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JIRAM Planning/Commanding Concepts

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TABLE OF CONTENTS

ACRONYM & ABBREVIATION LIST

AD	Applicable Document
AI	Action Item
ASI	Agenzia Spaziale Italiana
CDR	Critical Design Review
C&DH	Command and Data Handling
CICD	Communication Interface Control Document
CIDL	Configuration Item Data List
EDAC	Error Detection And Correction
EGSE	Electrical Ground Support Equipment
EM	Electrical Model
ESA	European Space Agency
FM	Flight Model
FSW	Flight SW
GA	Galileo Avionica
HEX	Hexadecimal format
HK	Housekeeping
HW	Hardware
HSSL	High Speed Serial Link
IF	Interface
IR	Infrared
INAF	Istituto Nazionale di Astrofisica
ITAR	International Traffic in Arms Regulations
JSOC	Juno Science Operations Centre (at SwRI, Texas)
JPL	Jet Propulsion Laboratory
JIRAM	Jovian Infrared Auroral Mapper
LM	Lockheed Martin
LSSL	Low Speed Serial Link
NA	Not Applicable
NASA	National Aeronautics and Space Administration
PI	Principal Investigator
RD	Reference Document
RID	Review Item Discrepancy
SC	Spacecraft
SCR	SW Change Request
SDD	SW Design Document

DISTRIBUTION LIST

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DOCUMENT CHANGE LOG

Issue	Date	Pages/Paragraphs affected	Changes Description

APPLICABLE DOCUMENTS

The following documents at the latest issue in effect shall apply. These documents are herein referred as [AD-XX].

Id	*Document Number*	*Description*

REFERANCE DOCUMENTS

The following documents shall be used as reference background and support information. These documents are herein referred as [RD-XX].

Id	*Document Number*	*Description*
[RD-01]	JIRAM_INAF_IAPS-2014-03	JIRAM Operation Control Document Issue 05
[RD-02]	JIRAM_INAF_IAPS-2014-05	JIRAM Commanding Tool SW Requirement Issue 01

1 PURPOSE OF THIS DOCUMENT

The purpose of this document is to describe and formalize Concepts and Rules to be satisfied in order to correctly operate the JIRAM instrument, during the interplanetary cruise phase and the Routine Operation Phase on Jupiter.

2 JIRAM INSTRUMENT DESCRIPTION

JIRAM is equipped with a single telescope that accommodates both an infrared camera and a spectrometer to facilitate a large observational flexibility in obtaining simultaneous images in the L and M bands with the spectral radiance over the central zone of the images. Moreover, JIRAM will be able to perform spectral imaging of the planet in the 2.0-5.0 μm interval of wavelengths with a spectral resolution better than 10 nm. Instrument design, modes, and observation strategy will be optimized for operations onboard a spinning satellite in polar orbit around Jupiter. The JIRAM heritage comes from Italian-made, visual-infrared imaging spectrometers dedicated to planetary exploration, such as VIMS-V on Cassini, VIRTIS on Rosetta and Venus Express, and VIR-MS on the Dawn mission.
JIRAM combines two data channels in one instrument: the **imager** and the **spectrometer**, which are housed in the same optical subsystem (fig. 1). The instrument is composed of the Optical Head (OH) and the Main Electronic (ME). The ME contains the electronics to drive the Focal Plane Arrays (FPAs) and compensating mirror, and perform the acquisition and conversion of the science and housekeeping data. It also manages the operation of the two channels, gathers data and housekeeping information from them, stores the data, performs data compression, and interfaces the instrument with the spacecraft.

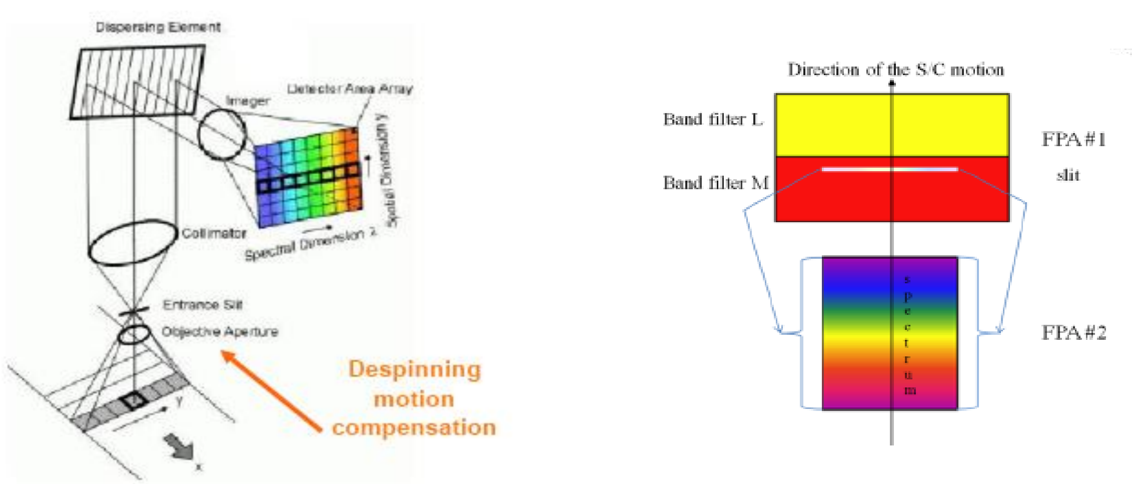

Fig. 2.1: the two FPAs

3 JIRAM INTERNAL REFERENCE SYSTEM

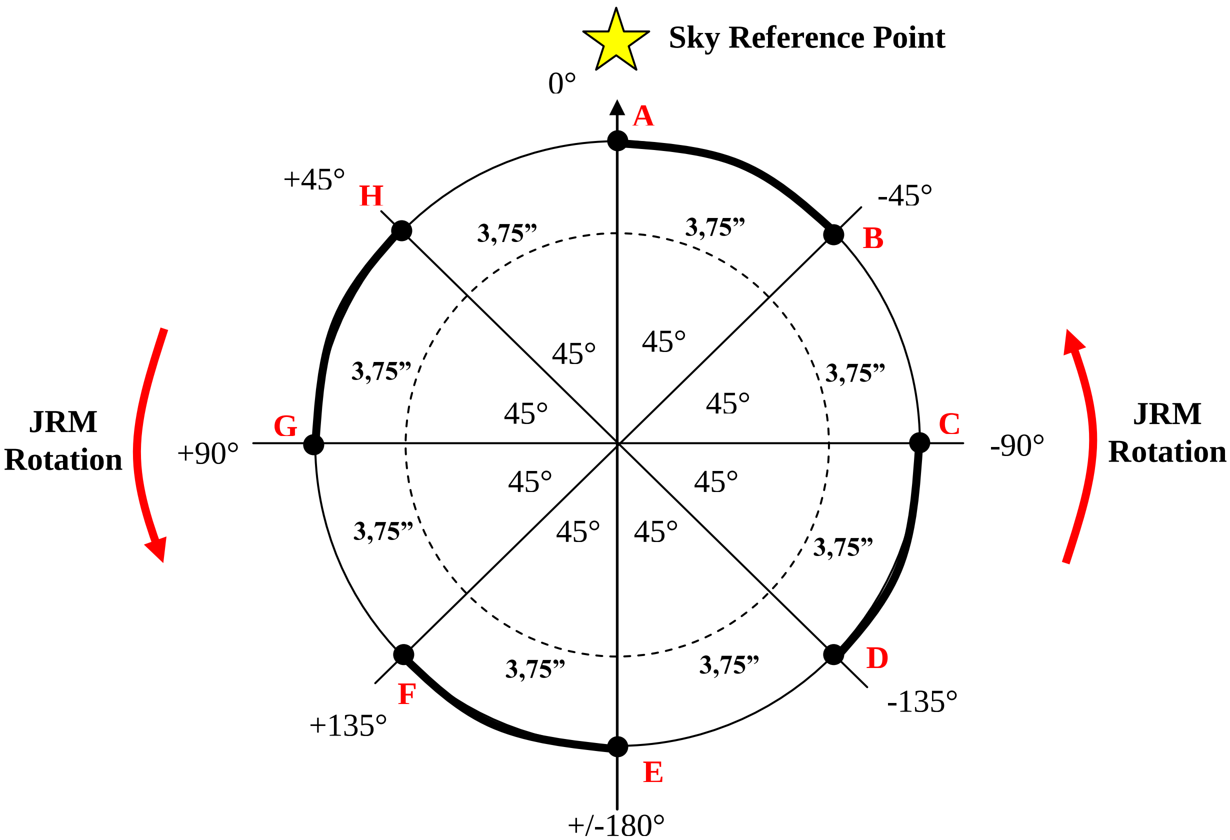

Fig 3.1

Considering a constant Spin rate of the SC of 30 seconds (SP_ACQ_DURATION = 30) and assuming that JIRAM is located in the position "A" (Sky Reference Point) when the Science Tele-Command (JRM_SCIENCE) is activated, for example at UTC 08:00:00.
Gradually, as time passes, the instrument first will explore the positive angles, from 0° to +/-180° and then the negative angles, from +/-180° till 0°.
At time UTC 08:00:15 the instrument will point the position "E" of the Sky and at UTC 08:00:30 the instrument will assume the same start position, highlighted with the letter "A" of Fig. 3.1. Indeed when the instrument ingests the Science Tele-Command, that in our example is at UTC 08:00:00, the instrument will go in science with one second of delay, due to the time necessary to arm the mirror motor.
The following two examples will better describe such mechanism:

3.1 OPERATIVE EXAMPLES

Example1:

NADIR_OFFSET_1 = -135° (Background)
NADIR_OFFSET_2 = 45° (Target)
SP_NADIR_DELTA = 0°
ACQ_DURATION = 30

- Science Tele-Command is activated at 08:00:00 UTC and JIRAM is in position "A"

- At 08:00:01 UTC starts the Science Cycle with the first acquisition (ACQ1), JIRAM believes to be in NADIR_OFFSET_1

- At 08:00:16 JIRAM performs the second acquisition (ACQ2)

- At 08:00:31 JIRAM ==> (ACQ1)

…
…

Example2:

NADIR_OFFSET_1 = 90° (Background)
NADIR_OFFSET_2 = -90° (Target)
SP_NADIR_DELTA = 0°
ACQ_DURATION = 30

- Science Tele-Command is activated at 08:00:00 UTC and JIRAM is in position "A"

- At 08:00:01 UTC starts the Science Cycle with the first acquisition (ACQ1), JIRAM believes to be in NADIR_OFFSET_1

- At 08:00:16 JIRAM performs the second acquisition (ACQ2)

- At 08:00:31 JIRAM ==> (ACQ1)

…
…

4 JIRAM IMAGER-SPECTROMETER ARCHITECTURE

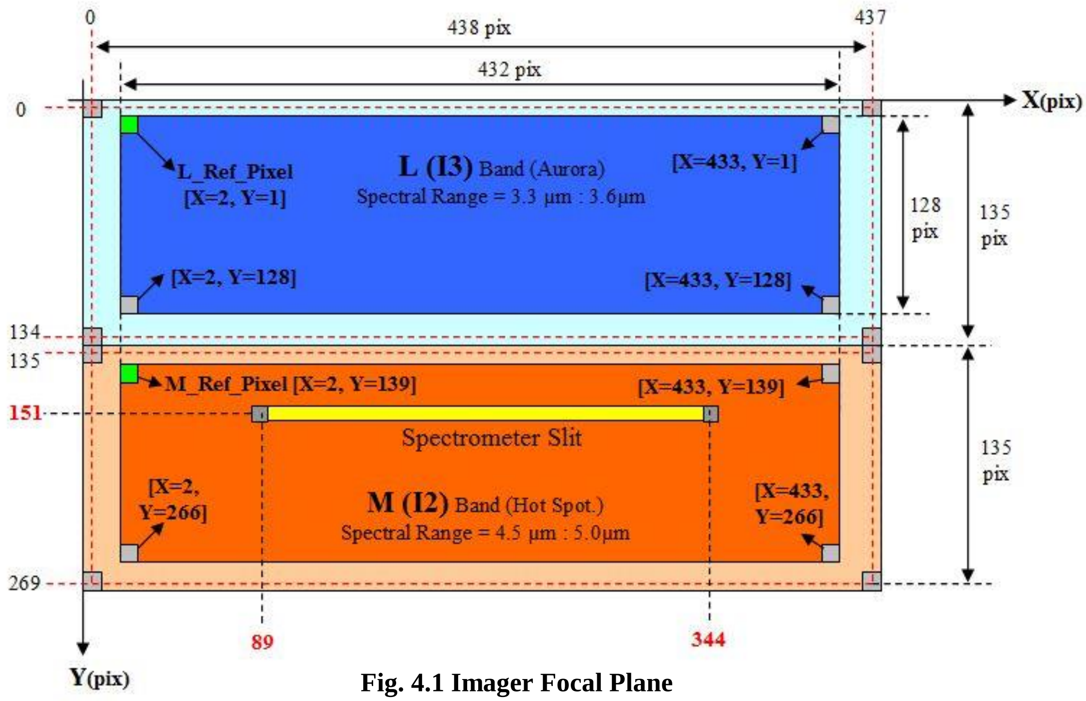

Fig. 4.1 Imager Focal Plane

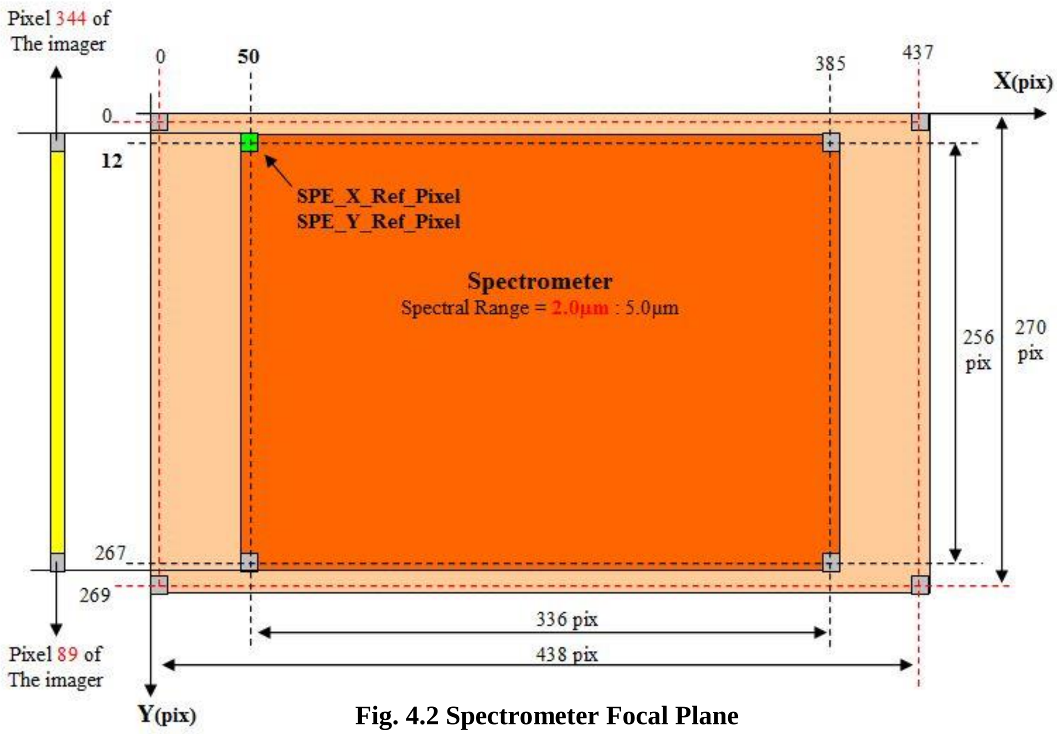

Fig. 4.2 Spectrometer Focal Plane

5 JIRAM OVERALL DATA VOLUME EVALUATION

5.1 SCIENCE AND CALIBRATION DV

$$Science\_DV\_bits = Nacq \cdot 16 \cdot \left[I \cdot \left(36 \cdot I\_Np + \frac{Slit\_I \cdot 432}{I\_Comp\_Factor} \right) + S \cdot \left(36 \cdot S\_Np + \frac{Slit\_S \cdot 336}{S\_Comp\_Factor} \right) \right]$$

$$Calibration\_DV\_bits = Nacq \cdot 6 \cdot 16 \cdot \left[I \cdot \left(36 \cdot I\_Np + \frac{Slit\_I \cdot 432}{I\_Comp\_Factor} \right) + S \cdot \left(36 \cdot S\_Np + \frac{Slit\_S \cdot 336}{S\_Comp\_Factor} \right) \right]$$

Where:

I_Np ➔ [3, 6]

I_Np = 3 ➔ if I2, I3
I_Np = 6 ➔ If I1

S_Np ➔ [3, 6]

S_Np = 3 ➔ if S2, S3
S_Np = 6 ➔ If S1

I ➔ [0,1].

I=0 ➔ Imager disabled
I=1 ➔ Imager enabled

S ➔ [0,1].

S=0 ➔ Imager disabled
S=1 ➔ Imager enabled

Slit_I ➔ [256, 128]

I1➔ Slit_I=256
I2➔ Slit_I=128 (band M) TBC
I3➔ Slit_I=128 (band L) TBC

Slit_S ➔ [256, 64, 16]

S1➔ Slit_S=256
S2➔ Slit_S=64
S3➔ Slit_S=16

I_Comp_Factor = [1; 4 : 8]   If I_Comp_Factor=1 ➔ Imager Compression disabled
S_Comp_Factor = [1; 1.5 : 2]   If S_Comp_Factor=1➔ Spectrometer Compression disabled

5.2 COMPRESSION FACTORS CONSIDERATIONS

In Thermo vacuum tests, due to the uniform environment, it is possible to set the maximum values for both the compression factors, as shown below:

I_Comp_Factor = 8
S_Comp_Factor = 2

In Routine Operations it is suggested to set the following Compression Factors to estimate the DV produced when the Compression is enabled:

I_Comp_Factor = 6
S_Comp_Factor = 1.5

5.3 HOUSE KEEPING DATA VOLUME

In each cycle of activity, the instrument produces a HK packet size equal to **1824** bits. The cycle of activity is expressed in seconds and it is defined by the Settable Parameter " **SP_TM_STATUS_PERIOD** " The default value is set to **10 sec**

5.4 EXAMPLE OF DATA VOLUME COMPUTATION

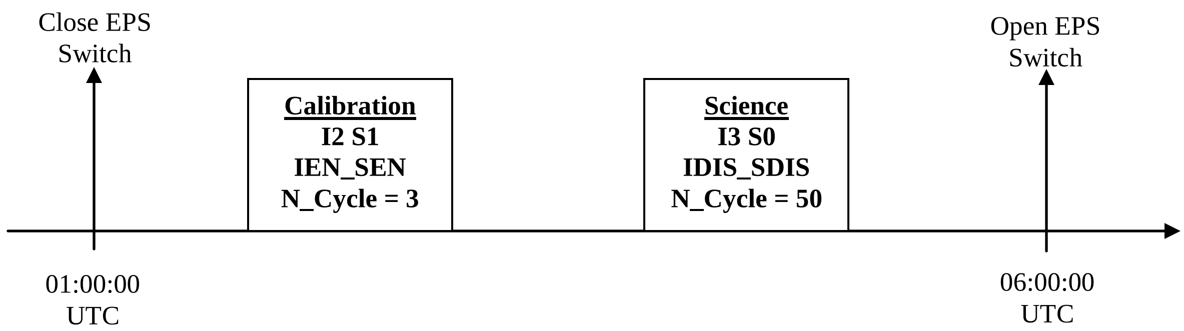

Fig. 5.4.1

Considering the following Compression Factors for the Imager and Spectrometer:

I_Comp_factor = 7
S_Comp_factor = 1.8

The data volume is

1) House Keeping DV

The total duration of the observation is 6 Hr (21600 sec). Considering an active cycle of 10 sec, the HK DV is:

HK_DV = (21600/10)*1824 **= 3939840 bit**

2) Calibration Segment DV = 16130908 bit

3) Science Segment DV= 44323200 bit

Total Data Volume = 3939840 + 16130908 + 44323200 **= 64393948 bit**

6 JIRAM SCIENCE TELE-COMAND DESCRIPTION

in each Space Craft revolution, the instrument execute two acquisitions, the collected data are stored in two temporary buffers (Buffer_A and Buffer_B). In routine operation the Spin Rate of the SC will be set to 2 rpm (12°/sec), while during the cruise phase the Spin Rate is 1 rpm (6°/sec).

The two acquisitions are characterized by the Science Tele-Command Parameters Setting, as described below:

The target type, acquired in the first observation and stored into the Buffer_A, depends on the parameter setting **SP_NADIR_OFFSET_1.**
Typically the first acquisition is the deep space (cold environment), where SP_NADIR_OFFSET_1 is set to -180°.

The target type, acquired in the second observation and stored into the Buffer_B, depends on the parameter setting **SP_NADIR_OFFSET_2.**
Typically the second acquisition is Jupiter, where SP_NADIR_OFFSET_2 is set to 0° (Nadir Observation).

Setting **SP_NADIR_OFFSET_1** and **SP_NADIR_OFFSET_2** it is possible to mix the typology of target (Jupiter, Cold environment, Star....) and the order of acquisition.

The first acquisition, stored in the Buffer_A (standard configuration) is characterized by the parameter **SP_BKG_RN**, with the following configurations:

SP_BKG_RN = 0 ➔ BKG. The Scanning Mirror is pointed on Calibration Lamps, that during the Science acquisitions are switched off. The mirror position is -12.377° and this position is stored and read in the **SP94** address of the **Settable Parameters.** Be careful to the wrong naming convention of this parameter **BKG** that indeed in not a Back Ground but a Dark !!

SP_BKG_RN = 1 ➔ RN. The exposition time is zero (20us), the measurement is not depending by the target

SP_BKG_RN = 2 ➔ **DARK** The Scanning Mirror points the centre of the filed of view (+6.4°), in this case the target is the deep cold space. The mirror position is stored and read in the **SP93** address of the **Settable Parameters**

-12.377° and this position is stored and led in the **SP94** address of the **Settable Parameters.** Be careful to the wrong naming convention of this parameter **DARK** that indeed in not a dark but a back ground !!

Another parameter that characterize the observation architecture is **SP_BKG_REPETITION.** The following schema highlights all the possible configurations:

Example 1

SP_BKG_REPETITION = 3, the sequence is:

X	**RN**	X	Target	X	Target	X	**RN**	X	………
Buffer_A	Buffer_B	Buffer_A	Buffer_B	Buffer_A	Buffer_B	Buffer_A	Buffer_B	Buffer_A	
Offset_1	Offset_2	Offset_1	Offset_2	Offset_1	Offset_2	Offset_1	Offset_2	Offset_1	
Round 1 (BKG)		Round 2		Round 3		Round 4 (BKG)		Round 5	

Typically X is the observation off Nadir (cold deep space) while Target is typically Jupiter. Note that the acquisition stored in the Buffer_B, of all the green blocks, is always RN(Read Out Noise); JIRAM is pointed to Jupiter while is performing RN, however the RN acquisition is not depending on the target type as the integration time is zero.
The subtraction of the two buffers is executed only if the parameter **SP_EN_DIS_BUB** is enabled(1), as following described:

Round 1 (BKG) ➔ **Buffer_A – Buffer_B** ➔ Data to Ground
Round 2 ➔ Buffer_B – Buffer_A ➔ Data to Ground
Round 3 ➔ Buffer_B – Buffer_A ➔ Data to Ground

Round 4 (BKG) ➔ **Buffer_A – Buffer_B** ➔ Data to Ground
………………………

In case the Subtraction in disabled (0) the instrument will execute the following actions

Round 1 (BKG) ➔ **Buffer_A – Buffer_B** ➔ Data to Ground
Round 2 ➔ Buffer_B ➔ Data to Ground
Round 3 ➔ Buffer_B ➔ Data to Ground

Round 4 (BKG) ➔ **Buffer_A – Buffer_B** ➔ Data to Ground

In this last case the Substruction is executed only in the(BKG) section

Example 2

SP_BKG_REPETITION = 0

Every SC revolution is a science acquisition (Target and Cold deep Space)

X	Target	X	Target	X	………
Buffer_A	Buffer_B	Buffer_A	Buffer_B	Buffer_A	
Offset_1	Offset_2	Offset_1	Offset_2	Offset_1	
Round 1		Round 2		Round 3	

For the Subtraction technique, refer to pervious example

Example 3

SP_BKG_REPETITION = 1

X	**RN**	X	**RN**
Buffer_A	Buffer_B	Buffer_A	Buffer_B
Offset_1	Offset_2	Offset_1	Offset_2
Round 1 (BKG)		Round 2 (BKG)	

Only BKG measurements will be executed, no science data take. The first acquisition (X) could be: DARK, BKG or RN, depending on the configuration of the parameter **SP_BKG_RN** and it is stored into Buffer_B. The second acquisition is always RN and it is stored into Bufffer_B

Compression and Subtraction are allowed, differently to the Science acquisition case, if the Subtraction is enabled, on ground the following product will be available:

Data On Ground = (Buffer A - Buffer B).

If the Subtraction is disabled, just the Buffer_A will be sent to ground

Another parameter that characterize the Science data take is **SP_ACQ_DURATION** that set the Spin Rate of the SC.

SP_ACQ_DURATION = 0 ➔ SC Dynamics Enabled

Two unlike events could be possible:

1. In case on anomaly, the SC could interrupt sending the SC dynamics to JIRAM, in this case the instrument will estimate the duration of the next acquisitions taking into account the latest available set of SC dynamics received by the SC. As soon as the link with the SC will be re-established , JIRAM will be automatically synchronized with the SC dynamics.

2. The SC dynamics were never sent to JIRAM, the instrument has not the possibility to estimate the Spin Rate of the SC; a default Science Observation will be performed.

SP_ACQ_DURATION = 30 ➔ SC Dynamics Disabled

The SC revolution has a fix dilatation of 30sec. As soon as the JIRAM Science Tele-Command is activated the instrument is set to stay in NADIR_OFFSET_1.

SP_NADIR_DELTA

Is the offset angle incrased every acquisition on **SP_NADIR_OFFSET_1/2.**

SP_EN_DIS_DOUC_SCI

This parameter, if enabled, permit the execution of double Science acquisition on Buffer_A and Buffer_B. The parameters necessary to configure JIRAM are:

1. **SP_EN_DIS_SUB** (must be disabled)
2. **SP_NADIR_OFFSET_1/2.**
3. **SP_BKG_REPETITION** (must be zero)
4. Mode I1S1 not allowed

6.1 Science Acquisition Duration

The duration of a generic Science segment is calculated by the following relation:

$$Science\_Segment\_duration\_Sec = (SP\_ACQ\_DURATION * SP\_ACQ\_N) + SP\_ACQ\_DURATION / 2$$

This formula has been tested and validated in JC023

7 JIRAM Calibration Tele-comand Description

In each Calibration Sequence JIRAM produces twelve products, six products for the Imager and six products for the Spectrometer. The generic cycle, valid for both the detectors is composed by the following steps:

1. Acq Readout Noise
2. Acq. BKG or DARK
3. Acq. Lamp_1 Setting
4. Acq. Lamp_2 Setting
5. Acq. Dark
6. Acq. BKG

The duration of the Calibration Segment is shown in the following equation:

$$Calibration\_DV\_bits = Nacq \cdot 240$$

8 CRUISE OPERATIONS LESSON LEARNED & EXPRESS RULES

JIRAM_MOTOR

If the field MOTR_MODE is set to "POINT" then MOTOR_MIRROR_DIRECTION mast be set to "1" (COUNTERCLOCKWISE)

DATA COMPRESSION

The compression algorithms performances are not efficient with the very noisy data. this is the case when the environment temperature exceed 100 K; however when the compression is enabled on the Spectrometer then the Subtraction must be also enabled.

DETECTORS WARKING RANGE

In order to avoid a fast aging of the detectors, the working temperature should be below 100 K.

EXPOSITION TIME & DESPINNING MIRROR

The maximum exposition time depends on the de-spinning mirror time that is 1.1sec. In case the de-spinning mirror is fix on the target, the exposition time can assume the max value of 10 sec.

READ OUT NOISE CONSIDERATION

When READ OUT NOIS is enabled the exposition time is automatically set to "0" by the onboard SW even if the user set a value greater than "0" in the Science Tele-Command field

DATA TRANSFERT RATE

Thanks to the data overflow that happened on JC023, it has been possible to calculate the data transfer rate from the Hard Partition Memory to the Soft Partition Memory, that is:

Data Transfert Rate = **4,428 Mbit/Sec**

Hard Partition Size = 537 Mbit
Soft Partition Size = 3204 Mbit

NADIR SCAN SETTING

The Nadir Scan Observation is achievable setting a negative angle in the NADIR_OFFSET_2 Science Tele-Command parameter, because the DELTA_NADIR can assume just positive values.

9 THERMAL DPU ONBOARD SW ANOMALY

During cruise operations we realized that due to a on board SW bag the thermal DPU is automatically disabled as soon as after the Power On Sequence and every time the JRM_SAFE Tele-Command is executed by the instrument.
In order to re-enable the DPU thermal control it in necessary to execute the JRM_DEF_PAR(6000) Tele-Command after the Power On Sequence and before the STBY Sequence.
In case during the sequence, for some reason, it is necessary to executed the JRM_SAFE Tele-Command remember that the next Tele-Command must be JRM_DEF_PAR(6000) because the JRM_SAFE Tc disables the DPU Thermal Control.

In order to mitigate the risk of error by the JIRAM Operation Team, the following update of the Onboard SC Power On Block, will be implemented by LM before to reach Jupiter: