SMOS L1 Full Polarisation Data Processing

Code : SO-TN-DME-L1PP-0024
Issue : 1.6
Date : 16/07/07

	Name	Function	Signature
Prepared by	A. Gutiérrez	Project Manager	
	M. Martín-Neira	ESA Staff	
Checked by	J. Freitas	Quality A. Manager	
Approved by	J. Barbosa	Project Manager	

DEIMOS Engenharia
Av. D. João II, Lote 1.17, Torre Zen, 10°,
1998-023 Lisboa, PORTUGAL
Tel: +351 21 893 3013
Fax: +351 21 896 9099
E-mail: mailto:deimos@deimos.com.pt

This page intentionally left blank

Document Information

Contract Data		Classification	
Contract Number:	DE04/B-434/P	**Internal**	☑
		Public	☐
Contract Issuer:	EADS CASA Espacio	**Industry**	☐
		Confidential	☐

Internal Distribution		
Name	Unit	Copies

External Distribution		
Name	Organisation	Copies
Michele Zundo	ESA	1
Josep Closa	EADS CASA Espacio	1

Archiving	
Word Processor:	MS Word 2000
File Name:	SO-TN-DME-L1PP-0024-Full-pol-processing.doc
Archive Code:	P/TN/DME/03/013-029

Document Status Log

Issue	Change description	Date	Approved
1.0	Description of approach after workshop discussion	2004-12-03	
1.1	Revision after comments by MMN	2004-12-09	
1.2	Updated after comments from P. Waldteufel	2005-01-21	
1.3	Updated after meeting in Paris (MZ, PW, EA)	2005-05-27	
1.4	Updated after CDR RIDs	2005-08-31	
1.5	Removal of NIR-NIR HV correlations when not in the same arm	2006-11-17	
1.6	Changed sequence ordering of full pol scenes after IVT testing with real instrument sequences	2007-07-16	

Table of Contents

List of Figures

List of Tables

1. INTRODUCTION

1.1. Purpose and Scope

This document describes the processing approach to combine raw data produced during full polarisation mode, in order to retrieve the brightness temperature map in cross-polarisation. This document started as a discussion item, presenting three identified processing options. From these three options, only one was determined as valid and is the one currently presented alone in the document.

1.2. Acronyms and Abbreviations

L1PP	Level 1 Processor Prototype
NIR	Noise Injection Radiometer
PMS	Power Measurement Signal

For the complete list of acronyms, please refer to the "Directory of Acronyms and abbreviations" [RD.05].

1.3. Applicable and Reference Documents

1.3.1. Applicable Documents

Ref.	Code	Title	Issue
SOW	SO-SOW-CASA-PLM-0385	Level 1 Processor Prototype Development Phase 3 and Support Activities. Statement of Work	*01*
SRD	SO-RS-ESA-PLM-0003	SMOS System Requirements Document	*3.0*
IOD	SMOS-GS-IDR-TR-005	Input Output Data Definition SMOS Ground Segment	*2.1*
ECSS	ECSS-E-40B	ECSS E-40 Software Engineering Standards	
FFS	PE-TN-ESA-GS-001	Earth Explorer Ground Segment File Format Standard	*1.4*

Table 1: Applicable Documents

1.3.2. Reference Documents

Ref.	Code	Title	Issue
RD.01	SO-TN-GMV-PLM-0003	SMOS End-to-End Performance Simulator Architectural and Detailed Design Document	*4.1*
RD.02	SO-IS-DME-L1PP-0002	SMOS L1PP Product Data Files Format	*2.2*

RD.03	SO-TN-ESA-GS-1250	SMOS Product Definition	***1.1***
RD.04	SO-TN-UPC-PLM-01	IN-ORBIT CALIBRATION PLAN	***3.3***
RD.05	SO-LI-CASA-PLM-0094	Directory of Acronyms and abbreviations	
RD.06	SO-TN-CASA-PLM-0279	Command and Control document	***2.5***
RD.07	SO-IS-DME-L1PP-0003	SMOS L1PP Auxiliary Data File Format	***2.2***
RD.08	SO-DS-DME-L1PP-0007	SMOS L1PP Detail Processing Model L0 to L1a	***2.3***
RD.09	SO-TN-UPC-PLM-0019	IN-ORBIT CALIBRATION PLAN Phase C/D	***1.2***

Table 2: Reference Documents

Ref.	Article
RA.01	*Introduction to Two-dimensional Aperture Synthesis Microwave Radiometry for Earth Observation: Polarimetric Formulation of the Visibility Function* (M. Martín-Neira, A. Martín-Polegre, S. Ribó), Internal ESTEC Working Paper nº 2130, October 2001

Table 3: Reference articles

2. FULL POLARISATION DATA PROCESSING

During the consolidation of L0 data produced in full polarisation mode into L1a products, and their later use on the Image Reconstruction module, some assumptions were needed, that affected the overall full-pol processing strategy.

These assumptions did not affect the format of L1a products, but only affected the format and content of L1b and L1c products. These assumptions were discussed during the SMOS workshop in ESRIN December 2004, and some conclusions were reached regarding the approach to be taken. A presentation of the approach is done here, together with some recommendations towards the Image Reconstruction algorithms.

2.1. ASIC decomposition

Correlators' data is provided by combining all the contents of all 24 Source Packets that define a scene. In dual-pol mode, a snapshot is produced every integration time (1,2s), composed of 24 Source Packets.

In full-pol mode, the first integration period produces a single scene with all receivers in all arms operating in H or V mode, while the next integration period produces three different scenes by alternating the polarisation in one arm and integrating along time. This integration time produces a total of 3x24 Science Data Source Packets.

Each of the sets of 24 Source Packets contains all the data gathered from all correlators, as described in the following figure for the nominal layer of correlators. Correlations of in-phase signals coming from each of the receiver pairs are set in the lower triangular part matrix, while in-phase to quadrature signal correlations of each of the receiver pairs is set on the diagonal and above.

Each of the elements in the matrix is a 2-byte correlations counter, signifying the number of times (counts) the signals correlated are coincident with each other in an integration time. The maximum number of times they can be coincident is AA69 in hexadecimal format (43625) for full-pol interlacing integration sub-intervals of 0.4s, while for the complete integration interval (1.2s) the maximum number is FF9D (65437). For these complete integration intervals, the number of correlations presented is not the total number of coincidences accumulated for that time, but rather a subset of the total.

Each of the values in the matrix can be represented as $N_C^{I_k Q_j}$, where I_k represents the row index, and Q_j the column index. The raw normalised correlation can be built using the following expression:

$$c_{kj}^{iq} = \frac{N_C^{I_k Q_j}}{N_{C\max}} \qquad \textbf{Eq. 1}$$

Where k and j indicate the row and column indices of the receivers being correlated respectively, and i and q represent the in-phase and quadrature signals being correlated. The raw normalised correlations are used to compute the complex normalised correlations by solving a non-linear equation, but for the purpose of this problem explanation, they following solution may be assumed:

$$\mu_{kj}^{iq} \Box \sin\left(\frac{\pi}{2}\left(2c_{kj}^{iq}-1\right)\right) \qquad \textbf{Eq. 2}$$

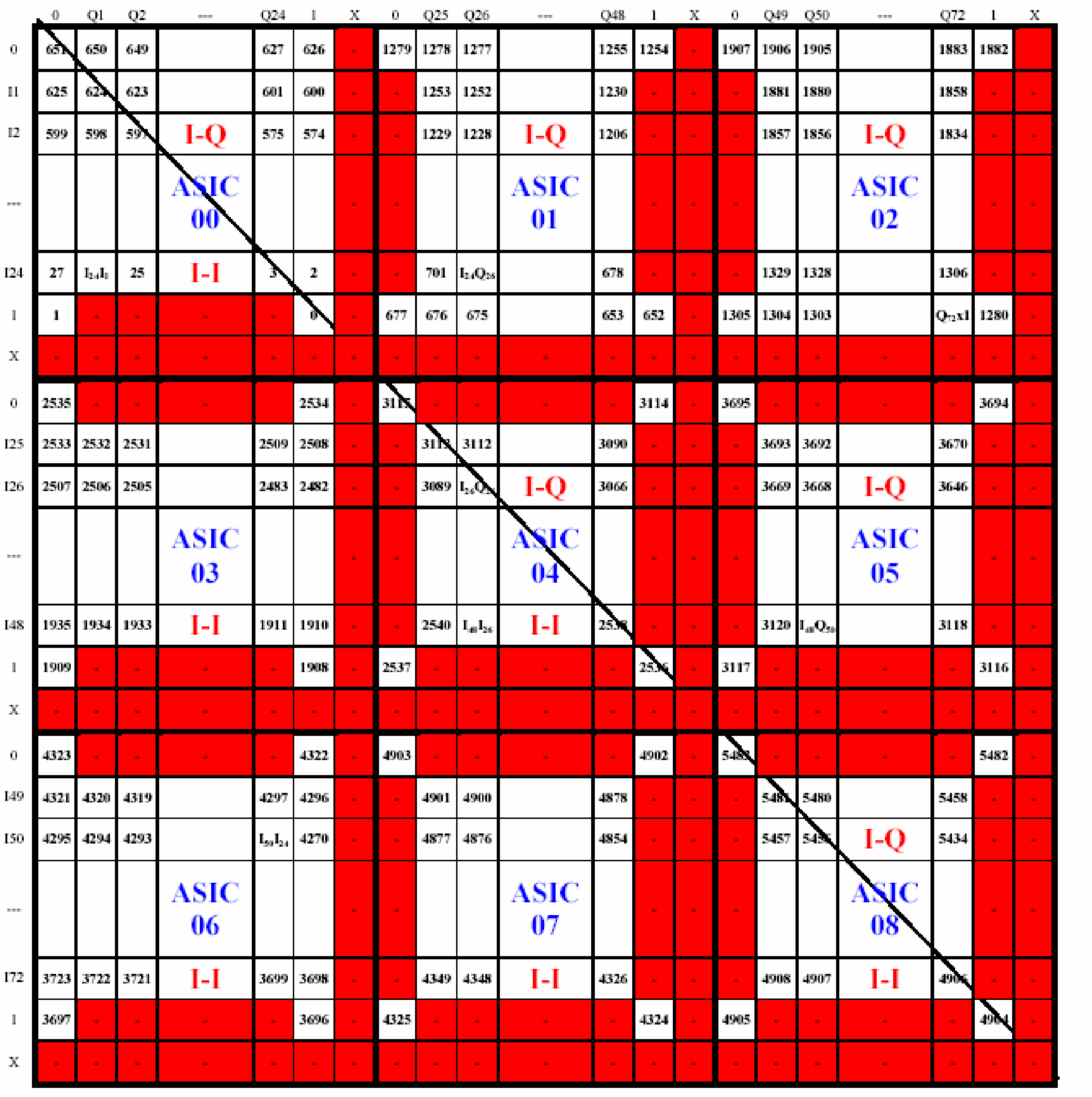

Figure 1: Nominal layer of correlators

Now, the purpose of measuring the complex normalised correlations is to provide the complex calibrated visibility for each pair of receivers, as expressed in the formula:

$$\hat{V}_{kj} = \frac{\sqrt{T_{sys_k} T_{sys_j}}}{g_{kj}} e^{j\alpha_{kj}} \frac{1}{\cos\theta_{qk}} \left(\mathrm{Re}\left[M_1\mu_{kj}\right] + j\,\mathrm{Im}\left[M_2\mu_{kj}\right]\right) \qquad \textbf{Eq. 3}$$

Where the terms built from the ASIC Correlators Board matrix are μ_{kj} and θ_{qk}. The other terms must be computed by calibrating the instrument with correlated noise injection.

The equations relating the complex normalised correlations obtained from the ASIC Correlator Board are the following, where in red it is indicated the parameters measured in the nominal correlations layer:

$$\mu_{kj} \equiv \mu_{kj}^{ii} + j\mu_{kj}^{qi} = \mu_{kj}^{ii} + j\mu_{jk}^{iq}$$
$$\mu_{kj} \equiv \mu_{kj}^{qq} - j\mu_{kj}^{iq} = \mu_{kj}^{qq} - j\mu_{jk}^{qi} \qquad \textbf{Eq. 4}$$

$$\theta_{qk} = \arcsin\left(-\mu_{kk}^{qi}\right) \qquad \textbf{Eq. 5}$$

The proposed way of expressing (4) makes it very clear that, in order to build the complex correlation *kj* one needs the elements *jk* (qi) and its opposite element in the ASIC Correlator Board matrix *kj* (ii).

μ_{kj}^{qi} represents the normalised correlation of the quadrature signal of receiver k with respect to the in-phase signal of receiver j.

The above equation (4) holds because the following relationships are always true:

$$\mu_{kj}^{ii} = \mu_{kj}^{qq}$$
$$\mu_{kj}^{qi} = -\mu_{kj}^{iq} \qquad \textbf{Eq. 6}$$

***We can see that the complex normalised correlations are not measured directly in the ASIC Correlator Board matrix, but must rather be constructed from two elements in opposite positions within the matrix*.**

We need to introduce the following domains and naming definitions, to establish a clear baseline when referring to elements:

- **ASIC Correlator Board**: PCB with the ASICs in DICOS that perform the correlations; the ASICs physically form a 3x3 ASIC array; on one side of the PCB we have the nominal ASICs; on the other side the redundant ones, only one of them is reported at a given integration time (see Figure 1). Contains the elements μ_{kj}^{qi}.
- **Baseline Star**: u-v complex plane showing the points corresponding to the baselines formed by all pairs of MIRAS receivers, including L and M baselines. (L-baseline= LICEF-LICEF baseline; M-baseline=Mixed LICEF-NIR baseline). Due to the particular MIRAS geometry, the envelope of this set of points is a 6-point star. Each position may contain more than one V_{kj} element, as there are redundant baselines (different antenna pairs may end up having the same u-v baseline)
- **Complex Visibility Matrix**: matrix of complex numbers built from the measurements V_{kj} for the SMOS data processing, where each position contains only one element

The following diagram depicts these three domains and their characteristics for the ***dual polarisation*** case. Information on the LICEF-NIR and LICEFs AB03, BC03 and CA03 has not been shown, to clarify the image.

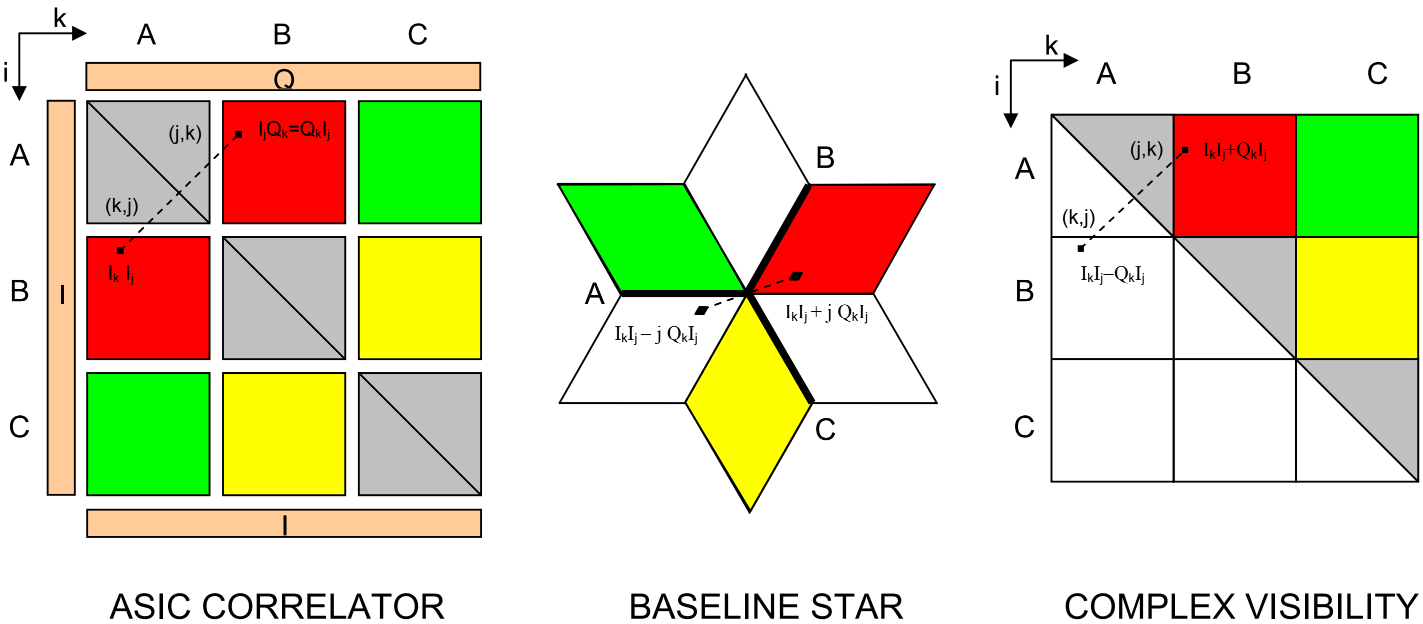

Figure 2: Domain convention

The nominal ASIC Correlator Board generates the real and imaginary parts of the complex visibility samples that lie above (or below depending on index convention) the main diagonal in the Complex Visibility Matrix. The lower (upper) part of the matrix is filled in using the hermiticity properties of the visibility function described in [RA.01] equation 3.22.

$$\left[V_{kj}^{pq}(u,v)\right]^* = V_{jk}^{qp}(-u,-v) \qquad \textbf{Eq. 7}$$

The correlations measured by the off-diagonal ASICs in the ASIC Correlator Board mostly correspond to three of the six petals of the Baseline Star. The remaining three petals correspond to the opposite baselines, associated to hermitic values of the visibility function, by the same equation above.

The Complex Visibility matrix so obtained is then used to retrieve the polarimetric Brightness Temperature, according to the already known equation that relates calibrated visibilities to brightness temperatures:

$$V_{kj}^{pq}(u,v) = \iint_{\xi^2+\eta^2\le 1} F_{n,k}^{p}(\xi,\eta) F_{n,j}^{q*}(\xi,\eta) \frac{T_B^{pq}(\xi,\eta) - \delta^{pq} T_{rec}}{\sqrt{1-\xi^2-\eta^2}} \tilde{r}_{kj}\left(-\frac{u\xi + v\eta + w\sqrt{1-\xi^2-\eta^2}}{f_0}\right) e^{-j2\pi\left(u\xi+v\eta+w\sqrt{1-\xi^2-\eta^2}\right)} d\xi d\eta \qquad \textbf{Eq. 8}$$

2.2. Full-pol operation

During full-pol mode, every alternate integration time, there shall be three complete ASIC Correlator Board matrices produced as output, generated by the correlation of receivers' signals when one arm is in the opposite polarisation as the other two.

Combining the ASIC Correlator Board matrices data into the mathematical matrix representation of the computed Complex Visibilities V_{kj}, according to Figure 2, one of the possible configurations (HVV) is shown in the following figure.

Sub-interval T1	Sub-interval T2	Sub-interval T3
Arm A: H pol Arm B: V pol Arm C: V pol	Arm A: V pol Arm B: H pol Arm C: V pol	Arm A: V pol Arm B: V pol Arm C: H pol

Sub-interval T1:

V_{AA}^{HH}	V_{AB}^{HV}	V_{AC}^{HV}
V_{BA}^{VH}	V_{BB}^{VV}	V_{BC}^{VV}
V_{CA}^{VH}	V_{CB}^{VV}	V_{CC}^{VV}

Sub-interval T2:

V_{AA}^{VV}	V_{AB}^{VH}	V_{AC}^{VV}
V_{BA}^{HV}	V_{BB}^{HH}	V_{BC}^{HV}
V_{CA}^{VV}	V_{CB}^{VH}	V_{CC}^{VV}

Sub-interval T3:

V_{AA}^{VV}	V_{AB}^{VV}	V_{AC}^{VH}
V_{BA}^{VV}	V_{BB}^{VV}	V_{BC}^{VH}
V_{CA}^{HV}	V_{CB}^{HV}	V_{CC}^{HH}

Figure 3: Complex Visibilities in full pol mode (HVV)

This diagram does not take into account cross-polarisation measurements due to baselines being correlated with the LICEF-NIR elements. These considerations shall be taken at a later chapter.

Each sector identifies the Complex Visibilities for particular conditions, using the V_{KJ}^{pq} expression, representing the complete set of complex visibilities for arm K against arm J, when all receivers in arm K are using polarisation p and all receives in arm J are using polarisation q.

As described in the previous chapter, for each complete matrix of ASIC Correlator Board measurements, only the upper (or lower) half of the Complex Visibilities Matrix can be directly extracted. The other half must be extrapolated using the hermiticity property described in Eq.7. In the above diagram, this means that we can build directly all 24x24 complex visibilities in V_{AB}^{HV} for time T1, combining the ASIC 01 and ASIC 03 Correlator Board pairs measured at time T1. However, in order to obtain the complex visibilities of the opposite coordinates of the matrix (below the diagonal), we must apply the complex conjugate relationship to it, obtaining V_{BA}^{VH} .

Now, in dual polarisation measurement, this has the nominal effect shown in figure 2, as all receivers are in the same polarisation, so the resulting Complex Visibilities Matrix domain is hermitic (the same as the Baseline Star domain). In full polarisation, the hermiticity property alters the order of the polarisation indexes, so the Baseline Star domain for a given cross-polarisation (i.e. HV) must be constructed using measured data for that cross-polarisation and the complex conjugates of the opposite cross-polarisation.

This means that from the Complex Visibilities Matrices obtained in the three integration times, the following information could be retrieved, grouping elements by polarisation indices:

HV info

	V^{HV}_{AB} (T1)	V^{HV}_{AC} (T1)
V^{HV}_{BA} (T2)		V^{HV}_{BC} (T2)
V^{HV}_{CA} (T3)	V^{HV}_{CB} (T3)	

VH info

	V^{VH}_{AB} (T2)	V^{VH}_{AC} (T3)
V^{VH}_{BA} (T1)		V^{VH}_{BC} (T3)
V^{VH}_{CA} (T1)	V^{VH}_{CB} (T2)	

VV info

V^{VV}_{AA}(T2,T3)	V^{VV}_{AB} (T3)	V^{VV}_{AC} (T2)
V^{VV}_{BA} (T3)	V^{VV}_{BB}(T1,T3)	V^{VV}_{BC} (T1)
V^{VV}_{CA} (T2)	V^{VV}_{CB} (T1)	V^{VV}_{CC}(T1,T2)

HH info

V^{HH}_{AA} (T1)		
	V^{HH}_{BB} (T2)	
		V^{HH}_{CC} (T3)

Figure 4: Complex Visibilities Matrices combination in full pol mode (HVV)

Due to the way in which the HV and VH Complex Visibilities Matrices are built, we obtain that BY CONSTRUCTION, the “HV info” and “VH info” complex visibilities matrices are exactly complex conjugates, and are not hermitic.

The fact that the HV and VH Complex Visibilities Matrices, and by definition the Baseline Star representations as well, are not hermitic means that the reconstructed polarimetric Brightness Temperature shall be complex in nature. For HH or VV, the Baseline Star representation is hermitic, so the resulting Brightness Temperature shall be real in nature.

The fact that HV and VH Complex Visibilities Matrices are perfect complex conjugates means that the reconstructed T_{HV} and T_{VH} shall be perfect complex conjugates as well, so it should only be needed to report one of them in the L1 products.

As during time T1, the Complex Visibilities between arm A and arm B are constructed by using the real and imaginary elements in ASIC 01 and ASIC 03 of the ASIC Correlator Board domain, the Complex Visibilities produced for arm A in H pol against arm B in V pol are exactly the complex conjugate of the Complex Visibilities produced for arm B in V pol against arm A in H pol. This relationship of complex conjugate is happening because these elements are BUILT as complex conjugates when going from the ASIC Correlator Board domain to the Complex Visibilities domain and also to the Baselines Star domain.

This can be seen in the following figure, where the combination of ASIC Correlators Board data is presented for HV and VH polarisations, in order to form the Complex Visibilities Matrices. Each of the sub-elements of the Complex Visibility Matrix is formed by elements from the ASIC Correlators Board, represented as ASIC##_TX (where ## means the ASIC number used and TX the time sub-interval from which the ASIC needs to be extracted):

HV info

	ASIC03_T1 + ASIC01_T1*j	ASIC06_T1 + ASIC02_T1*j
ASIC03_T2 - ASIC01_T2*j		ASIC07_T2 + ASIC05_T2*j
ASIC06_T3 - ASIC02_T3*j	ASIC07_T3 - ASIC05_T3*j	

VH info

	ASIC03_T2 + ASIC01_T2*j	ASIC06_T3 + ASIC02_T3*j
ASIC03_T1 - ASIC01_T1*j		ASIC07_T3 + ASIC05_T3*j
ASIC06_T1 - ASIC02_T1*j	ASIC07_T2 - ASIC05_T2*j	

Figure 5: ASIC Correlators Board combination to create Complex Visibilities in HV and VH mode (HVV)

The impact of this processing mode is that from full-pol during the three sub-integration times, there shall only be the need to reconstruct one HV scene and a VV scene in L1b products. VH reconstruction would be exactly the rotation of the HV scene (complex conjugate). However, for size considerations, the full polarimetric product shall be nearly double the size of a dual polarimetric one, as even if the data is restricted to three scenes (HH, HV and VV) for every 2.4 seconds, the Brightness Temperature of HV shall be complex, whereas the others are real.

The HH scene is a by-product, due to the fact that the Complex Visibilities domain can only be built using the diagonal ASICs Correlators Board measurements. Measurements in those ASICs are mostly contained in redundant baselines in the Baselines Star domain, representing very few significant independent baselines. This information cannot be used for Image Reconstruction, but it may be used for validation purposes through some specific processing, so it shall be stored in L1a products, but not propagated to L1b products.

In order to complete the information provided, the opposite polarisation case (VHH) shall be described and the re-ordering of data displayed.

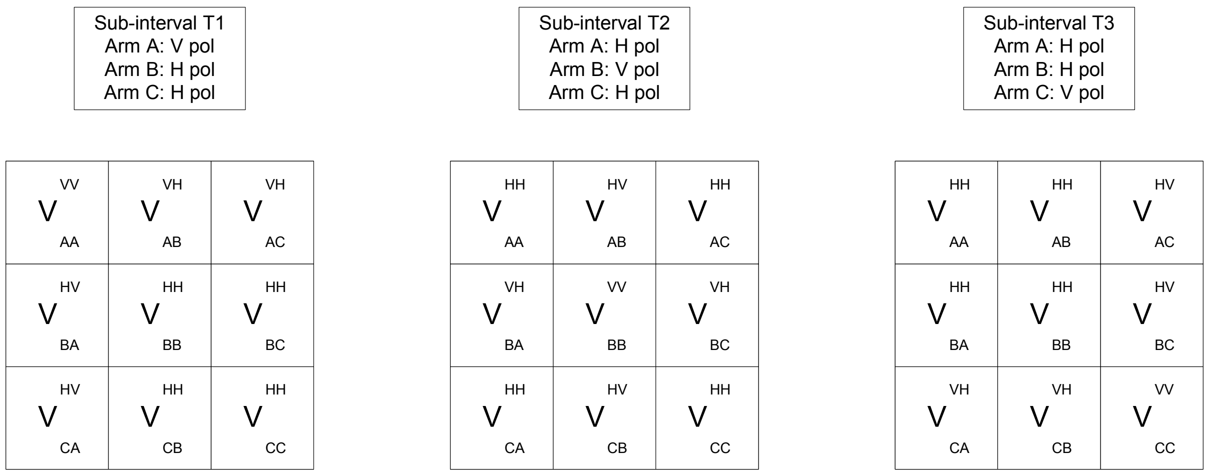

Figure 6: Complex Visibilities in full pol mode (VHH)

Combining the data in order to produce complex visibilities for the four separate polarisations, the diagram would be like the following:

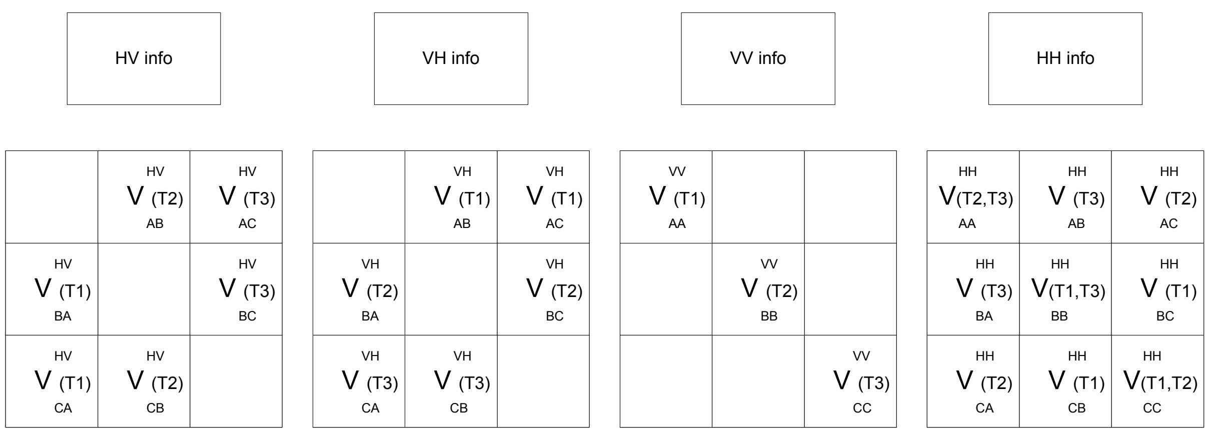

Figure 7: Complex visibilities combination in full pol mode (VHH)

Whereas the needed ASIC Correlators Board combination for extracting HV and VH information and representing it as Complex Visibilities would be:

HV info
	ASIC03_T2 + ASIC01_T2*j	ASIC06_T3 + ASIC02_T3*j
ASIC03_T1 - ASIC01_T1*j		ASIC07_T3 + ASIC05_T3*j
ASIC06_T1 - ASIC02_T1*j	ASIC07_T2 - ASIC05_T2*j	

VH info
	ASIC03_T1 + ASIC01_T1*j	ASIC06_T1 + ASIC02_T1*j
ASIC03_T2 - ASIC01_T2*j		ASIC07_T2 + ASIC05_T2*j
ASIC06_T3 - ASIC02_T3*j	ASIC07_T3 - ASIC05_T3*j	

Figure 8: ASIC Correlators Board combination to create Complex Visibilities in HV and VH mode (VHH)

All in all, the conclusion to be extracted from this processing strategy, is that the results for full-polarisation measurements reconstruction shall be:

- For the first integration time of 1.2s with one arm set to polarisation H and the other two to V, alternating the arm sequence: one scene of T_V brightness temperatures real valued, and one scene of T_{HV} brightness temperatures complex valued.
- For the next integration time of 1.2s with all receivers in H: one scene of T_H brightness temperatures real valued.
- For the next integration time of 1.2s with one arm set to polarisation V and the other two to H, alternating the arm sequence: one scene of T_H brightness temperatures real valued, and one scene of T_{HV} brightness temperatures complex valued.
- For the next integration time of 1.2s with all receivers in V: one scene of T_V brightness temperatures real valued.

2.3. LICEF-NIR baselines considerations

As seen in the ASIC Correlators Board matrix, every integration time there shall be the correlation of 72 signals instead of 69 as the number of receivers. This is due to the fact that the LICEF-NIRs are correlating all the time signals in both H and V polarisation.

We need to introduce here the term Complex Visibility Matrix elements, as the atomic constituents of the Complex Visibilities Matrix domain, formed by combination of individual elements of the ASIC Correlators Board. In the previous chapters, grouping was performed at the level of sub-matrices, but for the distinction of LICEF-NIR elements, it is necessary to enter into how the Complex Visibility Matrices are built.

During dual polarisation mode, it is most possible that the cross-polarisation Complex Visibilities elements produced by combination of the LICEF-NIR signal in the opposite polarisation shall not be used at all during reconstruction. However, in full polarisation, they may add additional redundant baselines to the Baseline Star domain.

However, the LICEF-NIR correlations for different arms cannot be used in the Full polarisation Image Reconstruction process either, as the integration periods are not synchronised along arms. Thus, they have been highlighted in the following images to indicate that they shall not be used at all.

As an example, in the following figure, there is a representation of the cross-polarisation Complex Visibilities Matrix elements obtained during the integration time when arm A is in H polarisation and arms B and C are in V polarisation.

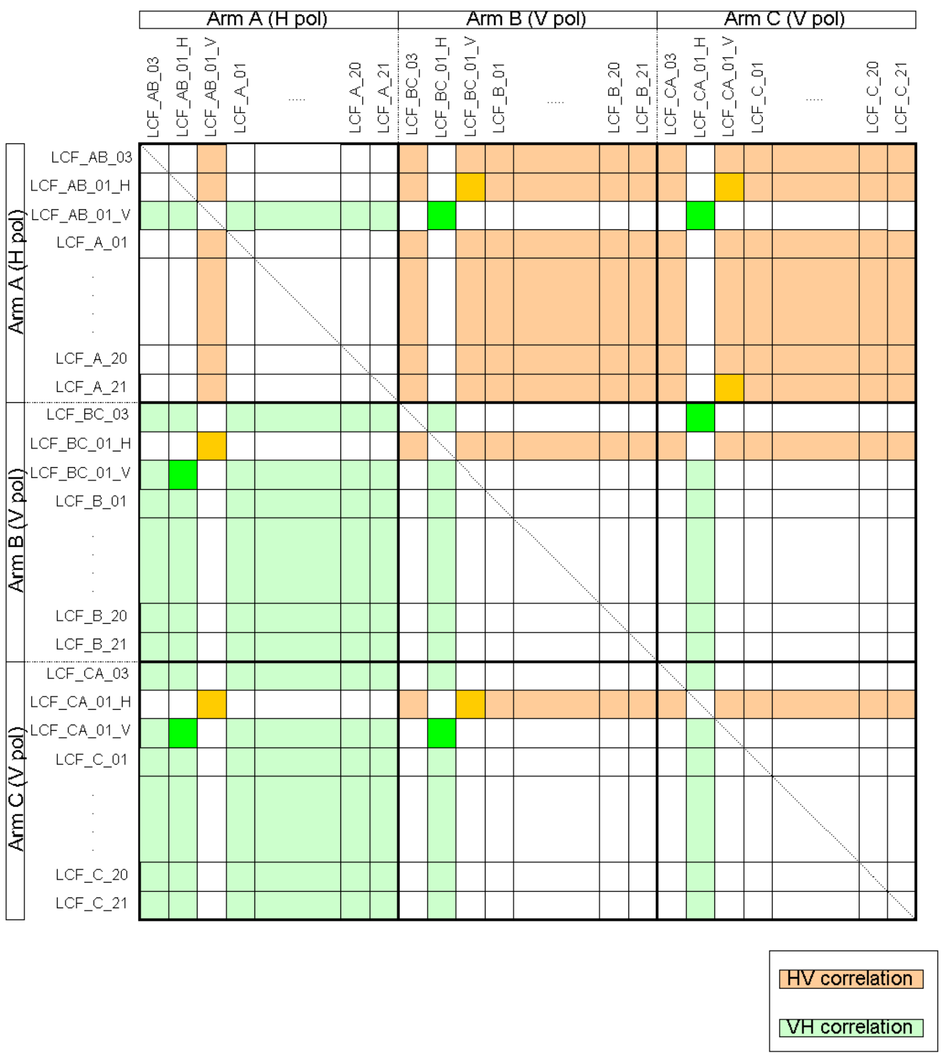

Figure 9: HV and VH Complex Visibilities elements in HVV mode

Combining the three integration times where the polarisation arm is rotated, would result in the following three matrices, using the same colour notation:

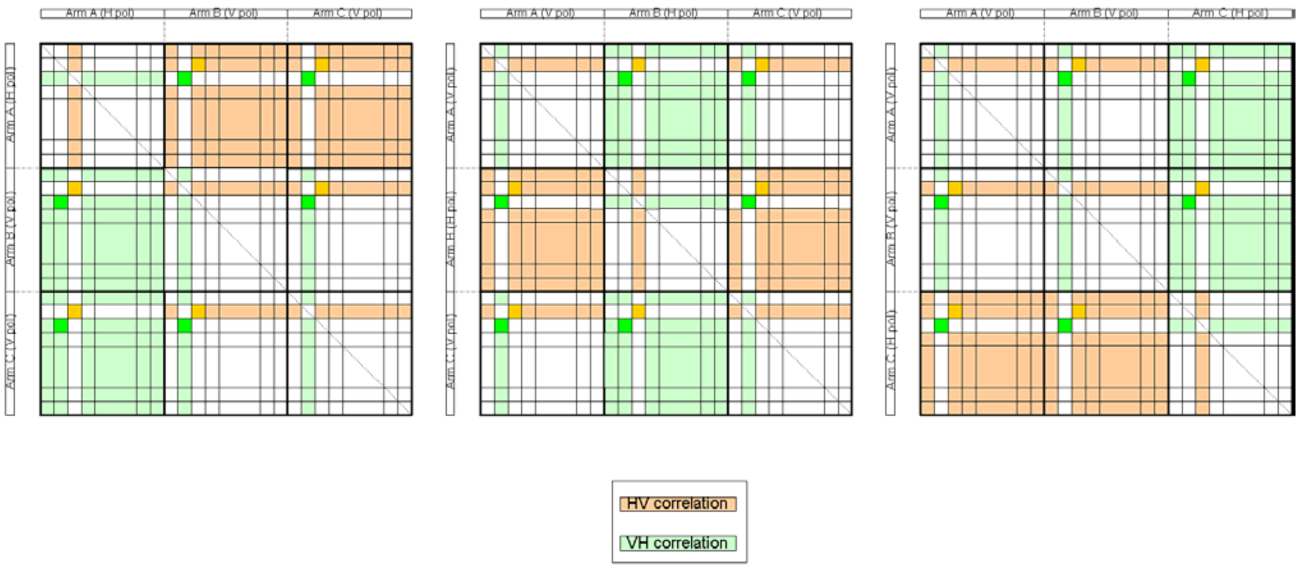

Figure 10: HV and VH Complex Visibilities elements in HVV, VHV and VVH mode

It can be seen that the process to group all the Complex Visibility elements (or Baselines) into the appropriate Complex Visibility Matrices, for reconstruction of the HV Brightness Temperature, shall also take into account the baselines produced with the LICEF-NIR. Some averaging strategy shall be needed, as it can be observed that for receivers in the same arm, cross-polarisations Complex Visibility elements are measured in two separate instances by the LICEF-NIR (i.e. Complex Visibilities in arm C against itself for polarisations HVV and VHV).

It can also be observed, that the LICEF-NIR shall be the only receivers able to produce an auto-correlation with cross-polarisation values. That is, for the same receiver, and in the ASIC Correlators Board matrix, it shall correlate the in-phase and quadrature signals coming from different polarisations. (Nominally the auto-correlation is the correlation of the in-phase and quadrature signals of one receiver, when it is operating at a given polarisation). *These values shall be very useful in full-pol processing, as they shall provide the only measurement for the zero baseline in cross-polarisation*.

Another issue that may also be observed, is that there is a certain degree of redundancy in the HV and VH values, as some correlations between antenna pairs are measured more than once during the same integration time. The positions for which this is happening are shown red in the next image for the HV polarisation case. They are named redundant pairs here not only because they refer to the same baseline, but also because they refer to the same antenna pairs at the same integration time, so the coefficients of the System Response Function would be completely identical in both cases. *Values measured in the same position, for the same antenna pair and for the same integration time should be averaged*, in order to present a unique value of calibrated visibilities to be reconstructed, and reduce the G matrix singularity in the reconstruction.

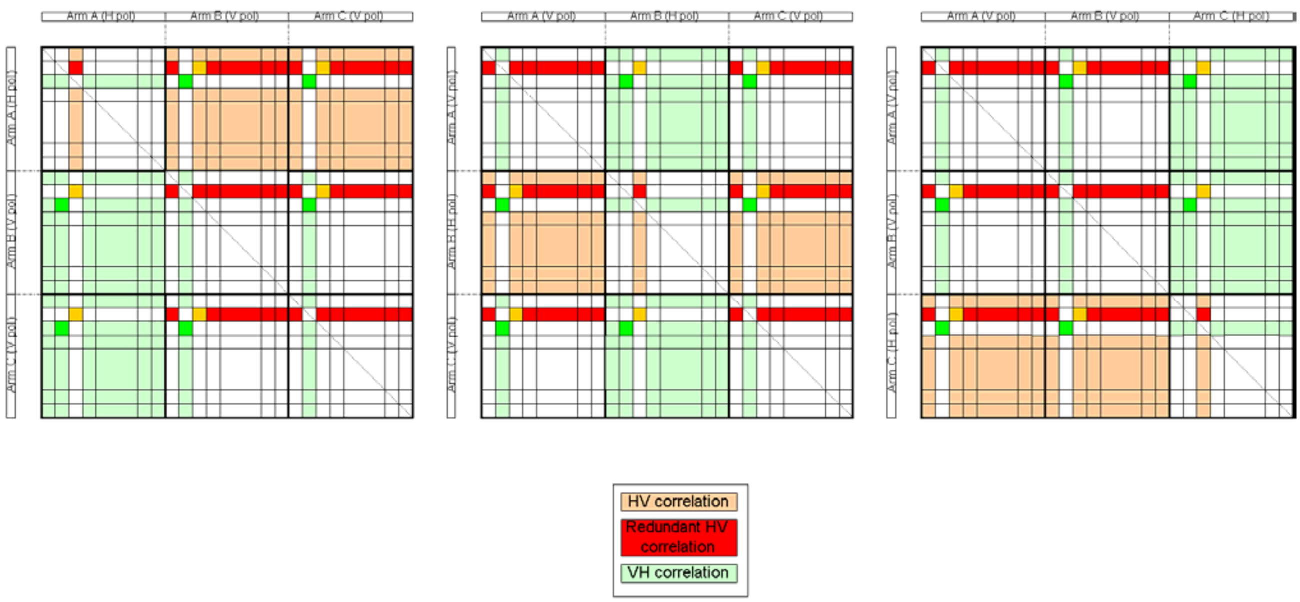

Figure 11: Redundant HV Complex Visibilities elements (red) in HVV, VHV and VVH mode

For each of the three arm configurations, it can be seen that the total number of elements for HV polarisation is 2x23x23 – 2 (two complete ASICs), plus 3x23 (individual rows and columns for arms A, B and C) plus 2x22 (remaining rows). This gives a total of 1169 elements in one mode, and 3507 in the complete integration time.

Taking out the redundancies can be done by simply considering that the visibilities covered in the rows marked in red are 3x23+6x22, whereas the total number of elements measured is 3x(2x23+4x22+1). This leaves a total of 3507–(405–201)=**3303 elements**.

2.4. Full-polarisation Image Reconstruction considerations

As shown in previous chapters, the Complex Visibilities domain (and the Baseline Star domain) is not hermitic for HV or VH polarisations, so any G matrix approach should take this into account, especially if it has been restricted to the real domain, as now the T_{HV} result shall be a complex number.

This means that any assumption taken based on dual polarisation mode, like the number of equations to solve or the way to average redundant baselines shall be necessary different in both operation modes. As a preliminary list, the following conditions shall be different:

- In dual polarisation, the number of available equations is 69*68/2+1=**2347**, falling more or less into one half of the Baseline Star domain, as the other half may be immediately retrieved using the hermitian property
- In full polarisation, the number of available equations is increased. As it has been demonstrated before, the total number of Complex Visibility values shall be **3303**. Hermiticity here does not allow for a reduction in equations, but forces to include more equations, as the solution in brightness temperatures must be complex.
- In dual polarisation, the reconstruction solution is restricted to the real numbers domain

- In full polarisation, the reconstruction solution for HV and VH is a complex number

For reconstruction methods using G matrix approaches, these items shall be significant, as they mean that the method to reconstruct a cross-polarised scene is not as straight-forward as changing the polarisation of the antenna patterns.

In the currently known methods that apply G matrix (Theoretical and Parametric), the following conditions are applied, and some new factors should be taken into account:

- The latest proposed G matrix baseline operates with all the Complex Visibilities available (including redundant ones), so no averaging of baselines is required. However, construction of the G matrix shall be totally different for dual and full polarisation modes, because the number of equations changes as it has been explained above.