id: USO_ENV_020

Rq. Source: MODIFIED

Rq. version: 1

Delay: -

Temp.: -

Verify: T

Compliance: AD1: NA

AD2: Y

AD3: Y

RD1: Y

The USO shall withstand without degradation a shock level on three axis with the following test conditions:
half sinus, 0,25 ms, 800g (qualification level)

Rq.- Id: USO_ITF_011

Rq. Source: RD1, AD3

Rq. version: 0

Delay: -

Temp.: -

Verify: T + A

Compliance: AD1: NA

AD2: NA

AD3: Y

RD1: Y

The first eigen frequency of the USO shall be above 150 Hz.

Rq.- Id: USO_SOW_001

Rq. Source: MODIFIED

Rq. version: 0,1

Delay: -

Temp.: -

Verify: A

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: N

The USO equipment shall be shipped in a container ensuring that the mechanical environment are less severe than the acceptance test environment for a fall of the container on a concrete soil from 1 meter height and for a quasi static load of 15 g.

12. MECHANICAL INTERFACES REQUIREMENTS

Rq.- Id: USO_ITF_015 Rq. Source: MODIFIED Rq. version: 0,1
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y (partially)

The mechanical interfaces of the USO shall be compliant with C-MAC drawing AD4..

Rq.- Id: USO_ITF_016 Rq. Source: MODIFIED Rq. version: 0
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y+

The USO mass shall be less than 1100g.

Rq.- Id: USO_ITF_017 Rq. Source: RD1 Rq. version: 0,2
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y

The attachment holes shall have a diameter 4.4 mm +0.1/-0 mm with a position tolerance of 0.15 mm.

Rq.- Id: USO_ITF_018 Rq. Source: RD1 Rq. version: 0
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y

The thickness of the attachment feet shall be 5 mm +/-0.2 mm.

Rq.- Id: USO_ITF_019 Rq. Source: MODIFIED Rq. version: 1
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y+

A paint reservation shall be provided for washers 9 mm diameter.

Rq.- Id: USO_ITF_020

Rq. Source: RD1

Rq. version: 0

Delay: -

Temp.: -

Verify: I

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: Y

All attachment points and the interface plane shall be in a common plane within +/- 0.1 mm.

Rq.- Id: USO_ITF_021

Rq. Source: RD1

Rq. version: 0,1

Delay: -

Temp.: -

Verify: T

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: Y

The interface plane rugosity shall be less than 3.2 micrometers RA.

13. MISCELLANEOUS REQUIREMENTS

Rq.- Id: USO_ITF_022 Rq. Source: MODIFIED Rq. version: 0,1
Delay: - Temp.: - Verify: T
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y+

The 20V return line and the RF ground of the USO shall be connected internally to the chassis ground with less than 5 mOhm.

Rq.- Id: USO_ITF_023 Rq. Source: MODIFIED Rq. version: 0
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y+

The USO shall be fitted with a label on the top of the USO and providing at least the following text or information:

- DORIS USO
- manufacturer name (C-MAC)
- C-MAC internal reference
- interface drawing reference
- serial number
- manufacturing date in the format year/week

Rq.- Id: USO_ITF_024 Rq. Source: RD1 Rq. version: 0
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y

Connector identification shall be marked on the USO box near each connector and shall be clearly visible, in accordance with the USO drawing interface.

Rq.- Id: USO_ITF_025	Rq. Source: RD1	Rq. version: 0
Delay: -	Temp.: -	Verify: R
Compliance: AD1: NA	AD2: NA	
AD3: NA	RD1: Y	

The external coating of the USO shall have an infrared emittance higher than 0.85 (kept for interchangeability issue and thermal vacuum tests at the USO level).

14. EMC REQUIREMENTS

Rq.- Id: USO_ENV_005 Rq. Source: AD3 Rq. version: 1
Delay: 2 s Temp.: NOM Verify: A
Compliance: AD1: NA AD2: NA
 AD3: Y RD1: NA

RS - H field AC
The requirements USO_PERF_002 and USO_PERF_009 shall be met under the following RS environment:
30 Hz - 10 kHz: 120 dBpT
10 kHz - 50 kHz: decreasing 10 dB per decade.
Compliance can be demonstrated by analysis and similarity.

Rq.- Id: USO_ENV_006 Rq. Source: RD1 Rq. version: 0
Delay: 2 h Temp.: NOM Verify: A
Compliance: AD1: NA AD2: Y (BDR filtering)
 AD3: Y (BDR filtering) RD1: Y

RS - E field AC
The requirements USO_PERF_002 and USO_PERF_009 shall be met under the following RS environment:
14 kHz to 1 GHz: 2 volts / m
1 GHz to 18 GHz: 10 volts / m
Test conditions are defined by USO_TEST_008.
Kept for compatibility issue.

Rq.- Id: USO_ITF_009 Rq. Source: Rq. version: 0
Delay: - Temp.: - Verify:
Compliance: AD1: AD2:
 AD3: RD1:

No requirement for Radiated Emission.

Rq.- Id: USO_ITF_010

Rq. Source: AD2, AD3

Rq. version: 1

Delay: 2 s

Temp.: EXT

Verify: T or A

Compliance: AD1: NA

AD2: Y

AD3: Y

RD1: NA

Magnetic cleanliness

The magnetic moment of the USO along any reference axis shall be kept lower than 0.01 Am2.

15. TEST REQUIREMENTS

Rq. Id: USO_TEST_001 Rq. Source: RD1 Rq. version: 0
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y

Savers shall be used for all connectors during Flight Models electrical tests at USO level.

Rq. Id: USO_TEST_002 Rq. Source: RD1 Rq. version: 0,1
Delay: - Temp.: - Verify: D
Compliance: AD1: N AD2: NA
 AD3: NA RD1: Y

The test conditions for medium term stability assessment are:

- test duration: 5h - 1800 samples per temperature step,
- total test duration: 40 h,
- method for the characterisation of the medium term stability defined by table TEST_002.

Rq. Id: USO_TEST_003 Rq. Source: RD1 Rq. version: 0
Delay: - Temp.: - Verify: R
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: Y

The precision of the relative frequency measurement for long term drift assessment shall be better than 3.10-12.

Rq.- Id: USO_TEST_004

Rq. Source: AD1

Rq. version: 0,2

Delay: -

Temp.: -

Verify: D

Compliance: AD1: Y

AD2: NA

AD3: NA

RD1: N

The short term stability shall be determined as follow:

- integration time: 10s
- dead time between two successive frequency measurements less than 1 s
- Picinbono standard deviation computed with 28 triplets with ponderation coefficient 4/9 - test duration: 2h
- requirement is applicable to the arithmetic mean of the Picinbono standard deviations (approximately 645 values over 2 h)

See table TEST_004 for definition of the Picinbono standard deviation and arithmetic mean.

A histogram of the results shall be plotted .

Rq.- Id: USO_TEST_005

Rq. Source: AD1

Rq. version: 0,1

Delay: -

Temp.: -

Verify: D

Compliance: AD1: Y

AD2: NA

AD3: NA

RD1: N

Method for time drift estimation:

- measurement of time drift every 10s during 24 h with respect to an atomic clock reference
- estimation of the parameters of a parabolic model of the USO time fitted over 24 h (time and frequency biases, frequency drift)
- computation of time residuals with respect to the parabolic model over 24 h
- computation of the standard deviation of the residuals.

Rq.- Id: USO_TEST_006

Rq. Source: CREATED

Rq. version: 0,1

Delay: -

Temp.: -

Verify: D

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: NA

The long term drift shall be estimated by using the method defined in RD7.

Rq.- Id: USO_TEST_007 Rq. Source: CREATED Rq. version: 2
Delay: - Temp.: - Verify: D
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

- Method for Conducted Susceptibility test:
- the spurious signal shall be 30% AM modulated by a square signal @ 1 kHz +/- 1%
 - the spurious frequencies shall comply with USO_TEST_009
 - for each spurious frequency tested, the phase noise spectrum between 10 Hz and 100 kHz shall be recorded
 - for each spurious frequency tested above 100 kHz, the compliance to USO_ITF_030 shall be verified at 30 Hz and 1 kHz (offset from carrier)
 - for each spurious frequency tested below or equal to 100 kHz, the compliance to USO_ITF_030 shall be verified at 1 kHz and at the spurious frequency (offset from carrier)
 - the test setup is defined as per test CS114 of RD6.

Rq.- Id: USO_TEST_008 Rq. Source: CREATED Rq. version: 1
Delay: - Temp.: - Verify: D
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

- Method for Radiated Susceptibility test:
- the spurious signal shall be 30% AM modulated by a square signal @ 1 kHz +/- 1%
 - the spurious frequencies shall comply with USO_TEST_009
 - for each spurious frequency tested, the phase noise spectrum between 10 Hz and 100 kHz shall be recorded
 - for each spurious frequency tested above 100 kHz, the compliance to USO_ITF_030 shall be verified at 30 Hz and 1 kHz (offset from carrier)
 - for each spurious frequency tested below or equal to 100 kHz, the compliance to USO_ITF_030 shall be verified at 1 kHz and at the spurious frequency (offset from carrier)
 - the test set-up is defined by MIL-STD-461 Rev. E.

Rq.- Id: USO_TEST_009

Delay: -

Compliance: AD1: NA

AD3: NA

Rq. Source: CREATED

Temp.: -

Rq. version: 2

Verify: D

AD2: NA

RD1: NA

Spurious frequency requirement for CS and RS tests:

- the spurious frequencies shall be selected in accordance with the frequency band specified for CS and RS tests within the following frequency list: 10 Hz, 20 Hz, 40 Hz, 120 Hz, 240 Hz, 480 Hz, 10 kHz, 20 kHz, 40 kHz, 64 kHz, 125 kHz, 250 kHz, 500 kHz, 1 MHz, 2 MHz, 2.5 MHz, 5 MHz, 10 MHz, 12 MHz, 20 MHz, 50 MHz, 100 MHz, 300 MHz, 600 MHz, 1 GHz, 3 GHz, 6 GHz, 10 GHz, 18 GHz
- the spurious frequencies above 100 kHz shall have a frequency offset of 30 Hz +/- 1 Hz with respect to the frequency of the USO under test (ie. USO and spurious pilot frequency bias shall be taken into account and compensated).

Rq.- Id: USO_TEST_010

Delay: -

Compliance: AD1: NA

AD3: NA

Rq. Source: CREATED

Temp.: -

Rq. version: 1

Verify: I

AD2: NA

RD1: NA

The USO test plan shall implement a measurement of the sensitivity to power supply variation in order to provide inputs to the medium term stability analysis.

The test shall be conducted with application of +5% and -5% variations of the supply voltage.

Rq.- Id: USO_TEST_011 Rq. Source: CREATED Rq. version: 0,2
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

The USO test plan shall implement a measurement of the sensitivity to the load variation in order to provide inputs to the medium term stability analysis.

The test conditions are:

- measurement of the frequency variation for 1.2 SWR loads with the following phase:. 0° (60 ohm resistive load), 90° (inductive load), 180° (41.6 ohm resistive load), 270° (capacitive load).

Rq.- Id: USO_TEST_012 Rq. Source: CREATED Rq. version: 0,2
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

The USO test plan shall implement a measurement of the sensitivity to the quasi static acceleration in order to provide inputs to the medium term stability analysis.

The test conditions are:

- measurement of the frequency variation for a variation of 2g of the static acceleration in three orthogonal axes (using 180° rotation of the USO around each axis in the natural gravity field).

Rq.- Id: USO_TEST_013 Rq. Source: CREATED Rq. version: 0,1
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

The USO test plan shall implement a measurement of the sensitivity to the quasi static magnetic field in order to provide inputs to the medium term stability analysis.

The test conditions are:

- power supply: 20 V DC +/- 1 mV,
- continuous measurement of the frequency with a resolution better than 1.10-12,
- application of a magnetic field added to the earth magnetic field, successively in 3 directions, with a profile defined in figure TEST_013 in annex 1.

Rq.- Id: USO_TEST_014

Rq. Source: AD1

Rq. version: 1

Delay: -

Temp.: -

Verify: I

Compliance: AD1: Y

AD2: NA

AD3: NA

RD1: Y

The USO test plan shall comply with the test matrixes defined in tables TEST_014_1 and TEST_014_2.

Rq.- Id: USO_TEST_015

Rq. Source: DR1

Rq. version: 0

Delay: -

Temp.: -

Verify: R

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: Y

The standard conditions for ambient condition tests are:

- temperature: 23 +/- 5°C
- relative humidity: 60 %
- pressure: 1013 +/- 330 hPa (760 +/- 25 mm mercury level).

When for reproducibility reasons, environment conditions need to be precisely controlled, the following conditions apply: 23°C, 50 % RH, 760 mm mercury.

Environment conditions shall be regularly monitored during all tests.

Rq.- Id: USO_TEST_016

Rq. Source: RD1

Rq. version: 1

Delay: -

Temp.: -

Verify: D

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: Y

The detailed test conditions and definitions are specified in RD1, chapter 4.

Rq.- Id: USO_TEST_017

Rq. Source: CREATED

Rq. version: 0

Delay: -

Temp.: -

Verify: T

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: NA

The conditions applicable to the ON/OFF cycles qualification test are:

- 1000 ON/OFF cycles consisting of 1 h ON and 1 h OFF,
- shall be applied to 3 test oscillators fitted with quartz representative of flight models,
- ambient pressure and temperature,
- measurement of the frequency and short term frequency stability (as defined per USO_PERF_002) after 0, 100, 300 and 1000 ON/OFF cycles.

Rq.- Id: USO_TEST_018 Rq. Source: CREATED Rq. version: 0
Delay: - Temp.: - Verify: T
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

The following procedure and test conditions are applicable to vibration and shock tests:

- the USO shall be ON during the tests,
- the USO frequency shall be recorded during the tests
- before vibration tests on each axis, a low level (0,5 g peak) sinus sweep from 5 Hz to 200 Hz shall be performed for proper response verification

Rq.- Id: USO_TEST_019 Rq. Source: CREATED Rq. version: 0
Delay: - Temp.: EXT Verify: T
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

For each USO, a power-on test shall be implemented at ambient pressure at the extreme temperatures defined by the extended (EXT) temperature range.

The following requirements applicable to the EXT range shall be verified:

USO_FUNC_001, USO_ITF_001, USO_ITF_005, USO_ITF_027 together with the delay associated to each of these requirements.

16. RELIABILITY REQUIREMENTS

Rq.- Id: USO_SDF_001

Rq. Source: RD1

Rq. version: 0,1

Delay: -

Temp.: -

Verify: A

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: Y

The USO failure rate shall be less than 500. 10-9 failure per hour @30°C in space flight.

Rq.- Id: USO_SDF_002

Rq. Source: CREATED

Rq. version: 0

Delay: -

Temp.: -

Verify: R

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: NA

All USO EEE parts shall be SEL or SEB free and SET events shall not cause catastrophic failures.

Rq.- Id: USO_SDF_003

Rq. Source: CREATED

Rq. version: 0

Delay: -

Temp.: -

Verify: A

Compliance: AD1: NA

AD2: NA

AD3: NA

RD1: NA

The probability of signal loss shall be less than 1 event per year in case of SET events.

17. SAFETY REQUIREMENTS

Rq.- Id: USO_SDF_004 Rq. Source: RD1 Rq. version: 0,1
Delay: 0 s Temp.: EXT Verify: T (MIQ)
Compliance: AD1: NA AD2: NA
AD3: NA RD1: Y

The USO shall withstand permanently without any damage, a short circuit to the ground on its output.

Rq.- Id: USO_SDF_005 Rq. Source: RD1 Rq. version: 0,1
Delay: 0 s Temp.: EXT Verify: T (MIQ)
Compliance: AD1: NA AD2: NA
AD3: NA RD1: Y

The USO shall withstand permanently without any damage, an open circuit on its output.

Rq.- Id: USO_SDF_006 Rq. Source: RD1 Rq. version: 0,1
Delay: 0 s Temp.: EXT Verify: T (MIQ)
Compliance: AD1: NA AD2: NA
AD3: NA RD1: Y

The USO shall withstand without any damage, any abrupt switch to a permanent voltage between 0 V and 32 V.

Rq.- Id: USO_SDF_007 Rq. Source: RD1 Rq. version: 1
Delay: 2 s Temp.: EXT Verify: T (MIQ)
Compliance: AD1: NA AD2: NA
AD3: NA RD1: Y

The USO shall recover its nominal performances after the end of the out of range conditions defined above.

Rq.- Id: USO_SDF_008 Rq. Source: CREATED Rq. version: 0
Delay: - Temp.: EXT Verify: A
Compliance: AD1: NA AD2: NA
AD3: NA RD1: NA

In case on a single failure, the USO output power shall be limited by design to +23 dBm.

Rq.- Id:	USO_SDF_009	Rq. Source:	RD1	Rq. version:	0
Delay:	-	Temp.:	-	Verify:	A
Compliance:	AD1: NA			AD2:	NA
	AD3: NA			RD1:	Y

The USO shall be designed to be hazard free for an operator even in case of an operator error.

18. QUALITY ASSURANCE REQUIREMENTS

Rq.- Id: USO_QA_001 Rq. Source: DR1 Rq. version: 1
Delay: - Temp.: - Verify: R
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

Deleted

Rq.- Id: USO_QA_002 Rq. Source: CREATED Rq. version: 0,1
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

C-MAC shall comply with the document AD8 for the development, manufacturing and tests of the USOs.

Rq.- Id: USO_QA_003 Rq. Source: CREATED Rq. version: 0
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

For each USO, CNES shall be informed of the date of the Mandatory Inspection Points (MIP), at least 5 working days before the planned date. CNES shall be authorized to assist to these MIP or to be represented.

Rq.- Id: USO_QA_004 Rq. Source: CREATED Rq. version: 0
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

The following key point meetings are mandatory:

- USO development kick off meeting (KOM) at THALES premises
- review of the technical and industrial definition (RTID) before USO MV1 integration, at C-MAC premises
- Test Readiness Review (TRR) for each USO before acceptance or qualification tests campaign, at C-MAC premises
- Test Review Board (TRB) for each USO at the end of the acceptance or qualification tests campaign, at C-MAC premises

CNES and THALES shall be invited to these meetings.

19. DELIVERY

Rq.- Id: USO_DLY_001 Rq. Source: CREATED Rq. version: 0
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

C-MAC shall provide the documents listed in table DLY_001.

Rq.- Id: USO_DLY_002 Rq. Source: CREATED Rq. version: 0
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

C-MAC shall present for review at the key point meetings, the documents listed in table DLY_002.

Rq.- Id: USO_DLY_003 Rq. Source: CREATED Rq. version: 0
Delay: - Temp.: - Verify: I
Compliance: AD1: NA AD2: NA
 AD3: NA RD1: NA

C-MAC shall provide the hardware items listed in table DLY_003.

ANNEX 1

TABLES AND FIGURES

Figure PERF 007 – retrace performance verification

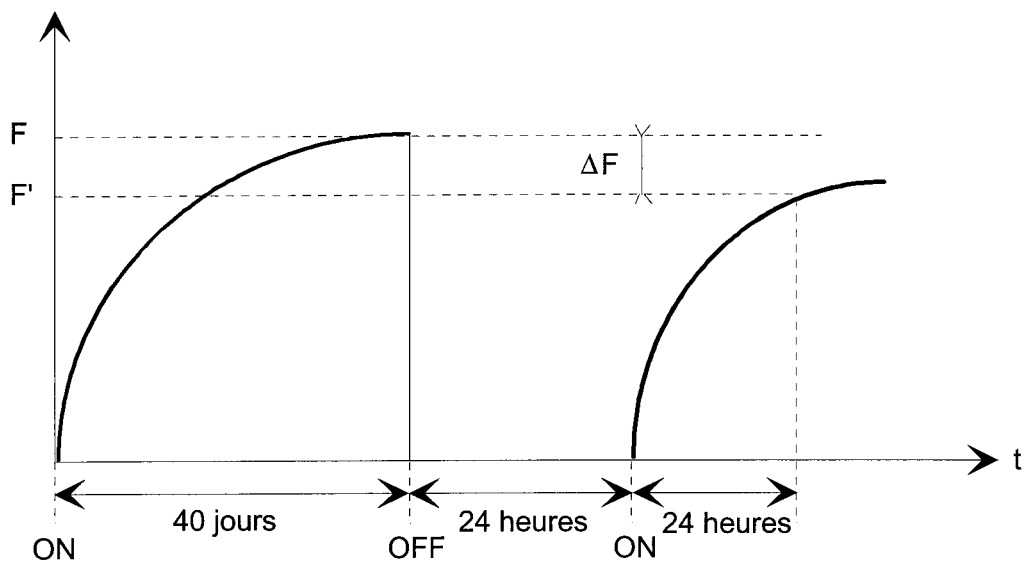


Table and figure ENV 013 – Total dose model

The total radiation dose of charged particles radiations (4 pi steradian) versus shielding protection thickness (margins included) is shown in Table ENV_013_1 and Figure ENV_013_2 and are extracted from AD5.

The radiations dose received at EEE parts level is a function of the protection given by:

- the other units and the satellite structure,
- the unit box and the other elements of the unit.

Table ENV_013_1 - RADIATION DOSE VS THICKNESS

ALUMINIUM EQUIVALENT THICKNESS (mm)	RADIATION DOSE (rad)
0.05	2.96E + 07
0.1	1.85E + 07
0.2	8.24E + 06
0.3	4.11E + 06
0.4	2.22E + 06
0.5	1.32E + 06
0.6	8.67E + 05
0.8	4.71E + 05
1	3.11E + 05
1.5	1.60E + 05
2	1.01E + 05
2.5	7.03E + 04
3	5.17E + 04
4	3.20E + 04
5	2.25E + 04
6	1.82E + 04
7	1.60E + 04
8	1.49E + 04
9	1.39E + 04
10	1.31E + 04
12	1.19E + 04
14	1.11E + 04
16	1.03E + 04
18	9.56E + 03
20	9.19E + 03

Figure ENV_013_2 - RADIATION DOSE VS THICKNESS

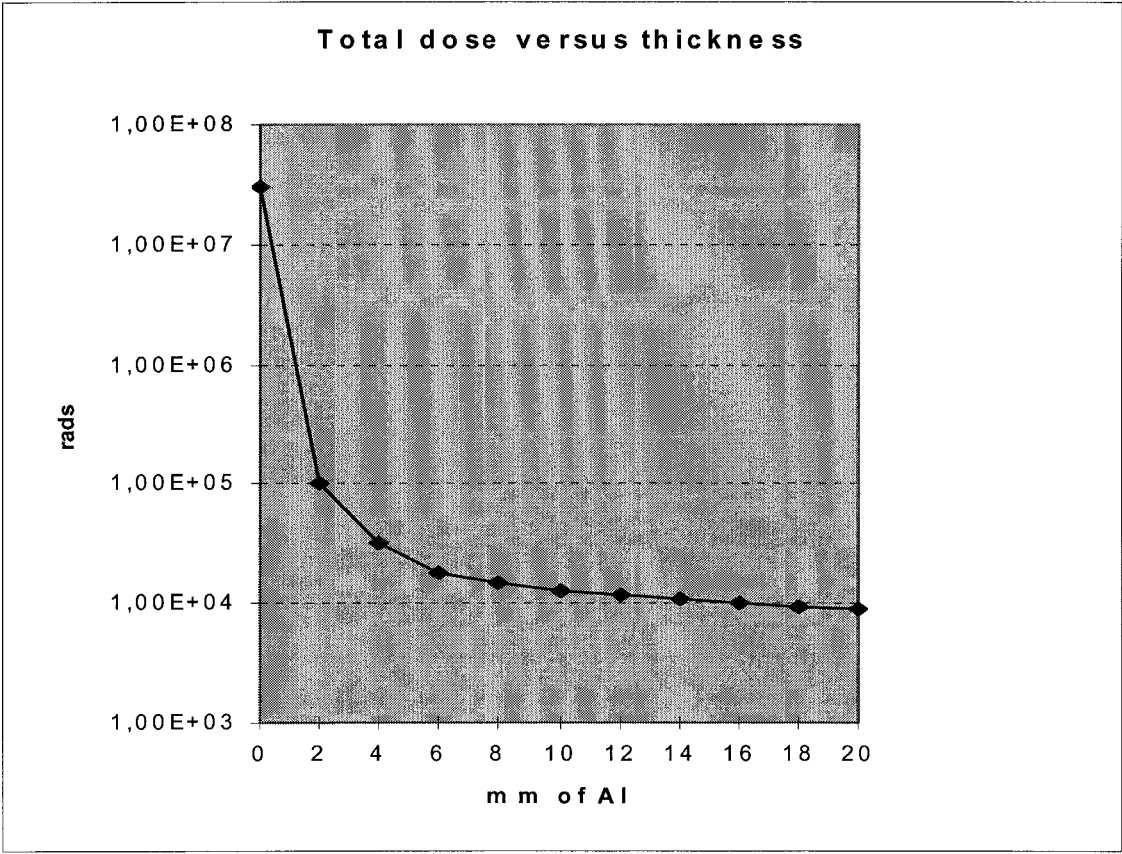
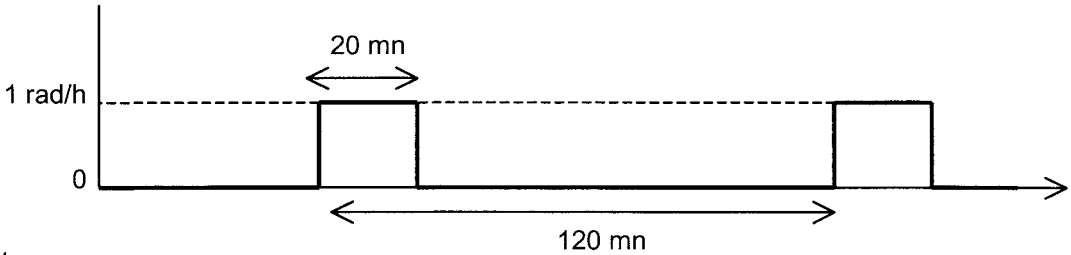


Table ENV 014 – Dose rate profile definition for medium term stability requirement

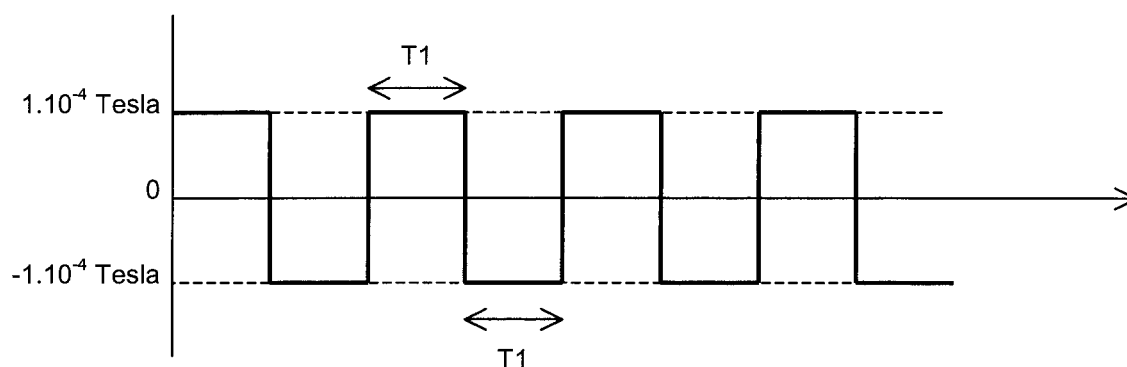


Notes:

- this is a worst case simplified cycle
- the dose profile is periodic with a period of 120 mn

Figure ENV 023 – Magnetic field environment for the medium term stability requirement

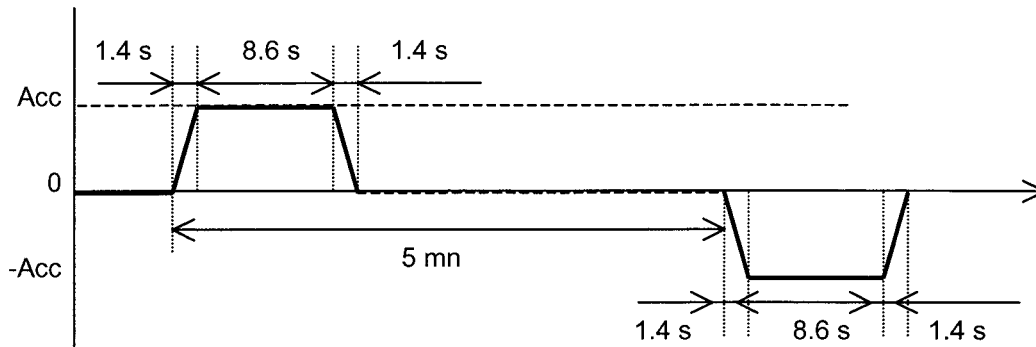
- fast field variation (magneto-torquer simulation)



- slow field variation (earth magnetic field)
 - sinusoidal variation with a period of 100 mn and a peak amplitude of 44 E^{-6} Tesla

Note: the medium term stability (slope and residuals) shall be analysed with $T1 = 7 \text{ mn } 30 \text{ s}$ and $T1 = 10 \text{ s}$ and summing fast and slow variations.

Figure ENV 024 – Acceleration profile environment for the medium term stability requirement



Notes:

- $Acc = 1.1 \cdot 10^{-2} \text{ m/s}^2$ ($\approx 1.1 \cdot 10^{-3} \text{ g}$).
- this is a worst case theoretical profile based on the following assumptions:
 - o satellite static de-pointing: 42° during 5 mn
 - o angular rate during attitude change: $4.2^\circ/\text{s}$ during 8.6 s
 - o angular acceleration during transitions: $3^\circ/\text{s}^2$ during 1.4 s
 - o distance between USO and satellite centre of mass: 2 m

These data are consistent with requirements from AD6.

Table TEST 002 – Method for the characterisation of the medium term frequency stability

The medium term frequency drift (slope/mn) shall be computed with the least square method applied to packets of 90 measurements samples. Two successive packets are offset by 10 s and then overlapping by 890 (sliding method).

The measurement integration time shall be 10 s with no dead time between measurements.

$$\text{Slope / minute} = \frac{1}{F_{\text{ous}}} * \frac{12 * \sum_{i=1}^N (i * F(i)) - 6 * (N+1) \sum_{i=1}^N F(i)}{N * (N^2 - 1) * r}$$

- N = 90, number of measurements
- $r = \frac{T}{60} = \frac{10}{60} = \frac{1}{6}$ per minute, this ratio is linked to the periodicity of the measurements.
- T = 10 seconds
- FOUS = nominal frequency of the OUS.

The slope / mn data set, p_i , allows the determination of:

$$\text{MQ} = 3 \times \text{quadratic mean} = 3 \times \sqrt{\frac{\sum_{i=1}^N (p_i)^2}{N_b}}$$

The p_i values shall be computed as defined above. The MQ value is computed using all the p_i values computed during the overall test duration (that is for 40 hours in the case of the thermal gradient testing, $N_b = 14400$ p_i values).

Table TEST 004 – Definition of the Picinbono standard deviation and arithmetic mean

Picinbono standard deviation

$$\sigma_y^2(\tau, j) = \frac{4}{9N} \sum_{i=1}^N \left(\frac{\frac{f_{i+j+2} + f_{i+j}}{2} - f_{i+j+1}}{F_0} \right)^2$$

τ = integration time

f_i = mean frequency over τ ($i = 1$ to N_m)

N_m = total number of frequency measurements

N = 28

F_0 = nominal frequency of the oscillator

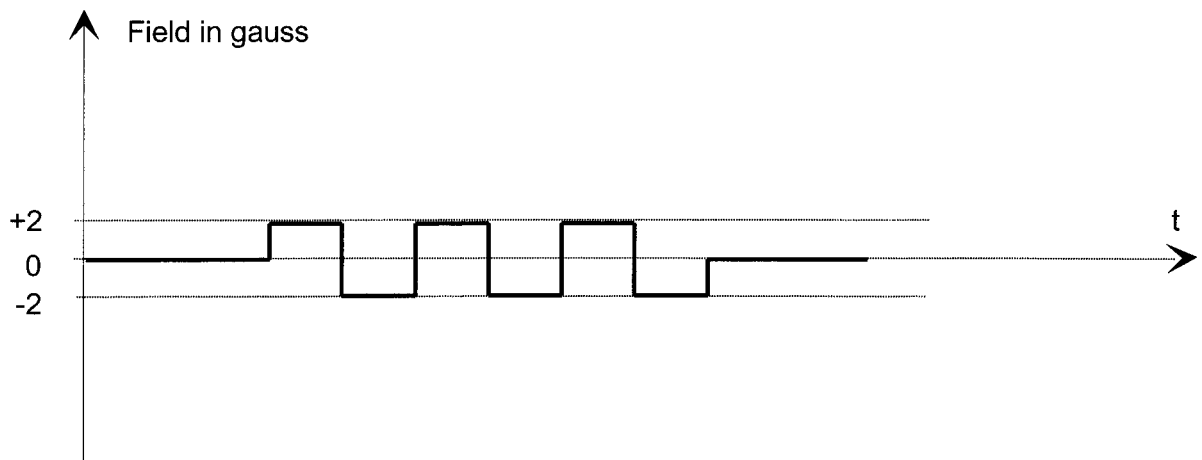
j = index of standard deviation value ($j = 1$ to $N_m - N - 2$)

σ_y = Picinbono standard deviation

Picinbono mean standard deviation

$$\bar{\sigma}_y(\tau) = \frac{\sum_{j=1}^{N_m-N-2} \sigma_y^2(\tau, j)}{N_m - N - 2}$$

Figure TEST 013 – profile of magnetic field for magnetic sensitivity test



- duration of high and low levels: 10 mn,
- 3 cycles

Table TEST 014 1 – Tests required

Tested parameter	Tests References													
	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11		
	Aging at PA	Characterisation under ambient and stable environment	Sensitivity to supply voltage	Sensitivity to the load	Mechanical environment tests	Corona test	Thermal vacuum tests	Final electric measurements under ambient environment	Magnetic field sensitivity	Retrace	EMC tests	Physical characteristics measurements	Ref. § DR1	DA1 requirement
Nominal frequency	X	X			X		X	X	X				3.2.1.	X
Nominal frequency bias	X	X											3.2.2.	X
Frequency stability														
wrt. Pressure							X						3.2.3.4.	X
wrt. Acceleration		X											3.2.3.5.	X
Short term		X					X						3.2.3.9.	X
Medium term		X					X						3.2.3.9.	X
Long term	X												3.2.3.9.	X
Time drift							X						3.2.3.9.	X
wrt. Temperature							X						3.2.3.3.	X
wrt. Power supply voltage							X						3.2.3.1.	
wrt. Load							X						3.2.3.2.	
Vibrations, shocks, accelerations					X								3.2.3.6.	
Magnetic field									X				3.2.3.8.	X
Retrace										X			3.2.5.	
Dose rate													NA	X
Output signal:													3.2.7.	
Level		X			X		X	X						
Level stability							X							
Phase noise spectral density		X						X					3.2.4.	X
Harmonics and sub harmonic		X					X	X						X
Non-harmonics		X					X	X						X
Output VSWR		X						X					3.2.8.	
Electro Magnetic Compatibility:													3.3.	
Switch ON current											X		3.3.1.4.	
Transient at switch OFF											X		3.3.1.4.	
Reinjected current											X		3.3.1.4.	
Conducted susceptibility											X		3.3.1.4.	
Other characteristics:														
Consumption		X			X		X	X		X			3.3.1.2.	X
Fault conditions compatibility		X											3.3.1.3.	
Dimensions												X	3.5.2.	
Mass												X		
Base plate planeity												X	3.5.2.	
Rugosity														
Centre of inertia													3.5.2.	
Inertia moments														

Table TEST 014 2 – Test plan

Test N°	Test designation	MIQ	1st FM	Next FM
T0	Aging at atmospheric pressure	X	X	X
T1	Characterisation under ambient and stable environment	X	X	X
T2	Sensitivity to supply voltage	(1)	(1)	(1)
T3	Sensitivity to the load	(1)	(1)	(1)
T4-1	Mechanical environment tests: random vibrations	Q	A	A
T4-2	Mechanical environment tests: sinus vibrations	Q	A	A
T4-3	Mechanical environment tests: shocks	Q		
T5	Corona test	(2)	(2)	(2)
T6	Thermal vacuum tests	X	X	X
T7	Final electric measurements under ambient environment	X	X	X
T8	Magnetic field sensitivity	X	X	X
T9	Retrace	X	X	X
T10	EMC tests			
	- Radiated Susceptibility – H field (USO_ENV_005)	(2)	(2)	(2)
	- Radiated Susceptibility – E field (USO_ENV_006)	(2)	(2)	(2)
	- Radiated Emission (USO_ITF_009)	(2)	(2)	(2)
	- Conducted Susceptibility (USO_ITF_031)	X	X	X
	- Conducted Emission – Inrush current (USO_ITF_007)	X	X	X
	- Conducted Emission – Spurious (USO_ITF_008)	X	X	X
	- Switch off voltage	X	X	X
	- Magnetic moment (USO_ITF_010)	(3)		
T11	Physical characteristics measurements and visual inspection	X	X	X
T12	Power-On test (USO_TEST_019)	X	X	X
T13	On-Off cycles qualification test (USO_TEST_017)	X		
T14	Low dose rate radiation test		X (4)	X (4)

Notes :

A = test required at Acceptance level

Q = test required at Qualification level

X = test required

(1) not used as a specific test phase but part of T6

(2) not required

(3) test or analysis

(4) at quartz level before integration in the USO and for 5 MHz quartz only

Table DLY 001 –DELIVERABLE DOCUMENTS LIST

<u>Documentation delivered for acceptance</u>	Due Date	Paper copies	Electronic file (pdf format)	Language (1)	Observations
Declared Component List (DCL)	RTID	4	X	E	
Declared Material List (DML)	RTID	4	X	E	
Declared Process List (DPL)	RTID	2	X	E or F	
Interface Control Document (Interface drawing)	RTID	4	X	E	Update
Design Description and Justification (DDJ or DJD)	RTID	2	X	F	Only for design modifications per respect to ONG 5 MHz design
Quality Plan	RTID	2	X	F	Update if any
Test Plan (Plan de test)	TRR	2	X	F	
Reliability Report (Dossier d'estimation de la fiabilité)	RTID	2	X	F	Update
Radiation Analysis Report (Analyse de radiation)	RTID	2	X	F	Update
Worst Case Analysis (Analyse pire cas)	RTID	2	X	F	Update
Acceptance log report including a conformity matrix	TRB	4		E or F	For each USO
Certificate of conformity	TRB	1		E	For each USO
Non Conformance Report (NCR - Constats d'anomalie)	When required	1		F	If any
Request for Waiver (RFW - Demandes de dérogation)	TRB	1		F	If any
Progress report by fax or mail	See obs.	1 per quarter		F	10 working days before each progress meeting with CNES

Note 1: E = English, F = Français

Table DLY 002 –CONSULTABLE DOCUMENTS LIST

<u>Available documentation for review at key point meetings</u>	Language (1)	Key Point Meeting	Observations
Applicable/Applied Configuration	F	TRR	
Production log sheets	F	TRR	
Test procedures	F	TRR	

Note 1: E = English, F = Français

Table DLY 003 –DELIVERABLE HARDWARE ITEMS LIST

	Quantity	Observation
<u>Hardware deliverable</u>		
Engineering and Qualification Model (EQM)	1	
Flight Model (FM)	8	Including 4 USO in the frame of a CNES Contract Change
<u>GSE deliverable</u>		
transport container	9	1 per USO
savers	0	

CIRCULATION

CNES:

one paper copy under the responsibility of Mr Marc BOUCHET

one electronic copy (PDF file) under the responsibility of Mr Marc BOUCHET

C-MAC:

one paper copy under the responsibility of Mr Marc BOUCHET

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