TECHNICAL NOTE

TITLE: INTEGRAL AOCS AND INSTRUMENTS - POINTING & ALIGNMENT BUDGET

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1. INTRODUCTION

This technical note is the natural evolution of the previous document INT-TN-AI-0170, Instruments Pointing Performance, Issue 01, 15/10/99, issued for INTEGRAL CDR and based on the STM alignment campaign data.

This current document is basically structured as the old one, and presents the following results:

- AOCS Pointing Error Budget
- INSTRUMENTS Pointing Error Budget
- INSTRUMENTS On-ground Alignment, as derived from last FM alignment campaign
- INSTRUMENTS Overall Pointing Performance

For absolute errors the analysed cases are:
- Hot steady state
- Cold steady state

For drift and relative errors the analysed cases are:
- Eclipse transient
- Slew transient, this one being an artificial case, which has been introduced as a reference only.

Note for the Readers:
In the following Tables, the nomenclature Rx, Ry, Rz is referring to rotation around the corresponding INTEGRAL S/L axes (see RD (11) for details). All numerical values are expressed in arcseconds, unless otherwise specified.

2. DOCUMENTS

The following documents, in their latest issue, have been taken as reference to compile the AOCS and INSTRUMENTS pointing and alignment budgets.

AOCS

RD (01) INT-TN-MMB-0027
INTEGRAL AOCS Pointing Budget

RD (02) INT-RP-GAL-0003
Addendum to the STR Design Report Applicable for INTEGRAL

RD (03) XM-RP-GAL-0005
Design Analysis Report of the STR

RD (04) INT-TR-GAL-0014
INTEGRAL STR FM 04 Summary Test Report

RD (05) INT-TR-GAL-0018
INTEGRAL STR FM 05 Summary Test Report

RD (06) IN-RP-ADC-0005
INTEGRAL FSS Performance Summary for FSS S/N 008, 009, 0010,0011; FSSE SN 006, 007

S/C STRUCTURE & THERMOELASTIC

RD (07) INT-TN-AI-0149
INTEGRAL Structure Stability Analysis

RD (08) INT-TN-AI-0021
INTEGRAL Thermal Mathematical Model and Analysis Results Description

ORBITAL EFFECTS

RD (09) ESOC Memo – 13 November 1996

RD (10) INT-RP-MMB-0025
IPS Performance Review Document

FM ON-GROUND ALIGNMENT

RD (11) INT-RP-AI-0231, Issue 01, 13/06/02
INTEGRAL Alignment Summary Report

RD (12) ASPI-01-BO/IT/MP-69
Pre Sine Alignment at Estec Test Report

RD (13) ASPI-01-BO/IT/MP-76
Post Sine Alignment at Estec Test Report

RD (14) ASPI-02-BO/IT/MP-31
Post TV/TB Alignment at Estec Test Report

3. AOCS POINTING ERROR BUDGET

3.1 Statistical Rules

To understand the following table-calculations the reader must know that, as a general rule, every error contribution is assigned a deterministic and a non-deterministic part identified in tables as Mean and 3σ values.

Then, Mean values are added linearly

$M = \sum_i m_i$

while Standard Deviations values are root sum squared

$\sigma = \sqrt{\sum \sigma_i^2}$

throughout all the contributions.

For the APE as an example:

i = star catalogue, change of guide star,………., noise/quantisation effects.

The AOCS pointing error budget is mainly based on the contents of RD (01) and refers to Inertial Pointing Mode stand-still performances because scientific observations will be made in this mode.

3.2 AOCS Absolute Pointing Error (APE) and Absolute Measurement Accuracy (AMA)

3.2.1 General Considerations

The classes of contribution to APE are:

Systematic (time invariant)
Long Term (variable over a time span of the order of 10^5 s)
Short Term (variable over a time span of the order of 10^3 s)
Random (having a frequency equal or lower than the AOCS duty cycle).

Systematic errors are further subdivided into 4 blocks:

- General (controller, operational aspects)
- Star Tracker
- Fine Sun Sensor
- FSS to STR calibration

Long Term are subdivided into:

- STR internal
- FSS internal
- FSS to STR thermoelastic

This last one is the relative deformation between the FSS and the STR in roll and depends strongly on the thermal case chosen; we have decided to consider the two extreme thermal conditions, hot and cold; there is a small cross-coupling effect on the other axes which is defined on the basis of the model shown in RD (10). Strictly speaking this is a “structural” effect, however it has been included in the AOCS budget because its consequence are on the AOCS pointing performance itself.

Note that the STR distortion due to S/C structure has been deleted from AOCS and it appears in the Instruments Alignment because it does not impact the AOCS itself but the relative alignment between the STR X-axis direction (reference for the AOCS) and the Instrument Line of Sight (ILS) directions.

Short Term structural effects are included into the Long Term because they are essentially thermoelastic effects; there are no proper AOCS short-term effects.

Random effects are true AOCS effects and are due to sensors noise and quantisation phenomena.

The AMA classes of contribution are the same of APE.
In general, because it is not possible to calibrate the attitude w.r.t. the instrument directions, the measurement error is equivalent to the pointing error except for the Controller offset and the Change of guide star errors which can be suppressed by reconstructing the attitude with the STR and FSS outputs.
Note that the change of guide star is performed from Ground in preparation of a slew and therefore can be corrected when the attitude is reconstructed.
In addition the STR bias can be reduced by a factor $1/\sqrt{5}$ using the measured positions of all the 5 stars present in the STR FOV.
Because the FSS to STR misalignment in roll can be measured it should be possible to use it for getting rid of thermoelastic deterministic contribution. However, for the moment this hypothesis is not implemented in the calculations. The benefits would principally be in roll, but some reduction of cross coupling in pitch and yaw would also be gained.

3.2.2 AOCS APE and AMA - Hot Steady State

This case is based on the FSS/STR thermoelastic deformation as calculated in the structure stability analysis hot thermal case, RD (07).
Note that:

- The above effect has been introduced as a longterm effect (i.e. variable) but it may also be appropriate to consider it a systematic effect, as it has been evaluated with a steady state analysis. From the calculation point of view this does not bear significant differences.

- In this budget it is assumed that the FSS/STR distortion is not calibrated and the figure given is an absolute worst case. In flight a check should be done and a calibration could be attempted, although the main contribution from this source is on roll which is never critical.

- The FSS/STR thermoelastic deformation is blinded reported in the AMA; however if there is a calibration in flight it may be significantly reduced; the same observation on the axis is valid.

AOCS ABSOLUTE POINTING ERROR (APE) - Hot Case

	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
Star Catalogue	0.0	0.0	0.0	1.4	1.5	1.5	1.4	1.5	1.5	-1.4	-1.5	-1.5			
Change of guide star	0.0	0.0	0.0	6.9	7.6	7.6	6.9	7.6	7.6	-6.9	-7.6	-7.6			
Controller offset	0.0	0.0	0.0	3.8	0.3	0.3	3.8	0.3	0.3	-3.8	-0.3	-0.3			
STR switch-on to switch-on	0.0	0.0	0.0	2.7	3.0	3.0	2.7	3.0	3.0	-2.7	-3.0	-3.0			
STR ageing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
STR bias (at 22 deg)	0.0	0.0	0.0	0.0	3.6	3.6	0.0	3.6	3.6	0.0	-3.6	-3.6			
STR internal alignment knowledge(pre-la	0.0	0.0	0.0	3.6	4.0	4.0	3.6	4.0	4.0	-3.6	-4.0	-4.0			
STR internal alignment change at launch	0.0	0.0	0.0	3.4	3.8	3.8	3.4	3.8	3.8	-3.4	-3.8	-3.8			
FSS ageing	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.0	0.0	-0.3	0.0	0.0			
FSS bias (at 75 deg)	0.0	0.0	0.0	58.0	1.5	2.0	58.0	1.5	2.0	-58.0	-1.5	-2.0			
FSS/STR calibration error	0.0	0.0	0.0	42.6	1.1	1.5	42.6	1.1	1.5	-42.6	-1.1	-1.5			
SYSTEMATIC	**0**	**0**	**0**	**73**	**11**	**11**	**73**	**11**	**11**	**-73**	**-11**	**-11**			
STR internal electronics-thermoelastic	0.0	0.0	0.0	0.0	2.4	2.4	0.0	2.4	2.4	0.0	-2.4	-2.4			
FSS internal electronics-thermoelastic	0.0	0.0	0.0	25.2	0.7	0.9	25.2	0.7	0.9	-25.2	-0.7	-0.9			
FSS/STR thermoelastic (structure)	83.0	2.2	2.9	12.5	0.3	0.4	95.5	2.5	3.3	70.6	1.8	2.5			
LONG TERM	**83**	**2**	**3**	**28**	**3**	**3**	**111**	**5**	**5**	**55**	**0**	**0**			
Noise/quantisation effects	0.0	0.0	0.0	4.1	2.8	2.9	4.1	2.8	2.9	-4.1	-2.8	-2.9			
SPI Compressor Induced Disturbance	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	-1.0	-1.0	-1.0			
SHORT TERM/RANDOM	**0**	**0**	**0**	**4**	**3**	**3**	**4**	**3**	**3**	**-4**	**-3**	**-3**			
APE	**83**	**2**	**3**	**78**	**12**	**12**	**161**	**14**	**15**	**5**	**-10**	**-9**	**739**	**286**	**285**
REQUIREMENT	**0**	**0**	**0**	**900**	**300**	**300**	**900**	**300**	**300**	**-900**	**-300**	**-300**			

AOCS ABSOLUTE MEASUREMENT ACCURACY (AMA) - Hot Case

	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
Star Catalogue	0.0	0.0	0.0	1.4	1.5	1.5	1.4	1.5	1.5	-1.4	-1.5	-1.5			
STR switch-on to switch-on	0.0	0.0	0.0	2.7	3.0	3.0	2.7	3.0	3.0	-2.7	-3.0	-3.0			
STR ageing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
STR bias (at 22 deg)	0.0	0.0	0.0	0.0	3.6	3.6	0.0	3.6	3.6	0.0	-3.6	-3.6			
STR internal alignment knowledge(pre-la	0.0	0.0	0.0	3.6	4.0	4.0	3.6	4.0	4.0	-3.6	-4.0	-4.0			
STR internal alignment change at launch	0.0	0.0	0.0	3.4	3.8	3.8	3.4	3.8	3.8	-3.4	-3.8	-3.8			
FSS ageing	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.0	0.0	-0.3	0.0	0.0			
FSS bias (at 75 deg)	0.0	0.0	0.0	58.0	1.5	2.0	58.0	1.5	2.0	-58.0	-1.5	-2.0			
FSS/STR calibration error	0.0	0.0	0.0	42.6	1.1	1.5	42.6	1.1	1.5	-42.6	-1.1	-1.5			
SYSTEMATIC	**0**	**0**	**0**	**72**	**8**	**8**	**72**	**8**	**8**	**-72**	**-8**	**-8**			
STR internal electronics-thermoelastic	0.0	0.0	0.0	0.0	2.4	2.4	0.0	2.4	2.4	0.0	-2.4	-2.4			
FSS internal electronics-thermoelastic	0.0	0.0	0.0	25.2	0.7	0.9	25.2	0.7	0.9	-25.2	-0.7	-0.9			
FSS/STR thermoelastic (structure)	83.0	2.2	2.9	12.5	0.3	0.4	95.5	2.5	3.3	70.6	1.8	2.5			
LONG TERM	**83**	**2**	**3**	**28**	**3**	**3**	**111**	**5**	**5**	**55**	**0**	**0**			
Noise/quantisation effects	0.0	0.0	0.0	4.1	2.8	2.9	4.1	2.8	2.9	-4.1	-2.8	-2.9			
SPI Compressor Induced Disturbance	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	-1.0	-1.0	-1.0			
SHORT TERM/RANDOM	**0**	**0**	**0**	**4**	**3**	**3**	**4**	**3**	**3**	**-4**	**-3**	**-3**			
AMA	**83**	**2**	**3**	**78**	**9**	**9**	**161**	**11**	**12**	**5**	**-7**	**-6**	**19**	**49**	**48**
REQUIREMENT	**0**	**0**	**0**	**180**	**60**	**60**	**180**	**60**	**60**	**-180**	**-60**	**-60**			

3.2.3 AOCS APE and AMA - Cold Steady State

This case is based on the FSS/STR thermoelastic deformation as calculated in the structure stability analysis cold thermal case, RD (07).

The same observations done for the hot case apply

AOCS ABSOLUTE POINTING ERROR (APE) - Cold Case															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
Star Catalogue	0.0	0.0	0.0	1.4	1.5	1.5	1.4	1.5	1.5	-1.4	-1.5	-1.5			
Change of guide star	0.0	0.0	0.0	6.9	7.6	7.6	6.9	7.6	7.6	-6.9	-7.6	-7.6			
Controller offset	0.0	0.0	0.0	3.8	0.3	0.3	3.8	0.3	0.3	-3.8	-0.3	-0.3			
STR switch-on to switch-on	0.0	0.0	0.0	2.7	3.0	3.0	2.7	3.0	3.0	-2.7	-3.0	-3.0			
STR ageing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
STR bias (at 22 deg)	0.0	0.0	0.0	0.0	3.6	3.6	0.0	3.6	3.6	0.0	-3.6	-3.6			
STR internal alignment knowledge(pre-launch)	0.0	0.0	0.0	3.6	4.0	4.0	3.6	4.0	4.0	-3.6	-4.0	-4.0			
STR internal alignment change at launch	0.0	0.0	0.0	3.4	3.8	3.8	3.4	3.8	3.8	-3.4	-3.8	-3.8			
FSS ageing	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.0	0.0	-0.3	0.0	0.0			
FSS bias (at 75 deg)	0.0	0.0	0.0	58.0	1.5	2.0	58.0	1.5	2.0	-58.0	-1.5	-2.0			
FSS/STR calibration error	0.0	0.0	0.0	42.6	1.1	1.5	42.6	1.1	1.5	-42.6	-1.1	-1.5			
SYSTEMATIC	**0**	**0**	**0**	**73**	**11**	**11**	**73**	**11**	**11**	**-73**	**-11**	**-11**			
STR internal electronics-thermoelastic	0.0	0.0	0.0	0.0	2.4	2.4	0.0	2.4	2.4	0.0	-2.4	-2.4			
FSS internal electronics-thermoelastic	0.0	0.0	0.0	25.2	0.7	0.9	25.2	0.7	0.9	-25.2	-0.7	-0.9			
FSS/STR thermoelastic (structure)	99.0	2.6	3.5	14.9	0.4	0.5	113.9	3.0	4.0	84.2	2.2	2.9			
LONG TERM	**99**	**3**	**3**	**29**	**3**	**3**	**128**	**5**	**6**	**70**	**0**	**1**			
Noise/quantisation effects	0.0	0.0	0.0	4.1	2.8	2.9	4.1	2.8	2.9	-4.1	-2.8	-2.9			
SPI Compressor Induced Disturbance	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	-1.0	-1.0	-1.0			
SHORT TERM/RANDOM	**0**	**0**	**0**	**4**	**3**	**3**	**4**	**3**	**3**	**-4**	**-3**	**-3**			
APE	**99**	**3**	**3**	**79**	**12**	**12**	**178**	**14**	**15**	**20**	**-9**	**-9**	**722**	**286**	**285**
REQUIREMENT	**0**	**0**	**0**	**900**	**300**	**300**	**900**	**300**	**300**	**-900**	**-300**	**-300**			

AOCS ABSOLUTE MEASUREMENT ACCURACY (AMA) - Cold Case	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
Star Catalogue	0.0	0.0	0.0	1.4	1.5	1.5	1.4	1.5	1.5	-1.4	-1.5	-1.5			
STR switch-on to switch-on	0.0	0.0	0.0	2.7	3.0	3.0	2.7	3.0	3.0	-2.7	-3.0	-3.0			
STR ageing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
STR bias (at 22 deg)	0.0	0.0	0.0	0.0	3.6	3.6	0.0	3.6	3.6	0.0	-3.6	-3.6			
STR internal alignment knowledge(pre-launch)	0.0	0.0	0.0	3.6	4.0	4.0	3.6	4.0	4.0	-3.6	-4.0	-4.0			
STR internal alignment change at launch	0.0	0.0	0.0	3.4	3.8	3.8	3.4	3.8	3.8	-3.4	-3.8	-3.8			
FSS ageing	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.0	0.0	-0.3	0.0	0.0			
FSS bias (at 75 deg)	0.0	0.0	0.0	58.0	1.5	2.0	58.0	1.5	2.0	-58.0	-1.5	-2.0			
FSS/STR calibration error	0.0	0.0	0.0	42.6	1.1	1.5	42.6	1.1	1.5	-42.6	-1.1	-1.5			
SYSTEMATIC	**0**	**0**	**0**	**72**	**8**	**8**	**72**	**8**	**8**	**-72**	**-8**	**-8**			
STR internal electronics-thermoelastic	0.0	0.0	0.0	0.0	2.4	2.4	0.0	2.4	2.4	0.0	-2.4	-2.4			
FSS internal electronics-thermoelastic	0.0	0.0	0.0	25.2	0.7	0.9	25.2	0.7	0.9	-25.2	-0.7	-0.9			
FSS/STR thermoelastic (structure)	99.0	2.6	3.5	14.9	0.4	0.5	113.9	3.0	4.0	84.2	2.2	2.9			
LONG TERM	**99**	**3**	**3**	**29**	**3**	**3**	**128**	**5**	**6**	**70**	**0**	**1**			
Noise/quantisation effects	0.0	0.0	0.0	4.1	2.8	2.9	4.1	2.8	2.9	-4.1	-2.8	-2.9			
SPI Compressor Induced Disturbance	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	-1.0	-1.0	-1.0			
SHORT TERM/RANDOM	**0**	**0**	**0**	**4**	**3**	**3**	**4**	**3**	**3**	**-4**	**-3**	**-3**			
AMA	**99**	**3**	**3**	**78**	**9**	**9**	**177**	**12**	**13**	**21**	**-6**	**-6**	**3**	**48**	**47**
REQUIREMENT	**0**	**0**	**0**	**180**	**60**	**60**	**180**	**60**	**60**	**-180**	**-60**	**-60**			

3.3 Absolute Pointing Drift (APD) and Relative Pointing Error (RPE)

3.3.1 General Considerations

Because the thermoelastic behaviour of the S/C has a big influence on the AOCS APD due to the FSS to STR misalignment, two cases are treated separately:

Eclipse transient:
This is the most realistic because it is based on the true transient thermoelastic analysis; coherently with the Alignment budget calculation, the deformation between the FSS and the STR is obtained taking the deformation difference between 100000 s and 1000 s and between 2000 s and 1000 s and further making their difference; this gives deformation between 2000 and 100000 s after the end of the eclipse.

Slew transient:
This is less realistic because no pure transient case was done and the approach is to subtract the deformation in cold case from the deformation in hot case.

In the RPE we have included the noise/quantisation effects, already appearing in the APE.
AOCS Transients at the end of a slew may be included or not , depending on the timing of performance evaluation.
In general we could say that we are interested in performance from the moment at which the On Target Flag is supplied by the ACC to the Instruments (via the OBDH bus and the CDMU). If we wait enough for the Transients to die out then they have not to be accounted in the RPE budget; simulations have proven that in few seconds from the end of a slew Transients are negligible. Because this time is deemed acceptable Transients are not included.
Also in this case, given the importance of thermoelastic effects, there are two cases, eclipse and slew; however here the approach is to take 1/10 of the long term distortions derived above for the APD from the thermoelastic analyses because no other data are effectively available.

According to the two thermal cases there are two separate AOCS APD/RPE budgets.

3.3.2 AOCS APD and RPE - Eclipse Transient

This AOCS Budget is based on the FSS/STR deformation obtained in the structure stability analysis, eclipse transient case, RD (07). The difference between distortion at 100000 s and at 2000 s constitutes the long-term contribution in the APD.
The short term contribution is deliberately taken as 1/10 of the above figure and used in the RPE.

AOCS ABSOLUTE POINTING DRIFT (APD) - Eclipse Transient	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
STR internal electronics-thermoelastic	0.0	0.0	0.0	0.0	2.4	2.4	0.0	2.4	2.4	0.0	-2.4	-2.4			
FSS internal electronics-thermoelastic	0.0	0.0	0.0	25.2	0.8	0.8	25.2	0.8	0.8	-25.2	-0.8	-0.8			
FSS/STR thermoelastic (structure)	60.0	1.6	2.1	9.0	0.2	0.3	69.0	1.8	2.4	51.0	1.3	1.8			
SPI Compressor Induced Disturbance	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	-1.0	-1.0	-1.0			
APD	**60**	**2**	**2**	**27**	**3**	**3**	**87**	**4**	**5**	**33**	**-1**	**-1**	**33**	**32**	**31**
REQUIREMENT	**0**	**0**	**0**	**120**	**36**	**36**	**120**	**36**	**36**	**-120**	**-36**	**-36**			

AOCS RELATIVE POINTING ERROR (RPE) - Eclipse Transient	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
FSS/STR thermoelastic (structure)	6.0	0.2	0.2	0.9	0.0	0.0	6.9	0.2	0.2	5.1	0.1	0.2			
Transients	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
Noise/quantisation effects	0.0	0.0	0.0	6.3	2.3	2.4	6.3	2.3	2.4	-6.3	-2.3	-2.4			
SPI Compressor Induced Disturbance	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	-1.0	-1.0	-1.0			
RPE	**6**	**0**	**0**	**6**	**2**	**2**	**12**	**2**	**3**	**0**	**-2**	**-2**	**48**	**16**	**15**
REQUIREMENT	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			

3.3.3 AOCS APD and RPE - Slew Transient

This AOCS budget is done by taking the FSS/STR thermoelastic deformation in hot steady state and cold stedy state, as from RD (07), and making their difference to get the contribution to APD (long term).
The equivalent contribution to RPE is deliberately assumed 1/10 of the above figure (short term).

AOCS ABSOLUTE POINTING DRIFT (APD) - Slew Transient															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
STR internal electronics-thermoelastic	0.0	0.0	0.0	0.0	2.4	2.4	0.0	2.4	2.4	0.0	-2.4	-2.4			
FSS internal electronics-thermoelastic	0.0	0.0	0.0	25.2	0.8	0.8	25.2	0.8	0.8	-25.2	-0.8	-0.8			
FSS/STR thermoelastic (structure)	-16.0	-0.4	-0.6	-2.4	-0.1	-0.1	-18.4	-0.5	-0.6	-13.6	-0.4	-0.5			
SPI Compressor Induced Disturbance	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	-1.0	-1.0	-1.0			
APD	**-16**	**0**	**-1**	**25**	**3**	**3**	**9**	**2**	**2**	**-41**	**-3**	**-3**	**79**	**33**	**33**
REQUIREMENT	**0**	**0**	**0**	**120**	**36**	**36**	**120**	**36**	**36**	**-120**	**-36**	**-36**			

AOCS RELATIVE POINTING ERROR (RPE) - Slew Transient															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
FSS/STR thermoelastic (structure)	-1.6	0.0	-0.1	-0.2	0.0	0.0	-1.8	0.0	-0.1	-1.4	0.0	0.0			
Transients	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
Noise/quantisation effects	0.0	0.0	0.0	6.3	2.3	2.4	6.3	2.3	2.4	-6.3	-2.3	-2.4			
SPI Compressor Induced Disturbance	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	-1.0	-1.0	-1.0			
RPE	**-2**	**0**	**0**	**6**	**2**	**2**	**5**	**2**	**2**	**-8**	**-2**	**-2**	**52**	**16**	**16**
REQUIREMENT	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			

4. ALIGNMENT ERROR BUDGET

4.1 Overall Misalignment Error

For the Overall Misalignment Error (OME), which is proper of the S/C structure, we practically have only systematic errors further subdivided into:

- Alignment Measurement Accuracy
- Launch Setting
- Gravity Release
- Moisture Release and Outgassing
- S/L Thermoelastic Distortion
- STR Thermoelastic Distortion

Among them only the thermoelastic contributions are different in different S/L attitudes and at different times along the mission life. The analyses and therefore budgets are done using two extreme thermal cases (see paragraph 3.6 for details).

Using these two extreme cases imply that no further variations have to be taken into account, hence no long term and short term contributions are assumed.
There are, obviously, no significant random contributions.

4.2 Overall Misalignment Error (post-facto determination)

Without further in-flight measurement of the Instruments alignment it is necessary to assume that the alignment error is completely reproduced as a measurement error.

4.3 Misalignment Variation – Long Term

The only long-term (10^5 s) variation contribution is due to the S/L thermoelastic deformation.
As discussed in the AOCS sections we calculate the Instrument depointing for two transients, eclipse and slew (see paragraph 3.6).

Short Term is encompassed in the Long Term contribution because this is physically sound; it is also shown by thermoelastic analysis, that the deformation curve is monotonically increasing and there is no temperature over-shoot, at least after the first 2000 s from the eclipse exit.

4.4 Misalignment Variation – Short Term

Also the short term (10^3 s) variation contribution is only due to the S/L thermoelastic deformation.
The transients used are the same of the long term analysis, but those numbers are scaled linearly to the time relevant for short term budget, taking 1/10 of the long term deformations.

4.5 Statistical rules

As for the AOCS a general valid rule is that every error contribution is assigned a deterministic and a non-deterministic part, identified in table as Mean and 3σ.
Then, Means are added linearly

$M = \sum_i m_i$

While Standard Deviations are root sum squared

$\sigma = \sqrt{\sum \sigma_i^2}$

throughout all the contributions.

For example in the OME:

i = sine + pyro, acoustic noise,………., STR thermoelastic distortion

Note that there are no separate table-budgets for alignment; the alignment contribution is always encompassed in the total error tables of chapter 5.

4.6 Thermoelastic Contributions

The thermoelastic behaviour of the structure may contribute to the alignment errors in two ways.

Steady-state Cases

Firstly there is a systematic contribution due to the fact that at any moment of the mission the S/C temperature distribution is different from ground and therefore introduces a distortion into the structure w.r.t. the rest (ground) condition.
Among the whole set of thermal cases, two are identified as the extreme ones (the names are derived from the Thermal Analysis document, RD (08):

Cold case for PLM

- sun illuminating the bottom of the satellite, SAA = (40^0 in pitch, 0^0 in roll)
- summer solar constant = 1321 W/m^2
- beginning of life thermal parameters (usually parameters life-degradation causes an increase of the mean temperatures)

Hot case for PLM

- sun illuminating the top of the satellite, SAA = (-40^0 in pitch, $+5^0$ in roll)
- winter solar constant = 1423 W/m^2
- end of life thermal parameters

In the rest of the document they are simply called Cold Case and Hot Case.

Transient Cases

Secondly there is a “variable” contribution; however, after many thinking iterations we reached the conclusions that, when speaking of OME and its measurement, the two steady state cases above do include every other long term behavior, because no further variations of the temperatures are possible.
The long-term behaviour is instead important when considering the Misalignment Variation over 10^3 and 10^5 s and this is discussed below.

As for the AOCS we are interested into variations over a time frame of 10^3 and 10^5 s; there are two mission conditions for which the thermal environment of the S/C changes significantly over those time frames:

- Exit from eclipse
- Slew manoeuvre from a hot attitude (sun from the top of the S/C) to a cold attitude (sun from the bottom of the S/C), or viceversa.

For the eclipse, to guarantee that the worst case situation (i.e. the largest possible variation of temperatures) is analysed the S/C is slewed from cold to hot attitude right before entering eclipse (the slew duration is assumed to be 1600 s ≈ 26 min). This is done for keeping the analysis within a “feasible” scheme of operations as it would not be possible to slew the S/C in eclipse. In this way the S/C is partially warmed before it starts cooling down in the subsequent eclipse.
The analysis is however done assuming a winter solstice (i.e. perigee passage followed by eclipse) but with an eclipse duration of 1.8 hrs (summer eclipse); this means that the S/C is let cooling down more than in the real case.
These two things together let us be sufficiently confident that a “realistic” worst case is analysed.
For the eclipse case a true “thermal transient simulation” is performed calculating the temperatures of the nodes at different times and then evaluating the structure Δ-deformation as follows:

- Between 10^5 s and 2000 seconds after the eclipse exit for the long term contribution
  1/10 of the deformation above to represent the behaviour between 3000 s and 2000 s after the eclipse exit

For the slew case a true thermal transient is not available; for this reason it was decided to represent the “slew” transient by taking:

- the deformation in hot state minus the deformation in cold state for the long term effect
  1/10 of the deformation above for the short term one.

5. ORBITAL EFFECTS

Orbital effects are errors in pointing due to the fact that the sun trajectory as seen from the S/C in orbit is only roughly modelled. The need to model the sun trajectory derives from the fact that the sun is a non-absolute attitude reference and the FSS output must be constantly corrected by means of the so-called Sun Steering Law (SSL) to inertially point the S/C.
There are basically two effects that should be modelled in the SSL but were not implemented in the AOCS modelling algorithm for INTEGRAL:

- Earth eccentricity
- Sun orbital parallax

The sign of these errors is always chosen such that it adds in roll (where they have some importance) to the figures obtained separately for AOCS and Alignment Errors.
Details of these errors are given in the ESOC Memo, RD (09).
Only for historical reasons those contributions are considered separately from the AOCS in our budget. The substance however does not change and is shortly explained hereafter.

5.1 Earth Eccentricity

If, at the perihelion (worst case.) of the earth orbit around the sun, the earth eccentricity is not corrected for a time span of t (seconds), the total error (radians) is:

ϕ (roll) = $(1 - 1.03416) * 1.99099\ 10^{-7} * t$

and as a consequence of the control algorithms this translates into the following worst case pitch and yaw errors when the star used is in a corner of the STR FOV:

θ (pitch) = $1.5 * 3600 * \phi$

ψ (yaw) = $2 * 3600 * \phi$

5.2 Orbital Parallax

The motion of the S/C around the Earth causes a parallax error which ranges from a minimum value when the sun is perpendicular to the semi-minor axis to a maximum when it is perpendicular to the semi-major axis. This error translates primarily into a roll error and then into pitch and yaw with the same mechanism described before.
The maximum roll error is given by:

ϕ (roll) = $\mathrm{atan}\,((r_a + r_p)/2 * a_E(1-e))$ e = earth orbit eccentricity = 0.016722

which for the Proton orbit gives:

ϕ (roll) = 123”

Both these errors can be corrected in-flight by updating the SSL parameters at a sufficient frequency, which may depend on the season (sun position w.r.t. the orbit).
For the purpose of the budget we have pushed this frequency to the minimum value which still guarantees meeting the APD requirements of the SPI, which is the most critical instrument, i.e. approximately 3 hrs.

The earth eccentricity and parallax errors on 3 hrs are:

$\phi = 15 + 3/36(123) = 25''$

$\theta < 1''$ (negligible)

$\psi = 1 + 0 = 1''$

Note that the calculations assume that the S/C runs from perigee to apogee in 36 hrs, hence, with some approximation, the parallax error in 3 hrs is 3/36 of the error accumulated in half orbit.

The same errors have also been evaluated, using a linear approximation, over a time span of 1000 s to use them in the short term drift (RPE); however for such a short time there is no problem as numbers show:

$\phi = 1 + 1 = 2''$

$\theta, \psi < 1''$ (negligible)

6. INSTRUMENTS POINTING ERROR BUDGET

6.1 Statistical rules

The Instruments pointing error budgets are obtained by adding togeteher the S/C (Misalignment) error, the AOCS error and the Orbital effects error. The rule followed is the usual one i.e.:

$$M_{TOT} = M_{S/C} + M_{AOCS} + M_{Orbital}$$

$$\sigma_{TOT} = \sqrt{}\sigma_{S/C}^2 + \sigma_{AOCS}^2 + \sigma_{Orbital}^2$$

Coherently the same rule is used to obtain the overall instrument requirements from the two separate pointing (AOCS) and alignment (Structure) requirements.
Note that from this point of view the SRD only ask "to combine" them but does not say how. The approach chosen is thought to be a sound worst case.

In the following paragraphs the total budgets are provided grouping the error classes in absolute (paragraph 5.2) and drift/relative errors (paragraph 5.3).

6.2 Instruments Absolute Pointing Error (APE) and Absolute Measurement Accuracy (AMA)

6.2.1 General Considerations

The AOCS APE, Overall Misalignment Error and Orbital Effects are combined together to get the Instrument APE.
Orbital effects are noticeably very important in roll and their sign is chosen positive such as to add to the other contributions in that axis.
Equivalently the AOCS AMA and Overall Misalignment Error are combined to get the Instruments AMA.
Here note that Orbital effects are assumed to be calibrated.
There are two thermal cases considered below

6.2.1.1 Instruments APE and AMA - Hot Steady State

This budget uses corresponding AOCS values hot case.
The following comments apply:

- The long-term distortion has been set to zero because it is already encompassed by the steady state thermoelastic deformation.
- The STR thermoelastic distortion is derived from the equivalent STR hot case.

SPI ABSOLUTE POINTING ERROR (APE) - Hot Case															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
ALIGNMENT MEASUREMENT ACCURA	0.0	0.0	0.0	10.2	10.2	10.2	10.2	10.2	10.2	-10.2	-10.2	-10.2			
LAUNCH SETTING	0.0	0.0	0.0	5.6	72.4	14.0	5.6	72.4	14.0	-5.6	-72.4	-14.0			
Sine + Pyro Test	0.0	0.0	0.0	4.0	14.0	7.2	4.0	14.0	7.2	-4.0	-14.0	-7.2			
Acoustic Noise Test	0.0	0.0	0.0	4.0	71.0	12.0	4.0	71.0	12.0	-4.0	-71.0	-12.0			
GRAVITY RELEASE	-1.2	-0.1	1.5	0.1	0.0	0.1	-1.1	-0.1	1.6	-1.3	-0.1	1.4			
MOISTURE RELEASE AND OUTGASSI	-1.5	-15.0	1.5	0.2	1.5	0.2	-1.4	-13.5	1.7	-1.7	-16.5	1.4			
S/L THERMOELASTIC DISTORTION	1.9	25.0	-14.6	0.1	1.3	0.7	2.0	26.3	-13.9	1.8	23.8	-15.3			
LONG TERM DISTORTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
STR THERMOELASTIC DISTORTION	0.0	0.0	-6.0	0.0	0.0	1.2	0.0	0.0	-4.8	0.0	0.0	-7.2			
OVERALL MISALIGNMENT ERROR	**-1**	**10**	**-18**	**12**	**73**	**17**	**11**	**83**	**0**	**-12**	**-63**	**-35**	**168**	**-23**	**25**
Requirement	**0**	**0**	**0**	**180**	**60**	**60**	**180**	**60**	**60**	**-180**	**-60**	**-60**			
AOCS APE	**83**	**2**	**3**	**78**	**12**	**12**	**161**	**14**	**15**	**5**	**-10**	**-9**	**739**	**286**	**285**
Requirement	**0**	**0**	**0**	**900**	**300**	**300**	**900**	**300**	**300**	**-900**	**-300**	**-300**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**61**	**2**	**2**	**0**	**0**	**0**	**61**	**2**	**2**	**61**	**2**	**2**			
Orbital Parallax	**41**	**1**	**1**	**0**	**0**	**0**	**41**	**1**	**1**	**41**	**1**	**1**			
Total APE	**184**	**15**	**-11**	**79**	**74**	**21**	**263**	**89**	**10**	**105**	**-59**	**-33**	**655**	**217**	**273**
Requirement	**0**	**0**	**0**	**918**	**306**	**306**	**918**	**306**	**306**	**-918**	**-306**	**-306**			

(*) SSL calibration period (hrs) 12

SPI ABSOLUTE MEASUREMENT ACCURACY (AMA) - Hot Case															
	Mean Misalignment			**3 σ**			**Mean +3 σ**			**Mean -3 σ**			**Margin**		
	Rx	**Ry**	**Rz**	**Rx**	**Ry**	**Rz**	**Rx**	**Ry**	**Rz**	**Rx**	**Ry**	**Rz**	**Rx**	**Ry**	**Rz**
OVERALL MISALIGNMENT ERROR	-1	10	-18	12	73	17	11	83	-1	-13	-63	-35	167	-23	25
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
AOCS AMA	83	2	3	78	9	9	161	11	12	5	-7	-6	19	49	48
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
Total AMA	**82**	**12**	**-15**	**79**	**74**	**19**	**161**	**86**	**5**	**3**	**-61**	**-34**	**93**	**-1**	**51**
Requirement	**0**	**0**	**0**	**255**	**85**	**85**	**255**	**85**	**85**	**-255**	**-85**	**-85**			

OMC ABSOLUTE POINTING ERROR (APE) - Hot Case															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
ALIGNMENT MEASUREMENT ACCURA	0.0	0.0	0.0	10.2	10.2	10.2	10.2	10.2	10.2	-10.2	-10.2	-10.2			
LAUNCH SETTING	0.0	0.0	0.0	48.0	14.3	10.9	48.0	14.3	10.9	-48.0	-14.3	-10.9			
Sine + Pyro Test	0.0	0.0	0.0	0.4	2.9	9.7	0.4	2.9	9.7	-0.4	-2.9	-9.7			
Acoustic Noise Test	0.0	0.0	0.0	48.0	14.0	5.0	48.0	14.0	5.0	-48.0	-14.0	-5.0			
GRAVITY RELEASE	-0.2	0.2	-6.5	0.0	0.0	0.3	-0.2	0.2	-6.2	-0.2	0.2	-6.8			
MOISTURE RELEASE AND OUTGASSI	3.7	5.9	-8.6	0.4	0.6	0.9	4.1	6.5	-7.7	3.3	5.3	-9.5			
S/L THERMOELASTIC DISTORTION	18.5	4.3	-20.8	0.9	0.2	1.0	19.4	4.5	-19.8	17.6	4.1	-21.8			
LONG TERM DISTORTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
STR THERMOELASTIC DISTORTION	0.0	0.0	-6.0	0.0	0.0	1.2	0.0	0.0	-4.8	0.0	0.0	-7.2			
OVERALL MISALIGNMENT ERROR	**22**	**10**	**-42**	**49**	**18**	**15**	**71**	**28**	**-27**	**-27**	**-7**	**-57**	**109**	**32**	**3**
Requirement	**0**	**0**	**0**	**180**	**60**	**60**	**180**	**60**	**60**	**-180**	**-60**	**-60**			
AOCS APE	**83**	**2**	**3**	**78**	**12**	**12**	**161**	**14**	**15**	**5**	**-10**	**-9**	**739**	**286**	**285**
Requirement	**0**	**0**	**0**	**900**	**300**	**300**	**900**	**300**	**300**	**-900**	**-300**	**-300**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**61**	**2**	**2**	**0**	**0**	**0**	**61**	**2**	**2**	**61**	**2**	**2**			
Orbital Parallax	**41**	**1**	**1**	**0**	**0**	**0**	**41**	**1**	**1**	**41**	**1**	**1**			
TOTAL APE	**207**	**15**	**-36**	**92**	**21**	**19**	**299**	**37**	**-16**	**114**	**-6**	**-55**	**619**	**269**	**251**
Requirement	**0**	**0**	**0**	**918**	**306**	**306**	**918**	**306**	**306**	**-918**	**-306**	**-306**			

OMC ABSOLUTE MEASUREMENT ACCURACY (AMA) - Hot Case	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
OVERALL MISALIGNMENT ERROR	22	10	-42	49	18	15	71	28	-27	-27	-8	-57	109	32	3
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
AOCS AMA	83	2	3	78	9	9	154	11	12	-2	-7	-6	26	49	48
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
TOTAL AMA	**105**	**13**	**-39**	**92**	**20**	**17**	**197**	**33**	**-21**	**13**	**-8**	**-56**	**57**	**52**	**28**
Requirement	**0**	**0**	**0**	**255**	**85**	**85**	**255**	**85**	**85**	**-255**	**-85**	**-85**			

IBIS ABSOLUTE POINTING POINTING ERROR (APE) - Hot Case															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
ALIGNMENT MEASUREMENT ACCURA	0.0	0.0	0.0	20.8	20.8	20.8	20.8	20.8	20.8	-20.8	-20.8	-20.8			
LAUNCH SETTING	0.0	0.0	0.0	35.6	35.6	35.6	35.6	35.6	35.6	-35.6	-35.6	-35.6			
Sine + Pyro Test	0.0	0.0	0.0	6.5	6.5	6.5	6.5	6.5	6.5	-6.5	-6.5	-6.5			
Acoustic Noise Test	0.0	0.0	0.0	35.0	35.0	35.0	35.0	35.0	35.0	-35.0	-35.0	-35.0			
GRAVITY RELEASE	4.0	0.0	0.0	0.2	0.0	0.0	4.2	0.0	0.0	3.8	0.0	0.0			
MOISTURE RELEASE AND OUTGASSI	0.1	-0.2	0.2	0.0	0.0	0.0	0.1	-0.2	0.2	0.1	-0.2	0.2			
S/L THERMOELASTIC DISTORTION	-4.6	0.9	-2.7	0.2	0.0	0.1	-4.4	0.9	-2.6	-4.8	0.9	-2.8			
LONG TERM DISTORTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
STR THERMOELASTIC DISTORTION	0.0	0.0	-6.0	0.0	0.0	1.2	0.0	0.0	-4.8	0.0	0.0	-7.2			
OVERALL MISALIGNMENT ERROR	**-1**	**1**	**-9**	**41**	**41**	**41**	**41**	**42**	**33**	**-42**	**-41**	**-50**	**138**	**18**	**10**
Requirement	**0**	**0**	**0**	**180**	**60**	**60**	**180**	**60**	**60**	**-180**	**-60**	**-60**			
AOCS APE	**83**	**2**	**3**	**78**	**12**	**12**	**161**	**14**	**15**	**5**	**-10**	**-9**	**739**	**286**	**285**
Requirement	**0**	**0**	**0**	**900**	**300**	**300**	**900**	**300**	**300**	**-900**	**-300**	**-300**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**61**	**2**	**2**	**0**	**0**	**0**	**61**	**2**	**2**	**61**	**2**	**2**			
Orbital Parallax	**41**	**1**	**1**	**0**	**0**	**0**	**41**	**1**	**1**	**41**	**1**	**1**			
TOTAL APE	**184**	**6**	**-2**	**88**	**43**	**43**	**272**	**48**	**41**	**96**	**-37**	**-45**	**645**	**257**	**261**
Requirement	**0**	**0**	**0**	**918**	**306**	**306**	**918**	**306**	**306**	**-918**	**-306**	**-306**			

IBIS ABSOLUTE MEASUREMENT ACCURACY (AMA) - Hot Case	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
OVERALL MISALIGNMENT ERROR	-1	1	-9	41	41	41	41	42	33	-42	-40	-50	139	18	11
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
AOCS AMA	83	2	3	78	9	9	161	11	12	5	-7	-6	19	49	48
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
TOTAL AMA	**83**	**3**	**-6**	**88**	**42**	**42**	**171**	**45**	**36**	**-6**	**-39**	**-47**	**84**	**40**	**37**
Requirement	**0**	**0**	**0**	**255**	**85**	**85**	**255**	**85**	**85**	**-255**	**-85**	**-85**			

JEM-X #2 (-Y) ABSOLUTE POINTING ERROR (APE) - Hot Case	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
ALIGNMENT MEASUREMENT ACCURA	0.0	0.0	0.0	20.8	20.8	20.8	20.8	20.8	20.8	-20.8	-20.8	-20.8			
LAUNCH SETTING	0.0	0.0	0.0	36.3	36.3	36.3	36.3	36.3	36.3	-36.3	-36.3	-36.3			
Sine + Pyro Test	0.0	0.0	0.0	26.3	26.3	26.3	26.3	26.3	26.3	-26.3	-26.3	-26.3			
Acoustic Noise Test	0.0	0.0	0.0	25.0	25.0	25.0	25.0	25.0	25.0	-25.0	-25.0	-25.0			
GRAVITY RELEASE	-1.7	0.0	0.0	0.1	0.0	0.0	-1.6	0.0	0.0	-1.8	0.0	0.0			
MOISTURE RELEASE AND OUTGASSI	-1.8	-0.1	0.2	0.2	0.0	0.0	-1.6	-0.1	0.2	-2.0	-0.1	0.2			
S/L THERMOELASTIC DISTORTION	27.2	-0.6	-1.7	1.4	0.0	0.1	28.6	-0.6	-1.6	25.8	-0.6	-1.8			
LONG TERM DISTORTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
STR THERMOELASTIC DISTORTION	0.0	0.0	-6.0	0.0	0.0	1.2	0.0	0.0	-4.8	0.0	0.0	-7.2			
OVERALL MISALIGNMENT ERROR	**24**	**-1**	**-8**	**42**	**42**	**42**	**66**	**41**	**34**	**-18**	**-43**	**-49**	**114**	**17**	**11**
Requirement	**0**	**0**	**0**	**180**	**60**	**60**	**180**	**60**	**60**	**-180**	**-60**	**-60**			
AOCS APE	**83**	**2**	**3**	**78**	**12**	**12**	**161**	**14**	**15**	**5**	**-10**	**-9**	**739**	**286**	**285**
Requirement	**0**	**0**	**0**	**900**	**300**	**300**	**900**	**300**	**300**	**-900**	**-300**	**-300**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**61**	**2**	**2**	**0**	**0**	**0**	**61**	**2**	**2**	**61**	**2**	**2**			
Orbital Parallax	**41**	**1**	**1**	**0**	**0**	**0**	**41**	**1**	**1**	**41**	**1**	**1**			
TOTAL APE	**208**	**4**	**-1**	**89**	**43**	**44**	**297**	**48**	**42**	**120**	**-39**	**-45**	**621**	**258**	**261**
Requirement	**0**	**0**	**0**	**918**	**306**	**306**	**918**	**306**	**306**	**-918**	**-306**	**-306**			

JEM-X #2 (-Y) ABSOLUTE MEASUREMENT ACCURACY (AMA) - Hot Case															
	Mean Misalignment			**3 σ**			**Mean +3 σ**			**Mean -3 σ**			**Margin**		
	Rx	**Ry**	**Rz**	**Rx**	**Ry**	**Rz**	**Rx**	**Ry**	**Rz**	**Rx**	**Ry**	**Rz**	**Rx**	**Ry**	**Rz**
OVERALL MISALIGNMENT ERROR	24	-1	-8	42	42	42	66	41	35	-18	-43	-50	114	17	11
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
AOCS AMA	83	2	3	78	9	9	161	11	12	5	-7	-6	19	49	48
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
TOTAL AMA	**107**	**1**	**-5**	**89**	**43**	**43**	**195**	**44**	**38**	**18**	**-41**	**-47**	**59**	**40**	**37**
Requirement	**0**	**0**	**0**	**255**	**85**	**85**	**255**	**85**	**85**	**-255**	**-85**	**-85**			

JEM-X #1 (+Y) ABSOLUTE POINTING ERROR (APE) - Hot Case															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
ALIGNMENT MEASUREMENT ACCURA	0.0	0.0	0.0	20.8	20.8	20.8	20.8	20.8	20.8	-20.8	-20.8	-20.8			
LAUNCH SETTING	0.0	0.0	0.0	76.6	76.6	76.6	76.6	76.6	76.6	-76.6	-76.6	-76.6			
Sine + Pyro Test	0.0	0.0	0.0	26.3	26.3	26.3	26.3	26.3	26.3	-26.3	-26.3	-26.3			
Acoustic Noise Test	0.0	0.0	0.0	72.0	72.0	72.0	72.0	72.0	72.0	-72.0	-72.0	-72.0			
GRAVITY RELEASE	-3.9	0.1	0.1	0.2	0.0	0.0	-3.7	0.1	0.1	-4.1	0.1	0.1			
MOISTURE RELEASE AND OUTGASSI	1.6	-0.1	0.1	0.2	0.0	0.0	1.8	-0.1	0.1	1.4	-0.1	0.1			
S/L THERMOELASTIC DISTORTION	-2.3	2.2	-3.4	0.1	0.1	0.2	-2.2	2.3	-3.2	-2.4	2.1	-3.6			
LONG TERM DISTORTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
STR THERMOELASTIC DISTORTION	0.0	0.0	-6.0	0.0	0.0	1.2	0.0	0.0	-4.8	0.0	0.0	-7.2			
OVERALL MISALIGNMENT ERROR	**-5**	**2**	**-9**	**79**	**79**	**79**	**75**	**82**	**70**	**-84**	**-77**	**-89**	**96**	**-22**	**-29**
Requirement	**0**	**0**	**0**	**180**	**60**	**60**	**180**	**60**	**60**	**-180**	**-60**	**-60**			
AOCS APE	**83**	**2**	**3**	**78**	**12**	**12**	**161**	**14**	**15**	**5**	**-10**	**-9**	**739**	**286**	**285**
Requirement	**0**	**0**	**0**	**900**	**300**	**300**	**900**	**300**	**300**	**-900**	**-300**	**-300**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**61**	**2**	**2**	**0**	**0**	**0**	**61**	**2**	**2**	**61**	**2**	**2**			
Orbital Parallax	**41**	**1**	**1**	**0**	**0**	**0**	**41**	**1**	**1**	**41**	**1**	**1**			
TOTAL APE	**180**	**7**	**-3**	**111**	**80**	**80**	**291**	**87**	**77**	**69**	**-73**	**-83**	**627**	**219**	**223**
Requirement	**0**	**0**	**0**	**918**	**306**	**306**	**918**	**306**	**306**	**-918**	**-306**	**-306**			

JEM-X #1 (+Y) ABSOLUTE MEASUREMENT ACCURACY (AMA) - Hot Case

	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
OVERALL MISALIGNMENT ERROR	-5	2	-9	79	79	79	74	81	70	-84	-77	-88	96	-21	-28
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
AOCS AMA	83	2	3	78	9	9	161	11	12	5	-7	-6	19	49	48
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
TOTAL AMA	**78**	**4**	**-6**	**111**	**80**	**80**	**189**	**84**	**73**	**-33**	**-75**	**-86**	**65**	**1**	**-1**
Requirement	**0**	**0**	**0**	**255**	**85**	**85**	**255**	**85**	**85**	**-255**	**-85**	**-85**			

6.2.1.2 Instruments APE and AMA - Cold Steady State

This budget uses the corresponding AOCS values in cold case.
The following are relevant comments to be considered:

- Long term distortion set to zero (see budget hot case)
- STR thermoelastic distortion derived from the corresponding cold case, in value and sign.
- The sign of the deterministic part of the AOCS APE, due to cross coupling into pitch and yaw of the FSS/STR roll misalignment, is chosen to maximise the module of the worst instrument total error (SPI with negative sign).

SPI ABSOLUTE POINTING ERROR (APE) - Cold Case	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
ALIGNMENT MEASUREMENT ACCURA	0.0	0.0	0.0	10.2	10.2	10.2	10.2	10.2	10.2	-10.2	-10.2	-10.2			
LAUNCH SETTING	0.0	0.0	0.0	5.6	72.4	14.0	5.6	72.4	14.0	-5.6	-72.4	-14.0			
Sine + Pyro Test	0.0	0.0	0.0	4.0	14.0	7.2	4.0	14.0	7.2	-4.0	-14.0	-7.2			
Acoustic Noise Test	0.0	0.0	0.0	4.0	71.0	12.0	4.0	71.0	12.0	-4.0	-71.0	-12.0			
GRAVITY RELEASE	-1.2	-0.1	1.5	0.1	0.0	0.1	-1.1	-0.1	1.6	-1.3	-0.1	1.4			
MOISTURE RELEASE AND OUTGASSI	-1.5	-15.0	1.5	0.2	1.5	0.2	-1.4	-13.5	1.7	-1.7	-16.5	1.4			
S/L THERMOELASTIC DISTORTION	41.8	-49.7	-9.4	2.1	2.5	0.5	43.9	-47.2	-8.9	39.7	-52.2	-9.9			
LONG TERM DISTORTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
STR THERMOELASTIC DISTORTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
OVERALL MISALIGNMENT ERROR	**39**	**-65**	**-6**	**12**	**73**	**17**	**51**	**8**	**11**	**27**	**-138**	**-24**	**129**	**-78**	**36**
Requirement	**0**	**0**	**0**	**180**	**60**	**60**	**180**	**60**	**60**	**-180**	**-60**	**-60**			
AOCS APE	**99**	**3**	**3**	**79**	**12**	**12**	**178**	**15**	**15**	**20**	**-9**	**-9**	**722**	**285**	**285**
Requirement	**0**	**0**	**0**	**900**	**300**	**300**	**900**	**300**	**300**	**-900**	**-300**	**-300**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**61**	**2**	**2**	**0**	**0**	**0**	**61**	**2**	**2**	**61**	**2**	**2**			
Orbital Parallax	**41**	**1**	**1**	**0**	**0**	**0**	**41**	**1**	**1**	**41**	**1**	**1**			
TOTAL APE	**240**	**-59**	**0**	**80**	**74**	**21**	**320**	**15**	**21**	**160**	**-133**	**-21**	**598**	**173**	**285**
REQUIREMENT	**0**	**0**	**0**	**918**	**306**	**306**	**918**	**306**	**306**	**-918**	**-306**	**-306**			

(*) SSL calibration period (hrs) 12

SPI ABSOLUTE MEASUREMENT ACCURACY (AMA) - Cold Case															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
OVERALL MISALIGNMENT ERROR	39	-65	-6	12	73	17	51	8	11	27	-138	-23	129	-78	37
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
AOCS AMA	99	3	3	78	9	9	177	12	12	21	-6	-6	3	48	48
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
TOTAL AMA	**138**	**-62**	**-3**	**79**	**74**	**19**	**217**	**12**	**16**	**59**	**-135**	**-23**	**38**	**-50**	**62**
REQUIREMENT	**0**	**0**	**0**	**255**	**85**	**85**	**255**	**85**	**85**	**-255**	**-85**	**-85**			

OMC ABSOLUTE POINTING ERROR (APE) - Cold Case	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
ALIGNMENT MEASUREMENT ACCURA	0.0	0.0	0.0	10.2	10.2	10.2	10.2	10.2	10.2	-10.2	-10.2	-10.2			
LAUNCH SETTING	0.0	0.0	0.0	48.0	14.3	10.9	48.0	14.3	10.9	-48.0	-14.3	-10.9			
Sine + Pyro Test	0.0	0.0	0.0	0.4	2.9	9.7	0.4	2.9	9.7	-0.4	-2.9	-9.7			
Acoustic Noise Test	0.0	0.0	0.0	-48.0	-14.0	5.0	48.0	14.0	5.0	48.0	14.0	-5.0			
GRAVITY RELEASE	-0.2	0.2	-6.5	0.0	0.0	0.3	-0.2	0.2	-6.2	-0.2	0.2	-6.8			
MOISTURE RELEASE AND OUTGASSI	3.7	5.9	-8.6	0.4	0.6	0.9	4.1	6.5	-7.7	3.3	5.3	-9.5			
S/L THERMOELASTIC DISTORTION	37.7	8.2	-6.3	1.9	0.4	0.3	39.6	8.6	-6.0	35.8	7.8	-6.6			
LONG TERM DISTORTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
STR THERMOELASTIC DISTORTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
OVERALL MISALIGNMENT ERROR	**41**	**14**	**-21**	**49**	**18**	**15**	**90**	**32**	**-6**	**-8**	**-3**	**-36**	**90**	**28**	**24**
Requirement	**0**	**0**	**0**	**180**	**60**	**60**	**180**	**60**	**60**	**-180**	**-60**	**-60**			
AOCS APE	**99**	**3**	**3**	**79**	**12**	**12**	**178**	**15**	**15**	**20**	**-9**	**-9**	**722**	**285**	**285**
Requirement	**0**	**0**	**0**	**900**	**300**	**300**	**900**	**300**	**300**	**-900**	**-300**	**-300**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**61**	**2**	**2**	**0**	**0**	**0**	**61**	**2**	**2**	**61**	**2**	**2**			
Orbital Parallax	**41**	**1**	**1**	**0**	**0**	**0**	**41**	**1**	**1**	**41**	**1**	**1**			
TOTAL APE	**242**	**20**	**-15**	**93**	**21**	**19**	**335**	**41**	**4**	**149**	**-1**	**-34**	**583**	**265**	**272**
REQUIREMENT	**0**	**0**	**0**	**918**	**306**	**306**	**918**	**306**	**306**	**-918**	**-306**	**-306**			

OMC ABSOLUTE MEASUREMENT ACCURACY (AMA) - Cold Case	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
OVERALL MISALIGNMENT ERROR	41	14	-21	49	18	15	90	32	-6	-8	-4	-36	90	28	24
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
AOCS AMA	99	3	3	78	9	9	177	12	12	21	-6	-6	3	48	48
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
TOTAL AMA	**140**	**17**	**-18**	**92**	**20**	**17**	**232**	**37**	**-1**	**48**	**-3**	**-36**	**22**	**47**	**49**
REQUIREMENT	**0**	**0**	**0**	**255**	**85**	**85**	**255**	**85**	**85**	**-255**	**-85**	**-85**			

IBIS ABSOLUTE POINTING POINTING ERROR (APE) - Cold Case															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
ALIGNMENT MEASUREMENT ACCURA	0.0	0.0	0.0	20.8	20.8	20.8	20.8	20.8	20.8	-20.8	-20.8	-20.8			
LAUNCH SETTING	0.0	0.0	0.0	35.6	35.6	35.6	35.6	35.6	35.6	-35.6	-35.6	-35.6			
Sine + Pyro Test	0.0	0.0	0.0	6.5	6.5	6.5	6.5	6.5	6.5	-6.5	-6.5	-6.5			
Acoustic Noise Test	0.0	0.0	0.0	35.0	35.0	35.0	35.0	35.0	35.0	-35.0	-35.0	-35.0			
GRAVITY RELEASE	4.0	0.0	0.0	0.2	0.0	0.0	4.2	0.0	0.0	3.8	0.0	0.0			
MOISTURE RELEASE AND OUTGASSI	0.1	-0.2	0.2	0.0	0.0	0.0	0.1	-0.2	0.2	0.1	-0.2	0.2			
S/L THERMOELASTIC DISTORTION	-4.2	-2.2	0.3	0.2	0.1	0.0	-4.0	-2.1	0.3	-4.4	-2.3	0.3			
LONG TERM DISTORTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
STR THERMOELASTIC DISTORTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
OVERALL MISALIGNMENT ERROR	**0**	**-2**	**1**	**41**	**41**	**41**	**41**	**39**	**42**	**-41**	**-44**	**-41**	**139**	**16**	**18**
Requirement	**0**	**0**	**0**	**180**	**60**	**60**	**180**	**60**	**60**	**-180**	**-60**	**-60**			
AOCS APE	**99**	**3**	**3**	**79**	**12**	**12**	**178**	**15**	**15**	**20**	**-9**	**-9**	**722**	**285**	**285**
Requirement	**0**	**0**	**0**	**900**	**300**	**300**	**900**	**300**	**300**	**-900**	**-300**	**-300**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**61**	**2**	**2**	**0**	**0**	**0**	**61**	**2**	**2**	**61**	**2**	**2**			
Orbital Parallax	**41**	**1**	**1**	**0**	**0**	**0**	**41**	**1**	**1**	**41**	**1**	**1**			
TOTAL APE	**201**	**3**	**7**	**89**	**43**	**43**	**290**	**46**	**50**	**111**	**-40**	**-36**	**628**	**260**	**256**
REQUIREMENT	**0**	**0**	**0**	**918**	**306**	**306**	**918**	**306**	**306**	**-918**	**-306**	**-306**			

IBIS ABSOLUTE MEASUREMENT ACCURACY (AMA) - Cold Case															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
OVERALL MISALIGNMENT ERROR	0	-2	1	41	41	41	41	39	42	-41	-43	-41	139	17	19
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
AOCS AMA	99	3	3	78	9	9	177	12	12	21	-6	-6	3	48	48
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
TOTAL AMA	**99**	**1**	**4**	**88**	**42**	**42**	**187**	**43**	**45**	**11**	**-41**	**-38**	**68**	**42**	**39**
REQUIREMENT	**0**	**0**	**0**	**255**	**85**	**85**	**255**	**85**	**85**	**-255**	**-85**	**-85**			

JEM-X #2 (-Y) ABSOLUTE POINTING ERROR (APE) - Cold Case	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
ALIGNMENT MEASUREMENT ACCURA	0.0	0.0	0.0	20.8	20.8	20.8	20.8	20.8	20.8	-20.8	-20.8	-20.8			
LAUNCH SETTING	0.0	0.0	0.0	36.3	36.3	36.3	36.3	36.3	36.3	-36.3	-36.3	-36.3			
Sine + Pyro Test	0.0	0.0	0.0	26.3	26.3	26.3	26.3	26.3	26.3	-26.3	-26.3	-26.3			
Acoustic Noise Test	0.0	0.0	0.0	25.0	25.0	25.0	25.0	25.0	25.0	-25.0	-25.0	-25.0			
GRAVITY RELEASE	-1.7	0.0	0.0	0.1	0.0	0.0	-1.6	0.0	0.0	-1.8	0.0	0.0			
MOISTURE RELEASE AND OUTGASSI	-1.8	-0.1	0.2	0.2	0.0	0.0	-1.6	-0.1	0.2	-2.0	-0.1	0.2			
S/L THERMOELASTIC DISTORTION	37.0	-1.4	1.9	1.9	0.1	0.1	38.9	-1.3	2.0	35.2	-1.5	1.8			
LONG TERM DISTORTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
STR THERMOELASTIC DISTORTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
OVERALL MISALIGNMENT ERROR	**34**	**-2**	**2**	**42**	**42**	**42**	**75**	**40**	**44**	**-8**	**-43**	**-40**	**105**	**17**	**16**
Requirement	**0**	**0**	**0**	**180**	**60**	**60**	**180**	**60**	**60**	**-180**	**-60**	**-60**			
AOCS APE	**99**	**3**	**3**	**79**	**12**	**12**	**178**	**15**	**15**	**20**	**-9**	**-9**	**722**	**285**	**285**
Requirement	**0**	**0**	**0**	**900**	**300**	**300**	**900**	**300**	**300**	**-900**	**-300**	**-300**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**61**	**2**	**2**	**0**	**0**	**0**	**61**	**2**	**2**	**61**	**2**	**2**			
Orbital Parallax	**41**	**1**	**1**	**0**	**0**	**0**	**41**	**1**	**1**	**41**	**1**	**1**			
TOTAL APE	**234**	**4**	**8**	**89**	**43**	**43**	**324**	**48**	**52**	**145**	**-39**	**-35**	**594**	**258**	**254**
REQUIREMENT	**0**	**0**	**0**	**918**	**306**	**306**	**918**	**306**	**306**	**-918**	**-306**	**-306**			

JEM-X #2 (-Y) ABSOLUTE MEASUREMENT ACCURACY (AMA) - Cold Case	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
OVERALL MISALIGNMENT ERROR	34	-2	2	42	42	42	76	41	44	-9	-44	-40	105	17	16
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
AOCS AMA	99	3	3	78	9	9	177	12	12	21	-6	-6	3	48	48
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
TOTAL AMA	**133**	**2**	**5**	**89**	**43**	**43**	**221**	**44**	**48**	**44**	**-41**	**-38**	**33**	**40**	**37**
REQUIREMENT	**0**	**0**	**0**	**255**	**85**	**85**	**255**	**85**	**85**	**-255**	**-85**	**-85**			

JEM-X #1 (+Y) ABSOLUTE POINTING ERROR (APE) - Cold Case	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
ALIGNMENT MEASUREMENT ACCURA	0.0	0.0	0.0	20.8	20.8	20.8	20.8	20.8	20.8	-20.8	-20.8	-20.8			
LAUNCH SETTING	0.0	0.0	0.0	76.6	76.6	76.6	76.6	76.6	76.6	-76.6	-76.6	-76.6			
Sine + Pyro Test	0.0	0.0	0.0	26.3	26.3	26.3	26.3	26.3	26.3	-26.3	-26.3	-26.3			
Acoustic Noise Test	0.0	0.0	0.0	72.0	72.0	72.0	72.0	72.0	72.0	-72.0	-72.0	-72.0			
GRAVITY RELEASE	-4.0	0.1	0.1	0.2	0.0	0.0	-3.8	0.1	0.1	-4.2	0.1	0.1			
MOISTURE RELEASE AND OUTGASSI	1.6	-0.1	0.1	0.2	0.0	0.0	1.8	-0.1	0.1	1.4	-0.1	0.1			
S/L THERMOELASTIC DISTORTION	-29.0	-1.8	-1.2	1.5	0.1	0.1	-27.6	-1.7	-1.1	-30.5	-1.9	-1.3			
LONG TERM DISTORTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
STR THERMOELASTIC DISTORTION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
OVERALL MISALIGNMENT ERROR	**0**	**-2**	**-1**	**79**	**79**	**79**	**79**	**78**	**78**	**-79**	**-81**	**-80**	**101**	**21**	**20**
Requirement	**0**	**0**	**0**	**180**	**60**	**60**	**180**	**60**	**60**	**-180**	**-60**	**-60**			
AOCS APE	**99**	**3**	**3**	**79**	**12**	**12**	**178**	**15**	**15**	**20**	**-9**	**-9**	**722**	**285**	**285**
Requirement	**0**	**0**	**0**	**900**	**300**	**300**	**900**	**300**	**300**	**-900**	**-300**	**-300**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**61**	**2**	**2**	**0**	**0**	**0**	**61**	**2**	**2**	**61**	**2**	**2**			
Orbital Parallax	**41**	**1**	**1**	**0**	**0**	**0**	**41**	**1**	**1**	**41**	**1**	**1**			
TOTAL APE	**201**	**4**	**5**	**112**	**80**	**80**	**313**	**84**	**86**	**89**	**-76**	**-75**	**605**	**222**	**220**
REQUIREMENT	**0**	**0**	**0**	**918**	**306**	**306**	**918**	**306**	**306**	**-918**	**-306**	**-306**			

JEM-X #1 (+Y) ABSOLUTE MEASUREMENT ACCURACY (AMA) - Cold Case	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
OVERALL MISALIGNMENT ERROR	0	-2	-1	79	79	79	79	77	78	-79	-81	-80	101	-21	-20
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
AOCS AMA	99	3	3	78	9	9	177	12	12	21	-6	-6	3	48	48
Requirement	0	0	0	180	60	60	180	60	60	-180	-60	-60			
TOTAL AMA	**99**	**1**	**2**	**111**	**80**	**80**	**210**	**81**	**82**	**-12**	**-78**	**-78**	**45**	**4**	**3**
REQUIREMENT	**0**	**0**	**0**	**255**	**85**	**85**	**255**	**85**	**85**	**-255**	**-85**	**-85**			

6.3 Instruments Absolute Pointing Drift (APD) and Relative Pointing Error (RPE)

6.3.1 General Considerations

The AOCS APD, Misalignment Variation – Long Term and Orbital effects are added together to give the Instrument Pointing Drift.
Similarly the AOCS RPE, Misalignment Variation - Short Term and Orbital Effects are combined to give the Instrument Relative Pointing.

6.3.2 Instruments APD and RPE - Eclipse Transient

This budget is based on the corresponding AOCS eclipse transient budget.
The following general comments apply:

- The STR thermoelastic contribution to long term drift is coherent with a transition from cold to hot state but is derived taking the difference of the STR hot and cold steday state cases; i.e. there has been no dedicated transient analysis for the STR.
- The short-term contribution of the STR thermoelastic distortion is taken as 1/10 of the long term component, same sign.

SPI RELATIVE POINTING ERROR (RPE) - Eclipse Transient

	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	1.8	1.0	-0.1	0.4	0.2	0.0	2.2	1.2	-0.1	1.4	0.8	-0.1			
STR Thermoelastic Distortion	0.0	0.0	-0.6	0.0	0.0	0.1	0.0	0.0	-0.5	0.0	0.0	-0.7			
MISALIGNMENT VARIATION - SHORT TERM	**2**	**1**	**-1**	**0**	**0**	**0**	**2**	**1**	**-1**	**1**	**1**	**-1**	**16**	**5**	**5**
Requirement	**0**	**0**	**0**	**18**	**6**	**6**	**18**	**6**	**6**	**-18**	**-6**	**-6**			
AOCS RPE	**6**	**0**	**0**	**6**	**2**	**2**	**12**	**2**	**2**	**0**	**-2**	**-2**	**48**	**16**	**16**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Orbital Parallax	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**						
TOTAL RPE	**10**	**1**	**0**	**6**	**2**	**2**	**16**	**3**	**2**	**4**	**-1**	**-2**	**46**	**16**	**17**
REQUIREMENT	**0**	**0**	**0**	**63**	**19**	**19**	**63**	**19**	**19**	**-63**	**-19**	**-19**			

(*) SSL calibration period (seconds) 1000

SPI ABSOLUTE POINTING DRIFT (APD) - Eclipse Transient															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	18.0	10.0	-1.0	3.6	2.0	0.2	21.6	12.0	-0.8	14.4	8.0	-1.2			
STR Thermoelastic Distortion	0.0	0.0	-6.0	0.0	0.0	1.2	0.0	0.0	-4.8	0.0	0.0	-7.2			
MISALIGNMENT VARIATION - LONG TERM	**18**	**10**	**-7**	**4**	**2**	**1**	**22**	**12**	**-6**	**14**	**8**	**-8**	**38**	**6**	**10**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
AOCS APD	**60**	**2**	**2**	**27**	**3**	**3**	**87**	**5**	**5**	**33**	**-1**	**-1**	**33**	**31**	**31**
Requirement	**0**	**0**	**0**	**120**	**36**	**36**	**120**	**36**	**36**	**-120**	**-36**	**-36**			
ORBITAL EFFECTS (**)															
Earth Eccentricity	**15**	**0**	**1**	**0**	**0**	**0**	**15**	**0**	**1**	**15**	**0**	**1**			
Orbital Parallax	**10**	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**0**						
Total APD	**103**	**13**	**-4**	**27**	**4**	**3**	**131**	**16**	**-1**	**76**	**9**	**-7**	**4**	**24**	**33**
Requirement	**0**	**0**	**0**	**134**	**40**	**40**	**134**	**40**	**40**	**-134**	**-40**	**-40**			

(**) SSL calibration period (hrs) 3

OMC RELATIVE POINTING ERROR (RPE) - Eclipse Transient	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	0.8	-0.2	-1.0	0.2	0.0	0.2	1.0	-0.2	-0.8	0.6	-0.2	-1.2			
STR Thermoelastic Distortion	0.0	0.0	-0.6	0.0	0.0	0.1	0.0	0.0	-0.5	0.0	0.0	-0.7			
MISALIGNMENT VARIATION - SHORT TERM	**1**	**0**	**-2**	**0**	**0**	**0**	**1**	**0**	**-1**	**1**	**0**	**-2**	**17**	**6**	**4**
Requirement	**0**	**0**	**0**	**18**	**6**	**6**	**18**	**6**	**6**	**-18**	**-6**	**-6**			
AOCS RPE	**6**	**0**	**0**	**6**	**2**	**2**	**12**	**2**	**2**	**0**	**-2**	**-2**	**48**	**16**	**16**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Orbital Parallax	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Total RPE	**9**	**0**	**-1**	**6**	**2**	**2**	**15**	**2**	**1**	**3**	**-2**	**-3**	**47**	**17**	**16**
Requirement	**0**	**0**	**0**	**63**	**19**	**19**	**63**	**19**	**19**	**-63**	**-19**	**-19**			

OMC ABSOLUTE POINTING DRIFT (APD) - Eclipse Transient	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	8.0	-2.0	-10.0	1.6	0.4	2.0	9.6	-1.6	-8.0	6.4	-2.4	-12.0			
STR Thermoelastic Distortion	0.0	0.0	-6.0	0.0	0.0	1.2	0.0	0.0	-4.8	0.0	0.0	-7.2			
MISALIGNMENT VARIATION - LONG TERM	**8**	**-2**	**-16**	**2**	**0**	**2**	**10**	**-2**	**-14**	**6**	**-2**	**-18**	**50**	**16**	**-0**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
AOCS APD	**60**	**2**	**2**	**27**	**3**	**3**	**87**	**5**	**5**	**33**	**-1**	**-1**	**33**	**31**	**31**
Requirement	**0**	**0**	**0**	**120**	**36**	**36**	**120**	**36**	**36**	**-120**	**-36**	**-36**			
ORBITAL EFFECTS (**)															
Earth Eccentricity	**15**	**0**	**1**	**0**	**0**	**0**	**15**	**0**	**1**	**15**	**0**	**1**			
Orbital Parallax	**10**	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**0**	**10**	**0**	**0**			
Total APD	**93**	**1**	**-13**	**27**	**3**	**4**	**120**	**4**	**-9**	**66**	**-2**	**-17**	**14**	**37**	**23**
Requirement	**0**	**0**	**0**	**134**	**40**	**40**	**134**	**40**	**40**	**-134**	**-40**	**-40**			

IBIS RELATIVE POINTING ERROR (RPE) - Eclipse Transient															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	0.5	-0.1	0.0	0.1	0.0	0.0	0.6	-0.1	0.0	0.4	-0.1	0.0			
STR Thermoelastic Distortion	0.0	0.0	-0.6	0.0	0.0	0.1	0.0	0.0	-0.5	0.0	0.0	-0.7			
MISALIGNMENT VARIATION - SHORT TERM	**1**	**0**	**-1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**-1**	**17**	**6**	**5**
Requirement	**0**	**0**	**0**	**18**	**6**	**6**	**18**	**6**	**6**	**-18**	**-6**	**-6**			
AOCS RPE	**6**	**0**	**0**	**6**	**2**	**2**	**12**	**2**	**2**	**0**	**-2**	**-2**	**48**	**16**	**16**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Orbital Parallax	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Total RPE	**9**	**0**	**0**	**6**	**2**	**2**	**15**	**2**	**2**	**3**	**-2**	**-2**	**48**	**17**	**17**
Requirement	**0**	**0**	**0**	**63**	**19**	**19**	**63**	**19**	**19**	**-63**	**-19**	**-19**			

IBIS ABSOLUTE POINTING DRIFT (APD) - Eclipse Transient															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	5	-1	0	1	0	0	6	-1	0	4	-1	0			
STR Thermoelastic Distortion	0	0	-6	0	0	1	0	0	-5	0	0	-7			
MISALIGNMENT VARIATION - LONG TERM	**5**	**-1**	**-6**	**1**	**0**	**1**	**6**	**-1**	**-5**	**4**	**-1**	**-7**	**54**	**17**	**11**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
AOCS APD	**60**	**2**	**2**	**27**	**3**	**3**	**87**	**5**	**5**	**33**	**-1**	**-1**	**33**	**31**	**31**
Requirement	**0**	**0**	**0**	**120**	**36**	**36**	**120**	**36**	**36**	**-120**	**-36**	**-36**			
ORBITAL EFFECTS (**)															
Earth Eccentricity	**15**	**0**	**1**	**0**	**0**	**0**	**15**	**0**	**1**	**15**	**0**	**1**			
Orbital Parallax	**10**	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**0**	**10**	**0**	**0**			
Total APD	**90**	**2**	**-3**	**27**	**3**	**3**	**117**	**5**	**0**	**63**	**-1**	**-6**	**17**	**36**	**34**
Requirement	**0**	**0**	**0**	**134**	**40**	**40**	**134**	**40**	**40**	**-134**	**-40**	**-40**			

JEM-X #2 (-Y) RELATIVE POINTING ERROR (RPE) - Eclipse Transient															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	-1.9	-0.1	0.0	0.4	0.0	0.0	-1.5	-0.1	0.0	-2.3	-0.1	0.0			
STR Thermoelastic Distortion	0.0	0.0	-0.6	0.0	0.0	0.1	0.0	0.0	-0.5	0.0	0.0	-0.7			
MISALIGNMENT VARIATION - SHORT TERM	**-2**	**0**	**-1**	**0**	**0**	**0**	**-2**	**0**	**0**	**-2**	**0**	**-1**	**16**	**6**	**5**
Requirement	**0**	**0**	**0**	**18**	**6**	**6**	**18**	**6**	**6**	**-18**	**-6**	**-6**			
AOCS RPE	**6**	**0**	**0**	**6**	**2**	**2**	**12**	**2**	**2**	**0**	**-2**	**-2**	**48**	**16**	**16**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Orbital Parallax	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Total RPE	**6**	**0**	**0**	**6**	**2**	**2**	**12**	**2**	**2**	**0**	**-2**	**-2**	**50**	**17**	**17**
Requirement	**0**	**0**	**0**	**63**	**19**	**19**	**63**	**19**	**19**	**-63**	**-19**	**-19**			

JEM-X #2 (-Y) ABSOLUTE POINTING DRIFT (APD) - Eclipse Transient	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	-19.0	-1.0	0.0	3.8	0.2	0.0	-15.2	-0.8	0.0	-22.8	-1.2	0.0			
STR Thermoelastic Distortion	0.0	0.0	-6.0	0.0	0.0	1.2	0.0	0.0	-4.8	0.0	0.0	-7.2			
MISALIGNMENT VARIATION - LONG TERM	**-19**	**-1**	**-6**	**4**	**0**	**1**	**-15**	**-1**	**-5**	**-23**	**-1**	**-7**	**37**	**17**	**11**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
AOCS APD	**60**	**2**	**2**	**27**	**3**	**3**	**87**	**5**	**5**	**33**	**-1**	**-1**	**33**	**31**	**31**
Requirement	**0**	**0**	**0**	**120**	**36**	**36**	**120**	**36**	**36**	**-120**	**-36**	**-36**			
ORBITAL EFFECTS (**)															
Earth Eccentricity	**15**	**0**	**1**	**0**	**0**	**0**	**15**	**0**	**1**	**15**	**0**	**1**			
Orbital Parallax	**10**	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**0**	**10**	**0**	**0**			
Total APD	**66**	**2**	**-3**	**27**	**3**	**3**	**94**	**5**	**0**	**39**	**-1**	**-6**	**40**	**36**	**34**
Requirement	**0**	**0**	**0**	**134**	**40**	**40**	**134**	**40**	**40**	**-134**	**-40**	**-40**			

JEM-X #1 (+Y) RELATIVE POINTING ERROR (RPE) - Eclipse Transient															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	0.4	0.0	0.1	0.1	0.0	0.0	0.5	0.0	0.1	0.3	0.0	0.1			
STR Thermoelastic Distortion	0.0	0.0	-0.6	0.0	0.0	0.1	0.0	0.0	-0.5	0.0	0.0	-0.7			
MISALIGNMENT VARIATION - SHORT TERM	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**-1**	**18**	**6**	**5**
Requirement	**0**	**0**	**0**	**18**	**6**	**6**	**18**	**6**	**6**	**-18**	**-6**	**-6**			
AOCS RPE	**6**	**0**	**0**	**6**	**2**	**2**	**12**	**2**	**2**	**0**	**-2**	**-2**	**48**	**16**	**16**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Orbital Parallax	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Total RPE	**9**	**0**	**-1**	**6**	**2**	**2**	**15**	**2**	**1**	**3**	**-2**	**-3**	**48**	**17**	**16**
Requirement	**0**	**0**	**0**	**63**	**19**	**19**	**63**	**19**	**19**	**-63**	**-19**	**-19**			

JEM-X #1 (+Y) ABSOLUTE POINTING DRIFT (APD) - Eclipse Transient															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	4.0	0.0	1.0	0.8	0.0	0.2	4.8	0.0	1.2	3.2	0.0	0.8			
STR Thermoelastic Distortion	0.0	0.0	-6.0	0.0	0.0	1.2	0.0	0.0	-4.8	0.0	0.0	-7.2			
MISALIGNMENT VARIATION - LONG TERM	**4**	**0**	**-5**	**1**	**0**	**1**	**5**	**0**	**-4**	**3**	**0**	**-6**	**55**	**18**	**12**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
AOCS APD	**60**	**2**	**2**	**27**	**3**	**3**	**87**	**5**	**5**	**33**	**-1**	**-1**	**33**	**31**	**31**
Requirement	**0**	**0**	**0**	**120**	**36**	**36**	**120**	**36**	**36**	**-120**	**-36**	**-36**			
ORBITAL EFFECTS (**)															
Earth Eccentricity	**15**	**0**	**1**	**0**	**0**	**0**	**15**	**0**	**1**	**15**	**0**	**1**			
Orbital Parallax	**10**	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**0**	**10**	**0**	**0**			
Total APD	**89**	**3**	**-2**	**27**	**3**	**3**	**116**	**6**	**1**	**62**	**0**	**-5**	**18**	**35**	**35**
Requirement	**0**	**0**	**0**	**134**	**40**	**40**	**134**	**40**	**40**	**-134**	**-40**	**-40**			

6.3.3 Instruments APD and RPE - Slew Transient

This budget uses the corresponding AOCS slew transient case.
The following general comments are remarked:

- Like in the eclipse transient the STR contribution is coherent with a transition from cold to hot state.
- Short term is 1/10 of the long-term thermoelastic contribution (see eclipse transient).

SPI RELATIVE POINTING ERROR (RPE) - Slew Transient	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	-4.0	7.5	-0.6	0.8	1.5	0.1	-3.2	9.0	-0.5	-4.8	6.0	-0.7			
STR Thermoelastic Distortion	0.0	0.0	-0.6	0.0	0.0	0.1	0.0	0.0	-0.5	0.0	0.0	-0.7			
MISALIGNMENT VARIATION - SHORT TERM	**-4**	**8**	**-1**	**1**	**2**	**0**	**-3**	**9**	**-1**	**-5**	**6**	**-1**	**13**	**-3**	**5**
Requirement	**0**	**0**	**0**	**18**	**6**	**6**	**18**	**6**	**6**	**-18**	**-6**	**-6**			
AOCS RPE	**-2**	**0**	**0**	**6**	**2**	**2**	**5**	**2**	**2**	**-8**	**-2**	**-2**	**52**	**16**	**16**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Orbital Parallax	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**						
Total RPE	**-3**	**7**	**-1**	**6**	**3**	**2**	**3**	**10**	**1**	**-10**	**5**	**-4**	**53**	**9**	**15**
Requirement	**0**	**0**	**0**	**63**	**19**	**19**	**63**	**19**	**19**	**-63**	**-19**	**-19**			

(*) SSL calibration period (seconds) 1000

SPI ABSOLUTE POINTING DRIFT (APD) - Slew Transient

	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	-40.0	75.0	-6.0	8.0	15.0	1.2	-32.0	90.0	-4.8	-48.0	60.0	-7.2			
STR Thermoelastic Distortion	0.0	0.0	-6.0	0.0	0.0	1.2	0.0	0.0	-4.8	0.0	0.0	-7.2			
MISALIGNMENT VARIATION - LONG TERM	**-40**	**75**	**-12**	**8**	**15**	**2**	**-32**	**90**	**-10**	**-48**	**60**	**-14**	**12**	**-72**	**4**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
AOCS APD	**-16**	**0**	**-1**	**25**	**3**	**3**	**9**	**2**	**2**	**-41**	**-3**	**-3**	**79**	**33**	**33**
Requirement	**0**	**0**	**0**	**120**	**36**	**36**	**120**	**36**	**36**	**-120**	**-36**	**-36**			
ORBITAL EFFECTS (**)															
Earth Eccentricity	**15**	**0**	**1**	**0**	**0**	**0**	**15**	**0**	**1**	**15**	**0**	**1**			
Orbital Parallax	**10**	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**0**						
Total APD	**-31**	**75**	**-12**	**27**	**15**	**3**	**-4**	**90**	**-9**	**-57**	**60**	**-15**	**77**	**-50**	**25**
Requirement	**0**	**0**	**0**	**134**	**40**	**40**	**134**	**40**	**40**	**-134**	**-40**	**-40**			

(**) SSL calibration period (hrs) 3

OMC RELATIVE POINTING ERROR (RPE) - Slew Transient															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	-2.0	-0.4	-1.5	0.4	0.1	0.3	-1.6	-0.3	-1.2	-2.4	-0.5	-1.8			
STR Thermoelastic Distortion	0.0	0.0	-0.6	0.0	0.0	0.1	0.0	0.0	-0.5	0.0	0.0	-0.7			
MISALIGNMENT VARIATION - SHORT TERM	**-2**	**0**	**-2**	**0**	**0**	**0**	**-2**	**0**	**-2**	**-2**	**0**	**-2**	**16**	**6**	**4**
Requirement	**0**	**0**	**0**	**18**	**6**	**6**	**18**	**6**	**6**	**-18**	**-6**	**-6**			
AOCS RPE	**-2**	**0**	**0**	**6**	**2**	**2**	**5**	**2**	**2**	**-8**	**-2**	**-2**	**52**	**16**	**16**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Orbital Parallax	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Total RPE	**-1**	**0**	**-2**	**6**	**2**	**2**	**5**	**2**	**0**	**-8**	**-3**	**-5**	**55**	**16**	**14**
Requirement	**0**	**0**	**0**	**63**	**19**	**19**	**63**	**19**	**19**	**-63**	**-19**	**-19**			

OMC ABSOLUTE POINTING DRIFT (APD) - Slew Transient															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	-20.0	-4.0	-15.0	4.0	0.8	3.0	-16.0	-3.2	-12.0	-24.0	-4.8	-18.0			
STR Thermoelastic Distortion	0.0	0.0	-6.0	0.0	0.0	1.2	0.0	0.0	-4.8	0.0	0.0	-7.2			
MISALIGNMENT VARIATION - LONG TERM	**-20**	**-4**	**-21**	**4**	**1**	**3**	**-16**	**-3**	**-18**	**-24**	**-5**	**-24**	**36**	**13**	**-6**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
AOCS APD	**-16**	**0**	**-1**	**25**	**3**	**3**	**9**	**2**	**2**	**-41**	**-3**	**-3**	**79**	**33**	**33**
Requirement	**0**	**0**	**0**	**120**	**36**	**36**	**120**	**36**	**36**	**-120**	**-36**	**-36**			
ORBITAL EFFECTS (**)															
Earth Eccentricity	**15**	**0**	**1**	**0**	**0**	**0**	**15**	**0**	**1**	**15**	**0**	**1**			
Orbital Parallax	**10**	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**0**	**10**	**0**	**0**			
Total APD	**-11**	**-4**	**-21**	**26**	**3**	**4**	**15**	**-1**	**-17**	**-36**	**-6**	**-25**	**98**	**34**	**15**
Requirement	**0**	**0**	**0**	**134**	**40**	**40**	**134**	**40**	**40**	**-134**	**-40**	**-40**			

IBIS RELATIVE POINTING ERROR (RPE) - Slew Transient															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	-0.1	0.3	-0.3	0.0	0.1	0.1	-0.1	0.4	-0.2	-0.1	0.2	-0.4			
STR Thermoelastic Distortion	0.0	0.0	-0.6	0.0	0.0	0.1	0.0	0.0	-0.5	0.0	0.0	-0.7			
MISALIGNMENT VARIATION - SHORT TERM	**0**	**0**	**-1**	**0**	**0**	**0**	**0**	**0**	**-1**	**0**	**0**	**-1**	**18**	**6**	**5**
Requirement	**0**	**0**	**0**	**18**	**6**	**6**	**18**	**6**	**6**	**-18**	**-6**	**-6**			
AOCS RPE	**-2**	**0**	**0**	**6**	**2**	**2**	**5**	**2**	**2**	**-8**	**-2**	**-2**	**52**	**16**	**16**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Orbital Parallax	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Total RPE	**1**	**0**	**-1**	**6**	**2**	**2**	**7**	**3**	**1**	**-6**	**-2**	**-3**	**56**	**16**	**16**
Requirement	**0**	**0**	**0**	**63**	**19**	**19**	**63**	**19**	**19**	**-63**	**-19**	**-19**			

IBIS ABSOLUTE POINTING DRIFT (APD) - Slew Transient															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	-1.0	3.0	-3.0	0.2	0.6	0.6	-0.8	3.6	-2.4	-1.2	2.4	-3.6			
STR Thermoelastic Distortion	0.0	0.0	-6.0	0.0	0.0	1.2	0.0	0.0	-4.8	0.0	0.0	-7.2			
MISALIGNMENT VARIATION - LONG TERM	**-1**	**3**	**-9**	**0**	**1**	**1**	**-1**	**4**	**-8**	**-1**	**2**	**-10**	**59**	**14**	**8**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
AOCS APD	**-16**	**0**	**-1**	**25**	**3**	**3**	**9**	**2**	**2**	**-41**	**-3**	**-3**	**79**	**33**	**33**
Requirement	**0**	**0**	**0**	**120**	**36**	**36**	**120**	**36**	**36**	**-120**	**-36**	**-36**			
ORBITAL EFFECTS (**)															
Earth Eccentricity	**15**	**0**	**1**	**0**	**0**	**0**	**15**	**0**	**1**	**15**	**0**	**1**			
Orbital Parallax	**10**	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**0**	**10**	**0**	**0**			
Total APD	**8**	**3**	**-9**	**25**	**3**	**3**	**34**	**6**	**-6**	**-17**	**1**	**-12**	**100**	**34**	**29**
Requirement	**0**	**0**	**0**	**134**	**40**	**40**	**134**	**40**	**40**	**-134**	**-40**	**-40**			

JEM-X #2 (-Y) RELATIVE POINTING ERROR (RPE) - Slew Transient															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	-1.0	0.0	-0.4	0.2	0.0	0.1	-0.8	0.0	-0.3	-1.2	0.0	-0.5			
STR Thermoelastic Distortion	0.0	0.0	-0.6	0.0	0.0	0.1	0.0	0.0	-0.5	0.0	0.0	-0.7			
MISALIGNMENT VARIATION - SHORT TERM	**-1**	**0**	**-1**	**0**	**0**	**0**	**-1**	**0**	**-1**	**-1**	**0**	**-1**	**17**	**6**	**5**
Requirement	**0**	**0**	**0**	**18**	**6**	**6**	**18**	**6**	**6**	**-18**	**-6**	**-6**			
AOCS RPE	**-2**	**0**	**0**	**6**	**2**	**2**	**5**	**2**	**2**	**-8**	**-2**	**-2**	**52**	**16**	**16**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Orbital Parallax	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Total RPE	**0**	**0**	**-1**	**6**	**2**	**2**	**6**	**2**	**1**	**-7**	**-2**	**-3**	**56**	**17**	**16**
Requirement	**0**	**0**	**0**	**63**	**19**	**19**	**63**	**19**	**19**	**-63**	**-19**	**-19**			

JEM-X #2 (-Y) ABSOLUTE POINTING DRIFT (APD) - Slew Transient	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	-10.0	0.0	-4.0	2.0	0.0	0.8	-8.0	0.0	-3.2	-12.0	0.0	-4.8			
STR Thermoelastic Distortion	0.0	0.0	-6.0	0.0	0.0	1.2	0.0	0.0	-4.8	0.0	0.0	-7.2			
MISALIGNMENT VARIATION - LONG TERM	**-10**	**0**	**-10**	**2**	**0**	**1**	**-8**	**0**	**-9**	**-12**	**0**	**-11**	**48**	**18**	**7**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
AOCS APD	**-16**	**0**	**-1**	**25**	**3**	**3**	**9**	**2**	**2**	**-41**	**-3**	**-3**	**79**	**33**	**33**
Requirement	**0**	**0**	**0**	**120**	**36**	**36**	**120**	**36**	**36**	**-120**	**-36**	**-36**			
ORBITAL EFFECTS (**)															
Earth Eccentricity	**15**	**0**	**1**	**0**	**0**	**0**	**15**	**0**	**1**	**15**	**0**	**1**			
Orbital Parallax	**10**	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**0**	**10**	**0**	**0**			
Total APD	**-1**	**0**	**-10**	**25**	**3**	**3**	**25**	**3**	**-7**	**-26**	**-2**	**-13**	**108**	**37**	**28**
Requirement	**0**	**0**	**0**	**134**	**40**	**40**	**134**	**40**	**40**	**-134**	**-40**	**-40**			

JEM-X #1 (+Y) RELATIVE POINTING ERROR (RPE) - Slew Transient															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	2.7	0.4	-0.2	0.5	0.1	0.0	3.2	0.5	-0.2	2.2	0.3	-0.2			
STR Thermoelastic Distortion	0.0	0.0	-0.6	0.0	0.0	0.1	0.0	0.0	-0.5	0.0	0.0	-0.7			
MISALIGNMENT VARIATION - SHORT TERM	**3**	**0**	**-1**	**1**	**0**	**0**	**3**	**0**	**-1**	**2**	**0**	**-1**	**15**	**6**	**5**
Requirement	**0**	**0**	**0**	**18**	**6**	**6**	**18**	**6**	**6**	**-18**	**-6**	**-6**			
AOCS RPE	**-2**	**0**	**0**	**6**	**2**	**2**	**5**	**2**	**2**	**-8**	**-2**	**-2**	**52**	**16**	**16**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
ORBITAL EFFECTS (*)															
Earth Eccentricity	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Orbital Parallax	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**			
Total RPE	**3**	**0**	**-1**	**6**	**2**	**2**	**10**	**3**	**2**	**-3**	**-2**	**-3**	**53**	**16**	**16**
Requirement	**0**	**0**	**0**	**63**	**19**	**19**	**63**	**19**	**19**	**-63**	**-19**	**-19**			

JEM-X #1 (+Y) ABSOLUTE POINTING DRIFT (APD) - Slew Transient	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			Margin		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz
S/L Thermoelastic Distortion	27.0	4.0	-2.0	5.4	0.8	0.4	32.4	4.8	-1.6	21.6	3.2	-2.4			
STR Thermoelastic Distortion	0.0	0.0	-6.0	0.0	0.0	1.2	0.0	0.0	-4.8	0.0	0.0	-7.2			
ISALIGNMENT VARIATION - LONG TEF	**27**	**4**	**-8**	**5**	**1**	**1**	**32**	**5**	**-7**	**22**	**3**	**-9**	**28**	**13**	**9**
Requirement	**0**	**0**	**0**	**60**	**18**	**18**	**60**	**18**	**18**	**-60**	**-18**	**-18**			
AOCS APD	**-16**	**0**	**-1**	**25**	**3**	**3**	**9**	**2**	**2**	**-41**	**-3**	**-3**	**79**	**33**	**33**
Requirement	**0**	**0**	**0**	**120**	**36**	**36**	**120**	**36**	**36**	**-120**	**-36**	**-36**			
ORBITAL EFFECTS (**)															
Earth Eccentricity	**15**	**0**	**1**	**0**	**0**	**0**	**15**	**0**	**1**	**15**	**0**	**1**			
Orbital Parallax	**10**	**0**	**0**	**0**	**0**	**0**	**10**	**0**	**0**	**10**	**0**	**0**			
Total APD	**36**	**4**	**-8**	**26**	**3**	**3**	**62**	**7**	**-5**	**11**	**2**	**-11**	**72**	**33**	**30**
Requirement	**0**	**0**	**0**	**134**	**40**	**40**	**134**	**40**	**40**	**-134**	**-40**	**-40**			

7. INSTRUMENTS ON-GROUND ALIGNMENT

This chapter provides a summary of the Instruments on-ground alignment results, as derived from the last alignment campaign performed on INTEGRAL FM S/L after the TV/TB test.
For details about Reference Frames orientation, chronology and methodology used for INTEGRAL on-ground alignment refer to RD (11).

Regarding the Instruments on-ground alignment requirements, the INTEGRAL SRD specifies qualitative requirements (i.e. the misalignment shall be much less than Instrument Field of View) while the Instruments EIDB's specify quantitative requirements (i.e. precise numerical values). The latter have been taken as applicable to evaluate the Instruments on-ground alignment performance.

The most important parameter to verify is the misalignment of Instrument Line of Sight (ILS) with respect to the STR Functional X-axis (i.e. STR Line of Sight).

The ILS is defined as follows:

- for OMC, the centerline of the optical field of view
- for SPI, IBIS and JEM-X's, the line joining the geometrical center of the mask and the geometrical center of the detector.

The ILS misalignment is expressed as half-cone angle computed with:

ILS half-cone angle = $\sqrt{Ry^2 + Rz^2}$

Table 7.1 provides the final status of Instruments ILS misalignment with respect to the STR #1 (i.e. primary STR) LOS. The IBIS ILS shows an out-of-spec value, that has been judged acceptable by the IBIS Principal Investigator also considering the excellent co-alignment of the overall Instruments.

The mutual Instrument co-alignment has been computed comparing the Instruments ILS-Vectors components. The result is depicted in Figure 7.1.

We can note that all the ILS's are within the –Y/-Z STR #1 quadrant and are inscribed in a circle with a maximum radius of 2.96 arcmin.

INSTRUMENT	**Field Of View [deg]**	**Rx [arcmin]**	**Ry [arcmin]**	**Rz [arcmin]**	**ILS Half-Cone Angle [arcmin]**	
					Requirement	**Measured**
SPI	16, corner to corner	N/A	7.28	-5.18	8.5	8.94
OMC	5 x 5, square	N/A	3.09	-1.00	7.1	3.24
IBIS	9 x 9, square	N/A	7.20	-4.37	3.0	8.42
JEM-X #1 (+Y)	4.8, half-cone	N/A	6.87	-4.87	15.0	8.42
JEM-X #2 (-Y)	4.8, half-cone	N/A	7.25	-4.29	15.0	8.42

Table 7-1 Instruments ILS On-Ground Misalignment

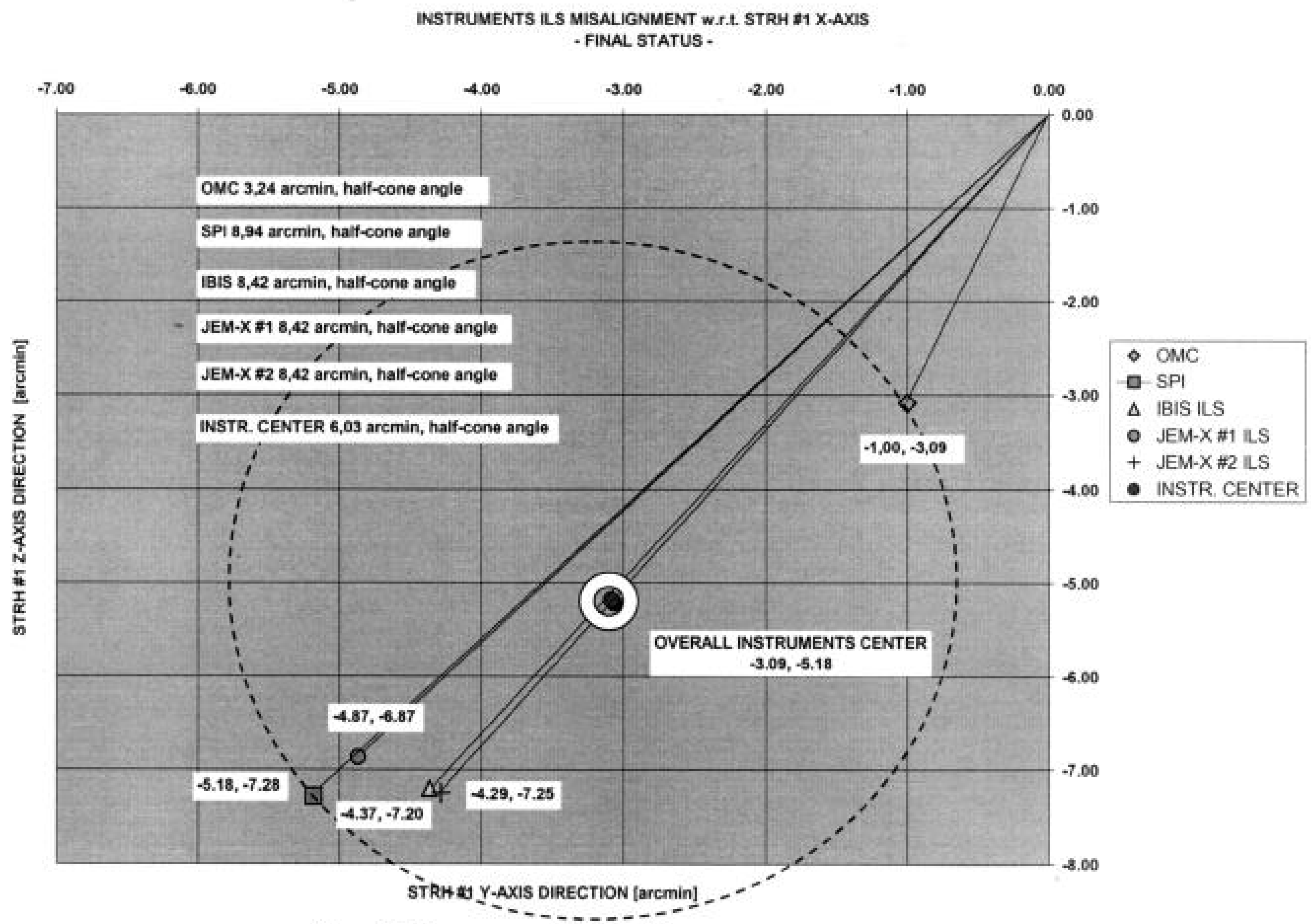

Figure 7.1 Instruments ILS Co-Alignment

8. INSTRUMENTS OVERALL POINTING PERFORMANCE

For completeness, the Instruments overall pointing performances have been evaluated “summing” the contribution of Instrument APE and the Instrument On-Ground Alignment.

Pointing the STR LOS on a given target, the Instruments ILS’s will stay within the min-max values depicted in the following Tables.

Two thermal cases are treated:

- Hot Steady State
- Cold Steady State

INSTRUMENTS TOTAL POINTING PERFORMANCE - Hot Case															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			ILS Half-Cone		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	min		max
ON-GROUND MISALIGNMENT	109	437	-311	0	0	0	109	437	-311	109	437	-311			
SPI APE	184	15	-11	79	74	21	263	89	10	105	-59	-32			
SPI POINTING PERFORMANCE	**293**	**452**	**-322**	**79**	**74**	**21**	**372**	**526**	**-301**	**214**	**378**	**-343**	**8.50**	**arcmin**	**10.10**
ON-GROUND MISALIGNMENT	529	184	-61	0	0	0	529	184	-61	529	184	-61			
OMC APE	207	15	-36	92	21	19	299	36	-17	115	-6	-55			
OMC POINTING PERFORMANCE	**736**	**199**	**-97**	**92**	**21**	**19**	**828**	**220**	**-78**	**644**	**178**	**-116**	**3.54**	**arcmin**	**3.89**
ON-GROUND MISALIGNMENT	104	432	-262	0	0	0	104	432	-262	104	432	-262			
IBIS APE	184	6	-2	88	43	43	272	49	41	96	-37	-45			
IBIS POINTING PERFORMANCE	**288**	**438**	**-264**	**88**	**43**	**43**	**376**	**481**	**-221**	**200**	**395**	**-307**	**8.34**	**arcmin**	**8.82**
ON-GROUND MISALIGNMENT	877	435	-257	0	0	0	877	435	-257	877	435	-257			
JEM-X #2 APE	208	4	-1	89	43	43	297	47	42	119	-39	-44			
JEM-X #2 (+Y) POINTING PERFORMANCE	**1085**	**439**	**-258**	**89**	**43**	**43**	**1174**	**482**	**-215**	**996**	**396**	**-301**	**8.29**	**arcmin**	**8.80**
ON-GROUND MISALIGNMENT	324	412	-292	0	0	0	324	412	-292	324	412	-292			
JEM-X #1 APE	180	7	-3	111	80	80	291	87	77	69	-73	-83			
JEM-X #1 (-Y) POINTING PERFORMANCE	**504**	**419**	**-295**	**111**	**80**	**80**	**615**	**499**	**-215**	**393**	**339**	**-375**	**8.43**	**arcmin**	**9.06**

INSTRUMENTS TOTAL POINTING PERFORMANCE - Cold Case															
	Mean Misalignment			3 σ			Mean +3 σ			Mean -3 σ			ILS Half-Cone		
	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	Rx	Ry	Rz	min		max
ON-GROUND MISALIGNMENT	109	437	-311	0	0	0	109	437	-311	109	437	-311			
SPI APE	240	-59	0	80	74	21	320	15	21	160	-133	-21			
SPI POINTING PERFORMANCE	**349**	**378**	**-311**	**80**	**74**	**21**	**429**	**452**	**-290**	**269**	**304**	**-332**	**7.50**	**arcmin**	**8.95**
ON-GROUND MISALIGNMENT	529	184	-61	0	0	0	529	184	-61	529	184	-61			
OMC APE	242	20	-15	93	21	19	335	41	4	149	-1	-34			
OMC POINTING PERFORMANCE	**771**	**204**	**-76**	**93**	**21**	**19**	**864**	**225**	**-57**	**678**	**183**	**-95**	**3.43**	**arcmin**	**3.86**
ON-GROUND MISALIGNMENT	104	432	-262	0	0	0	104	432	-262	104	432	-262			
IBIS APE	201	3	7	89	43	43	290	46	50	112	-40	-36			
IBIS POINTING PERFORMANCE	**305**	**435**	**-255**	**89**	**43**	**43**	**394**	**478**	**-212**	**216**	**392**	**-298**	**8.21**	**arcmin**	**8.72**
ON-GROUND MISALIGNMENT	877	435	-257	0	0	0	877	435	-257	877	435	-257			
JEM-X #2 APE	234	4	8	89	43	43	323	47	51	145	-39	-35			
JEM-X #2 (+Y) POINTING PERFORMANCE	**1111**	**439**	**-249**	**89**	**43**	**43**	**1200**	**482**	**-206**	**1022**	**396**	**-292**	**8.20**	**arcmin**	**8.74**
ON-GROUND MISALIGNMENT	324	412	-292	0	0	0	324	412	-292	324	412	-292			
JEM-X #1 APE	201	4	5	112	80	80	313	84	85	89	-76	-75			
JEM-X #1 (-Y) POINTING PERFORMANCE	**525**	**416**	**-287**	**112**	**80**	**80**	**637**	**496**	**-207**	**413**	**336**	**-367**	**8.30**	**arcmin**	**8.96**

9. CONCLUSIONS

All the pointing requirements for AOCS and Instruments are met.

Not considering the non-realistic Slew Transient case, the only out-of-specification found is the SPI AMA around Y-axis in the cold steady state case, 135” against a specification of 85”.

Instead of considering the rotational requirements about orthogonal axes (i.e. Ry and Rz), the depointing of the SPI functional axis (i.e. X-axis) becames:

- Depointing req. $= \sqrt{85^2 + 85^2} = 120''$

and the performance is then:

- Depointing perf.$= \sqrt{135^2 + 23^2} = 137''$

However, there are other ways to reduce the total measurement error on-orbit, by doing calibrations between the Instruments and the AOCS STR. This on-orbit calibration activity is simplified by the fact that the Gamma-ray Instruments have been found well co-aligned (see Fig. 7.1 above).

Regarding the Instruments on-ground alignment, two out-of-specification values have been found:

- IBIS 8.42’ vs. 3.0’

- SPI 8.94’ vs. 8.5’

The IBIS value has already been accepted by PI, remarking the fact that the real important alignment performance is the co-alignment of the gamma ray Instruments.
We assume that the same considerations apply to the SPI. This is more evident when comparing the SPI to IBIS ILS co-alignment, which is less than 4 arcmin.