



SUPERFLAT

Welcome

Superflat Workpackage Meeting 17 October 2023, SOLEIL

Ray Barrett, ESRF



Co-funded by
the European Union

 **LEAPS**
INNOVATION

The logo for LEAPS INNOVATION, featuring a stylized yellow and blue graphic element resembling a microscope or a beamline component to the left of the text. The word "LEAPS" is in white and "INNOVATION" is in yellow.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 101004728

Agenda

Tue. 17 Oct March	
14:00-15:45	Session I
	<ul style="list-style-type: none">• Welcome – general news• Update on Workpackage/PCP progress – R.Barrett• D3.2 Universal data format specification – F. Polack• IBF at Diamond – K. Sawhney• D3.5 Systematic study of performance of different deterministic processing methods – S. Alcock
15:45-16:00	Break
16:00-18:00	Session II
	<ul style="list-style-type: none">• Error Estimation after LEEP – J. Nicolas• D3.4 Report on performance of candidate metrology techniques supporting manufacturing process of freeform optics – F. Siewert• Discussion Microroughness measurements• Discussion Zeiss specification• After Superflat – R. Barrett
19:30	Networking Dinner with WP4 NeXtgrating (Restaurant L'Invitation, Place de la Mairie,91190 Saint-Aubin)

Welcome

- Hybrid meeting: Teams
- Remote participants: use raise hand (or chat if you have problems with microphone)



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WP and PCP update

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WP 3 Superflat Tasks (LEAD, CO-LEAD)

1. **PCP (and WP) Management (ESRF, SOLEIL)**
2. **Development of processing methods for the industrial production of flat Si mirrors (SOLEIL, ESRF, ALBA-CELLS, DIAMOND, ELETTRA, EuXFEL, HZB, PSI, ULUND)**
3. **Development and characterisation of deterministic corrective figuring techniques for the production of reflective X-ray substrates (DIAMOND, HZB, ALBA-CELLS, ESRF, SOLEIL)**
4. **Development of new metrology methods and measurement protocols suitable for production environments (HZB, ALBA-CELLS, DIAMOND, ESRF, EuXFEL, SOLEIL)**

WP3 Deliverables

- ✓ **D3.1** Report on Open Market Consultation (~~M3~~ M9)
- ✓ **D3.2** Universal data format specification for surface topography description (M24) – ~~31 March 2023~~ **30 September 2023**
- **D3.3** Report on performance of candidate metrology techniques supporting manufacturing process (M44) **30 November 2024**
- **D3.4** Prototype mirrors with < 50 nrad rms slope errors (M47) **28 February 2025**
- **D3.5** Systematic study of performance of different deterministic processing methods for X-ray reflective optics (**IBF, MRF, Differential Deposition**) (M48) **31 March 2025**

WP3 Milestones (all PCP related)

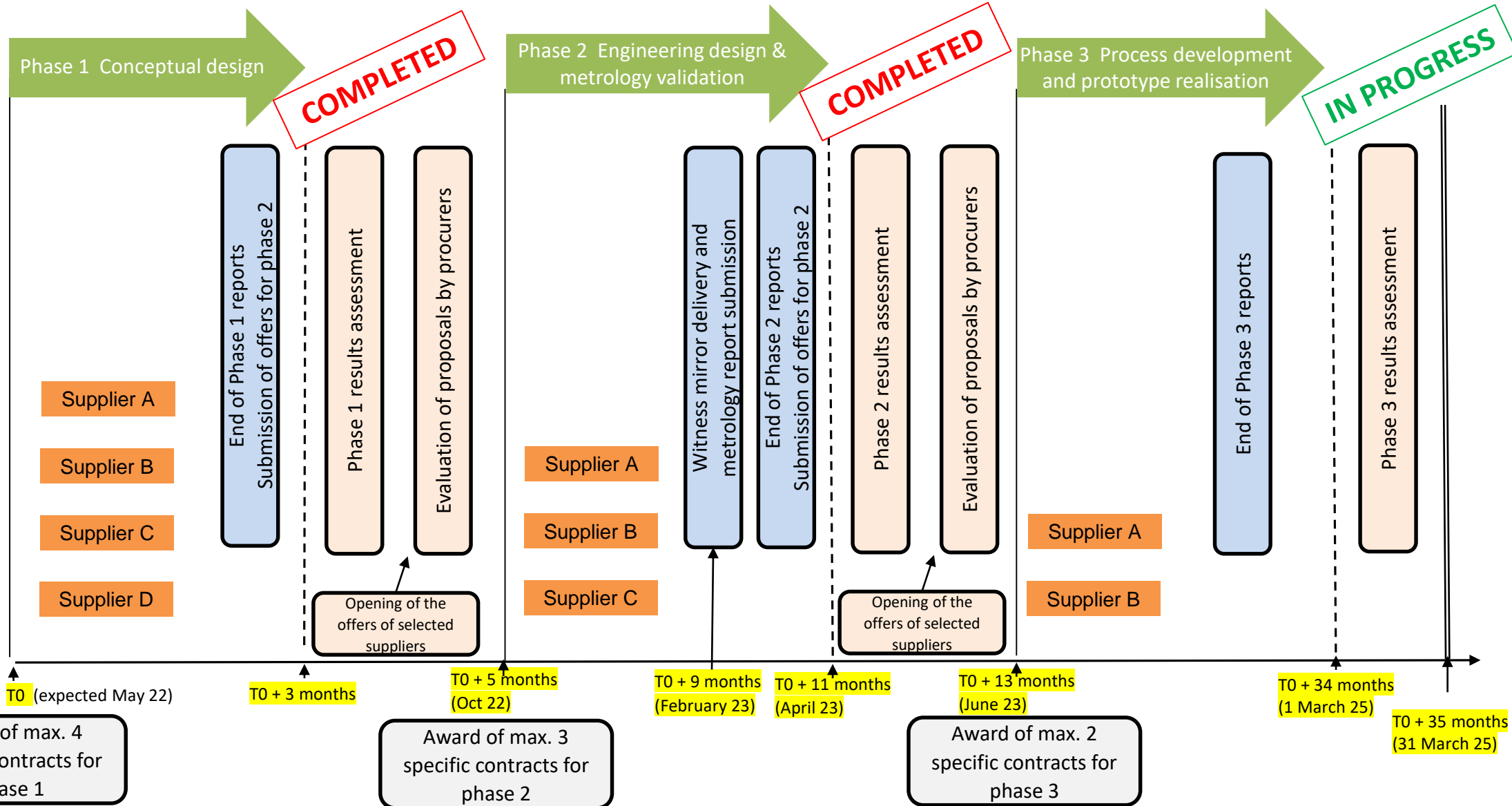
- ✓ **MS 14** Signature framework and phase 1 specific contracts (~~M8 M14~~) **12 May 22**
- ✓ **MS 15** Signature of phase 2 specific contracts (~~M13 M19~~) **13 Oct 22**
- ✓ **MS 16** Signature of phase 3 specific contracts (~~M25 M26~~) **31 May 23**
- **MS 17** Submission of phase 3 deliverables by PCP contractors: Metrology report, Final Project report and End of project results and conclusions (~~M45 M47~~) **1 Mar 25**

(Schedule is unchanged since issue of Request for Tender at beginning of project)

PCP Status

- All three companies (Thales SESO, Winlight-Bertin, Safran REOSC) completed Phase 2 satisfactorily
- Contracts were signed (May 2023) with two contractors (Thales SESO, Winlight-Bertin) for Phase 3:
- Phase 3 will continue until the end of the project (March 2025)
 - Monthly follow up meetings for members of PCP assessment committee
 - 6-monthly reports by contractors
 - Site visit to both companies foreseen in contract by 15 June 2024
- Prototype full size mirrors to be delivered by 15 February 2025
- The two companies are exploring rather different processing routes to achieve the PCP goals

Task 2: Superflat-PCP Phase Timeline



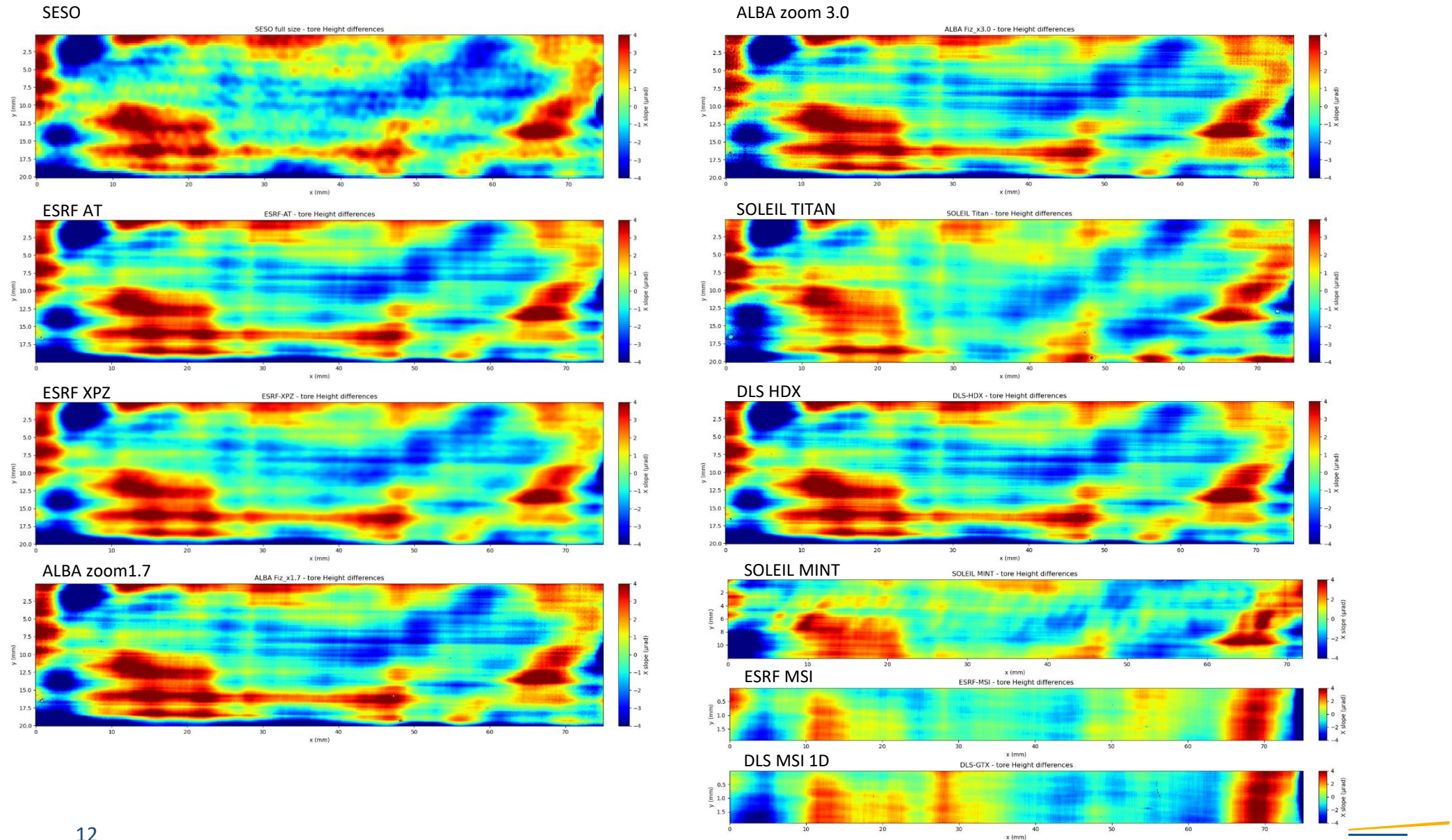
Measurement of Phase 2 Metrology validation samples

- As part of Phase 2 all companies delivered validation samples with accompanying metrology reports
- ESRF, Diamond, ALBA and SOLEIL measured all Phase 2 samples
- Results of the comparisons were provided to each of the manufacturers (for their own samples only) after the phase 2.

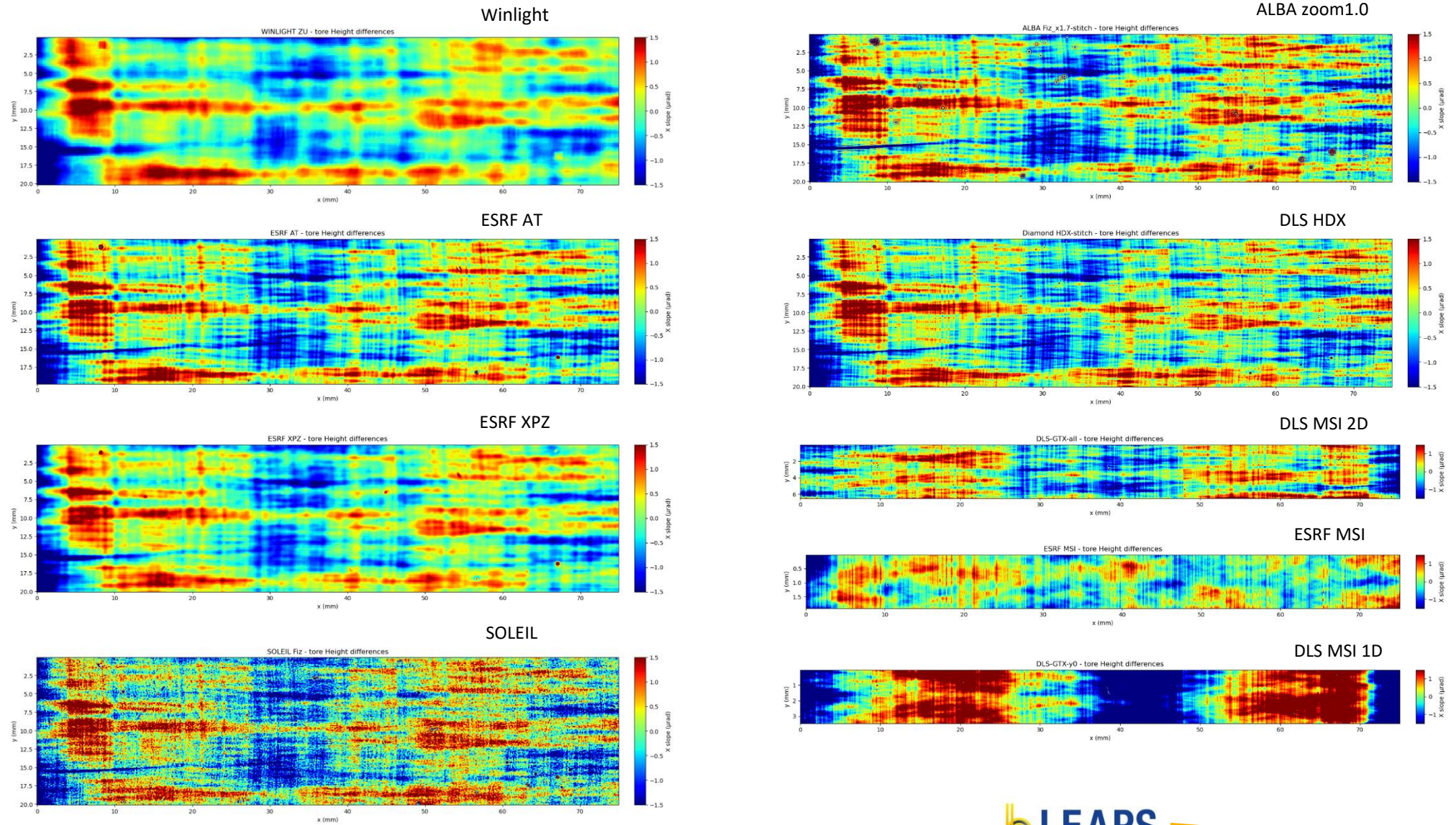
Measurements performed by the Superflat partners

- ESRF
 - Fizeau Zygo GPI AT, side measurement, stitching px=79.156 μm
 - Fizeau Zygo GPI XPZ, measuring from top, stitching px=64.475 μm
 - WYKO NT9300, (top view):
 - Micro-stitching interferometry (MSI) **2.5X**, px=3.968 μm ; FoV 75 x 1.9 mm (on centre line)
 - Micro-roughness: 2.5X - 5X - 50X with 3 different objectives
 - Long Trace Profiler (LTP), slope profile along the centre line
- ALBA
 - Fizeau Zygo Verifire HD 100: from side, 3 zoom values, stitching
 - Zoom 1.0 : px=89.017 μm , Zoom 1.7 : px=51.516 μm and Zoom 3.0 px=29.656 μm
- SOLEIL
 - Fizeau Zygo Verifire HD, from side, full size recording, px= 89.00 μm
 - MINT Phase-shift Michelson interferometer, from above px 20.689 μm ; FOV 75 x 12 mm (on centre line)
 - Long Trace Profiler (LTP), from side, slope profile on 3 lines, aperture $\varnothing\sim 2.5$ mm
- DLS
 - Fizeau Zygo HDX: from side, stitching, px=45.693 μm ;
 - Bruker GTx, MSI, px=3.957 μm , X step=1 mm
 - 1D stitch width=1.9 mm
 - VeNOM (AC based slope measuring machine)
 - Slope profile along centre line
 - Scans at different 0.5 mm separated Y positions to create composite 2D slope map

Height maps comparison: SESO sample



Height maps comparison: Winlight sample



Measurement of Phase 2 Metrology validation samples

- The Safran-REOSC sample was returned to the manufacturer at the end of Phase 2.
- Bertin-Winlight sample is currently at HZB
 - it may be necessary to return the sample to Winlight in November (tbc)
- Thales-SESO sample is currently at the ESRF
- Overall conclusion is that, at least on short samples, the manufacturers metrology is 'fit-for-purpose' and in good agreement with Superflat consortium results
- Some possible discrepancies were observed for higher spatial-frequencies (microroughness) measurements – see later

EU-XFEL?

Specifications of final flat mirrors to be delivered in mid-Feb 2025

Clear aperture	Length (X)	500 mm
	Width (Y)	20 mm
Curvature	Tangential (C_x)	$< 0.015 \text{ km}^{-1}$
	Sagittal (C_y)	$< 0.05 \text{ km}^{-1}$
Figure error on 99% of the clear aperture	PV	$\leq 1 \text{ nm}$
	RMS	$\leq 0.2 \text{ nm}$
Tangential slope error on 99% of the clear aperture	PV	$\leq 250 \text{ nrad}$
	RMS	$\leq 50 \text{ nrad}$
Sagittal slope error on 99% of the clear aperture	PV	$\leq 1 \text{ } \mu\text{rad}$
	RMS	$\leq 200 \text{ nrad}$
Cumulated RMS tangential slope as defined above	Freq. $< 0.1 \text{ mm}^{-1}$	$< 20 \text{ nrad RMS}$
	$0.1 \text{ mm}^{-1} < \text{Freq.} < 1 \text{ mm}^{-1}$	$< 30 \text{ nrad RMS}$
Roughness Measured on at least 9 locations	$2 \text{ mm}^{-1} < \text{Freq.} < 200 \text{ mm}^{-1}$	$< 0.3 \text{ nm RMS}$
	$5 \text{ mm}^{-1} < \text{Freq.} < 500 \text{ mm}^{-1}$	$< 0.3 \text{ nm RMS}$
	$10 \text{ mm}^{-1} < \text{Freq.} < 1000 \text{ mm}^{-1}$	$< 0.3 \text{ nm RMS}$

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Phase 2 Metrology sample Microroughness results

- Available results from: Winlight, ESRF, ALBA, DLS GTX
 - DLS GTX measurements for stitching not initially processed for roughness evaluation
- 3 Frequency ranges specified in the RFT but not directly related to an objective NA

		SPECS	Winlight		ESRF		ALBA	
Roughness (nm RMS)	$2 < F < 200 \text{ mm}^{-1}$	< 0.3	10x zoom 0.36	0.27	2.5x	0.414		
	$5 < F < 500 \text{ mm}^{-1}$	< 0.3	10x zoom 1	0.20	5x	0.37	5x (assumed)	0.386
	$10 < F < 10^3 \text{ mm}^{-1}$	< 0.3	50x zoom 1	0.17	50x	0.19		

Phase 2 Metrology validation samples - microroughness

- rms roughness values generally not directly comparable between different labs and some (apparent) discrepancies
 - Measurements with different objective lens magnifications (NA)
 - Use of zoom/fov lenses for some Winlight datasets
 - Known that for classically polished surfaces roughness tends to decrease at higher spatial frequencies BUT these surfaces have seen IBF correction
- These aspects have not really been studied between different sites
 - ✓ Opportunity to use the datasets to compare microroughness measurements
 - ✓ Use of psd to show the frequency range of the measurements and perhaps show impact of instrument response function
 - ✗ Significant variation of roughness point-to-point – no common measurement grid used (need to average psd from various points and hope that statistical variations are sufficiently sampled)
- Comments? Suggestions?
- Need to define a more detailed protocol for measurements of final 500 mm mirrors



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Zeiss - Specifications for future Synchrotron Optics

- Contact by Norman Niewrzella (Zeiss)
- [Slides](#) prepared by Zeiss engineers Philipp Rupp and Aitor Olarra re: Mirror specifications
- Zeiss questions from Norman:
 - Did you understand, what we put down in the lines, or are there any questions?
 - Can you comment on the specification we have proposed here? Would this – in your opinion - fulfil the requirements for Mirrors (especially for Flats and KB-Optics)?
 - What is your perspective on the upcoming years, also looking for and beyond source upgrades – surely we want to be prepared for a couple of years here, since the investment is massive
 - In the last two slides we have prepared a few questions regarding the mounting mechanics, which become very important on this level of quality. May you share your thoughts here as well?

AOB: Dissemination

- Dissemination activities
 - Website
 - Publications/meetings where LEAPS-INNOV/Superflat was cited
 - All publications should be Open Access to satisfy EU requirements
- Please inform us of any such activity

Superflat Website: leaps-superflat.eu

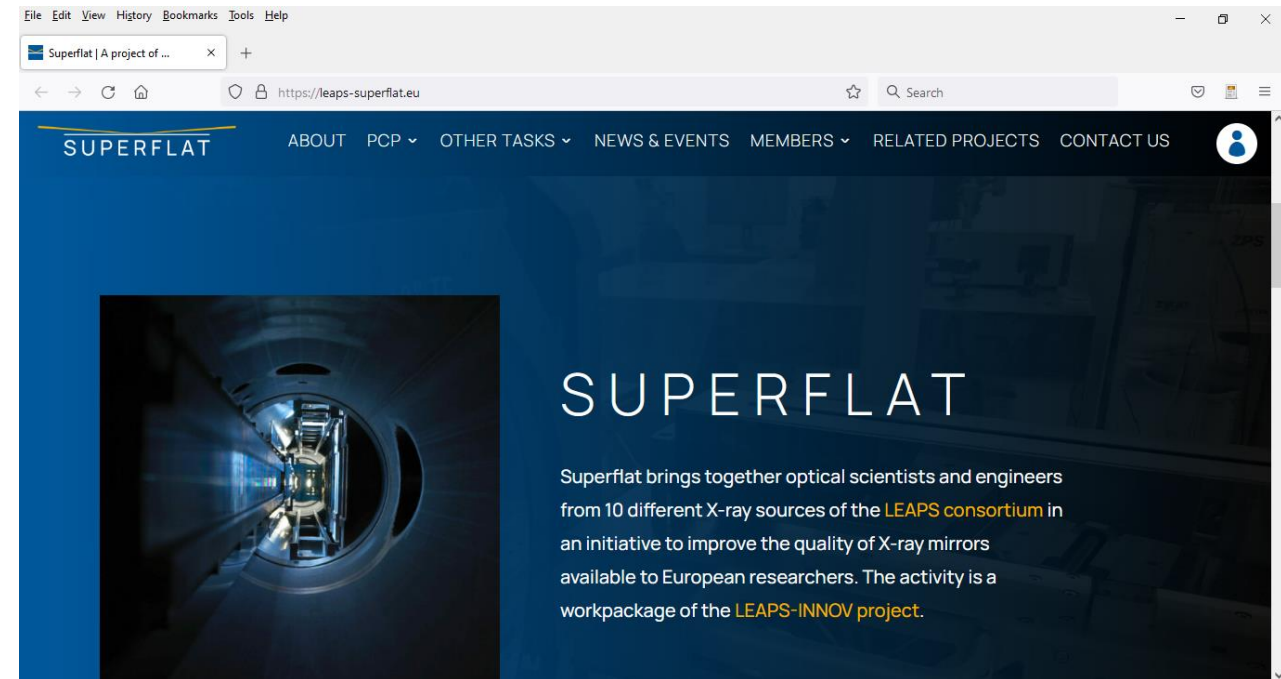
- Please let us know if you would like to see anything added (even just links to useful resources)

Latest additions:

- PyLOSt information
- Hamburg meeting
- D3.2 File format deliverable

Future:

- Metrology sample results (in members area only)?



AOB

- Next overall WP meeting
 - LEAPS-INNOV Annual Meeting will be hosted by SOLARIS (Kracow) from 8-10 April 2024. Specific Superflat WP meeting
- Hiring
 - Please inform us if you are opening posts paid by the project (send links to the job offers) and also introduce the people once hired (ask for them to be added to superflat@esrf.fr list)

AOB

- *Other issues?*