POLARIMETRIC SAR INTERFEROMETRY

(PolInSAR)

3rd STEREO/VEGETATION DAY
Brussels, 6 May 2004

Three information channels of SAR imagery.

The amplitude : $\rightarrow$ traditional SAR imagery.

The phase : $\rightarrow$ SAR interferometry (InSAR).

The polarisation : $\rightarrow$ SAR polarimetry (PolSAR).

What is PolInSAR?

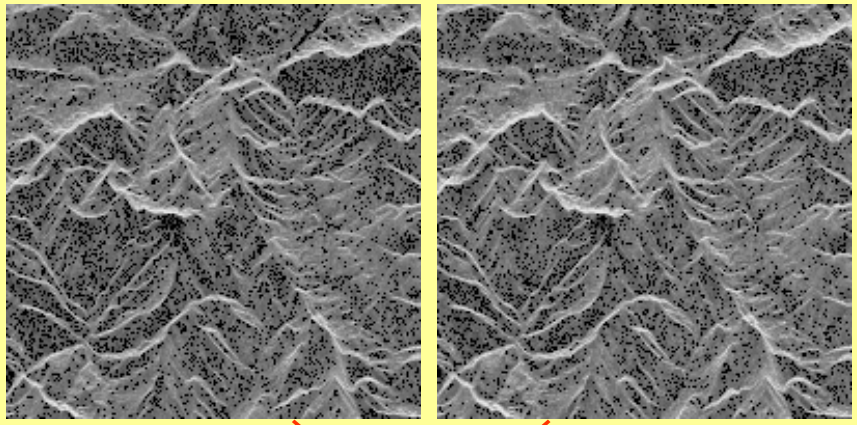
PolInSAR = vector InSAR

InSAR → height information.
PolSAR → scattering mechanisms information.

PolInSAR → height distribution of scattering mechanisms

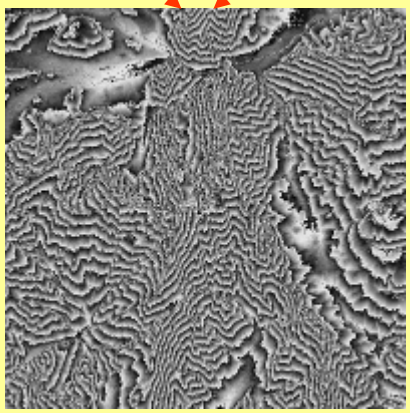
InSAR provides height information.

Pass 1
(μ_1)



Pass 2
(μ_2)

($\mu_1\mu_2^*$)



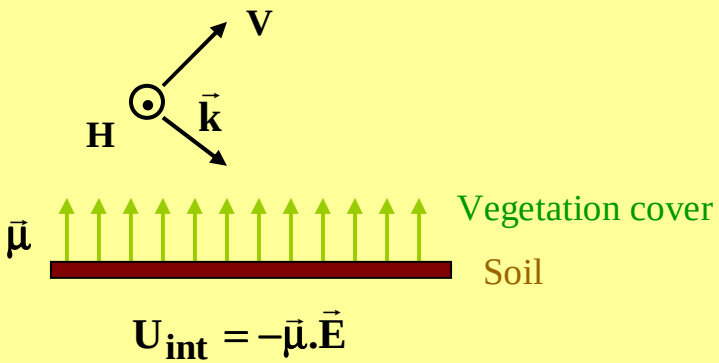
Interference pattern
==> DTM

Quality figure :

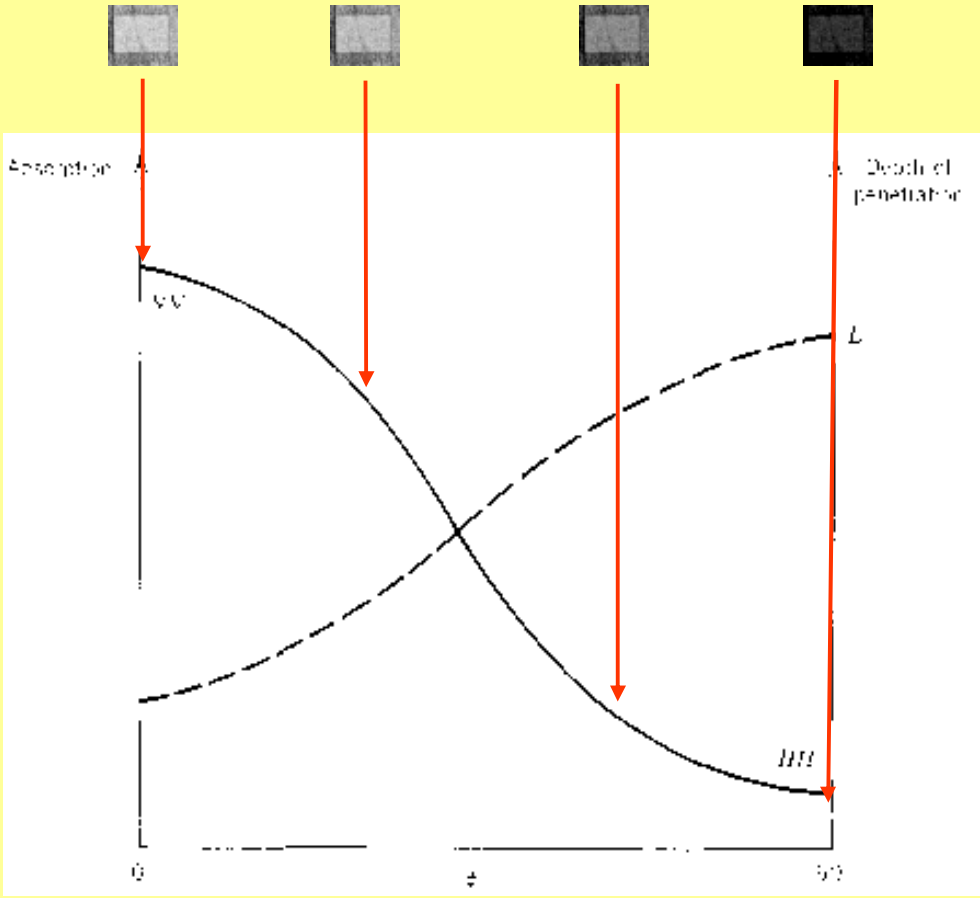
$$\gamma = \frac{\left|\left\langle \mu_1 \middle| \mu_2^* \right\rangle\right|}{\sqrt{\left\langle \mu_1 \middle| \mu_1^* \right\rangle \left\langle \mu_2 \middle| \mu_2^* \right\rangle}}$$

$$= \gamma_{SNR}\ \gamma_{Baseline}\ \gamma_{Temporal}$$

PolSAR provides scattering mechanisms information.



$$U_{int} = -\vec{\mu}.\vec{E}$$



Basic scattering definitions.

The full polarimetric SAR mesures the scattering matrix :

$$\begin{pmatrix} E_H^r \\ E_V^r \end{pmatrix} = \frac{e^{-jkr}}{kr} \begin{pmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{pmatrix} \begin{pmatrix} E_H^t \\ E_V^t \end{pmatrix}$$

The scattering matrix can be vectorized into a scattering vector :

$$\vec{k} = \sum_i \mu_i \vec{w}_i$$

A polarimetric image is given by :

$$\mu_i = \vec{k}.\vec{w}_i$$

The basis set is arbitrary, but some choices reflect decompositions into elementary scattering mechanisms (e.g., Cloude decomposition).

Polarimetric representations.

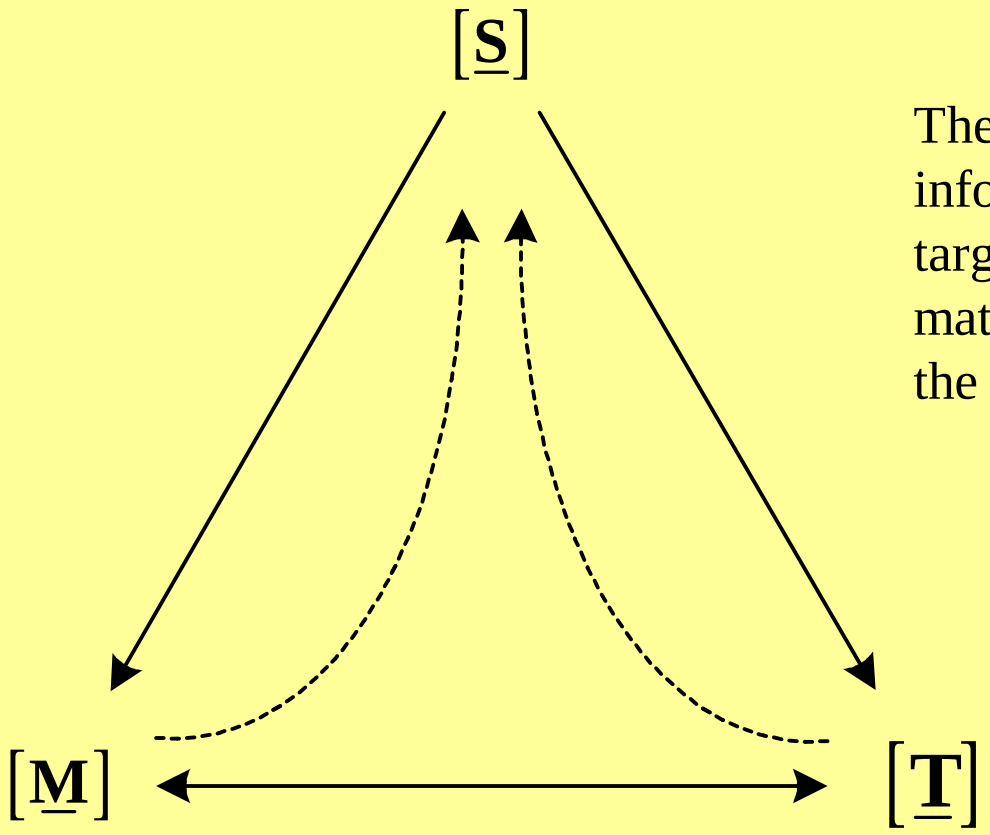
The polarimatric radar echo may be described by :

- the scattering matrix **S**,
- the Müller matrix **M**,
- the coherency matrix **T**,
- the covariance matrix **C**, etc.

In the case of a **deterministic** target, these matrices contain the same information: these representation are EQUIVALENT.

But for a **random distributed** target : **???**

Relationships involving *Müller*, *Scattering* and *Target Coherency* matrices.



The extraction of the information about a random target depends on the matrix used to investigate the scattering phenomena.

Advantages in using the *Coherency* matrix with respect to the *Müller* matrix.

- identification of the correspondence between a measured **T** and physical scattering mechanisms.
- to describe qualitatively each observed target by a :

  - single,

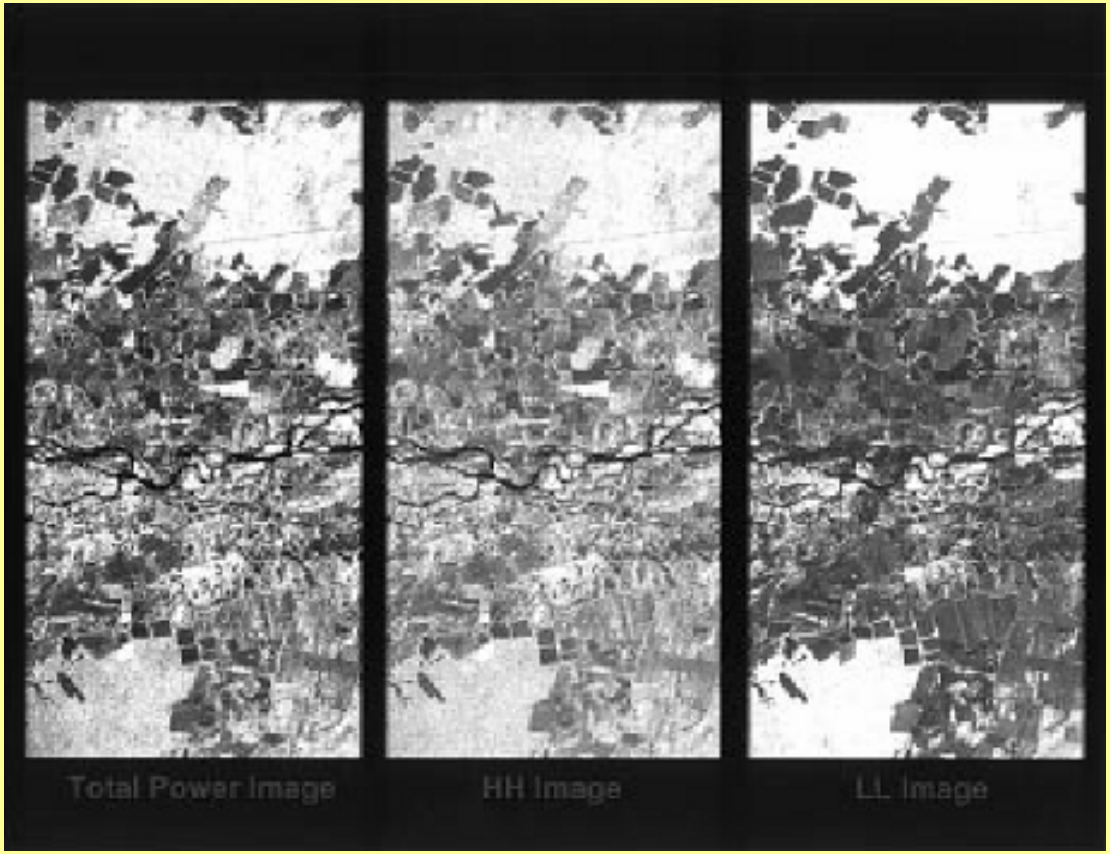
  - simple,

  - dominant,

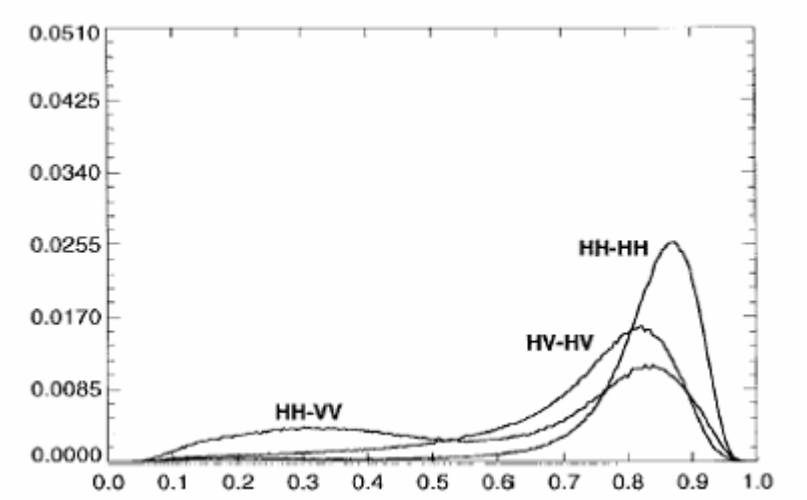
  - scattering mechanism.

A Picture Book Example.

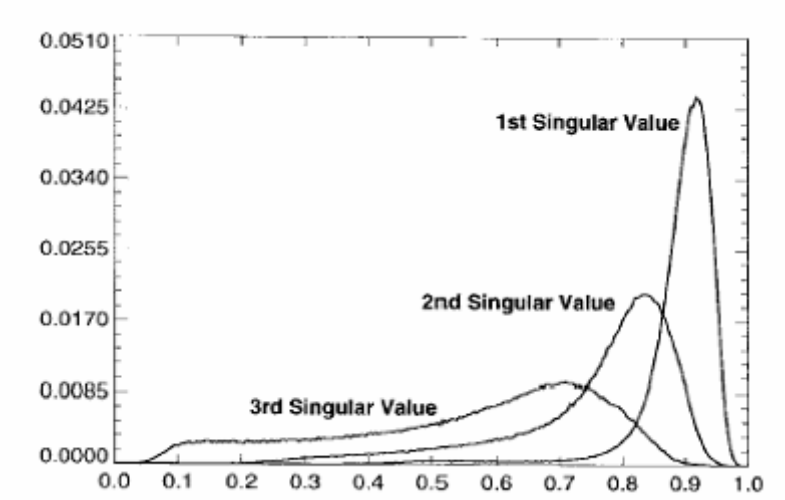
S.R. Cloude and K.P. Papathanasiou, “Polarimetric SAR Interferometry”, IEEE Trans. Geosci. Remote Sensing 36(5), 1551-1656

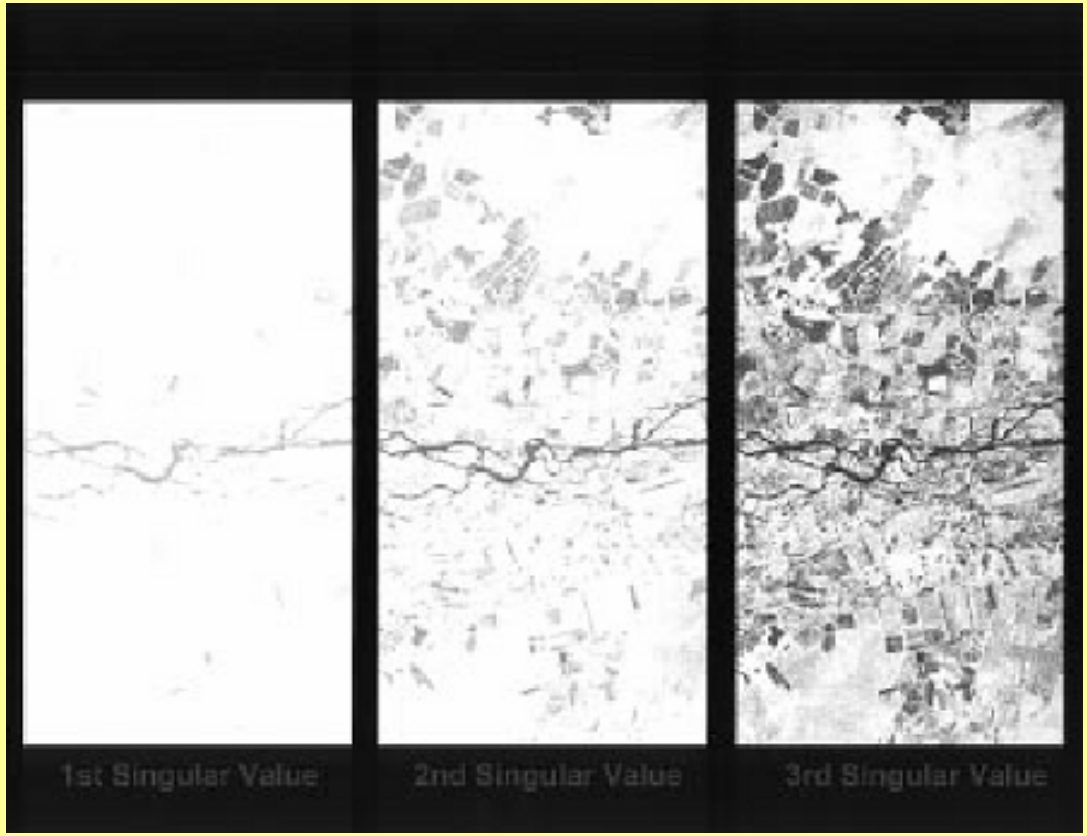


The Coherence Maps.



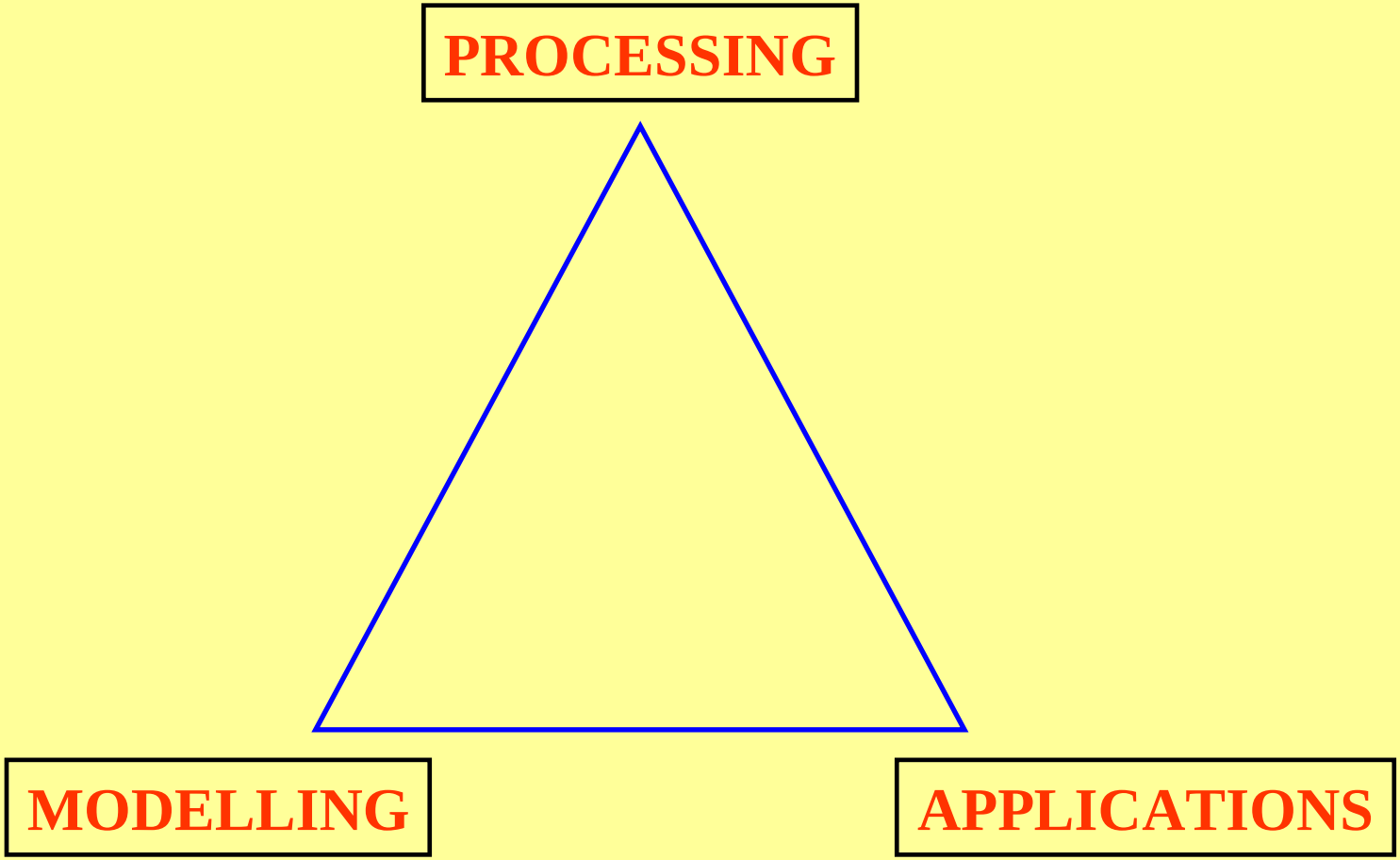
Decomposition Into Coherence-Optimized States.





Interpretation through a MODEL.

PolInSAR Logics.



PROJECT OBJECTIVES.

PolInSAR processing **:**

Theory, incl. literature review, algorithmics and calibration issues.
Processor design and coding.
Test data selection.
Transfer of results to modlling and fusion teams.

PolInSAR Physics **:**

Literature review.
Polarisation states and coherent model analysis.
Scattering mechanisms decomposition.

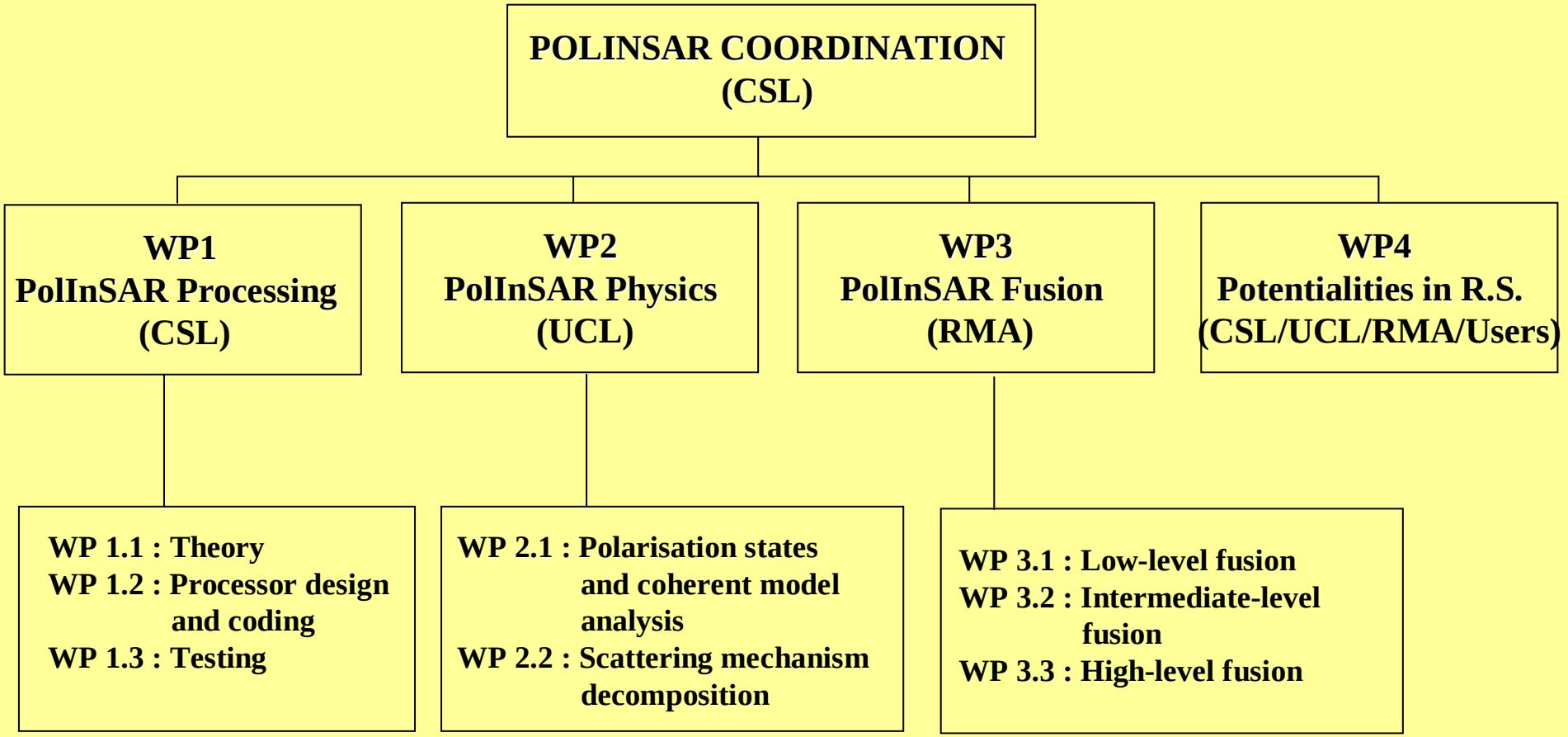
PolInSAR Fusion Feasibility Study **:**

Land-cover classification.
Object of interest detection.

PolInSAR Potentialities in Remote Sensing **:**

Humanetarian demining.
Crisis Management.

PARTNERSHIP AND WBS.



PLANNING AND DELIVERABLES.

Epoch (months)	WP ID (Partner)	Description of output
T0	WP1 (CSL)	Start of WP1
T0 + 6	WP1.1 (CSL)	PolInSAR theoretical study results
T0 + 6	WP2 (UCL)	Start of WP2
T0 + 12	WP1.2 (CSL)	PolInSAR processor
T0 + 12	WP2.1 (UCL)	Polarisation states and coherent model analysis for PolInSAR (report)
T0 + 19	WP3 (RMA)	Start of WP3
T0 + 24	WP1.3 (CSL)	Test results
T0 + 24	WP3 (RMA)	PolInSAR fusion feasibility study (report)
T0 + 27	WP2.2 (UCL)	Scattering mechanisms decomposition for PolInSAR (report)
T0 + 27	WP4 (CSL/UCL/RMA/Users)	Start WP4
T0 + 29	WP4 (CSL/UCL/RMA/Users)	Potentialities in RS for PolInSAR (report)