FIG WORKING WEEK 2019

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"Geospatial Information for a Smarter Life and Environmental Resilience"

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Terrestrial Laser Scanner and Close Range Photogrammetry point clouds accuracy assessment for the structure deformations monitoring

Giuseppina VACCA
DICAAR, Dep. of Civil and Environmental Engineering and Architecture
University of Cagliari (Italy)

Summary

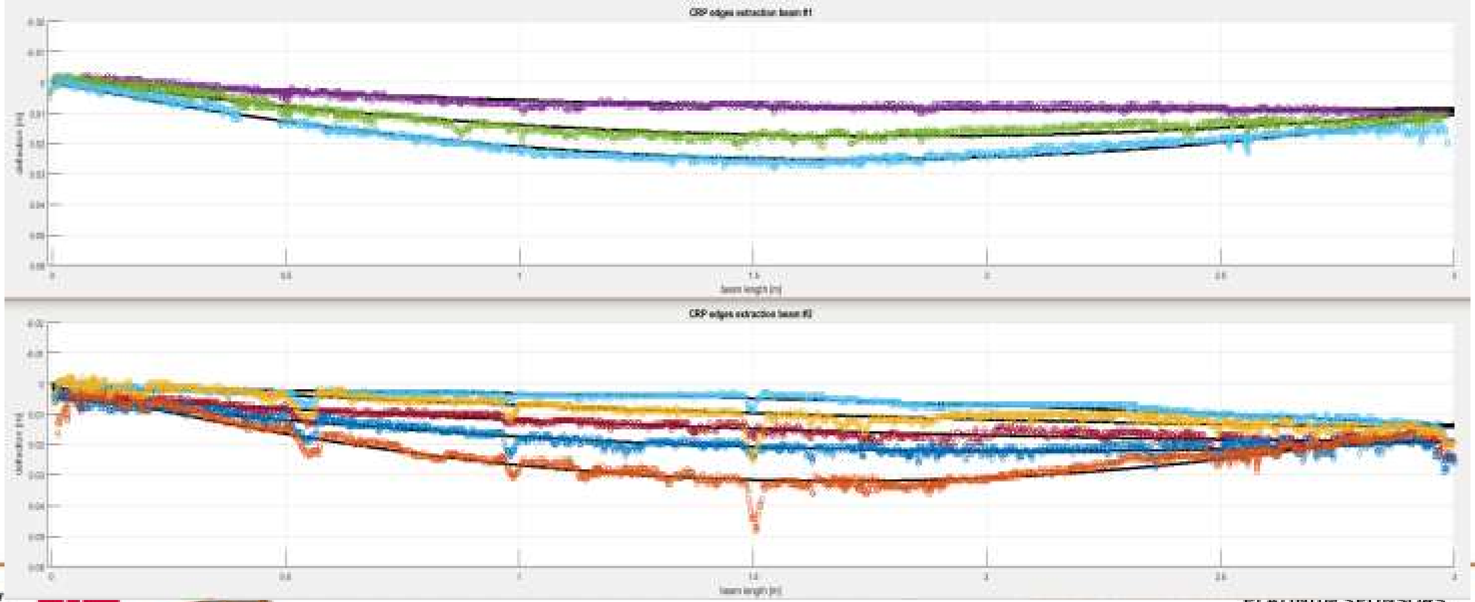
- Introduction
- Aims and targets
- Instrumentations
- Processing strategy
- Results
- Conclusions

Introduction

The structures monitoring is one of the main objectives of engineering surveys and concerns especially buildings, bridges, or other infrastructures subject to deformations because of natural (earthquakes, wind, flooding) or man-made (fires) calamities, or due to natural deterioration/decay.

Introduction

Monitoring the displacements or deformations of structures is a complex problem. The knowledge of the typology, characteristics and scale of the structural deformations is thus essential for defining their nature and verify the permanent damage.



Aims and targets

The presented work thus concerns a comparison between the Terrestrial Laser Scanner (TLS) technique and the low-cost Close Range Photogrammetry (CRP) using Structure from Motion (SfM) method, in order to evaluate the accuracy and precision that can be obtained, especially with the CRP, in studying of the deformations of the structures.

Aims and targets

Several bending tests were did on Reinforced Concrete (RC) beam. The RC beam was subjected to four points bending test. The load was applied by a hydraulic jack, with incremental steps from 0 to 68 kN.

Instrumentations

The two instrumentations to test were:
- the TLS Focus 3d from FARO Technologies;
- the low-cost CRP is a camera Canon PowerShot S110 and software Photoscan from Agisoft which implements the SFM.

Metrological Instrumentations

Two **metrological** equipment were used to measure displacements:

- The Laser Tracker Leica AT402 (LT) with +/-15 μm + 6 μm/m (Maximum Permissible Error)
- The Aicon Moveinspect DPA system with camera Nikon D3x (DPA) with a nominal measurement accuracy of 2 μm + 5 μm/m (RMS)

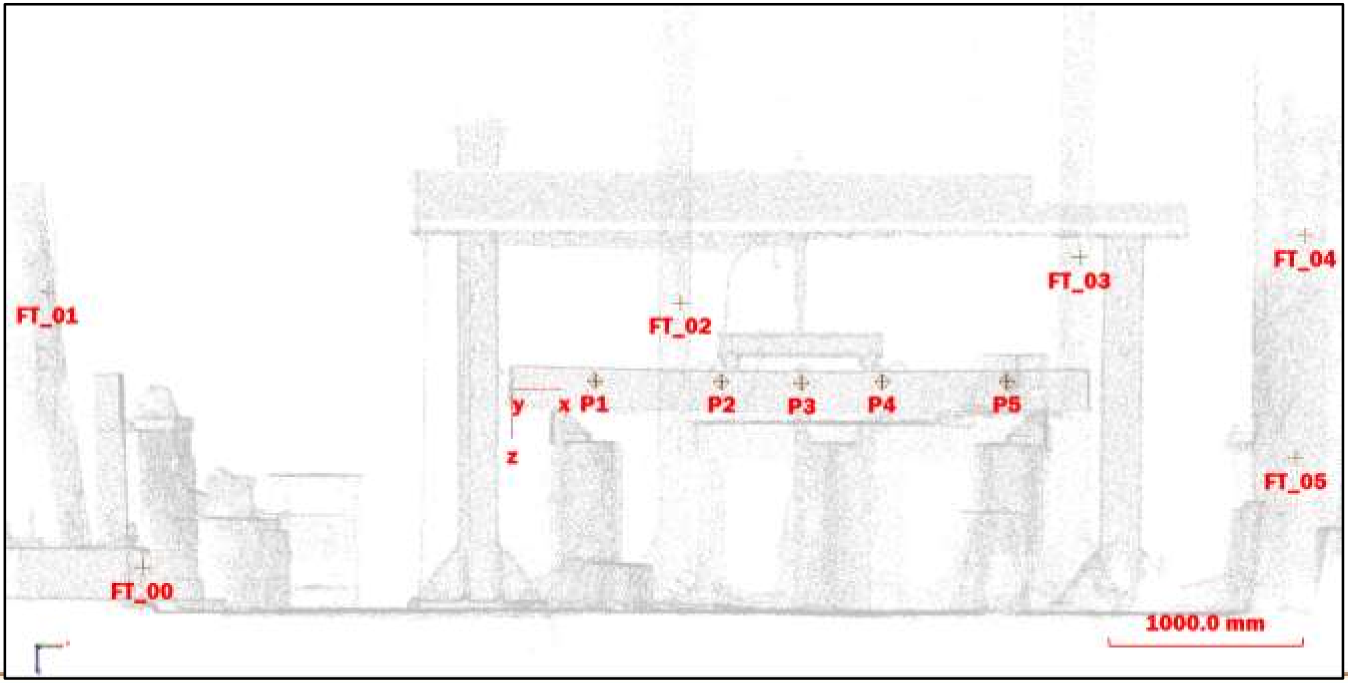
Processing strategy - Measurement points for metrological equipment

The Laser Tracker (LT) was used with a twofold purpose:

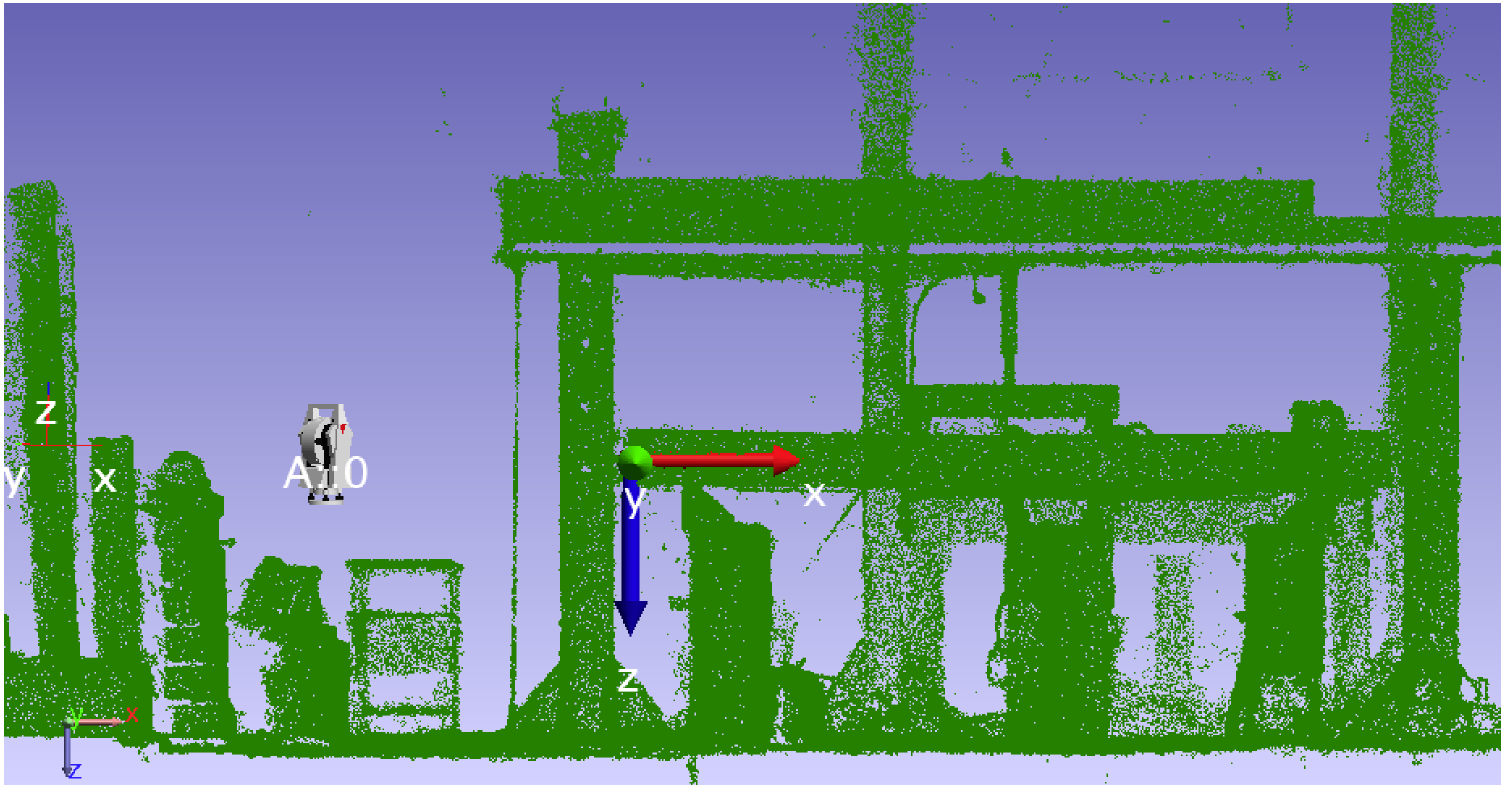
- set up a **reference frame** with a vertical axis that can be adopted by the other measuring techniques;
- **ensure the measurements of the deformations** on the beam for a some number of points.

Reference frame

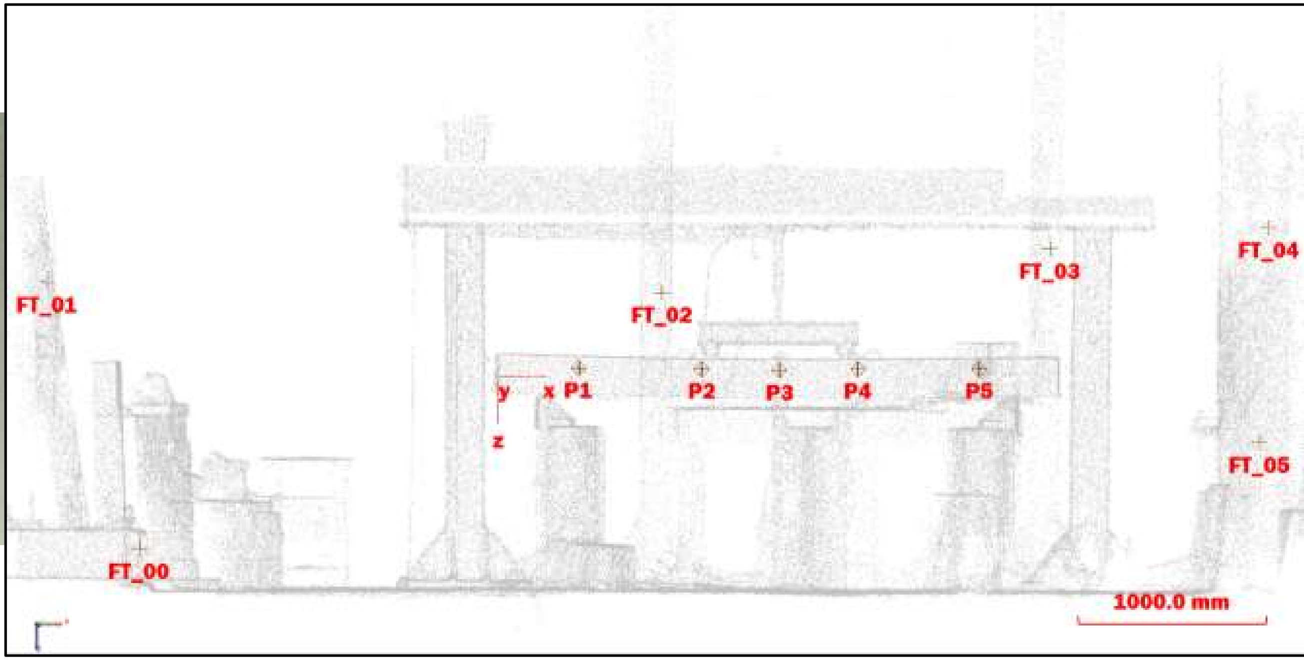
In order to fix a reference frame with **one vertical axis**, **six targets FT#** were stably mounted in the area of the laboratory not subjected to loads.



The reference frame

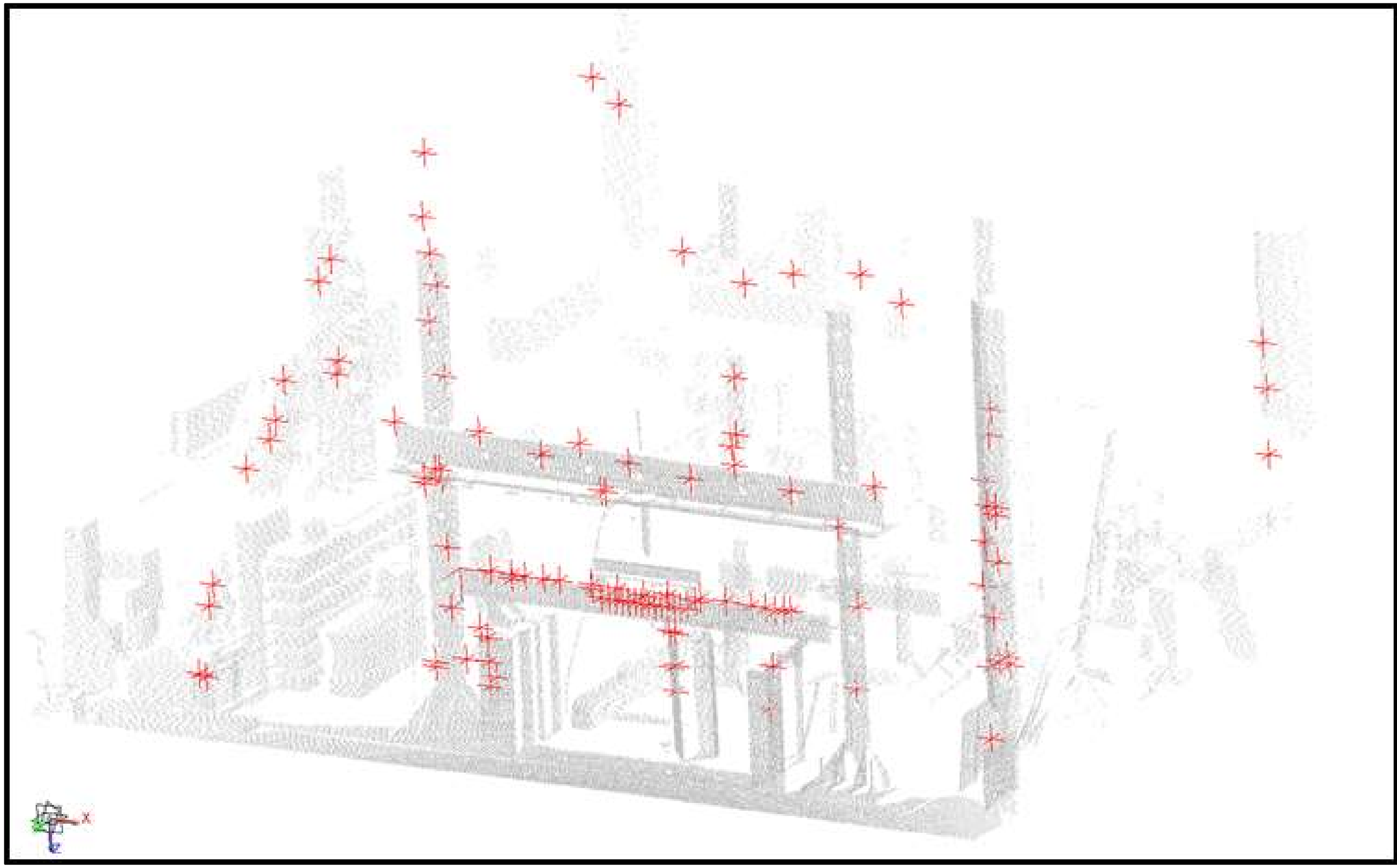


To ensure the measurement of the deformation on the beam for a reasonable number of points, we fixed **five target** with name **P#**



DPA
Target set

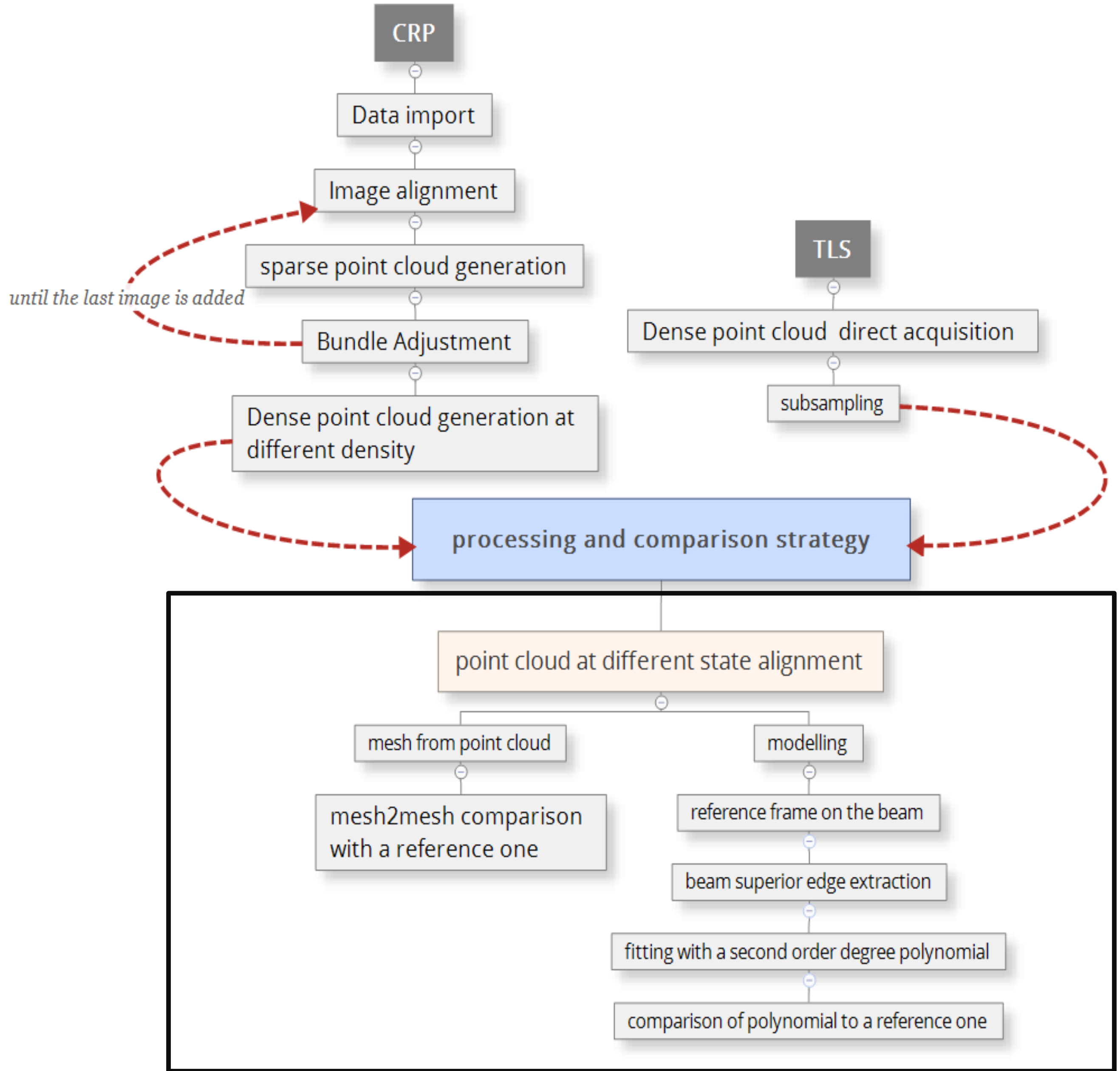
over 100



Processing strategy -TEST

Load (kN)	LT	DPA	TLS	CRP
0	√	√	√	√
11	√	√	√	√
26	√	√	√	√
40	√	√	√	√
54	√	√	√	√
68	√	√	√	

Processing strategy



RESULTS

CRP measurements – GCPs RMS

Load (kN)	RMS X (mm)	RMS Y (mm)	RMS Z (mm)
0	1.01	1.36	0.71
11	2.62	1.34	0.69
26	0.64	0.83	0.68
40	0.70	0.60	0.33
54	3.25	5.03	2.27

DPA - CRP: mesh2mesh methodology

Load (kN)	RMS (mm)
11	2.71
26	2.16
40	2.42
54	1.43
Global RMS	**2.18**

DPA - CRP: modeling methodology

Load (kN)	RMS (mm)
11	1.42
26	1.5
40	1.69
54	0,78
Global RMS	**1.35**

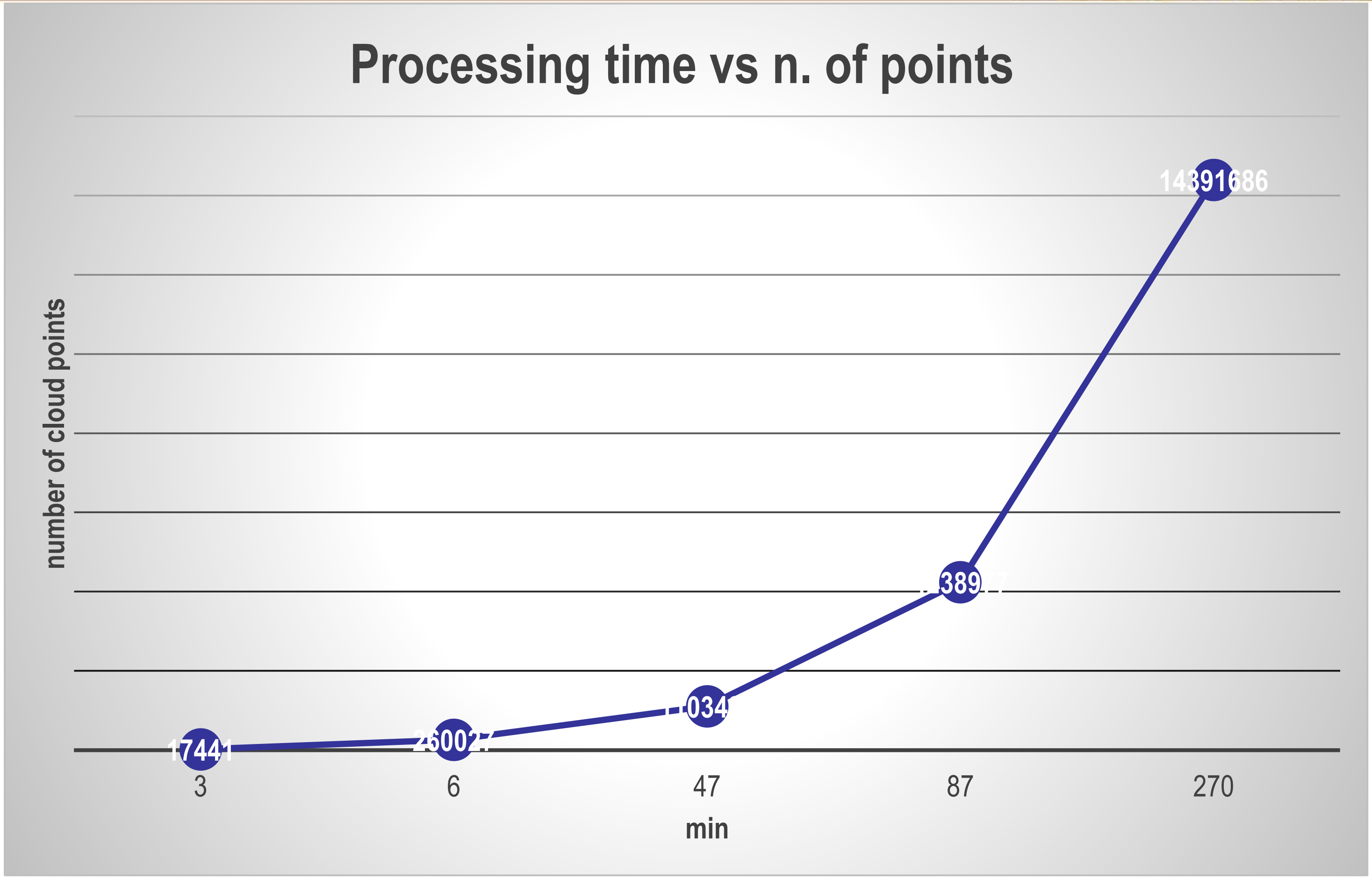
CRP – Photoscan Processing Parameters

Load (kN)	n. images	Parameters dense point cloud	Processing time
0	98	Ultra High	2 h 10’
11	112	Ultra High	3 h 40’
26	114	Ultra High	4 h 30’
40	108	Ultra High	4 h
54	105	Ultra High	3 h 15’

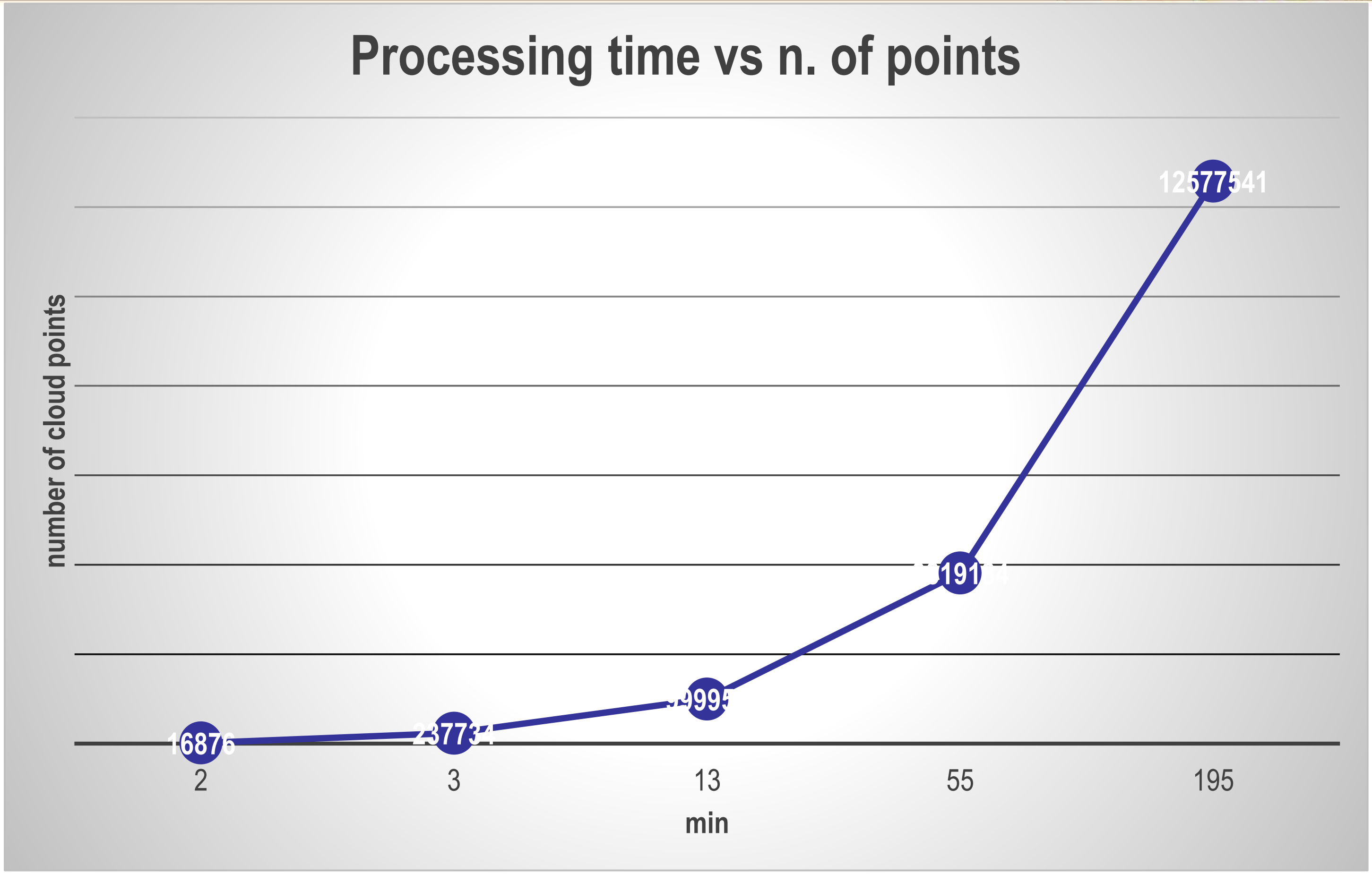
CRP – variation of density

Load (kN)	n. images	density	Processing time	n. points
26	114	Ultra High	4 h 30'	14,391,686
26	114	High	1 h 26'	4,238,977
26	114	Medium	47'	1,103,430
26	114	Low	6'	260,027
26	114	Lowest	3'	17,441
54	105	Ultra High	3 h 15'	12,577,541
54	105	High	55'	3,819,184
54	105	Medium	13'	999,958
54	105	Low	3'	237,734
54	105	Lowest	2'	16,876

Load 26

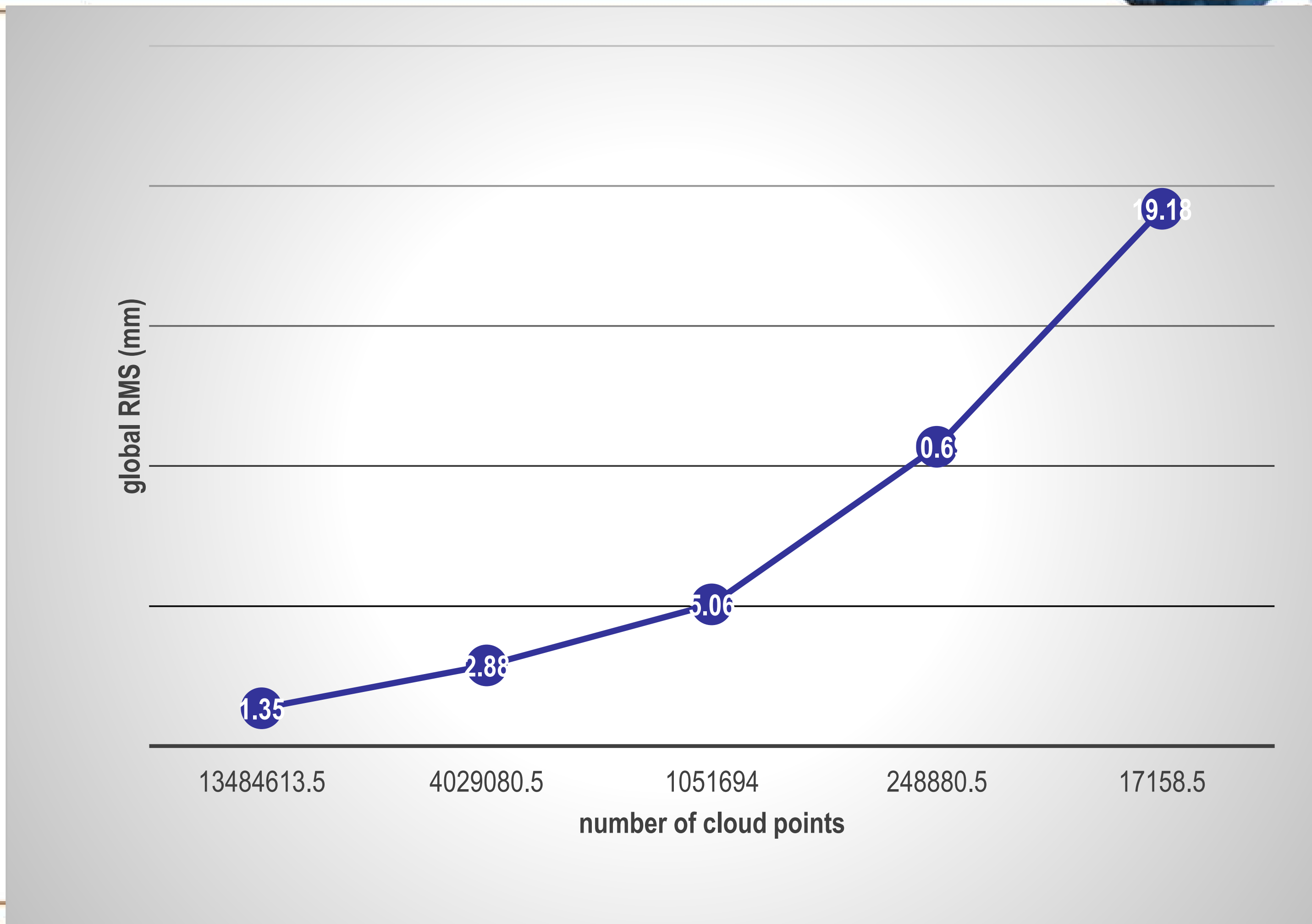

Processing time vs n. of points
number of cloud points
14391686
17441
260027
034
389
3
6
47
87
270
min

Load 54


Processing time vs n. of points
number of cloud points
16876
237734
12577541
2
3
13
55
195
min

DPA and the CRP modelling methodology at different density

	26 kN RMS (mm)	54 kN RMS (mm)	Mean RMS (mm)
Ultrahigh	1.50	0.78	1.35
High	4.42	1.35	2.88
Medium	5.62	4.51	5.06
Low	4.06	17.32	10.69
Lowest	23.08	15.28	19.18


global RMS (mm)
1.35
2.88
5.06
0.6
19.18
13484613.5
4029080.5
1051694
248880.5
17158.5
number of cloud points

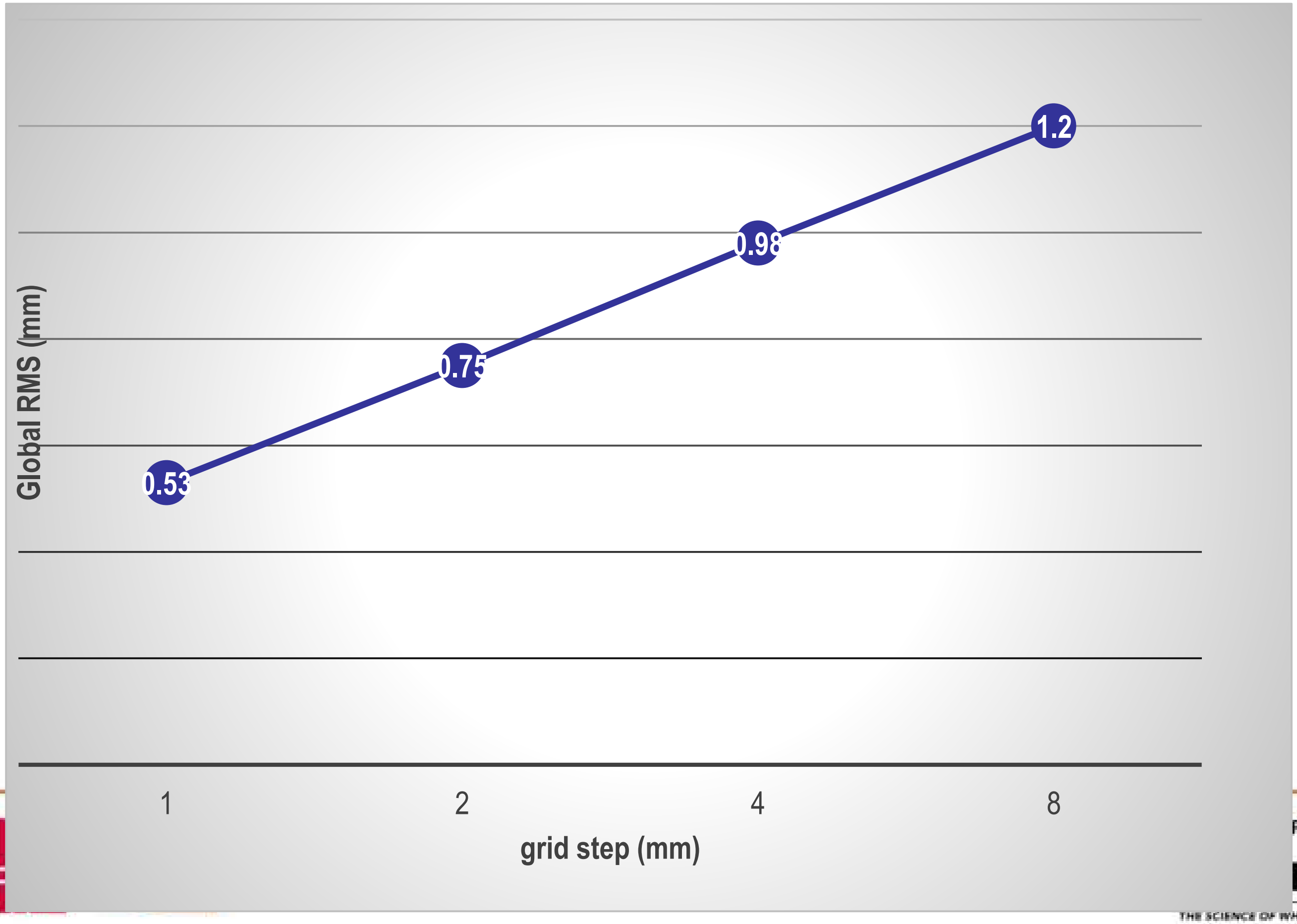
DPA-TLS: mesh2mesh methodology

Load (kN)	Sub 1 (mm)	Sub 2 (mm)	Sub 4 (mm)	Sub 8 (mm)
11	1.01			
26	0.98	1.18	2.03	2.66
40	0.97			
54	0.99	1.27	2.06	2.99
68	0.92			
Global RMS	**0.96**	**1.23**	**2.05**	**2.83**

DPA-TLS: modeling methodology

Load (kN)	Sub 1 (mm)	Sub 2 (mm)	Sub 4 (mm)	Sub 8 (mm)
11	0.38	0.56	0.72	0.58
26	0.42	0.74	1.16	1.16
40	0.6	0.92	1.2	1.64
54	0.63	0.88	1.18	1.28
68	0.62	0.63	0.66	0.8
Global Rms	**0.53**	**0.75**	**0.98**	**1.2**

Global RMS vs TLS grid step in mm (modeling methodology)



Conclusion

- The **comparisons** performed between the different techniques highlighted shown that modelling the behavior of the beam leads to significantly better results than using the mesh2mesh comparison. For the CRP the increase in accuracy was in the order of 40 %, while for the TLS of 50%.
- Regarding **CRP methodology**, we stated that decreasing the density of the point cloud did not bring great results.
- With **TLS** we experienced a linear trend between the global RMS and grid step. Even grid steps of 2, 4 and 8 mm, RMS could be compatible with the accuracy needed for displacements.

THANK YOU FOR YOUR ATTENTION

Giuseppina Vacca
DICAAR, University of Cagliari (Italy)
vaccag@unica.it