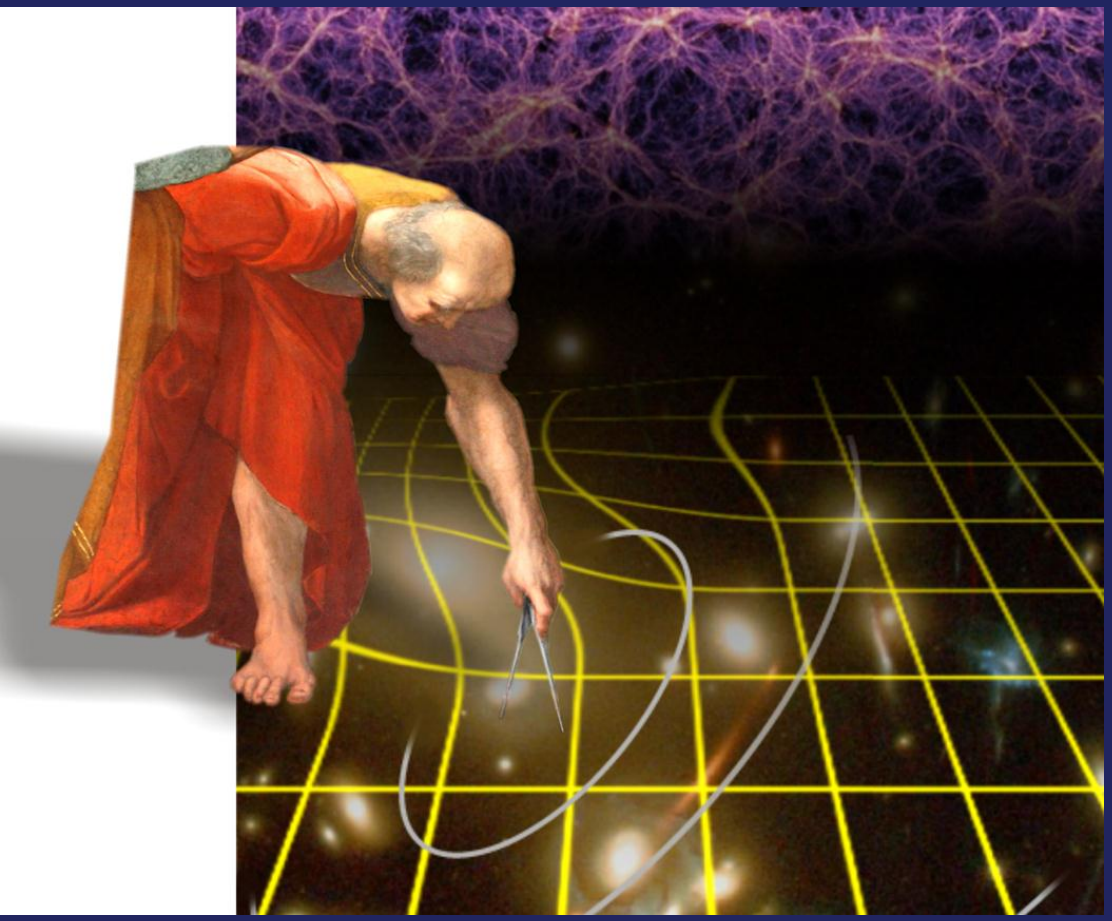


Science Performance Verification discussion

J. Amiaux
CEA / Irfu / SAp

Follow-on Mission PDR

The Euclid Mission Preliminary Design Review

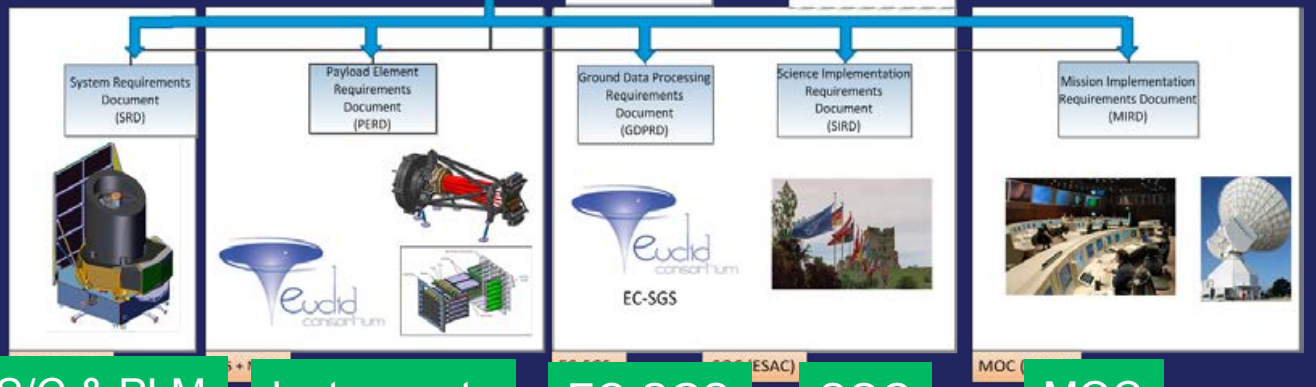
1) To ensure the adequate progress of each element: spacecraft, instruments, ground segment (science and operations), launcher;
2) To verify that the mission performances are compliant with the top level Mission Requirement Document (MRD)
3) Furthermore, during this review, the feasibility of the survey and of the suitability of the calibration shall be assessed since they have not been submitted to any other official ESA review before.

Revue ESA (category 1) → Mission Requirement Document

CAVEAT: No Science Verifications (SciRD)

Survey

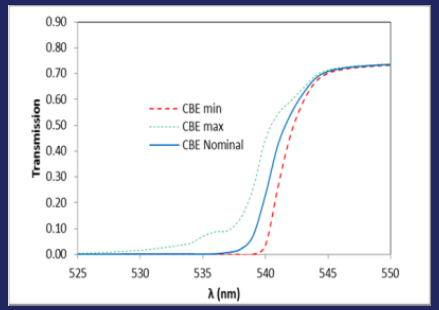
Calibration

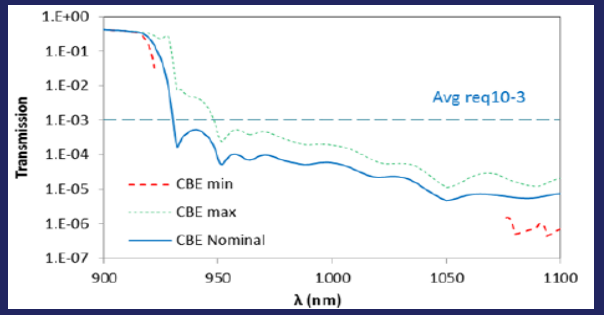


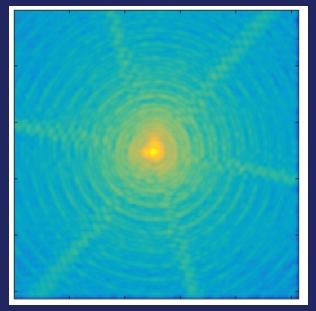
Launcher | S/C & PLM | Instruments | EC-SGS | SOC | MOC

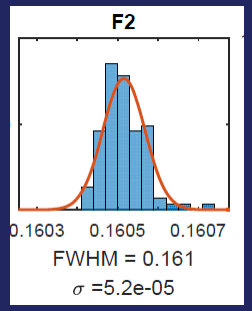
Mission PDR: Performances

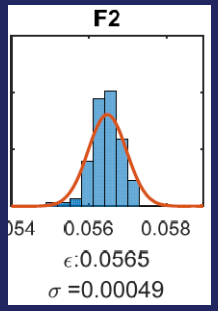
Technical Performance Measure		Requirement	CBE
Image Quality			
VIS Channel	FWHM (@ 800nm)	180 mas	163 mas
	ellipticity	15.0%	5.9%
	R2 (@ 800 nm)	0.0576	0.0530
	ellipticity stability σ(εi)	2.00E-04	2.00E-04
	R2 stability σ(R2)/<R2>	1.00E-03	1.00E-03
	Plate scale	0.10 "	0.10 "
	Out-of-band avg red side	1.00E-03	1.13E-05
	Out-of-band avg blue side	1.00E-03	2.12E-04
	Slope red side	35 nm	15 nm
	Slope blue side	25 nm	8 nm
NISP Channel	rEE50 (@1486nm)	400 mas	217 mas
	rEE80 (@1486nm)	700 mas	583 mas
	Plate scale	0.30 "	0.30 "
Sensitivity			
VIS SNR (for mAB = 24.5 sources)		10	17.1
NISP-S SNR (@ 1.6um for 2xe-16 erg cm-2 s-1 source)		3.5	4.87
NISP- P SNR (for mAB = 24 sources)	Y-band	5	5.78
	J-band	5	6.69
	H-band	5	5.35
NISP-S Performance			
Purity		80%	72%
Completeness		45%	0.52
Survey			
Wide Survey Coverage		15,000 deg2	15,000
Survey length [years]		5.5	5.4

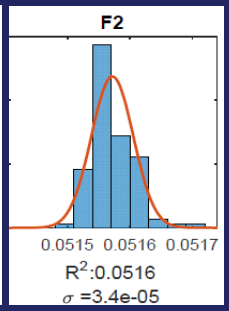










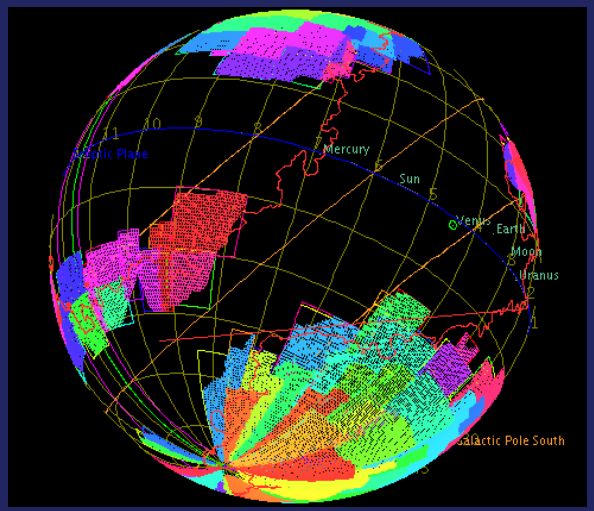


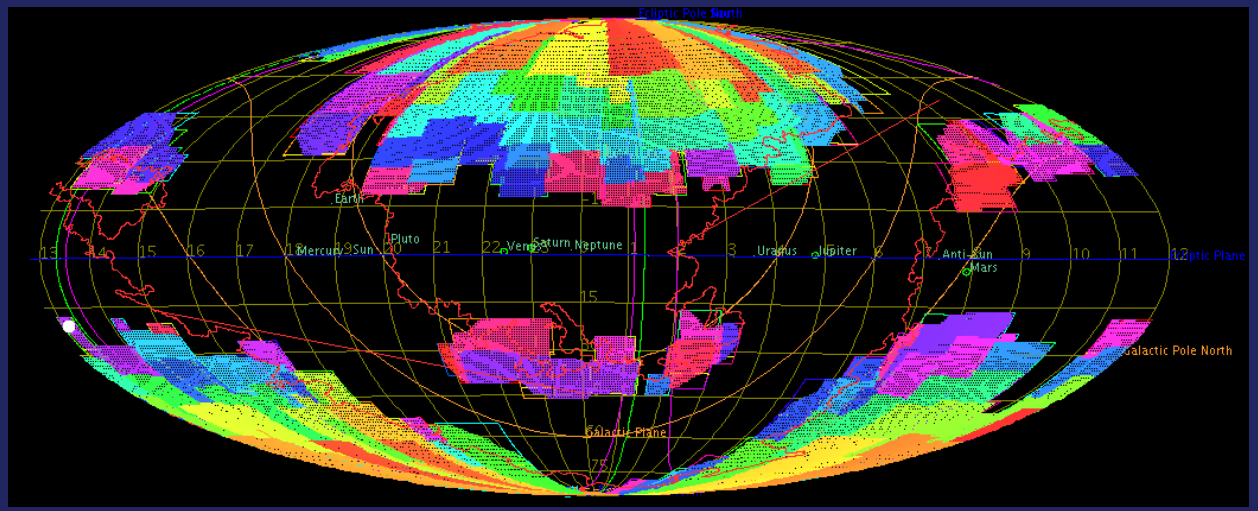
- Performance at mission level in general in very good state (based on Current Best Estimate).
- Image quality of the system fully in line with needs.
- Ellipticity, R2 stability and Non-convolutive errors performance dictated mainly by ground processing and will be evaluated at SGS DR
- *Purity* not compliant with current data processing methods but expected to be recovered.

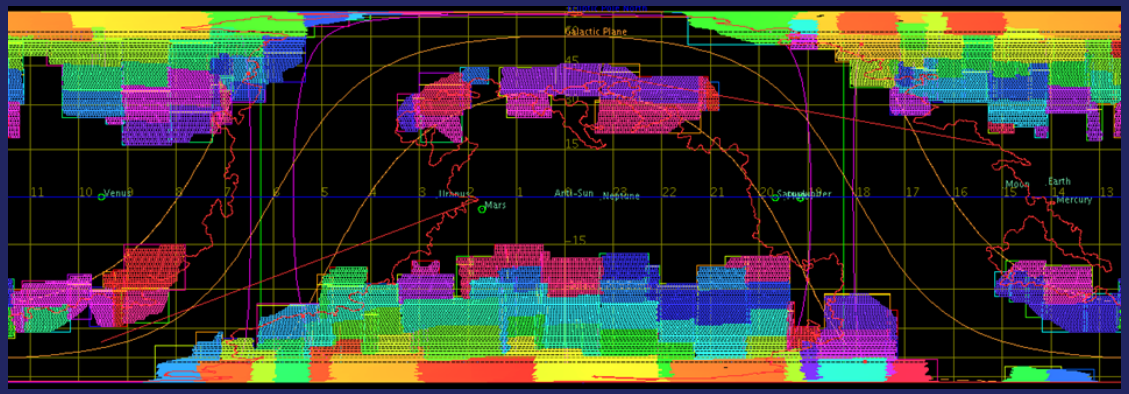
Euclid update Reference Survey

For Mission PDR, use of automatic Survey Generation tool taking into account:

- Spacecraft observational constraints and agility
- Calibration and orbit maintenance
- Best observable area on the sky
- For different operation scenario (**nominal: 4400 s and with margin: 5000 s**)



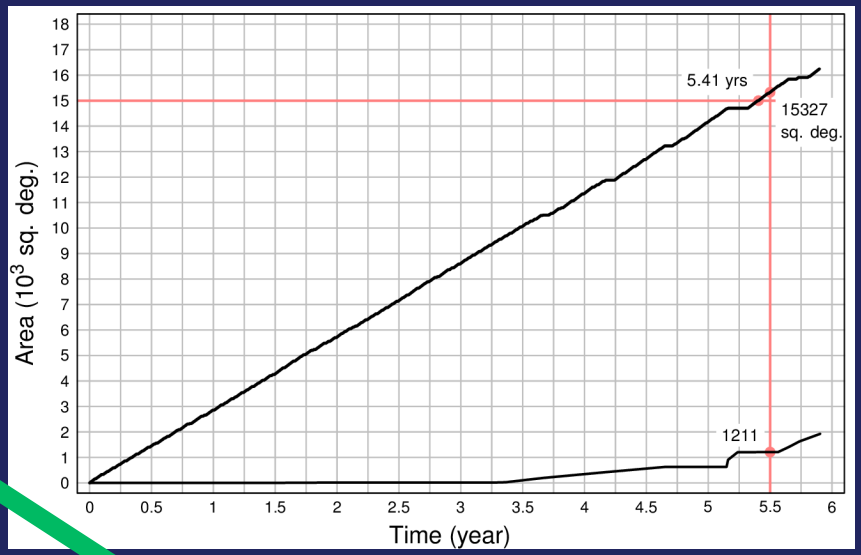




Euclid update Reference Survey

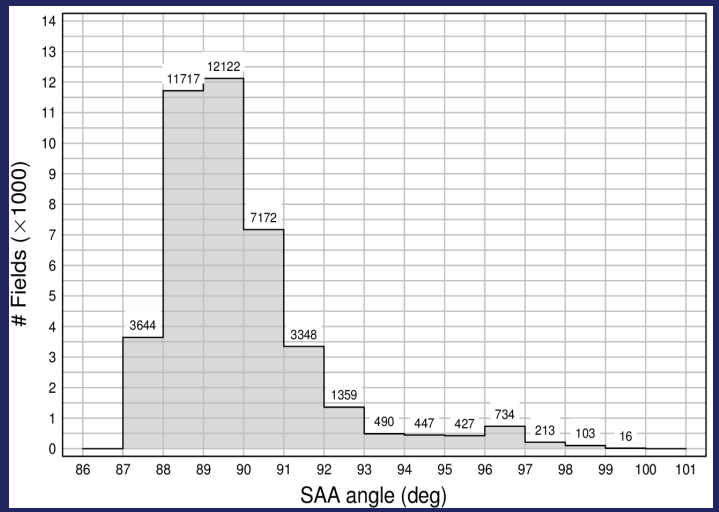
Survey can be implemented with required performance:

- Sky coverage of 15 000 deg² + calibration
- In less than 6 years of operations:
  - < 5,5 ans for nominal case (4400 s)
  - < 6 ans for case with margin (5000 s)
- While respecting the Spacecraft constraints

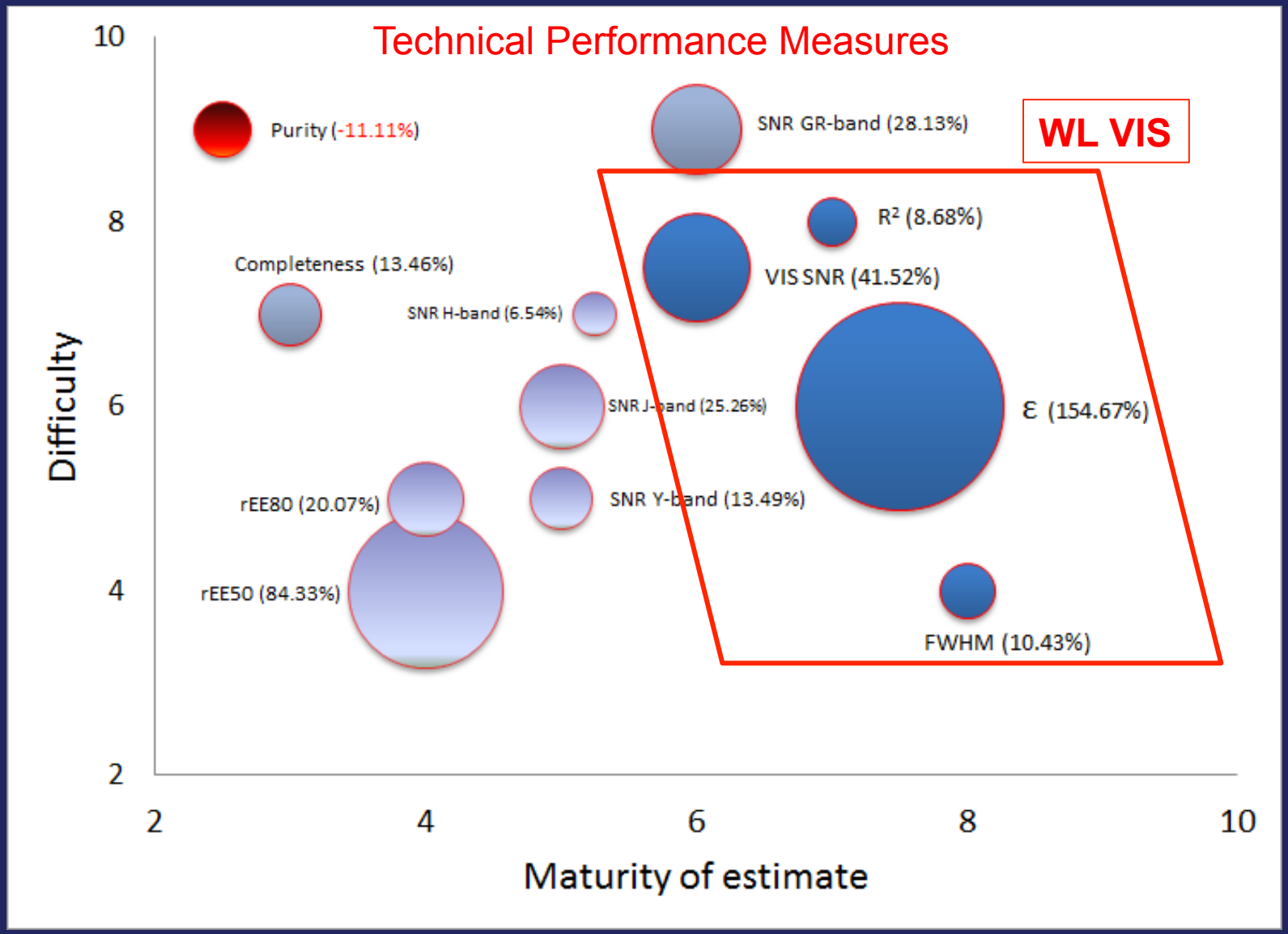


Key contributors: Calibrations + Deep + Station Keeping + Large Slewing		% of survey duration
P-R-NP-CAL-F-002: NISP-P Survey Self-Calibration	37.5 days	1.8 %
P-R-NP-CAL-F-005: NISP-P Absolute Standards Observations	4.6 days	0.3 %
P-R-NP-CAL-F-009: NISP-P Color Gradient Observations	3.3 days	0.2 %
P-R-NP-CAL-F-010: NISP-P Photo-z Training Sample	19.1 days	0.9 %
P-R-NS-CAL-F-001: NISP-S Absolute Standards Observations	27.9 days	1.3 %
P-R-NS-CAL-F-003: NISP-S Planetary Nebula Observations	4 days	0.2 %
P-R-NS-CAL-F-004: NISP-S Purity Sample	41.7 days	2 %
P-R-VS-CAL-F-003: VIS Non-Linearity Observations	1.9 days	0.1 %
P-R-VS-CAL-F-004: VIS PSF Model 1	47 days	2.2 %
P-R-VS-CAL-F-006: VIS Color Gradient Observations	4.9 days	0.3 %
P-R-VS-CAL-F-009: VIS Absolute Standards Observations	2 days	0.1 %
Deep Field (additional to calibration)	125.1 days	5.8 %
Station Keeping	72 days	3.3 %
Large Slewing (rotations from calibration to calibration targets and from calibration to wide survey pointings; wide to calibration slewing times are not accounted for here)	5.4 days	0.3 %
Total NISP P	64.5 days	3 %
Total NISP S	73.6 days	3.4 %
Total VIS	55.8 days	2.6 %
Total C … Note: …		… %
Total D…		… %
Total Calibration + Deep (the data used in the pie chart)	319 days	14.6 %
Overall Total: Calibrations + Additional Deep + Station Keeping + Large slewing	396.4 days	18.2 %

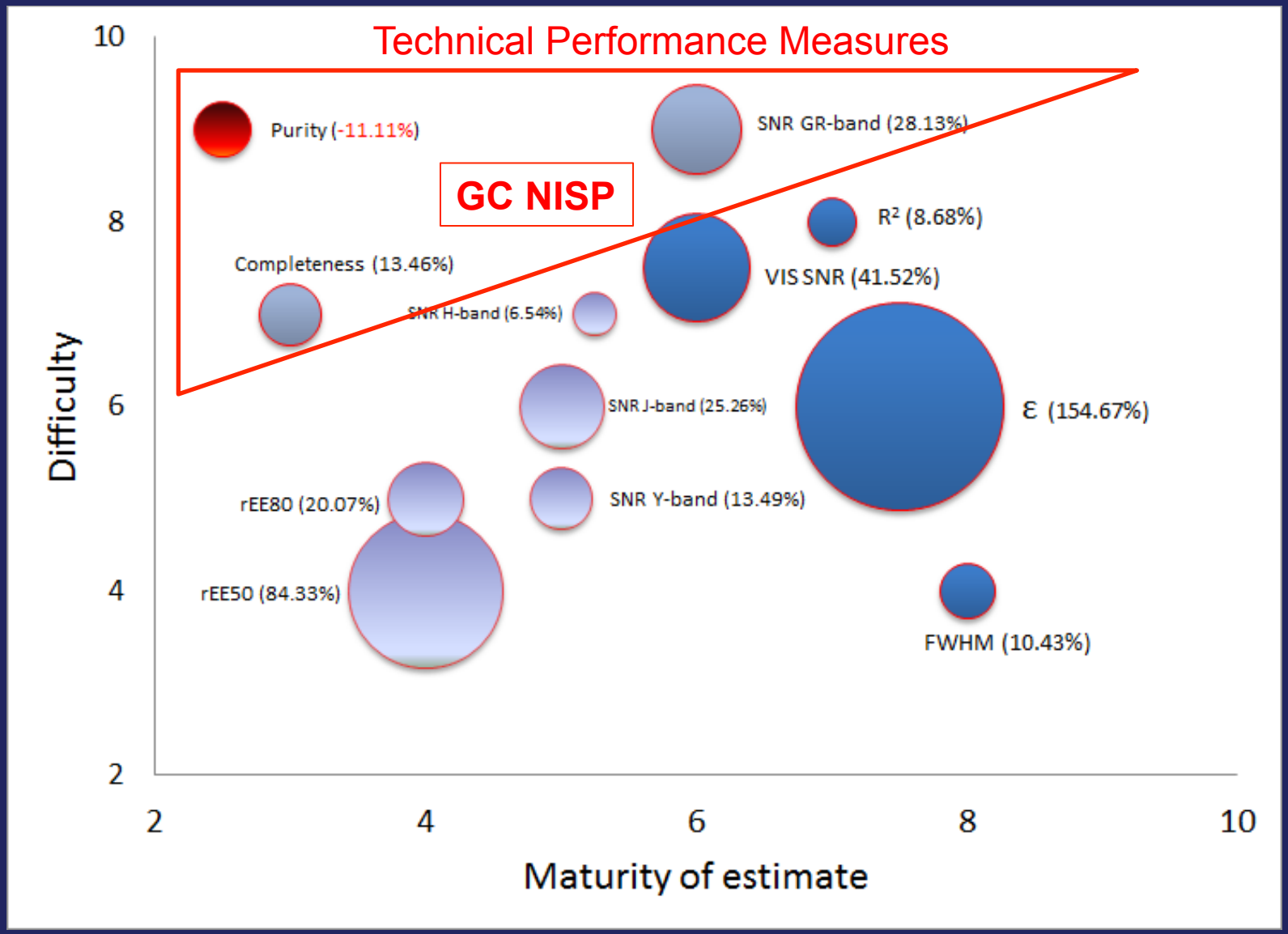
Total calibration and Deep Survey account for 14.6% of mission time



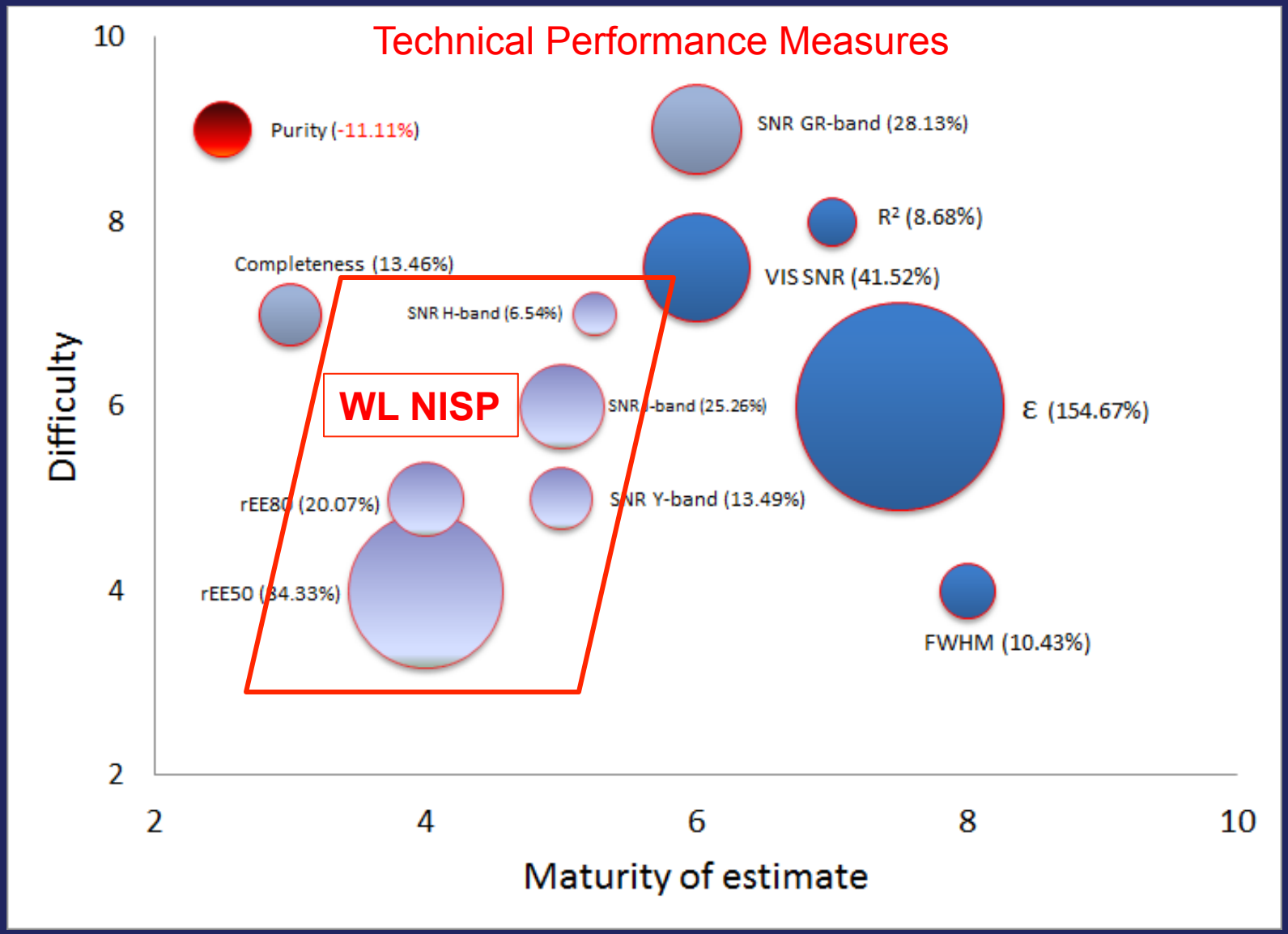
Mission PDR: Margin Summary



Mission PDR: Margin Summary



Mission PDR: Margin Summary



Mission PDR oct. 2015

Mission PDR was successful and this is a major achievement for Euclid

However, some point of discussions were raised requiring activities in the mid-term:

1. Need for joint Hardware (Instrument, Satellite) + Operations (Survey, Calibrations) + Data processing (pipeline prototype). This is within ESA verification scope.

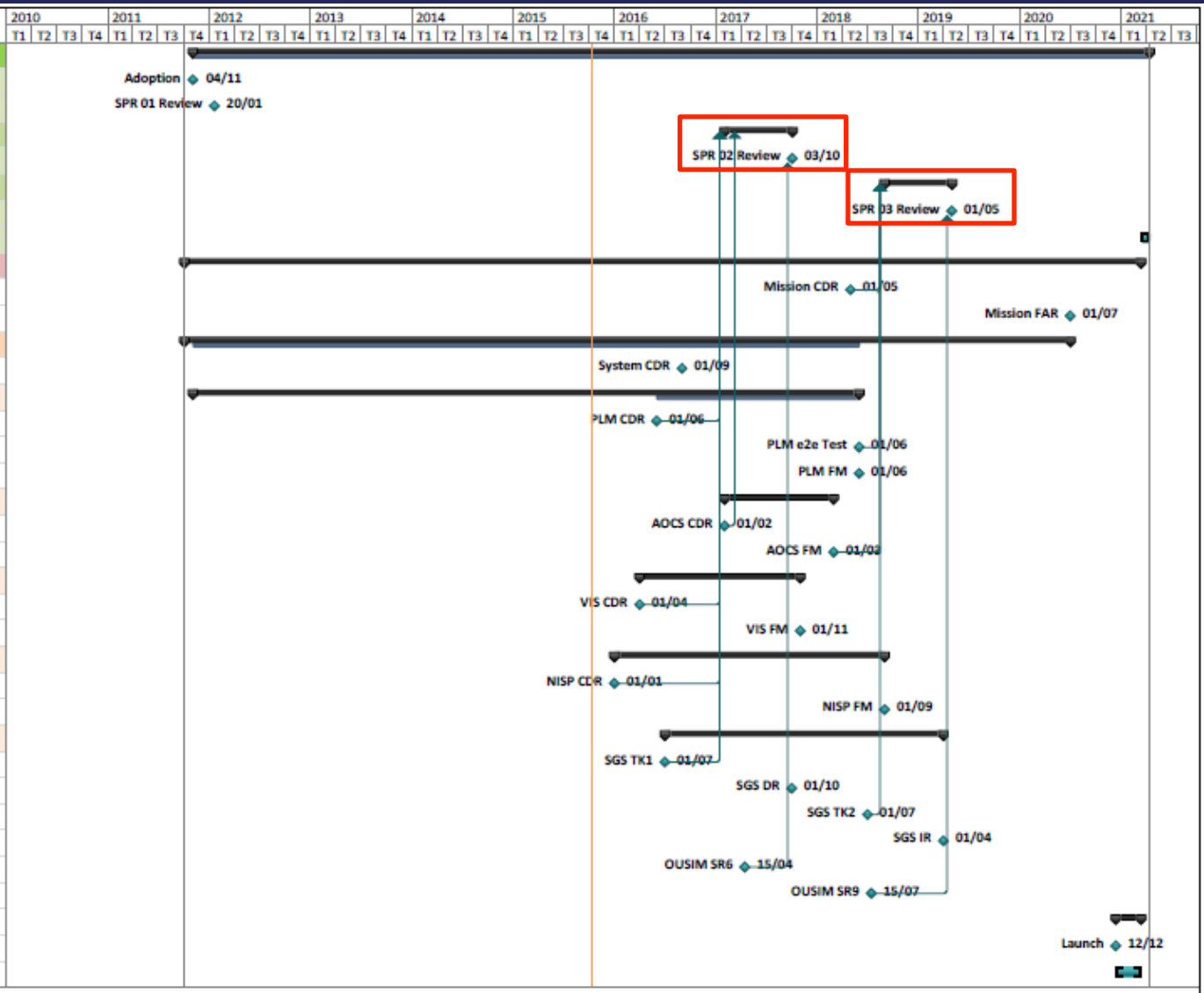
2. Need for Science performance evaluation based on the current reference Euclid baseline. Beyond ESA scope including Space Segment / Ground Segment / ground data.

Action within the consortium to organise an additional cycle of science verifications:

- Cycle 01: Science Performance Verification 01 (jan 2012)
- Cycle 02: Science Performance Verification 02 (June 2017)
- Cycle 03: Science Performance Verification 03 (April 2019)

Planning for Science Performance Cycle

N°	Nom de la tâche	Durée	Début	Fin
1	**Science**	**2463 jours**	**Ven 04/11/11**	**Mar 13/04/21**
2	Adoption	0 jour	Ven 04/11/11	Ven 04/11/11
3	SPR 01 Review	0 jour	Ven 20/01/12	Ven 20/01/12
4	**SPR02**	**175 jours**	**Mer 01/02/17**	**Mar 03/10/17**
5	SPR 02 Review	0 jour	Mar 03/10/17	Mar 03/10/17
6	**SPR03**	**174 jours**	**Sam 01/09/18**	**Mer 01/05/19**
7	SPR 03 Review	0 jour	Mer 01/05/19	Mer 01/05/19
8	Science Survey	23 jours	Sam 13/03/21	Mar 13/04/21
9	**Mission**	**2464 jours**	**Mar 04/10/11**	**Ven 12/03/21**
10	Mission CDR	0 jour	Mar 01/05/18	Mar 01/05/18
11	Mission FAR	0 jour	Mer 01/07/20	Mer 01/07/20
12	**Space Segment**	**2282 jours**	**Mar 04/10/11**	**Mer 01/07/20**
13	System CDR	0 jour	Jeu 01/09/16	Jeu 01/09/16
14	**PLM**	**1716 jours**	**Ven 04/11/11**	**Ven 01/06/18**
15	PLM CDR	0 jour	Mer 01/06/16	Mer 01/06/16
16	PLM e2e Test	0 jour	Ven 01/06/18	Ven 01/06/18
17	PLM FM	0 jour	Ven 01/06/18	Ven 01/06/18
18	**AOCS**	**281 jours**	**Mer 01/02/17**	**Jeu 01/03/18**
19	AOCS CDR	0 jour	Mer 01/02/17	Mer 01/02/17
20	AOCS FM	0 jour	Jeu 01/03/18	Jeu 01/03/18
21	**VIS**	**413 jours**	**Ven 01/04/16**	**Mer 01/11/17**
22	VIS CDR	0 jour	Ven 01/04/16	Ven 01/04/16
23	VIS FM	0 jour	Mer 01/11/17	Mer 01/11/17
24	**NISP**	**696 jours**	**Ven 01/01/16**	**Sam 01/09/18**
25	NISP CDR	0 jour	Ven 01/01/16	Ven 01/01/16
26	NISP FM	0 jour	Sam 01/09/18	Sam 01/09/18
27	**SGS**	**716 jours**	**Ven 01/07/16**	**Lun 01/04/19**
28	SGS TK1	0 jour	Ven 01/07/16	Ven 01/07/16
29	SGS DR	0 jour	Dim 01/10/17	Dim 01/10/17
30	SGS TK2	0 jour	Dim 01/07/18	Dim 01/07/18
31	SGS IR	0 jour	Lun 01/04/19	Lun 01/04/19
32	OUSIM SR6	0 jour	Sam 15/04/17	Sam 15/04/17
33	OUSIM SR9	0 jour	Dim 15/07/18	Dim 15/07/18
34	**Launch**	**65 jours**	**Sam 12/12/20**	**Ven 12/03/21**
35	Launch	0 jour	Sam 12/12/20	Sam 12/12/20
36	Commisionning	66 jours	Sam 12/12/20	Ven 12/03/21



Planning for Science Performance Cycle

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17	PLM FM	0 jour	Ven 01/06/18	Ven 01/06/18
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26	NISP FM	0 jour	Sam 01/09/18	Sam 01/09/18
27	**SGS**	**716 jours**	**Ven 01/07/16**	**Lun 01/04/19**
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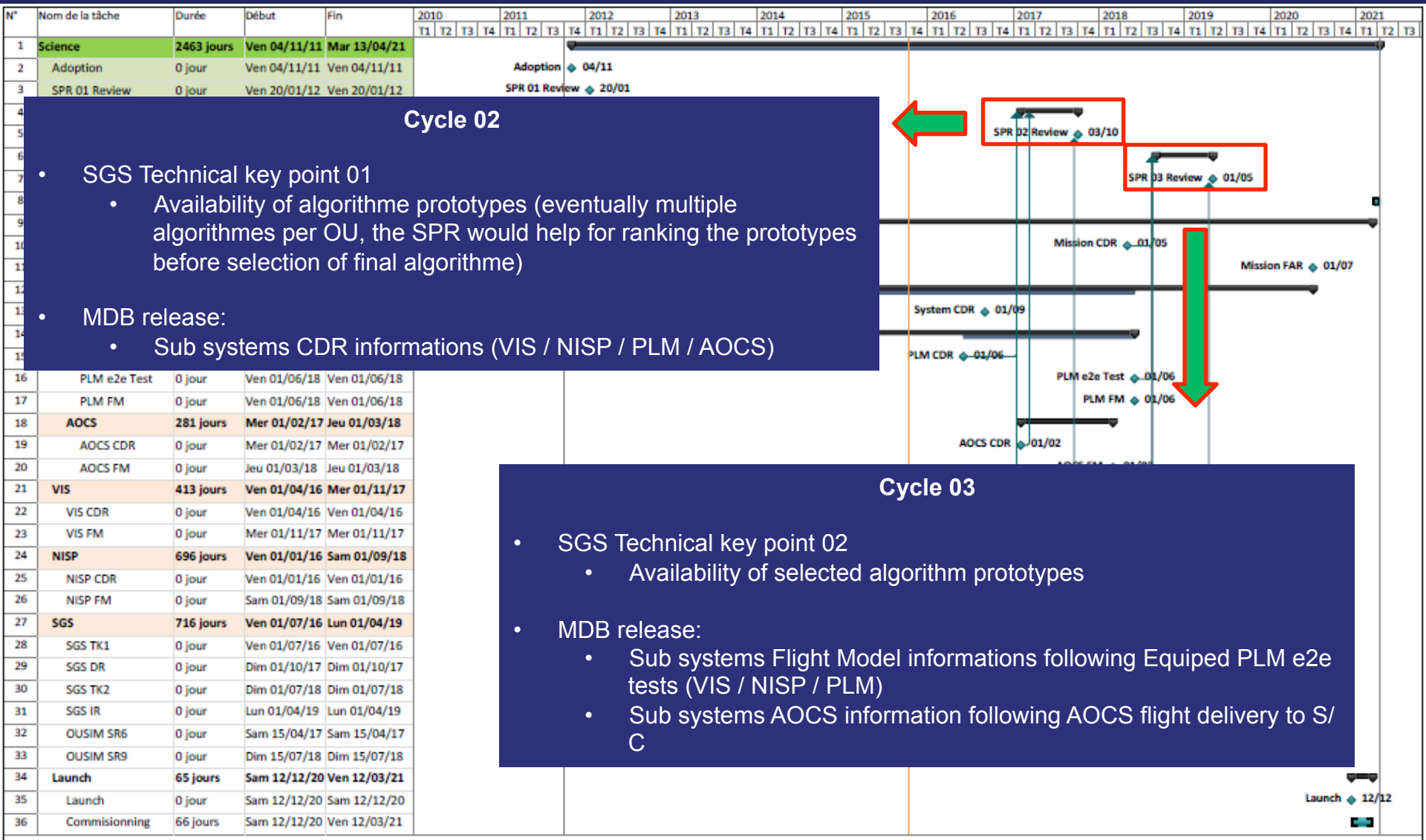


Cycle 02

- SGS Technical key point 01
  - Availability of algorithme prototypes (eventually multiple algorithmes per OU, the SPR would help for ranking the prototypes before selection of final algorithme)
- MDB release:
  - Sub systems CDR informations (VIS / NISP / PLM / AOCS)

Cycle 03

- SGS Technical key point 02
  - Availability of selected algorithm prototypes
- MDB release:
  - Sub systems Flight Model informations following Equiped PLM e2e tests (VIS / NISP / PLM)
  - Sub systems AOCS information following AOCS flight delivery to S/C

Objectives for Science Verification

1. Need for joint Hardware (Instrument, Satellite) + Operations (Survey, Calibrations) + Data processing (pipeline prototype):

- PSF calibration and corrections
- Galaxy Shape performance
- CTI correction performance
- Signal-to-Noise ratio – simulations with realistic PSF, background, galaxy properties, etc
- Spectroscopy processing chains and impact on Completeness and Purity

→ These performance will rely on integration of OUSIM pixel simulations and OU pipeline. Need typically few (10) x 10 deg² Patches with realistic system effects (straylight, CTI, PSF, detectors…).

2. Need for Science performance evaluation based on the current reference Euclid baseline:

- P(k), C(l), C(l,k) projection analysis comparison
- Ha Luminosity function knowledge and sensitivity
- Joint WL + GC Figure of Merit update
- Impact of relative spectrophotometry on GC Performance

→ These simulations will rely on catalog generations through by-pass to be used by Science Working group. Need typically 2000 to 20 000 deg of joint WL and GC catalogues.

These different needs can lead to parallel approaches with different levels of integration in the Euclid infrastructure.

Typical Scenarios for simulations

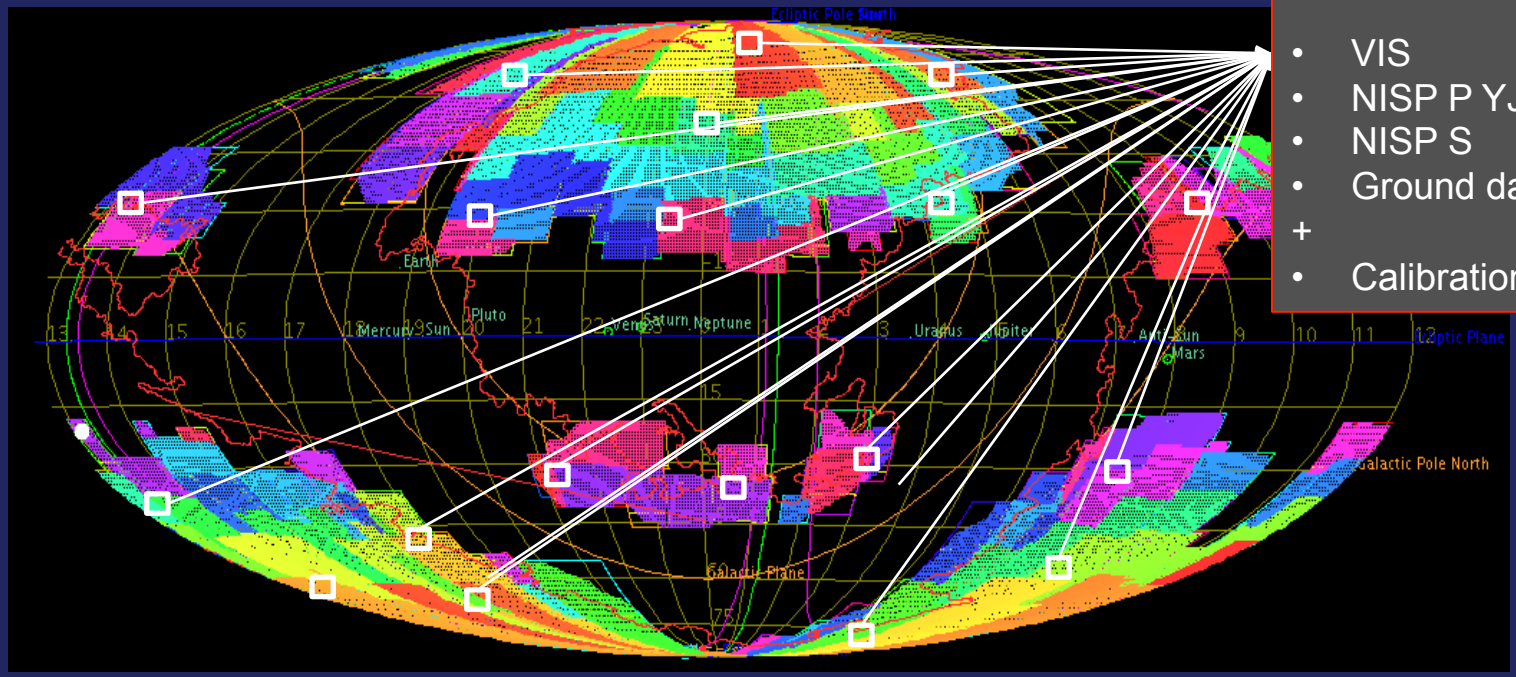
1. Need for joint Hardware (Instrument, Satellite) + Operations (Survey, Calibrations) + Data processing (pipeline prototype)

20 fields x 1 deg²:
- Stars
- Galaxy (mag 25,5)

- VIS
- NISP P YJH
- NISP S
- Ground data

+

- Calibration images



Images including parameters impacting radiometry and background:
- Zodi / Straylight (on/off)/ Extinction (on/off)
- PSF / Ghosts (on/off)/ Detectors (on/off)

- Background substraction
- Detector effect Correction
- Evaluation of SNR on point source
- Evaluation of SNR on galaxy
- Spectroscopy processing chains and impact on Completeness and Purity

Typical Scenarios for simulations

1. Need for joint Hardware (Instrument, Satellite) + Operations (Survey, Calibrations) + Data processing (pipeline prototype)

Images including parameters impacting radiometry and background:

- **Zodi / Straylight / Extinction**
- **PSF / Ghosts / Detectors**

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- **Zodi / Straylight/ Extinction**
- **PSF / Ghosts / Detectors**

20 fields x 1 deg²:

- Stars
- Galaxy (mag 25,5)

- VIS
- NISP P YJH
- NISP S
- Ground data

+

- Calibration images

6 x 20 x 1 deg² = 120 deg²

- Background substraction
- Detector effect Correction
- Evaluation of SNR on point source
- Evaluation of SNR on galaxy
- Spectroscopy processing chains and impact on Completeness and Purity

Typical Scenarios for simulations

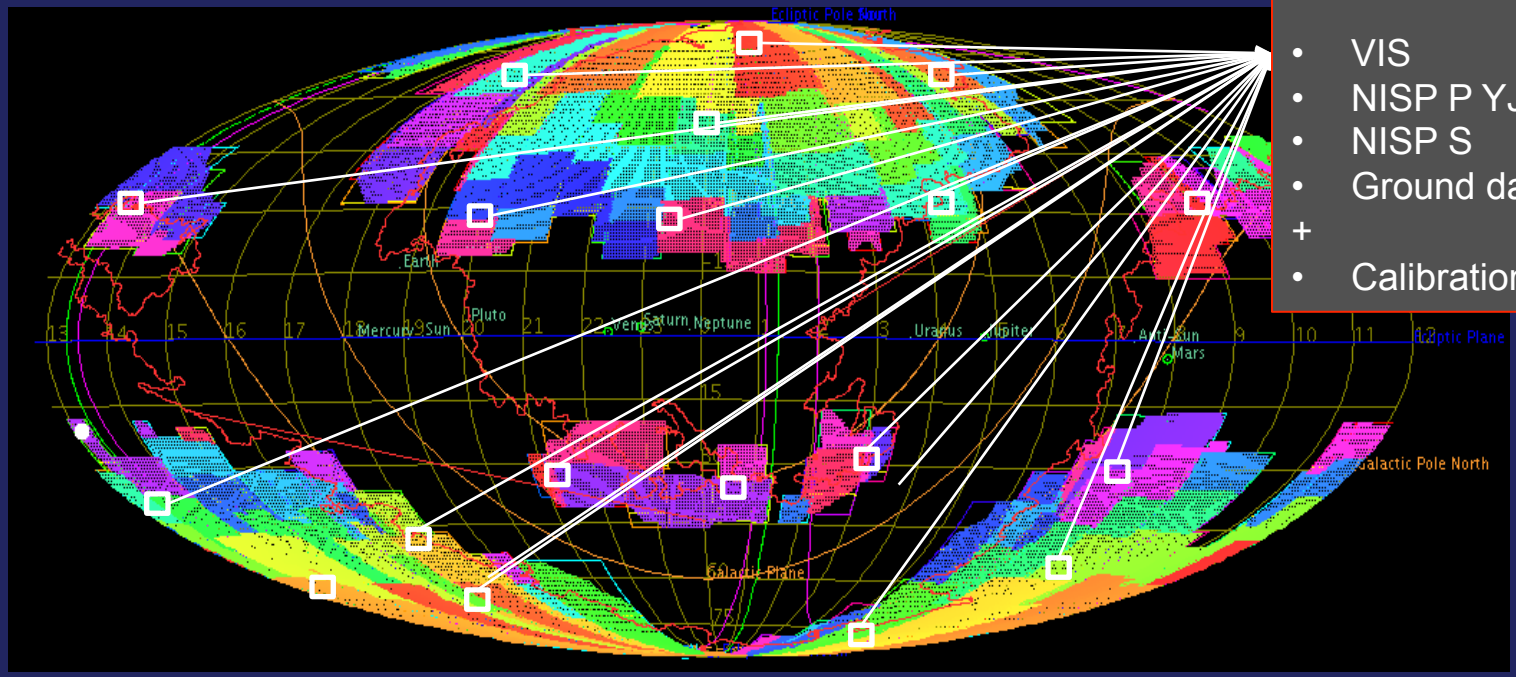
1. Need for joint Hardware (Instrument, Satellite) + Operations (Survey, Calibrations) + Data processing (pipeline prototype)

20 fields x 1 deg²:
- Stars
- Galaxy (mag 25,5)

- VIS
- NISP P YJH
- NISP S
- Ground data

+

- Calibration images



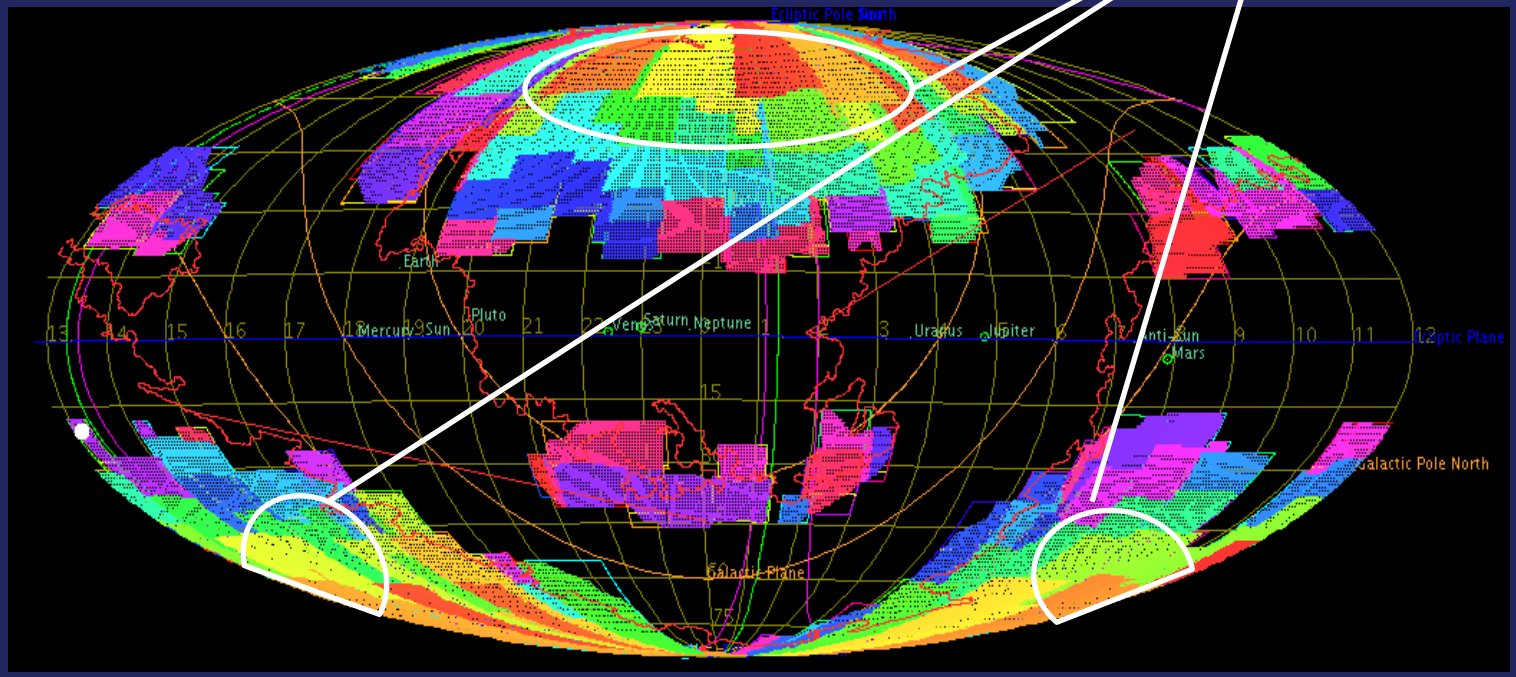
Images including parameters:
- Cosmics
- CTI

- Background substraction
- Detector effect Correction
- Evaluation of SNR on point source
- Evaluation of SNR on galaxy
- Spectroscopy processing chains and impact on Completeness and Purity

Typical Scenarios for simulations

2. Need for Science performance evaluation based on the current reference Euclid baseline

2 000 to 20 000 deg²:
- Galaxy catalog



Joint Input catalog for WL and GC.
For a reference cosmological model
With correct clustering, magnitude, size, shape parameter, redshift, spectrum.

- Science Performance of Euclid in the current baseline.

Match with OUSIM production

SR#6: Input Simulation for **SC#7**	Level 1	~250 deg² imaging ~2000 deg² catalogues blind systematics (x4)	15/04/2017
SR#7: Simulation Scenario for **E2E#1**	TBD	-	31/05/2017
SR#6b: Complementary Simulation	MER / SHE / EXT / SPE / PHZ / LE3	Same as SR#7	01/07/2017
SR#8: Simulation Scenario for **E2E#2**	TBD	-	15/05/2018
SR#9: Input Simulation for **SC#8**	LE3	10000 deg² (3x cosmologies)	15/07/2018
SR#9b: Complementary Simulation	Level 1 / EXT	500 deg² + 1 deep field (3x cosmologies)	31/08/2018
SR#10: Simulation Scenario for **E2E#3**	TBD	-	15/05/2019
SR#11: Additional Simulation	Level 1 / EXT / LE3	~2500 deg² imaging (Year 1 of observation: DR1) ~15000 deg² catalogues (Full survey)	01/07/2019
SR#12: Additional Simulation	Level 1 / EXT/ LE3	~500 deg² imaging ~10000 deg² catalogues	01/12/2020

SPR Cycle 02

SPR Cycle 03

Coming months:

Mission PDR was successful and this is a major achievement for Euclid

Already succesful Satellite + Survey + Data processing realised for GC at Mission PDR:

lessons learned and follow-on activities to carry on with specific emphases on:

- OUSIM capabilities to generate pixel level simulations of galaxies
- OU pipeline prototype availability
- Integration OUSIM / OU
- Joint catalog for GC + WL
- By-pass to generate the Euclid catalogues
- Ground data model