Title: **MSI Mission Data ICD**

DRD IF-07

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Change Record

Issue	Date	Sheet	Description of Change
1	01-09-2008	all	first issue
2	15-12-08	Section 1.2	Update of issues of applicable documents
		Section 1.2 Section 3.4.3.1	**PDR MSI Rid n° MPC-23 :** Missing document is now inserted as [RD 4]
		Table 3.4-7	**PDR MSI Rid n° MPC-22 :** Prior IRDB generation, preliminary calibration are implemented (for Integration time, health status, and FPA temperature).
		Section 3.4.3.1	**PDR MSI Rid n° MPC-20 :** “Stiffing” bytes clarification put in the RID answer has been inserted
		Section 3.3 Table 3-6 Table 3-10	**PDR MSI Rid n° MPC-OPS-16 :** Wording : The “Satellite Ancillary Data” is replaced by “System Ancillary Data”
		Section 3.2	**PDR MSI Rid n° MPC-OPS-15 :** Jitter between both half scenes The Jitter figure of ± 1 Clock period, provided in the frame of the RID answer has been added.
		Section 3.2	**PDR MSI Rid n° MPC-OPS-14 :** Number of packet transmitted in both half scenes An explication is given in the number of packets that can be transmitted inside both half scenes, in Nominal compressed mode case and during by-pass compressed mode and failures.
		Section 3.2.2	**PDR MSI Rid n° MPC-OPS-13 :** New section which described in details the order of source packets for both Compressed and By-Pass modes, using the file content provided in the frame of the MSI PDR RID answer.

Issue	Date	Sheet	Description of Change
2	15-12-08	Figure 3.2	**PDR MSI Rid n° MPC-19 :** 1) Section 3.3 : A dedicated explanation is given for IAD transmission during By-Pass compressed mode. 2) Figure 3.2 : Pixel data (12bits) transmission are transmitted consecutively within 16 bits fields. The “0000” field has been removed
		Table 3.4-7	Table has been updated in order to be consistent with latest bit assignment provided in [RD 1]
3	18-02-09	Table 3.4-5	**Secondary Header :** According to S2 PDR action (GS2.RP.ESA.SY.0068-200 : "JOP to confirm the solution proposed by ASF for solving the datation ambiguity, consisting in adding an extra bit"), an additional bit has been implemented in order to guarantee the time accuracy feature. The SAD field has been reduced from 11 bits down to 10 bits accordingly, in order not to exceed the 80 bits of the overall field.
4	18-12-09	Section 1.2.2	Update of applicable documents
		Section 3.1	**Figure 3.1 :** Figure is modified considering that, in by-pass mode, IAD are not transmitted within the secondary header (field is now “dummy”) but together with the uncompressed data (field is now “IAD + uncompressed data”)
		Section 3.2.2	**Figure 3.2.2 :** Figure is updated including the sub-scene location Correction of explanation on sub-scene content. Table 3.2-2 & Table 3.2-3: remark on WICOM configuration possibilities in by-pass mode
		Section 3.3	Image ancillary data replaced with instrument ancillary data Reference to Figure 3.3-1 for IAD transmission principle in compressed mode

Issue	Date	Sheet	Description of Change
4 (Cont)	18-12-09 (Cont)	Section 3.4.2.1	<u>**Table 3.4-5 :**</u> SAD field is 80 bits instead of 16. The resolution of the time correction value (56..67) is 119 nsec instead of 250 nsec. The synchronization status (68) is now clarified, tbd is removed The system operation (70..79) is clarified, tbd is removed
		Section 3.4.2.1	<u>**Table 3.4-7 :**</u> The FPAT temperature ranges have been modified according to last VCU implementation : modification form [10°C;30°C] to [0°C;50°C]
		Section 3.4.2.2	<u>**Table 3.4-9 :**</u> The resolution of the time correction value (56..67) is 119 nsec instead of 250 nsec. The synchronization status (68) is now clarified, tbd is removed The system operation (70..79) is clarified, tbd is removed
		Section 3.4.2.2	<u>**Table 3.4-9 :**</u> ***This modification was forgotten at Issue 3, it was only implemented in Table 3.4-7 for compression mode.*** According to S2 PDR action (GS2.RP.ESA.SY.0068-200 : "JOP to confirm the solution proposed by ASF for solving the datation ambiguity, consisting in adding an extra bit"), an additional bit has been implemented in order to guarantee the time accuracy feature. The SAD field has been reduced from 11 bits down to 10 bits accordingly, in order not to exceed the 80 bits of the overall field.

Issue	Date	Sheet	Description of Change
		Section 3.4.2.2	**Table 3.4-8 :** **Table 3.4-11 :** In BY-PASS mode, the secondary header is reduced from 864 bits down to 160 bits, because the IAD field is much shorter in this mode : IAD field is reduced from 768 bits (16 x 48 bits) down to 64 bits (8 x 8 bits)
		Section 3.2.2	**Figure 3.4 :** Figure is corrected with a simple typo for word 6,7 and 8.
5	23-07-10	Section 1.2.2	Document issues have been upgraded. AD2, RD4 documents are added.
		Section 3.2.1	Sub sections 3.2.1.1 and 3.2.1.2 have been added in order to identify clearly : - The Nominal transmission case (with 12960 packets) - The NON-nominal transmissions cases (all other possible cases with relevant packet number)
		Section 3.2.1.5	Sections 3.2.1.5 has been added in order to identify the specific behaviour during the first scene transmission (synchronisation marker followed by no data)
		Section 3.2.2	**Table 3.2.4 :** Title correction. Table of the 26 sub-scenes definition is valid for all the bands type, not only for a 10 m band.
		Section 3.2.2	**Table 3.2.5 :** Title correction. The sub-scene definition is valid for a 10 m band (with 144 source packet per detector)
		Section 3.3	A minor clarification is added to identify the split of the 12 bytes of IAD over the odd and even lines.
		Section 3.4.2.1 Section 4.1	**Table 3.4.5 / SAD Field / Time correction value :** The detailed calibration curve is provided in Annex, in section 4.1

Issue	Date	Sheet	Description of Change
5 (Cont)	23-07-10 (Cont)	Section 3.4.2.1, 3.4.2.2	**Table 3.4.5 / SAD Field / System Operation :** **Table 3.4.9 / SAD Field / System Operation :** A clarification is added in order to indicate that commandability is performed through IPS table.
		Section 3.4.2.1, 3.4.2.2	**Table 3.4.5 / Compression Status Field / GPI(1) :** **Table 3.4.10 / Compression Status Field / GPI(1) :** This bit is always set to “1”.
		Section 3.4.2.1	**Table 3.4.5 / Compression Status Field / WMODE :** **Table 3.4.10 / Compression Status Field / WMODE :** This field is always set to “11” whatever the Compression or By-pass mode of the WICOM. The MODOP field really informs of the Compression or By-pass operating mode.
		Section 3.4.2.1 Section 4	**Table 3.4.7 / IAD-ODD line / Integration time :** The calibration curves have been updated and the definition is now located in ANNEX 1
		Section 3.4.2.1 Section 4	**Table 3.4.7 / IAD-ODD line / FEEM Health Status :** The calibration curves have been updated and the definition is now located in ANNEX 1
		Section 3.4.2.1 Section 4	**Table 3.4.7 / IAD-ODD line / FPATM :** The calibration curves have been updated and the definition is now located in ANNEX 1
		Section 3.4.2.1 Section 4	**Table 3.4.7 / IAD-ODD line / FPATR :** The calibration curves have been updated and the definition is now located in ANNEX 1
		Section 3.4.2.1 Section 4	**Table 3.4.7 / IAD-EVEN line / Compression Ratio :** The calibration curves have been updated and the definition is now located in ANNEX 1
		Section 3.4.2.1 Section 4	**Table 3.4.7 / IAD-EVEN line / SYNC bit :** The calibration curves have been updated in accordance with GS2.NCR.JOP.MSI.63138

Issue	Date	Sheet	Description of Change
5 (Cont)	23-07-10 (Cont)	Section 3.4.2.1 Section 4	**Table 3.4.7 / IAD-EVEN line / TDI/A/B :** The calibration curves has been updated in order to avoid any ambiguity between TDI bands and all the remaining other bands.
		Section 3.4.2.2 Section 4	**Table 3.4.10 / Compression status / SSE :** The clarification has been inserted in order to be consistent with the one given in table 3.4.6
6	03.03.2011	Section 1.2.2	Update of reference documents
		Section 1.3	**GS2.NCR.JOP.MSI.63187 HSDL interface bit order** Addition of bit and byte numbering convention.
		Figure 3.3-2	**GS2.NCR.JOP.MSI.63187 HSDL interface bit order** Update of bit numbering
		Table 3.4-1	**GS2.NCR.JOP.MSI.63187 HSDL interface bit order** Update of bit numbering
		Table 3.4-4	**GS2.NCR.JOP.MSI.63187 HSDL interface bit order** Update of bit numbering
		Table 3.4-5	**GS2.NCR.JOP.MSI.63187 HSDL interface bit order** Update of bit numbering
		Table 3.4-6	**GS2.NCR.JOP.MSI.63187 HSDL interface bit order** Update of bit numbering
		Table 3.4-7	**GS2.NCR.JOP.MSI.63187 HSDL interface bit order** Update of bit numbering
		Table 3.4-8	**GS2.NCR.JOP.MSI.63187 HSDL interface bit order** Update of bit numbering
		Table 3.4-9	**GS2.NCR.JOP.MSI.63187 HSDL interface bit order** Update of bit numbering

Issue	Date	Sheet	Description of Change
		Table 3.4-10	**GS2.NCR.JOP.MSI.63187 HSDL interface bit order** Update of bit numbering
		Table 3.4-11	**GS2.NCR.JOP.MSI.63187 HSDL interface bit order** Update of bit numbering
		Figure 3-2	**GS2.NCR.JOP.MSI.63187 HSDL interface bit order** Update of bit numbering
		Section 4.8	**Answer to action item RID PCO-PC-16** Clarification of compression ratio calibration curve
		Section 4.9	**Answer to action item RID PCO-PC-23** Addition of system operation calibration curve

Table of Contents

1 Introduction

1.1 Scope of the Document

The objective of the current document is to provide the ICD for the data contained in the Mission data I/F link

1.2 References

1.2.1 Applicable Documents

[AD 1]	MSI requirement specification	GS2.RS.ASD.MSI.00001	Issue 7
[AD 2]	MSI Software ICD	GS2.ICD.ASF.MSI.00004	Issue 6

1.2.2 Reference Documents

[RD 1]	Electrical ICD Mission Data I/F	GS2-ICD-JOP-MSI-22201 Issue 2 rev 2
[RD 2]	MSI Electrical ICD	GS2-ICD-ASF-MSI-00001 Issue 9
[RD 3]	Specification d'un Algorithme de compression multiresolution par codage de plans binaires.	R&D-COMP-SP-00333-VASTR Issue 2 Rev 8 06/03/2007
[RD 4]	Wavelet Image Compression & memory (WICOM) module data sheet	WICOM.MA.00001.V.ASTR Issue 2 Rev 2
[RD 5]	HSDL interface bit order	GS2.NCR.JOP.MSI.63187

1.3 Definitions

1.3.1 Bit number ordering

Unless otherwise stated, the following conventions are used in this document:

- Bit 7 in a byte shall be the most significant bit, and positioned on the left.
- Bit 0 in a byte shall be the least significant bit, and positioned on the right.
- Bit 0 shall be transmitted first.

1.3.2 Byte number ordering

Unless otherwise stated, the following conventions are used in this document:

- Byte 0 in data fields shall be the most significant byte, and positioned on the left.
- Byte 1 in data fields shall be the least significant byte, and positioned on the right.
- Byte 0 shall be transmitted before byte 1.

Word 0															
Byte 0								Byte 1							
MSB															LSB
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2^{15}															2^{0}
32,768															0

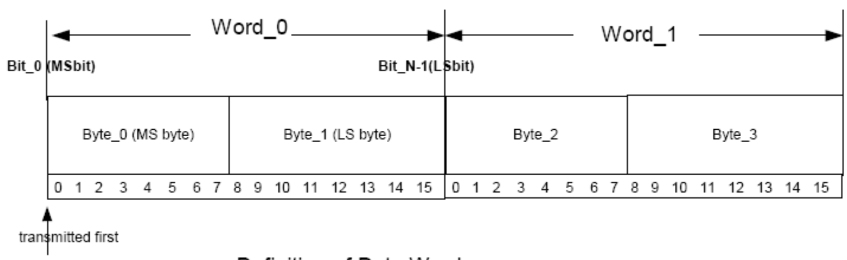
Note : The bit number ordering convention is derived from the definition in [RD-4]. This part uses identical bit/byte naming rules, and determines the interface behaviour to the MMFU in a significant manner. The bit number ordering convention defined above **is in conflict with the convention defined in [AD-1] (MSI-12161//GDIR-971/R)**

MSI-12161//GDIR-971/R

In all project specific documentation including commented code, the following convention shall be applied:

- *Bit 0 in a byte shall be the most significant bit and bit 0 shall be transmitted first.*
- *Byte 0 in data fields shall be the most significant byte, and byte 0 shall be transmitted before byte 1.*

  Figure below shall apply



Definition of Data Words
and its byte allocations

This deviation wrt **[AD 1]**, has been expressed in **[RD 5]**, has been accepted and reflected in the current ICD document

This deviation has no impact on the actual positioning of the information into the data words, it only modifies the bit numbering : the MSB isi the bit on the left side of the word, this bit is numbered 15 in the VCU standard and 0 according to [AD-1] standard.

In order to keep traceability to the applicable standard [AD-1], both numbering standards are kept through the document. The VCU bit numbering is indicated in yellow cells while the [AD-1] bit numbering is indicated in blue cells (see example below).

Example :

Bits		Name	Remarks
Source Packet Identifier (SPKID) 16 bit			
AD-1	VCU		
0…2	15…13	Version Number	“000”
3	12	Type	“0”
4	11	Secondary Header Flag	“1”
5…15	10…0	Application Identifier	

1.4 Abbreviations

General Sentinel-2 abbreviations are in [RD 1]

Specific abbreviations used in this document are given below.

2 Recall of MSI features

2.1 Detector implementation from focal plane to VCU high speed link

The order of transmitted source packets is derived from the internal circuitry. The figure below shows the data flow from FEE side up to the Mission Data Interface.

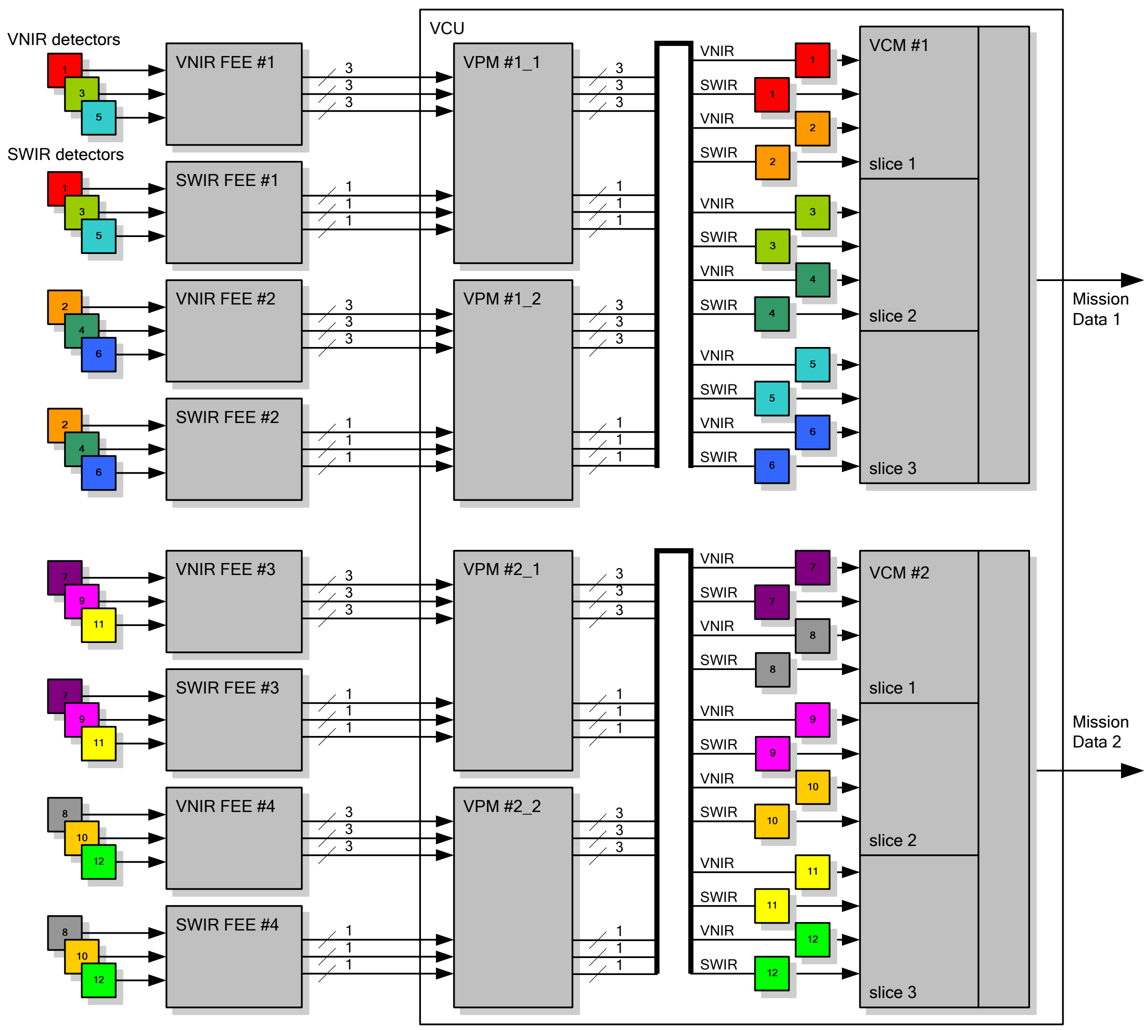


Figure 2-1: Image data flow overview

2.2 Band definition

The 13 bands implemented in MSI are described in Table 2.2-1

Table 2.2-1 : Band assignment

Band (implementation)	Detection type	SSD
B2	VNIR	10m
B8		10m
B3		10m
B4		10m
B5		20m
B6		20m
B7		20m
B8A		20m
B1		60m
B9		60m
B10	SWIR	60m
B11		20m
B12		20m

2.3 High Speed Digital Link (HSDL)

Details of implementation and H/W protocol are defined in [RD 2]

3 MISSION DATA interface

3.1 Recall of CCSDS Source Packet Structure

Formatted CCSDS source packets contain the following :

- Primary Header
- Secondary Header
- Data : compressed or uncompressed
- Stuffing Bytes (with compressed data)
- Error Check

An overview of CCSDS source packet implementation on MSI for both data transmission (compressed or uncompressed) is described in Figure 3-1

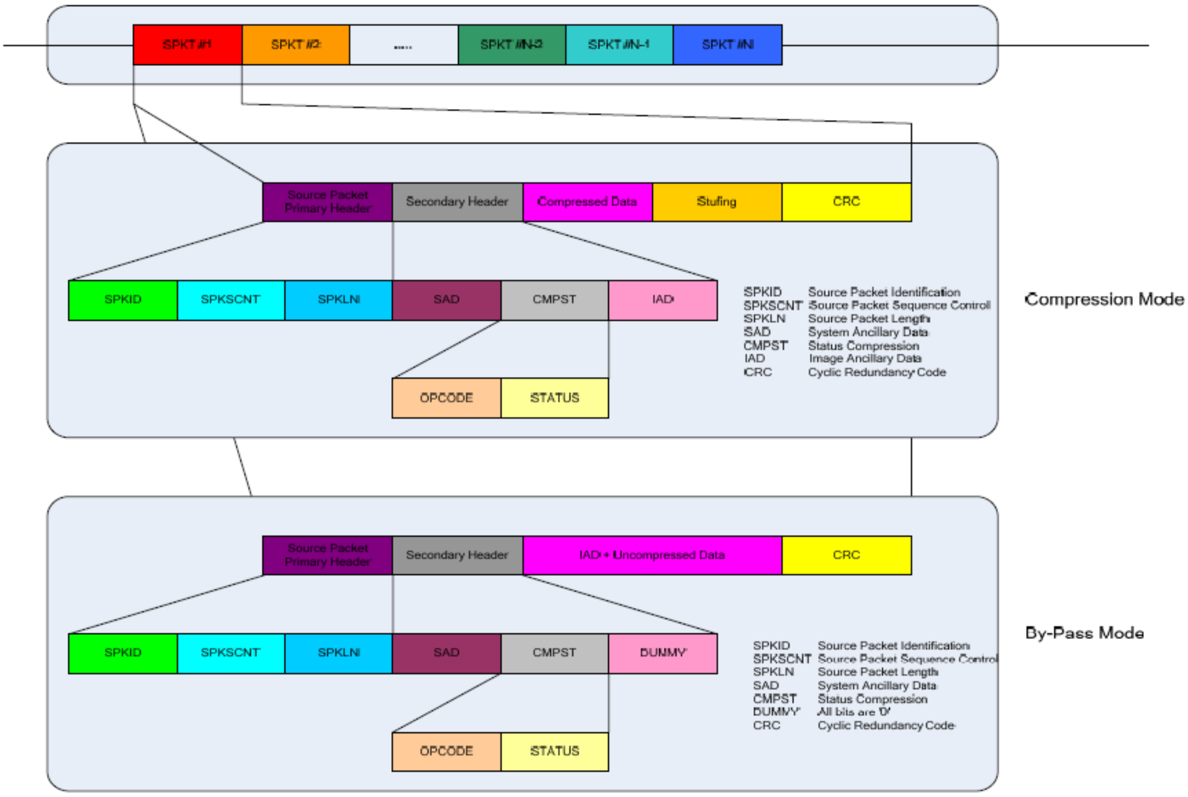


Figure 3-1: Overview of CCSDS packet content in both data transmission mode : Compressed or uncompressed (Primary, secondary, Data, Stuffing, CRC)

Note :

3.2 Description of transmitted packets over a scene

3.2.1 Overview of packet and transmission characteristics

A strip is a set of 16 contiguous lines corresponding to one detector and one spectral band. A CCSDS packet corresponds to data of a strip. One strip per detector and per band is transmitted in one CCSDS source packet. The instrument transmits complete source packets only.

3.2.1.1 Source packet delivery in Nominal transmission mode

Each scene consists of a deterministic number of CCSDS source packets as specified in Table 3.2-1

Table 3.2-1 : Number of Packets per Scene

SSD	Number of packets (strips) per detector and band	Number of detectors	Number of bands	Number of CCSDS packets	Bands
10 m	144	12	4	6912	B2, B8, B3, B4,
20 m	72	12	6	5184	B5, B6, B7, B8a, B11, B12
60 m	24	12	3	864	B1, B9, B10
total			**13**	**12960**	

Complete scene

Mission data are transferred from the VCU to the platform in complete scenes. When a scene transmission is initiated in compression mode, MSI delivers the 12960 packets over the scene duration.

In the CCSDS header, the source packet provides information in primary header in order to assign a unique identification number which allows to unambiguously identify the data it contains :

- Detector number identification : from 1 to 12. This achieved by 3 sub-fields decoding
  - VCM board number (bit 7 of SPKID)
  - WICOM number (bit 9, 10 of SPKID)
  - Detector number (bit 11 of SPKID)
- Band identification : from B1 to B12. (bit 12 to 15 of SPKID)
- A packet sequence counter dedicated for each band :
  - From 0 to 143 is the transmitted band is a 10m band
  - From 0 to 72 is the transmitted band is a 20m band
  - From 0 to 23 is the transmitted band is a 60m band

The overall source packet counting over a scene is performed at Platform level. If source packet counter is not 12960 at the beginning of next frame, an error flag is raised.

As presented in Figure 2-1, the CCSDS source packets are transmitted in parallel by means of 2 distinct HSDL hardware interfaces, called “MEAS 1 I/F” and “MEAS 2 I/F”.

Each half scene is able to deliver all the bands sampled information associated to 6 detectors. Each half scene provides a low level distribution over 3 slices. Each slice corresponds to one WICOM (see [RD 4]) interface.

- For “MEAS 1 I/F” : Source packets of detectors 1 to 6 are transmitted.
  - Slice 1 (WICOM 1_1) : Source packets of detectors 1 to 2 are transmitted
  - Slice 2 (WICOM 1_2) : Source packets of detectors 3 to 4 are transmitted
  - Slice 3 (WICOM 1_3) : Source packets of detectors 5 to 6 are transmitted
- For “MEAS 1 I/F” : Source packets of detectors 7 to 12 are transmitted.
  - Slice 1 (WICOM 2_1) : Source packets of detectors 7 to 8 are transmitted
  - Slice 2 (WICOM 2_2) : Source packets of detectors 9 to 10 are transmitted
  - Slice 3 (WICOM 2_3) : Source packets of detectors 11 to 12 are transmitted

Each WICOM always delivers 2160 source packets, whatever the operating mode (compression or by-passed).

From a commandability point of view, each WICOM can be :

- enabled or disabled
- configured in compression or by-passed mode.

This commandability is performed through the IPS table commanding. For details, refer to [AD 2]

The transmission nominal case corresponds to all WICOMs enabled and used in compression mode.

In this transmission nominal case, without any failure, the number of packets transmitted in both half scenes is identical. See Table 3.2-2

3.2.1.2 Source packet delivery in NON-Nominal transmission mode

For several reasons (use of the by-passed mode for calibration activities, investigations from ground following a failure, or H/W failures) the number of source packets may be different at a scene level and/or between both half scenes.

As an outcome of the WICOM commandability or H/W failures, the number of WICOM used in both half scenes could be different, leading to unbalanced cases.

Compression bypassed affects the packet length, but not the packet number per WICOM.

A complete list of non nominal cases is presented in Table 3.2-3

Table 3.2-2 : Number of CCSDS source packets per half scene in nominal transmission case

	Mission Data 1	**Mission Data 2**	**Total**
Transmission Nominal	**6480** (All Wicoms enabled, in compression mode) (without failure)	**6480** (All Wicoms enabled, in compression mode) (without failure)	**12960**

Table 3.2-3 : Number of CCSDS source packets per half scene in NON nominal transmission case

	Mission Data 1	**Mission Data 2**	**Total**
NON-Nominal Case 1	**2160** (1 Wicom enabled, in by-pass mode) (without failure)	**2160** (1 Wicom enabled, in by-pass mode) (without failure)	**4320**
NON-Nominal Case 2	**0** (all Wicom disabled) Or (failure)	**0** (all Wicom disabled) Or (failure)	**0**
NON-Nominal Case 3	**2160** (1 Wicom enabled, in by-pass mode) (without failure)	**0** (all Wicom disabled) Or (failure)	**2160**
NON-Nominal Case 4	**0** (all Wicom disabled) Or (failure)	**2160** (1 Wicom enabled, in by-pass mode) (without failure)	**2160**
NON-Nominal Case 5	**6480** (All Wicoms enabled, in compression mode) (without failure)	**4320 / 2160 / 0** (0, 1 or 2 Wicoms enabled, in compression mode) Or (failure)	**10800 / 8640 / 6480**
NON-Nominal Case 6	**4320 / 2160 / 0** (less than 3 Wicoms enabled, in compression mode / or failure)	**6480** (All Wicoms enabled, in compression mode) (without failure)	**10800 / 8640 / 6480**

3.2.1.3 End of transmission

When an image transmission end (by the STOP MSI IMAGE Command = CONTROL command) is requested to the VCU, the current acquired scene is terminated and then transmitted completely during the next scene duration.

Then, in the worst case, if the STOP IMAGE command is sent at the beginning of scene “n-1”, the end of the Imaging activities is done after a 2 scene duration (around 7,3 sec)

3.2.1.4 Scene start event

Within the HSDL interface protocol, MSI provides a synchronization marker to the platform at begin of each scene transmission.

For ASF AIT activities, this signal is available also at a test connector level

3.2.1.5 First scene transmission

During the first scene transmission, the synchronisation marker is followed with no mission data.

This period corresponds to the first scene acquisition by the MSI and no detection data are available to be transmitted.

3.2.2 Sequential Order of Source Packets

The sequential order of source packets, within a scene, is fully deterministic and always identical.

Synchronization between MEAS1 and MEAS2 I/F is only guaranteed on scene level (common control by SCENE SYNC signal). Interruption inside packets is controlled by the MCI ASICs independently.

Each MEAS I/F is synchronised wrt master clock.

There will be a relative jitter between both MEAS1 and MEAS2 I/F at the beginning of a scene.

Both VCM units, which generate MEAS1 and MEAS2, get identical synchronization signals from ICM side including the System Main Clock. So all circuitry starts at the same time after SCENE_SYNC. Internal synchronization works identically on all VCM units.

So the jitter on the Mission Data I/F MEAS1/MEAS2 is ± 1 clock period = 30 ns.

Band transmission (whatever the selected Mode transmission)

For both transmission Mode selection (Compressed or By-Pass) , the sequential order of source packets within a scene is described In Figure 3.2-1 : For each scene, band 1 is transmitted first

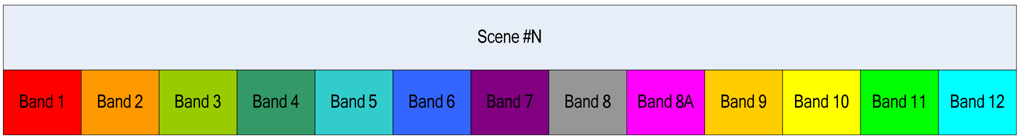


Figure 3.2-1: Sequential Order of bands over a scene (compressed or uncompressed data)

Nominal Compressed mode

For nominal Compressed Mode, the sequential order of source packets within a scene is described In Figure 3.2-2 : For each band, the detectors 1 and 7 are transmitted first.

Because the time-division multiplexing of the Mission Data at the VCM output over the 3 WICOM per half scene, the 3 detector information is scattered during a band transmission.

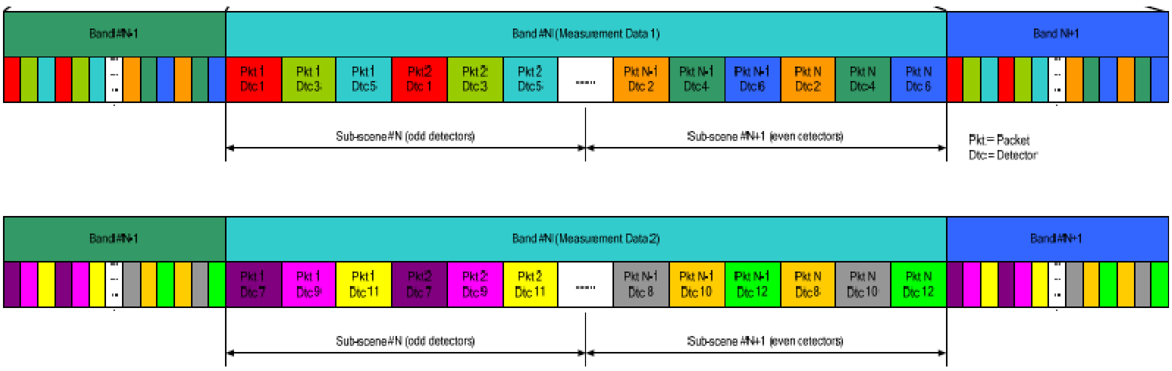


Figure 3.2-2: Sequential Order of Source Packets in Compression mode during a band transmission (exemple with a band n° 5 transmission with a time division multiplexing over the 3 detectors for MEAS1 and MEAS 2)

A detailed transmission description is presented inside Table 3.2-4 and Table 3.2-5

The transmission is organised over 26 sub-scenes, each sub-scene corresponding to one of the 13 spectral bands and either three odd or three even detectors.

By-Pass compressed mode

A detailed transmission description is presented inside Table 3.2-4 and Table 3.2-5

The transmission is organised over 26 sub-scenes, each sub-scene corresponding to one of the 13 spectral bands and either one odd or one even detector.

Table 3.2-4 : Scene transmission for Compressed and By-Pass modes

sub-scene #	band	compression mode		bypass mode *)	
		mission data interface #1	mission data interface #2	mission data interface #1	mission data interface #2
		detector	detector	detector	detector
1	B1	1,3,5	7,9,11	3	11
2	B1	2,4,6	8,10,12	4	12
3	B2	1,3,5	7,9,11	3	11
4	B2	2,4,6	8,10,12	4	12
5	B3	1,3,5	7,9,11	3	11
6	B3	2,4,6	8,10,12	4	12
7	B4	1,3,5	7,9,11	3	11
8	B4	2,4,6	8,10,12	4	12
9	B5	1,3,5	7,9,11	3	11
10	B5	2,4,6	8,10,12	4	12
11	B6	1,3,5	7,9,11	3	11
12	B6	2,4,6	8,10,12	4	12
13	B7	1,3,5	7,9,11	3	11
14	B7	2,4,6	8,10,12	4	12
15	B8	1,3,5	7,9,11	3	11
16	B8	2,4,6	8,10,12	4	12
17	B8A	1,3,5	7,9,11	3	11
18	B8A	2,4,6	8,10,12	4	12
19	B9	1,3,5	7,9,11	3	11
20	B9	2,4,6	8,10,12	4	12
21	B10	1,3,5	7,9,11	3	11
22	B10	2,4,6	8,10,12	4	12
23	B11	1,3,5	7,9,11	3	11
24	B11	2,4,6	8,10,12	4	12
25	B12	1,3,5	7,9,11	3	11
26	B12	2,4,6	8,10,12	4	12

*) example for WIC1_2_EN = WIC2_3_EN = 1, any combination with one WICOM active on each of the 2 mission data interface is possible.

Table 3.2-5 : Sub-Scene transmission for Compressed and By-Pass modes (example for a 10 m SSD band)

source packet #	***compression mode***		***source packet #***	***bypass mode *)***	
	mission data interface #1	***mission data interface #2***		***mission data interface #1***	***mission data interface #2***
	detector	***detector***		***detector***	***detector***
1	1	7	***1***	3	11
2	3	9			
3	5	11			
4	1	7	***2***	3	11
5	3	9			
6	5	11			
7	1	7	***3***	3	11

…

426	5	11			
427	1	7	***143***	3	11
428	3	9			
429	5	11			
430	1	7	***144***	3	11
431	3	9			
432	5	11			

*) example for WIC1_2_EN = WIC2_3_EN = 1, any combination with one WICOM active on each of the 2 mission data interface is possible.

3.3 Ancillary data definition within secondary header

Ancillary data located inside the secondary header are split into 3 types :

- System Ancillary Data (SAD).
- Compression status.
- Instrument Ancillary Data (IAD).

System Ancillary Data (SAD)

The system ancillary data are provided within the Source Packet Data Field Secondary Header.

The system ancillary data includes

- the scene start time is CUC with Agency defined epoch with Coarse Time (seconds) using 4 octets and three octets for fine time.
- the time correction value and the MSI On Board Time synchronisation status
- and the system operation information. This information is provided by the Platform prior any mode transition towards IMAGE mode. Then VCU inserts this information inside SAD field.

Instrument Ancillary Data (IAD)

The VCM adds instrument ancillary data (IAD)

The instrument ancillary data are provided within the instrument source packets, in the Source Packet Data Field Secondary Header.

The IAD field include uncompressed data as following which are tailored per CCSDS source packet pending on the data transmitted (detector number, band transmitted).

The IAD field is limited to 6 bytes per line and then to 96 bytes per strip transmission. The IAD implementation is described over 12 bytes. These data are repeated 8 times within the same strip.

The detailed definition of the 12 bytes is the following :

- Band integration time (8 bits)
- FEEM status (8 bits)
  - Error words coming from relevant FEEM by serial link
- FPA temperature (12 bits), thermal control, relevant to the detector transmission VNIR or SWIR
- FPA temperature (12 bits), monitoring, relevant to the detector transmission VNIR or SWIR
- Spare (8 bits)
- Band compression ratio (8 bits)
- NUC table ID (10 bits) : it identifies the correction coefficient table used in-flight. This ID figure will be loaded by the platform
- VPM control (6 bits)
  - TDI mode
  - Test generator status
- Spare (24 bits)

Compression Status

The status of the WICOM is provided in the Packet data field Secondary Header. It includes at least:

- the compression on/by-passed status
- the equalization on/by-passed status
- the WICOM ASIC status

and all further WICOM information needed for on-ground processing of the Mission data.

IAD transmission principle

IAD transmission principle is different for both Compressed and By-Pass mode

- For Compressed mode : IAD are transmitted within IAD field over 96 bytes. IAD data are scattered over a 12 bytes brick. Each brick is composed of 6 bytes before and odd line and 6 bytes before the following even line. This elementary brick is repeated 8 times over the strip (see Figure 3.3-1).
- For By-Pass mode, IAD are transmitted within Data Field as depicted in Figure 3-3

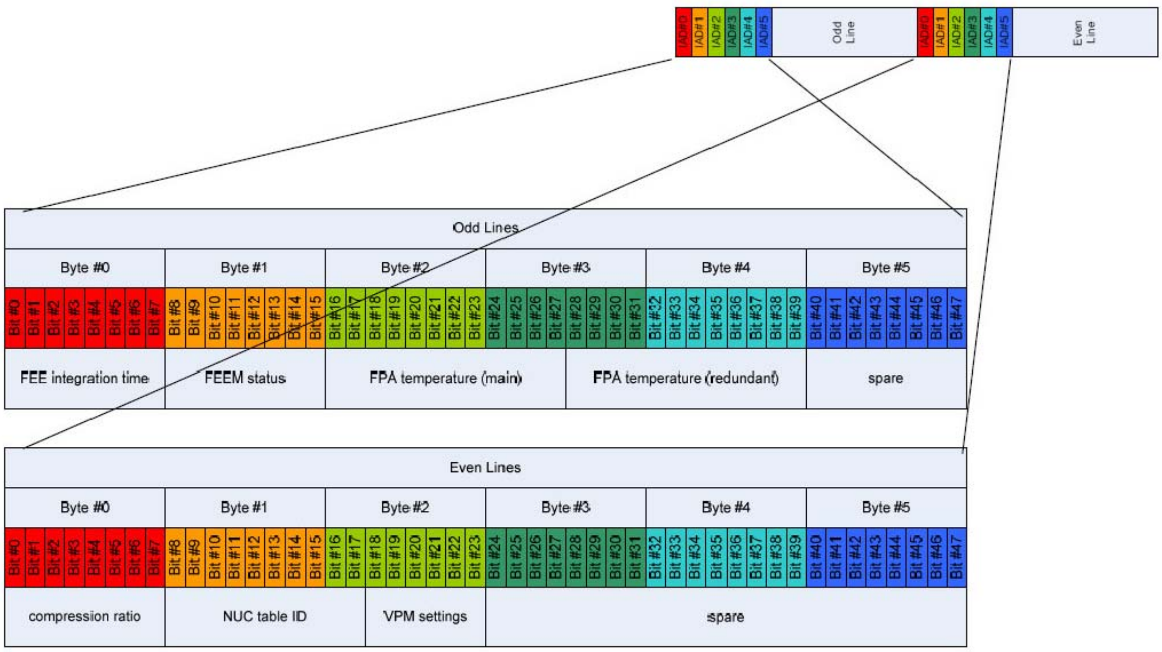


Figure 3.3-1: IAD implementation over the 12 bytes within a strip ([AD-1] bit numbering convention)

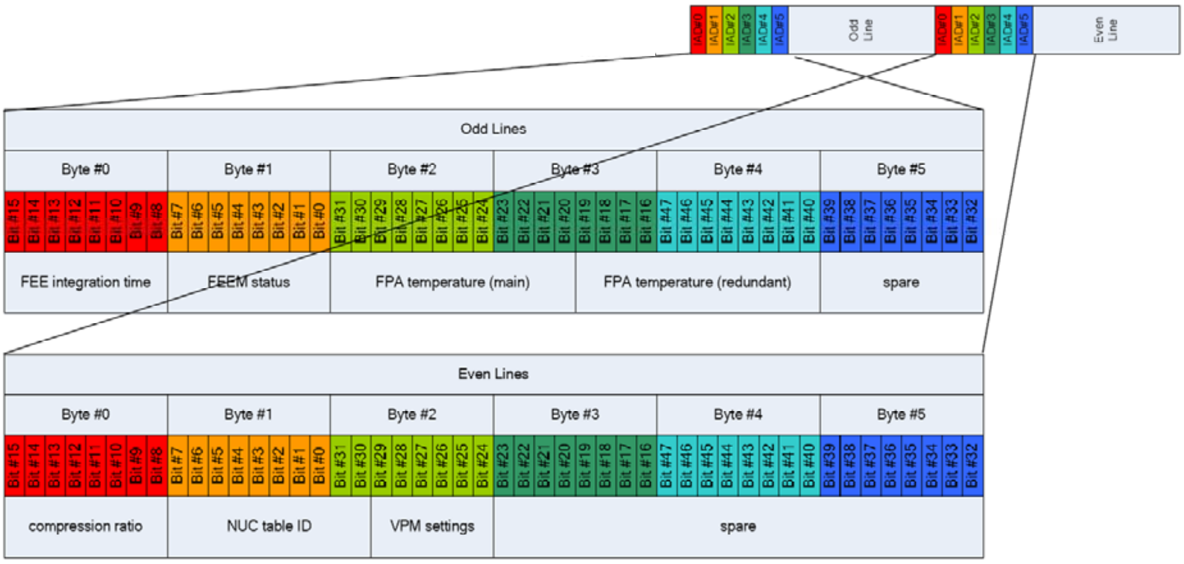


Figure 3.3-2: IAD implementation over the 12 bytes within a strip (VCU bit numbering convention)

3.4 Detailed definition of MSI CCSDS source packets

3.4.1 Primary Header

The primary header definition is described in Table 3.4-1

Table 3.4-1 Primary Header definition

Source Packet Primary Header (48 bit)																																															
Source Packet Identifier (16 bit)																Packet Sequence Control (16 bit)																Packet Length (16bit)															
0															15	0															15	0															15
15															0	15															0	15															0

Bits		Name	Remarks	
Source Packet Identifier (SPKID) 16 bit				
AD-1	VCU			
0…2	15…13	Version Number	“000”	
3	12	Type	“0”	
4	11	Secondary Header Flag	“1”	
5…15	10…0	Application Identifier		
5…6	10…9	Spare	“00”	
7	8	VCM Board Number	“0” “1”	see Table 3.4-2
8	7	reserved	“0”	
9…10	6…5	WICOM Number	“00” “01” “10” “11”	see Table 3.4-2
11	4	Detector Number (Odd/Even)	“0” “1”	see Table 3.4-2

Bits		Name	Remarks	
12…15	3…0	Band Number	"0000" : : "1111"	see Table 3.4-3
Packet Sequence Control 16 bit				
0…1	15…14	Sequence Flag	"11"	unsegmented
2…15	13…0	Packet Sequence Count (modulo 16384)	The number of the first packet for each band is 0. For an image acquisition, this count is reset on : • first strip of first scene for compression with overlapping [1]), • first strip of each scene for compression without overlapping The allowed range is • 0…143 for the 10m band • 0…71 for the 20m band • 0…23 for the 60m band	
Packet Length 16 bit				
0…15	15…0	Packet Length	Number of octets in the packet data field minus one	

1 Not used in this application. In the current application "Compression without overlapping" is used, see [RD 4]

Table 3.4-2: Detector Number Coding

The table below shows the correlation between VNIR/SWIR detector number, VCM Board Number, and WICOM number.

VNIR and SWIR Detector	VCM Board #	Detector #	WICOM #
1	“0”	“0”	“00”
2	“0”	“1”	“00”
3	“0”	“0”	“01”
4	“0”	“1”	“01”
5	“0”	“0”	“10”
6	“0”	“1”	“10”
not applicable	“0”	“0”	(“11” not applicable)
not applicable	“0”	“1”	(“11” not applicable)
7	“1”	“0”	“00”
8	“1”	“1”	“00”
9	“1”	“0”	“01”
10	“1”	“1”	“01”
11	“1”	“0”	“10”
12	“1”	“1”	“10”
not applicable	“1”	“0”	(“11” not applicable)
not applicable	“1”	“1”	(“11” not applicable)

Table 3.4-3: Band Number Coding

Next table shows the correlation between the Band number, Band name, and output order.

Band # “decimal”	Physical Band	Packet Output Order
“0”	B1	1 (sent first)
“1”	B2	2
“2”	B3	3
“3”	B4	4
“4”	B5	5
“5”	B6	6
“6”	B7	7
“7”	B8	8
“8”	B8a	9
“9”	B9	10
“10”	B10	11
“11”	B11	12
“12”	B12	13

3.4.2 Secondary Header

3.4.2.1 Compression Mode

Table 3.4-4 Secondary Header in Compression mode

Source Packet Secondary Header (864 bit)																																															
System Ancillary Data (80 bit)																Compression Status (16 bit)																Instrument Ancillary Data (16 x 48 bit)															
0															79	0															15	IAD0: 0...47	IAD1: 0...47	IAD2: 0...47	.	.	.	.	.	.	.	.	.	.	.	IAD14: 0...47	IAD15: 0...47
79															0	15															0	IAD0: 47...0	IAD1: 47...0	IAD2: 47...0	.	.	.	.	.	.	.	.	.	.	.	IAD14: 47...0	IAD15: 47...0
Refer to Table 3.4-5																Refer to Table 3.4-6																Refer to Table 3.4-7															

Table 3.4-5 Secondary Header for compressed data transmission / SAD detailed content

Bits		Name	Remarks
System Ancillary Data (SAD) 80 bits			
AD-1	VCU		
0…55	79…24	Scene Start Time	
0…31	79…48	CUC coarse time	CCSDS Unsegmented Time Code Coarse Time (seconds) (32 bits)
32…55	47…24	CUC fine time	CCSDS Unsegmented Time Code Fine Time (subseconds) (24 bits)
		Bit Position Seconds	(see bit position table below) Smallest time period: 0x0000.001 = 2^{-24} seconds ≈ 59.6 ns Largest time: 0xFFFF.FFF = $2^{32} - 2^{-24}$ seconds ≈ 136 years
56…67	23…12	Time Correction Value	It represents the MSI time deviation relating to PPS interval (12 bits) The Time Correction Value is defined as the difference between the clock count between two PPS pulses measured on VCU side and the nominal clock count between two PPS pulses. The resolution is 1 / 8.37 MHz = 119 ns. Number representation is done in two's complement. The calibration curve is provided in section 4.1.
68…69	11…10	MSI Synchronization Status	Indicates the validity of the time data.
68	11	Time status flag (CLK_ASYNC)	1 : VCU on-board clock is synchronised 0 : VCU on-board clock is not synchronised
69	10	Time status flag PPS	lsb of coarse time of last time synchronisation message
70…79	9…0	System Operation	Content defined by the system prime (10 bits) It will be commanded by TC (it is a parameter inside the IPS table, as defined in [AD 2]) and will be forwarded by the VCU without any modifications in the "System Operation" field of the SAD field. Refer to section 4.9 for calibration curve.

	Course Time								**Fine Time**				
Bit Position	0	1	2	3	4…27	28	29	30	31	32	33	34…53	54	55
	79	78	77	76	75…52	51	50	49	48	47	46	45…26	25	24
Seconds	2^{31}	2^{30}	2^{29}	2^{28}	$2^{27} \ldots 2^{28}$	2^{3}	2^{2}	2^{1}	2^{0}	2^{-1}	2^{-2}	$2^{-3} \ldots 2^{-22}$	2^{-23}	2^{-24}

Table 3.4-6 Secondary Header for compressed data transmission / Compression status detailed content

Bits		Name	Remarks
Compression Status 16 bit			
AD-1	VCU		
0…2	15…13	MODOP	Status of the current compression (3 bits) Compress and Output Image Data: “000”
3…5	12…10	reserved	“110”
6	9	BYPNUC	Non-Uniformity Correction Active: “0” Bypass: “1”
7…8	8…7	reserved	“10”
9	6	SSE	Strip Sequence Error No error: “0” Error: “1” Error detected during a strip. It indicates that the MCI ASIC was not able to finish all the operations to be performed during this strip. This error occurs when the operating frequency is too low according to the input data rate or the output data rate.
10	5	GPI(1)	Status General Purpose Input (1) In compression mode this bit is always set to “1”
11	4	Reserved	“0”
12…13	3…2	Reserved	“00”
14…15	1…0	WMODE	WICOM Mode (2 bits) « Running » mode : “11” Remark: The WICOM modes “OFF”, “INIT”, and “IDLE” are never seen during data transfer.

Table 3.4-7 Secondary Header for compressed data transmission / IAD detailed content

Bits		Name	Remarks
Instrument Ancillary Data (IAD, ODD lines) 8 x 48 bit			
AD-1	VCU		
0…7	47…40	INTTIME	FEE Integration Time (8 bit) There are 13 different Integration Time values INTTIME0…INTTIME12. The values are unique for each band and correspond with the transmitted band number. The calibration curve is provided in section 4.2, for each integration band
8…15	39…32	FEE health status	FEEM health status (8 bit) There are 8 unique status values (1 per FEEM). The value corresponds to the FEEM concerned by the detector number and the SWIR or VNIR type. The calibration curve is provided in section 4.3, for each integration band and for each detector
16…27	31…20	FPATM	FPA Temperature (12 bit) / Thermal control There are 2 unique FPA Temperature values FPATM0, FPATM1 (1 for VNIR FPA, 1 for SWIR FPA). The values corresponds to the FPA temperature provided by the thermistor used for the thermal control of the current detector type (VNIR or SWIR) The information delivered is band dependant. The correct calibration curve assignment is present in the table below

	B1	B2	B3	B4	B5	B6	B7	B8	B8a	B9	B10	B11	B12
See Section	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.6	4.6	4.6

<table>
<tr><th colspan="2">Bits</th><th>Name</th><th>Remarks</th></tr>
<tr><td>28…39</td><td>19…8</td><td>FPATR</td><td>FPA Temperature (12 bit) / Monitoring
There are 2 unique FPA Temperature values FPATR0, FPATR1 (1 for VNIR FPA, 1 for SWIR FPA).
The values corresponds to the FPA temperature provided by the thermistor used for the monitoring of the current detector type (VNIR or SWIR)
The information delivered is band dependant. The correct calibration curve assignment is present in the table below
<table><tr><th></th><th>B1</th><th>B2</th><th>B3</th><th>B4</th><th>B5</th><th>B6</th><th>B7</th><th>B8</th><th>B8a</th><th>B9</th><th>B10</th><th>B11</th><th>B12</th></tr><tr><td>See Section</td><td>4.5</td><td>4.5</td><td>4.5</td><td>4.5</td><td>4.5</td><td>4.5</td><td>4.5</td><td>4.5</td><td>4.5</td><td>4.5</td><td>4.7</td><td>4.7</td><td>4.7</td></tr></table></td></tr>
<tr><td>40…47</td><td>7…0</td><td>Spares</td><td>8 bit spares</td></tr>
</table>

Bits		Name	Remarks
Instrument Ancillary Data (IAD, EVEN lines) 8 x 48 bit			
AD-1	VCU		
0…7	47…40	CRATIO	Compression Ratio WICOM (8 bit) The values represent the programmed output rate defined in number of bits per pixel (BPP) of the corresponded band. The calibration curve is provided in section 4.8, for each integration band
8…17	39…30	NUCTID	NUC Table ID (10 bit) This ID is uniform for all transmitted bands
18…23	29…24	VPMSET	VPM settings (6 bits, 5 used)
18	29	TMODE	Video Channel Source Select (1 bit) Channel connected to ADC: “0” Channel connected to Test Generator: “1” Configurable for each Video Channel (48 unique values), value corresponds with transmitted band & detector
19	28	SYNC	Test clock synchronisation to the sync of the 10m band (1bit) Free running : “1” Synchronized: “0” Configurable for each VPM, value corresponds with transmitted band & detector
20	27	NOISE	Noise Insertion in Test Mode (1 bit) Noise OFF: “0” PSR Noise ON: “1” Configurable for each VPM, value corresponds with transmitted band and detector

Bits		Name	Remarks
21-22	26…25	TDI/A/B	TDI mode (2 bits) 1) For TDI bands (B3, B4, B11, B12) TDI applied: “00” TDI not applied, Line A transmitted “01” TDI not applied, Line B transmitted “10” 2) For other bands without TDI capability (B1, B2, B5, B6, B7, B8, B8a, B9, B10) Fixed value “11” There are 48 unique values : 1 per detector (12) and 1 per TDI band (4)
23	24	Spare	Spare bit
24…47	23…0	Spares	Spare bit

3.4.2.2 By-Pass / Uncompressed Mode

Table 3.4-8 Secondary Header in Compression mode

<table>
<tr><th colspan="33">Source Packet Secondary Header (160 bit)</th></tr>
<tr><td colspan="16">System Ancillary Data (80 bit)</td><td colspan="16">Compression Status (16 bit)</td><td>Instrument Ancillary Data (8 x 8 bit)</td></tr>
<tr><td>0</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>7
9</td><td>0</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1
5</td><td>All bits are “0”</td></tr>
<tr><td>7
9</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0</td><td>1
5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0</td><td>All bits are “0”</td></tr>
<tr><td colspan="16">Refer to Table 3.4-9</td><td colspan="16">Refer to Table 3.4-10</td><td>Refer to Table 3.4-11</td></tr>
</table>

Table 3.4-9 Secondary Header for uncompressed data transmission / SAD detailed content

Bits		Name	Remarks
System Ancillary Data (SAD) 80 bits			
AD-1	VCU		
0…55	79…24	Scene Start Time	
0…31	79…48	CUC coarse time	CCSDS Unsegmented Time Code Coarse Time (seconds) (32 bits)
32…55	47…24	CUC fine time	CCSDS Unsegmented Time Code Fine Time (subseconds) (24 bits)

	Course Time									**Fine Time**				
	0	1	2	3	4…27	28	29	30	31	32	33	34…53	54	55
Bit Position	79	78	77	76	75…52	51	50	49	48	47	46	45…26	25	24
Seconds	2^{31}	2^{30}	2^{29}	2^{28}	2^{27} … 2^{28}	2^{3}	2^{2}	2^{1}	2^{0}	2^{-1}	2^{-2}	2^{-3}…2^{-22}	2^{-23}	2^{-24}

Smallest time period: 0x0000.001 = 2^{-24} seconds ≈ 59.6 ns
Largest time: 0xFFFF.FFF = $2^{32} – 2^{-24}$ seconds ≈ 136 years

Bits		Name	Remarks
56…67	23…12	Time Correction Value	It represents the MSI time deviation relating to PPS interval (12 bits) The Time Correction Value is defined as the difference between the clock count between two PPS pulses measured on VCU side and the nominal clock count between two PPS pulses. The resolution is 1 / 8.37 MHz = 119 ns. Number representation is done in two's complement. The calibration curve is provided in section 4.1.
68…69	11…10	MSI Synchronization Status	Indicates the validity of the time data.
68	11	Time status flag (CLK_ASYNC)	1 : VCU on-board clock is synchronised 0 : VCU on-board clock is not synchronised
69	10	Time status flag PPS	lsb of coarse time of last time synchronisation message
70…79	9…0	System Operation	Content defined by the system prime (10 bits) It will be commanded by TC (it is a parameter inside the IPS table, as defined in [AD 2]) and will be forwarded by the VCU without any modifications in the "System Operation" field of the SAD field. Refer to section 4.9 for calibration curve.

Table 3.4-10 Secondary Header for uncompressed data transmission / Compression status detailed content

Bits		Name	Remarks
Compression Status 16 bit			
AD-1	VCU		
0…2	15…13	MODOP	Status of the current compression (3 bits) Compress and Output Image Data: "000"
3…5	12…10	reserved	"110"
6	9	BYPNUC	Non-Uniformity Correction Active: "0" Bypass: "1"
7…8	8…7	reserved	"10"
9	6	SSE	Strip Sequence Error No error: "0" Error: "1" Error detected during a strip. It indicates that the MCI ASIC was not able to finish all the operations to be performed during this strip. This error occurs when the operating frequency is too low according to the input data rate or the output data rate.
10	5	GPI(1)	Status General Purpose Input (1) In compression mode this bit is always set to "1"
11	4	Reserved	"0"
12…13	3…2	Reserved	"00"
14…15	1…0	WMODE	WICOM Mode (2 bits) « Running » mode : "11" Remark: The WICOM modes "OFF", "INIT", and "IDLE" are never seen during data transfer.

Table 3.4-11 Secondary Header for uncompressed data transmission / IAD detailed content

Bits		Name	Remarks
Instrument Ancillary Data (IAD) 64 bits			
AD-1	VCU		
0…63	63…0	DUMMY	All bits are “0”

3.4.3 Data

This field contains the compressed data of a strip of spectral band. The structure is shown in following table:

3.4.3.1 Compression Mode

Table 3.4-12: Data Field for Compressed Data

Data		
Compressed Data (CD)	Stuffing (ST)	Cyclic Redundancy Code (CRC)
Variable bits	Variable bits	16 bit
The Compressed Data (CD) Field contains the Embedded Bitstream (EBB) of one strip (16 lines), which includes all and only the compressed data information. The EBB contains the compressed information to describe an image area up to the requested image quality as set by minimum quantization step. The EBB data is organized in a fixed order attempting to place the most important information. The EBB of each rate regulated image area is truncated at the target EBB length, thereby loosing least important information. The structure of the EBB is described in detail in [RD 4].	The Stuffing (ST) Field is necessary, if the number of compressed data is lower than the target size. In this case, Stuffing Bits will be added, to reach exactly the target size (a).	The CRC calculation is performed by the following formula: • The generator polynomial is: $x^{16} + x^{12} + x^5 + 1$ • The encoder is initialized to the “all ones” state for each packet.

Note (a) : Target size is defined by the target compressed bit rate and the number of pixels for each strip. It is both an Upper limit and a lower limit. Stuffing are inserted in strips with very low complexity such as desert or oceans. Stuffing allow memory management with deterministic file sizes and telemetry with deterministic file transmission durations.

3.4.3.2 By Pass / Uncompressed Mode

Table 3.4-13: Data Field for Uncompressed Data

Data	
Uncompressed Data (UD)	Cyclic Redundancy Code (CRC)
Variable bits	16 bit
The Uncompressed Data (UD) Field contains the IAD data and image data of one strip (16 lines) according to the order defined in Figure 3-3. There is no Stuffing Field in By-Pass Mode.	The CRC calculation is performed by the following formula: • The generator polynomial is: $x^{16} + x^{12} + x^5 + 1$ • The encoder is initialized to the "all ones" state for each packet.

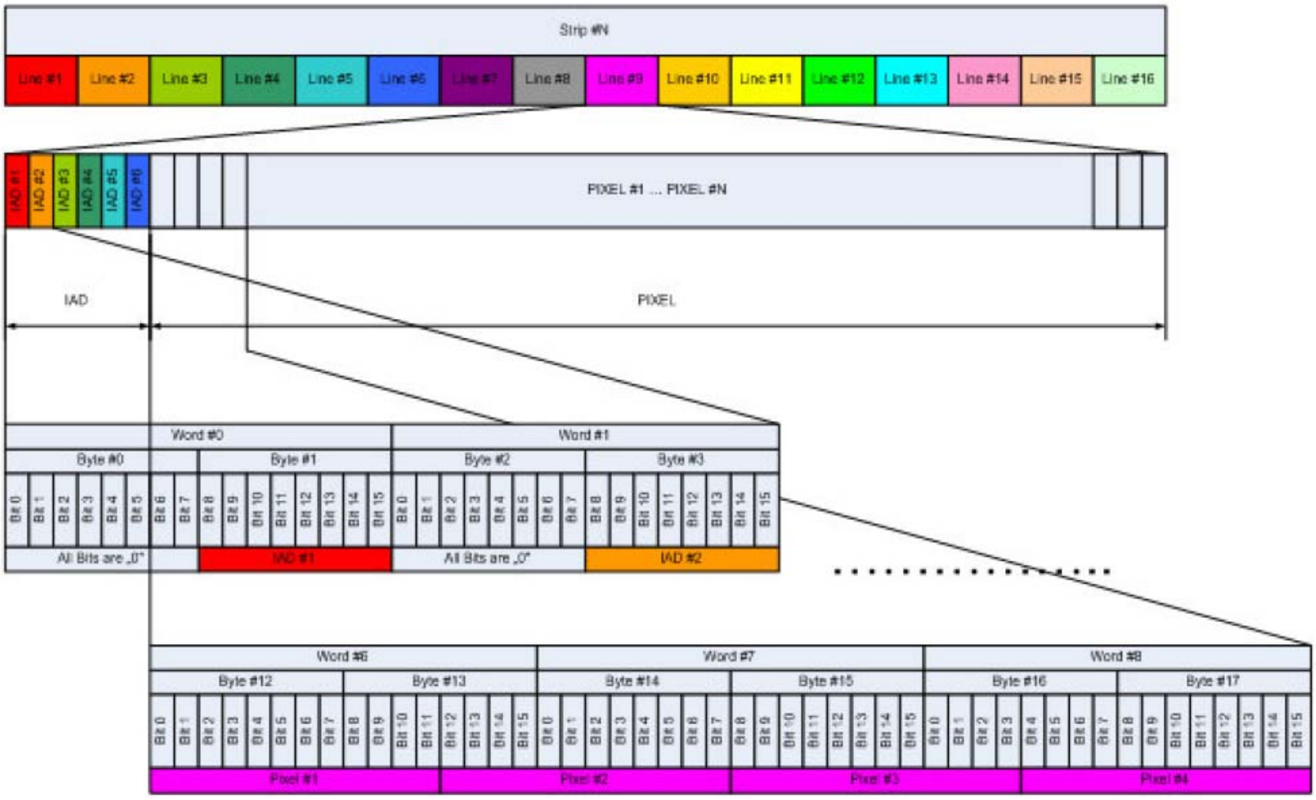


Figure 3-3: Uncompressed Data Field (AD-1 bit numbering standard)

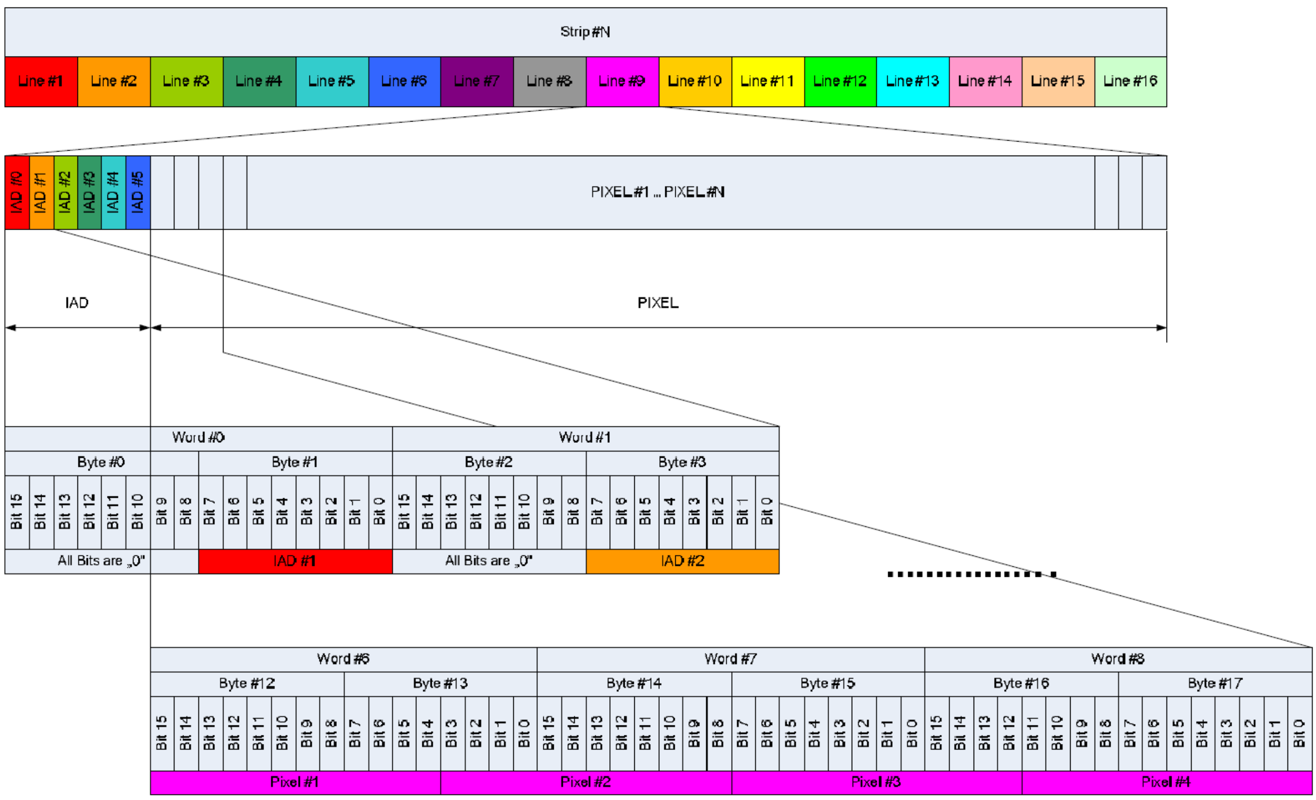


Figure 3-4: Uncompressed Data Field (VCU bit numbering standard)

4 ANNEX 1 : Calibration curves

4.1 Time Correction Value (Secondary Header / SAD field)

The Following table shows the implementation of the bits 56 to 67 (23 to 12 according to VCU bit numbering standard) of the SAD field.

	Msb										Lsb	
AD-1	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**Raw**
VCU	**23**	**22**	**21**	**20**	**19**	**18**	**17**	**16**	**15**	**14**	**13**	**12**	**Raw**
	0	1	1	1	1	1	1	1	1	1	1	1	2047
	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..
	0	0	0	0	0	0	0	0	0	0	1	0	2
	0	0	0	0	0	0	0	0	0	0	0	1	1
	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	1	1	1	1	1	1	1	1	1	1	1	-1
	1	1	1	1	1	1	1	1	1	1	1	0	-2
	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..
	1	0	0	0	0	0	0	0	0	0	0	0	-2048

$$(\text{CALIBRATED})_{\text{Value}} = (\text{RAW})_{\text{Value}} \times \text{Step}$$

Where :

Step = 1 / (2^26 / 8) = 119 nsec

The overall range of calibrated value is then

$$(\text{CALIBRATED})_{\text{Value}} = [-244{,}14\ \mu\text{sec} ;\ +244{,}02\ \mu\text{sec}]$$

4.2 Integration time (Secondary Header / IAD field / ODD lines)

The Following table shows the implementation of the bits 0 to 7 (47 to 40 according to VCU bit numbering standard) of the IAD field / ODD line

The elementary calibration curves C1 to C5 are provided herebelow

	RAW value	Integration time (msec)
C1	4	0.04965
	255	1.5158

	RAW value	Integration time (msec)
C2	0	0.04965
	255	3.08188

	RAW value	Integration time (msec)
C3	0	0.0363
	255	9.34578

	RAW value	Integration time (msec)
C4	0	0.0121
	255	3.09753

	RAW value	Integration time (msec)
C5	0	0.0363
	255	9.29258

The assignment of elementary calibration curves wrt each integration band is presented in the table hereafter

Integration Times	Band	Calibration curve
INTTIME0	B1	C3
INTTIME1	B2	C1
INTTIME2	B3	C1
INTTIME3	B4	C1
INTTIME4	B5	C2
INTTIME5	B6	C2
INTTIME6	B7	C2
INTTIME7	B8	C1
INTTIME8	B8a	C2
INTTIME9	B9	C3
INTTIME10	B10	C5
INTTIME11	B11	C4
INTTIME12	B12	C4

4.3 FEEM Health Status (Secondary Header / IAD field / ODD lines)

The Following table shows the implementation of the bits 8 to 15 (39 to 32 according to VCU bit numbering standard) of the IAD field / ODD line

Bit assignment of IAD / Odd line

	Msb							Lsb	
AD-1	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Description**
VCU	**39**	**38**	**37**	**36**	**35**	**34**	**33**	**32**	
	E1	E2	-	-	-	TO	S	P	Byte n°V1 (VNIR FEEM n°1)
	E1	E2	-	-	-	TO	S	P	Byte n°V2 (VNIR FEEM n°2)
	E1	E2	-	-	-	TO	S	P	Byte n°V3 (VNIR FEEM n°3)
	E1	E2	-	-	-	TO	S	P	Byte n°V4 (VNIR FEEM n°4)
	E1	E2	L1	L2	L3	TO	S	P	Byte n°S1 (SWIR FEEM n°1)
	E1	E2	L1	L2	L3	TO	S	P	Byte n°S2 (SWIR FEEM n°2)
	E1	E2	L1	L2	L3	TO	S	P	Byte n°S3 (SWIR FEEM n°3)
	E1	E2	L1	L2	L3	TO	S	P	Byte n°S4 (SWIR FEEM n°4)

Where :

E1 = indicates error (not corrected) at EEPROM reading
E2 = indicates error (corrected) at EEPROM reading
L1 = indicates any latchup on the VDA voltages
L2 = indicates any latchup on the VDD voltages
L3 = indicates any latchup on the VDDO voltages
TO = indicates Time-out error, if it is not received 12 TC DATA byte before the next LC2
S = indicates Stop bit error in any byte received
P = indicates Parity error in any byte received

The calibration curves are

For E1	"0"	No error
	"1"	Error not corrected
For E2	"0"	No error
	"1"	Error corrected
For L1, L2, L3	"0"	No_latchup
	"1"	Latchup_active
For P, S, TO	"0"	OK
	"1"	Error

The following table identifies clearly the assignment of the hereabove 8 possible bytes V1 to S4, within the source packets headers of each detector and for each band.

	Detector											
	1	2	3	4	5	6	7	8	9	10	11	12
B1	V1	V2	V1	V2	V1	V2	V3	V4	V3	V4	V3	V4
B2	V1	V2	V1	V2	V1	V2	V3	V4	V3	V4	V3	V4
B3	V1	V2	V1	V2	V1	V2	V3	V4	V3	V4	V3	V4
B4	V1	V2	V1	V2	V1	V2	V3	V4	V3	V4	V3	V4
B5	V1	V2	V1	V2	V1	V2	V3	V4	V3	V4	V3	V4
B6	V1	V2	V1	V2	V1	V2	V3	V4	V3	V4	V3	V4
B7	V1	V2	V1	V2	V1	V2	V3	V4	V3	V4	V3	V4
B8	V1	V2	V1	V2	V1	V2	V3	V4	V3	V4	V3	V4
B8a	V1	V2	V1	V2	V1	V2	V3	V4	V3	V4	V3	V4
B9	V1	V2	V1	V2	V1	V2	V3	V4	V3	V4	V3	V4

B10	S1	S2	S1	S2	S1	S2	S3	S4	S3	S4	S3	S4
B11	S1	S2	S1	S2	S1	S2	S3	S4	S3	S4	S3	S4
B12	S1	S2	S1	S2	S1	S2	S3	S4	S3	S4	S3	S4

4.4 Temperature VNIR (Thermal control) (Secondary Header / IAD field / ODD lines)

The Following table shows the implementation of the bits 16 to 27 (31 to 20 according to VCU bit numbering standard) of the IAD field / ODD line

The calibration curve for VNIR thermal control temperature is provided in the following table for VCU Nominal

RAW value	Temperature (°C)
0	-1
54	0
348	4
661	8
989	12
1329	16
1675	20
2106	25
2364	28
2701	32
3026	36
3337	40
3631	44
3840	47
4038	50
4095	51

The calibration curve for VNIR thermal control temperature is provided in the following table for VCU Redundant

RAW value	Temperature (°C)
0	-1
54	0
348	4
661	8
989	12
1329	16
1675	20
2106	25
2364	28
2701	32
3026	36
3337	40
3631	44
3840	47
4038	50
4095	51

Note : At this stage of the development, both curves are identical but might be different according to the real temperature sensor specific calibration curve

4.5 Temperature VNIR (Monitoring) (Secondary Header / IAD field / ODD lines)

The Following table shows the implementation of the bits 28 to 39 (19 to 8 according to VCU bit numbering standard) of the IAD field / ODD line

The calibration curve for VNIR monitoring temperature is provided in the following table for VCU Nominal

RAW value	Temperature (°C)
0	-1
54	0
348	4
661	8
989	12
1329	16
1675	20
2106	25
2364	28
2701	32
3026	36
3337	40
3631	44
3840	47
4038	50
4095	51

The calibration curve for VNIR monitoring temperature is provided in the following table for VCU Redundant

RAW value	Temperature (°C)
0	-1
54	0
348	4
661	8
989	12
1329	16
1675	20
2106	25
2364	28
2701	32
3026	36
3337	40
3631	44
3840	47
4038	50
4095	51

Note : At this stage of the development, both curves are identical but might be different according to the real temperature sensor specific calibration curve

4.6 Temperature SWIR (Thermal control) (Secondary Header / IAD field / ODD lines)

The Following table shows the implementation of the bits 16 to 27 (31 to 20 according to VCU bit numbering standard) of the IAD field / ODD line

The calibration curve for SWIR thermal control temperature is provided in the following table for VCU Nominal

RAW value	Temperature (°C)
0	-91
49	-90
363	-88
832	-85
1299	-82
1609	-80
2075	-77
2539	-74
3003	-71
3464	-68
3925	-65
4095	-64

The calibration curve for SWIR thermal control temperature is provided in the following table for VCU Redundant

RAW value	Temperature (°C)
0	-91
49	-90
363	-88
832	-85
1299	-82
1609	-80
2075	-77
2539	-74
3003	-71
3464	-68
3925	-65
4095	-64

Note : At this stage of the development, both curves are identical but might be different according to the real temperature sensor specific calibration curve

4.7 Temperature SWIR (Monitoring) (Secondary Header / IAD field / ODD lines)

The Following table shows the implementation of the bits 28 to 39 (19 to 8 according to VCU bit numbering standard) of the IAD field / ODD line

The calibration curve for SWIR monitoring temperature is provided in the following table for VCU Nominal

RAW value	Temperature (°C)
0	-91
49	-90
363	-88
832	-85
1299	-82
1609	-80
2075	-77
2539	-74
3003	-71
3464	-68
3925	-65
4095	-64

The calibration curve for SWIR monitoring temperature is provided in the following table for VCU Redundant

RAW value	Temperature (°C)
0	-91
49	-90
363	-88
832	-85
1299	-82
1609	-80
2075	-77
2539	-74
3003	-71
3464	-68
3925	-65
4095	-64

Note : At this stage of the development, both curves are identical but might be different according to the real temperature sensor specific calibration curve

4.8 Compression ratio (Secondary Header / IAD field / EVEN lines)

The Following table shows the implementation of the bits 0 to 7 (47 to 40 according to VCU bit numbering standard) of the IAD field / EVEN line.
Bit rate is equal to 0.04 times the raw value.
Compression ratio is equal to 300 divided by the raw value.

The calibration curve for compression ratio is provided in the following table

RAW value	Compression Ratio	Bitrate (bit per pixel)
150	2.000	6.0
145	2.069	5.8
140	2.143	5.6
135	2.222	5.4
130	2.308	5.2
125	2.400	5.0
121	2.479	4.84
117	2.564	4.68
113	2.655	4.52
109	2.752	4.36
105	2.857	4.20
101	2.970	4.04
98	3.061	3.92
96	3.125	3.84
94	3.191	3.76
90	3.333	3.60
87	3.448	3.48
84	3.571	3.36
80	3.750	3.20
78	3.846	3.12
75	4.000	3.00
73	4.110	2.92
71	4.225	2.84
69	4.348	2.76
67	4.478	2.68
65	4.615	2.60
63	4.762	2.52
61	4.918	2.44
59	5.085	2.36
57	5.263	2.28
55	5.455	2.20

4.9 System operation (Secondary Header / SAD field)

The Following table provides the implementation of system operation : bits 70 to 79 (9 to 0 according to VCU bit numbering standard) of the secondary header.

Mnemonic	*Value* **[hex]**	MSI Mode (10 bit)
INS-IMG	**0x000**	SPARE
INS-NOBS	**0x001**	Nominal Observation Mode
INS-EOBS	**0x002**	Extended Observation Mode
INS-DASC	**0x011**	Dark Signal Calibration Mode
INS-ABSR	**0x012**	Absolute Radiometry Calibration Mode
INS-VIC	**0x013**	Vicarious Calibration Mode
INS-RAW	**0x021**	Raw Measurement Mode
INS-TST	**0x022**	Test Mode

NB : other modes (INS-STB, INS-SRV, INS-DEC, …) where no data transmission is performed are not reflected in this table.