FIG WORKING WEEK 2015 *SOFIA, BULGARIA*

Accuracy of Zeb1 hand-held mapping system

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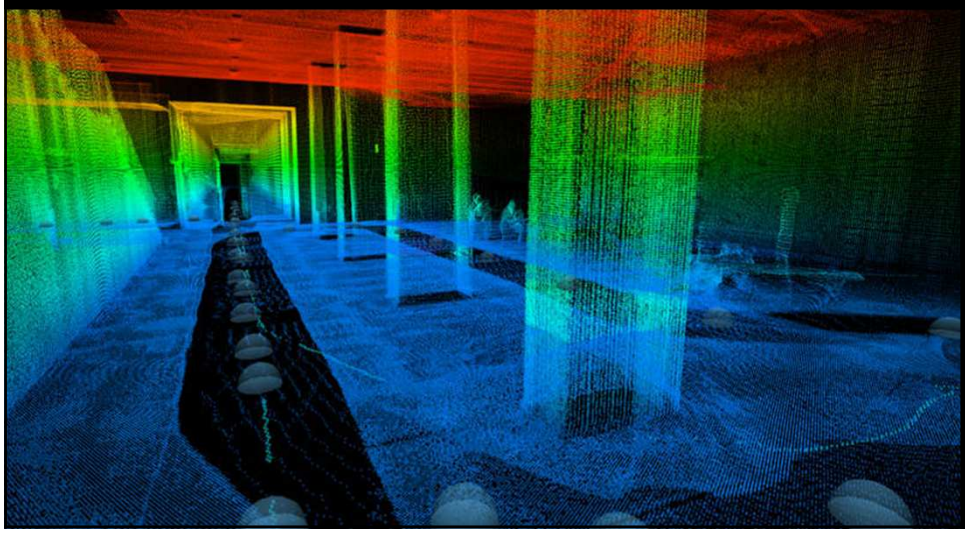
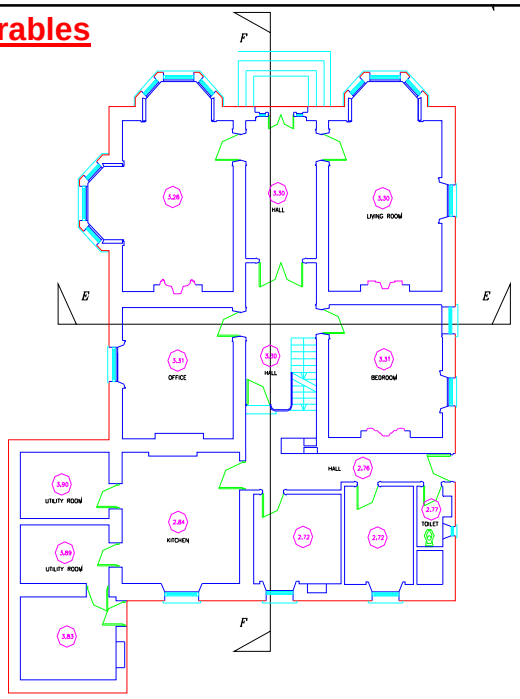


Why Survey Buildings?

- Sale
- Repair
- Conservation
- Reconstruction
- Recording
- Change of use
- 3D Modelling
- Facilities Management
- Demolition
- Etc.

Typical deliverables

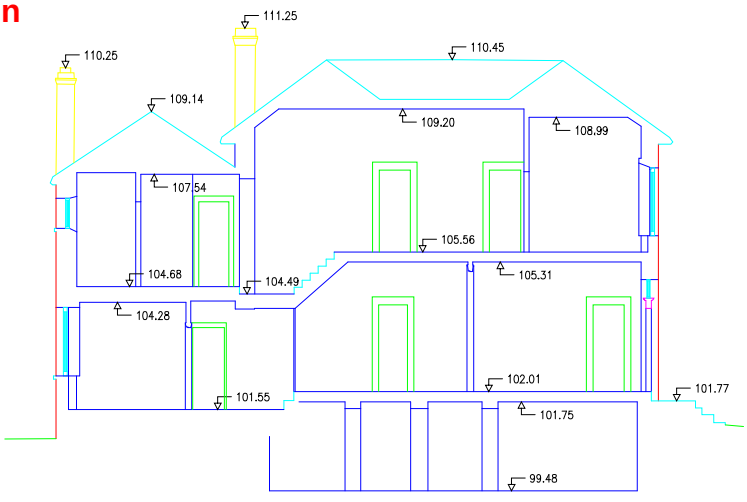
Floor Plan



GROUND FLOOR PLAN

Typical deliverables

Section

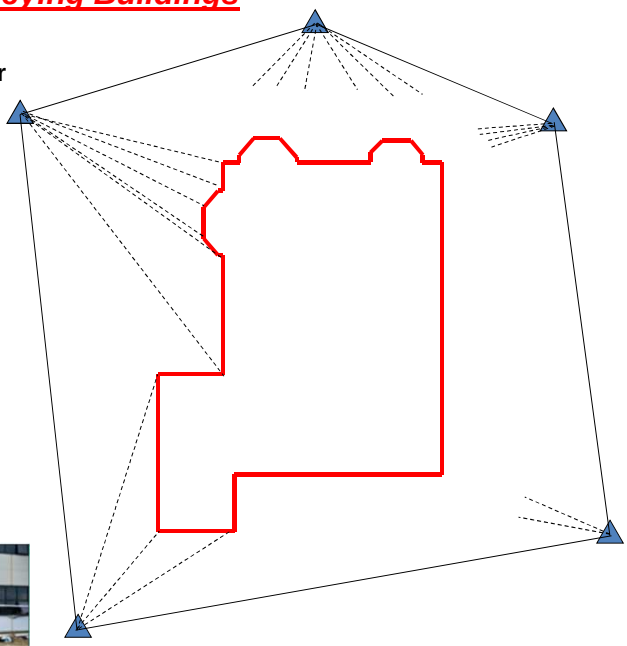


SECTION F–F

DATUM 97m

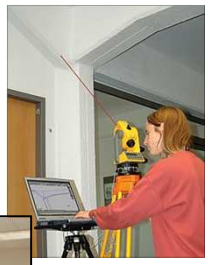
Methods for Surveying Buildings

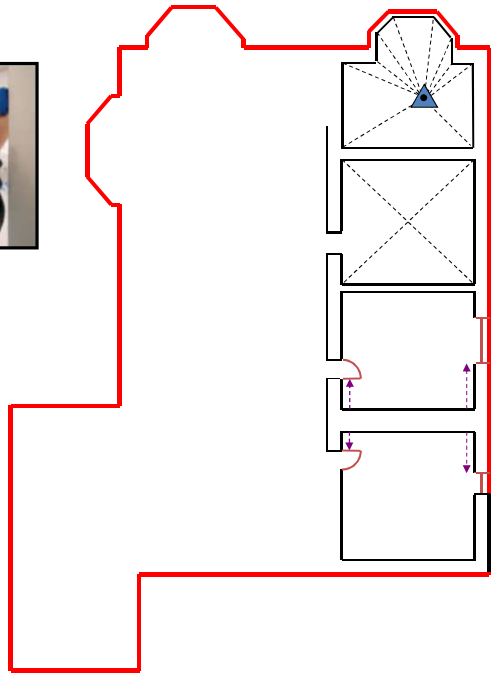
1. Establish perimeter control



2. Survey outer footprint

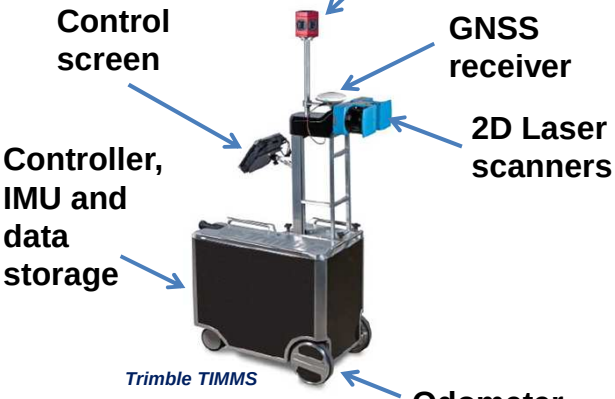
3. Measure rooms





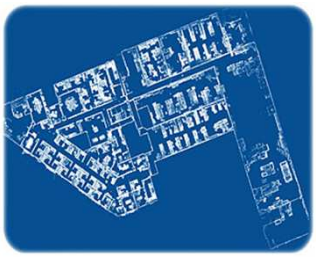
Mobile mapping systems for indoors

(i) Pushcart (Trolley)-based



Trimble TIMMS

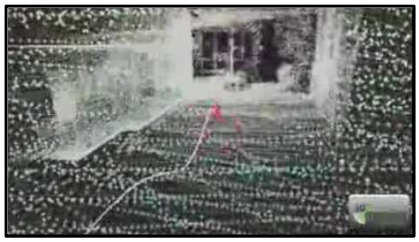
Viametris



Indoor mobile mapping systems

(ii) Handheld

ZEB1

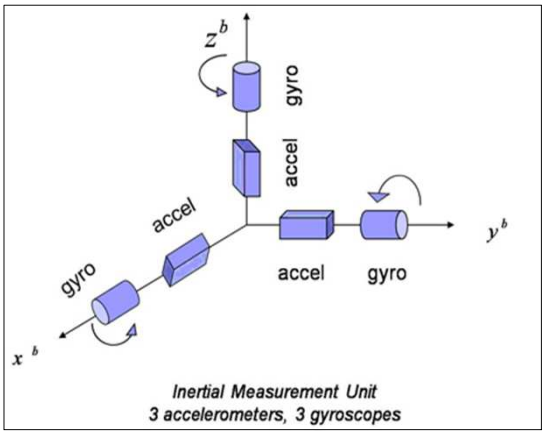


Cloud-based processing

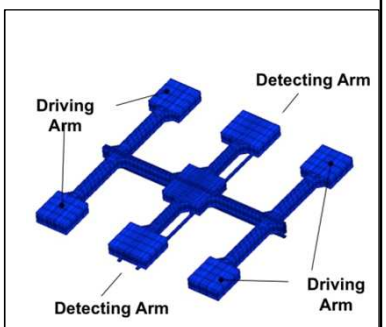
IMU (Inertial Measurement Unit)

- **Accelerometers - directional forces**
- **Gyros - rotational forces**

IMU - MEMS-based
(Micro-electro-mechanical System)



Inertial Measurement Unit
3 accelerometers, 3 gyroscopes



T-shaped quartz crystal IMU elements

SLAM
(Simultaneous Localization and Mapping)

Developed by the robotics industry to enable robots to navigate in previously unknown, and often enclosed spaces.

To do this a robot must be capable of determining:

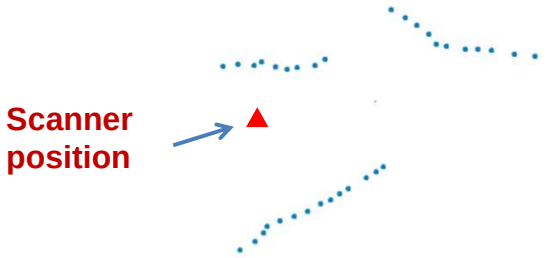
(i) It's location

(ii) Where it is relative to it's surroundings.....

.....where there is no existing spatial information, i.e. no map, and no GNSS reception

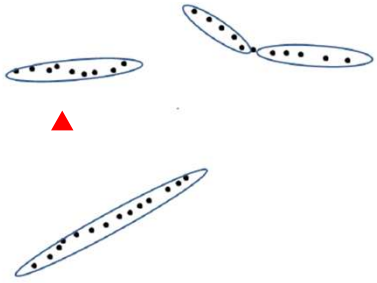
The SLAM solution

(i) Create point cloud from an initial scan



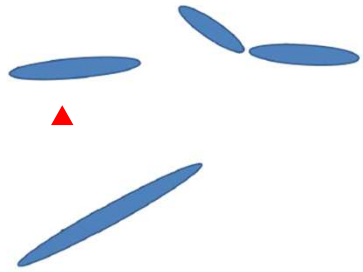
The SLAM solution…..

**(ii) Identify Landmarks,
e.g. Surfels (Surface Elements)**



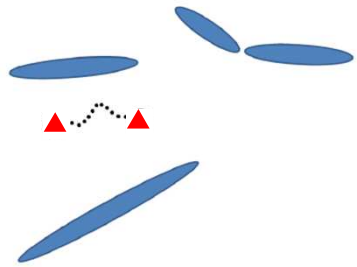
The SLAM solution…..

Extract shape information



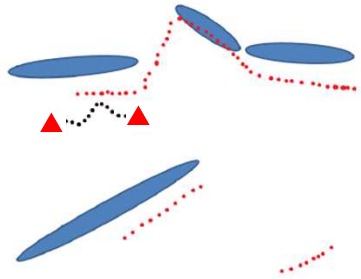
The SLAM solution…..

(iii) Move forward and calculate new position using navigation sensors



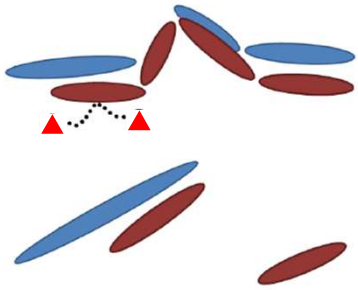
The SLAM solution…..

(iv) Scan again



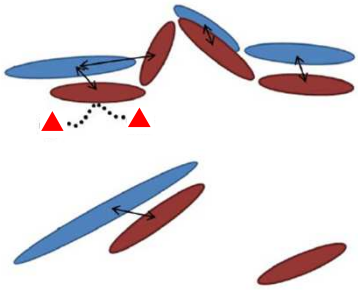
The SLAM solution…..

(v) Identify new Surfels



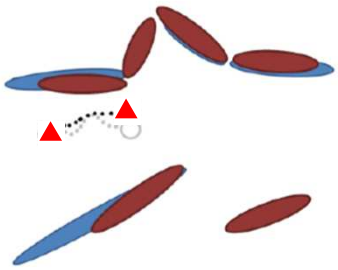
The SLAM solution…..

(vi) Data Association based on matching Surfels



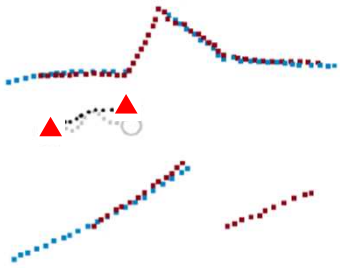
The SLAM solution…..

(vii) Smooth and Optimise



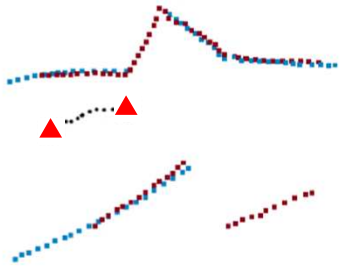
The SLAM solution…..

(viii) Transform all points in second scan based on optimal solution



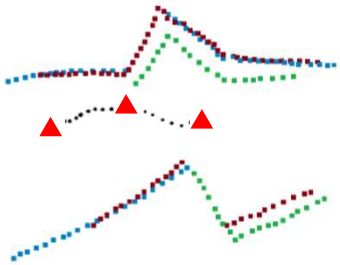
The SLAM solution…..

(ix) Optimise trajectory



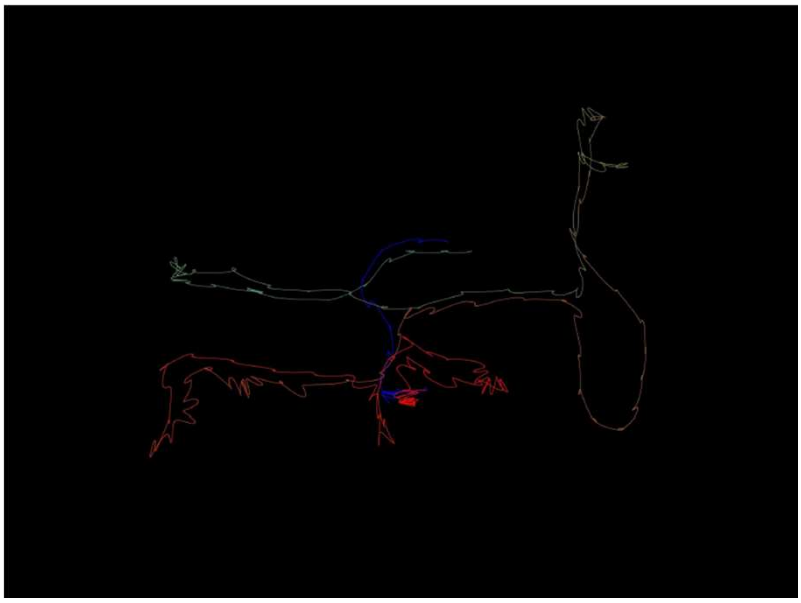
The SLAM solution…..

(x) Move on and repeat process……

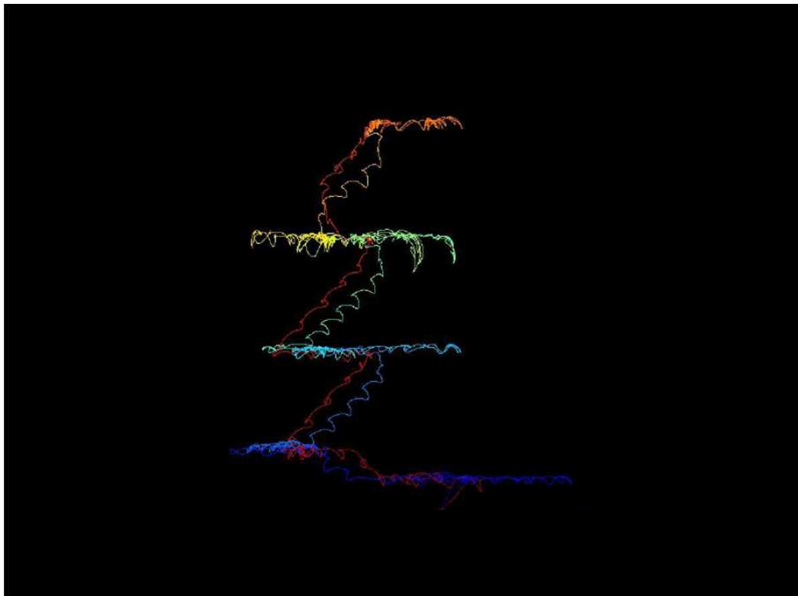


Example – Floor Plan

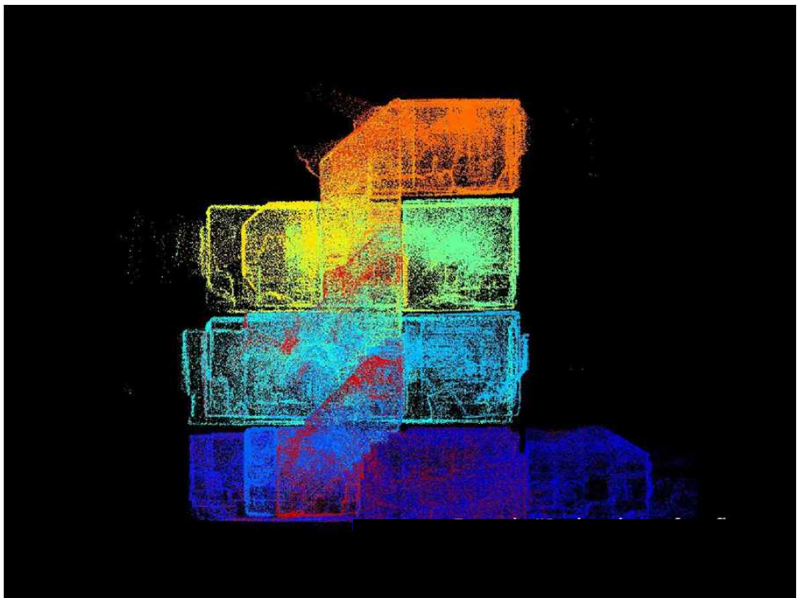
Floor Plan - ZEB1 Trajectory



Cross-section - ZEB1 Trajectory

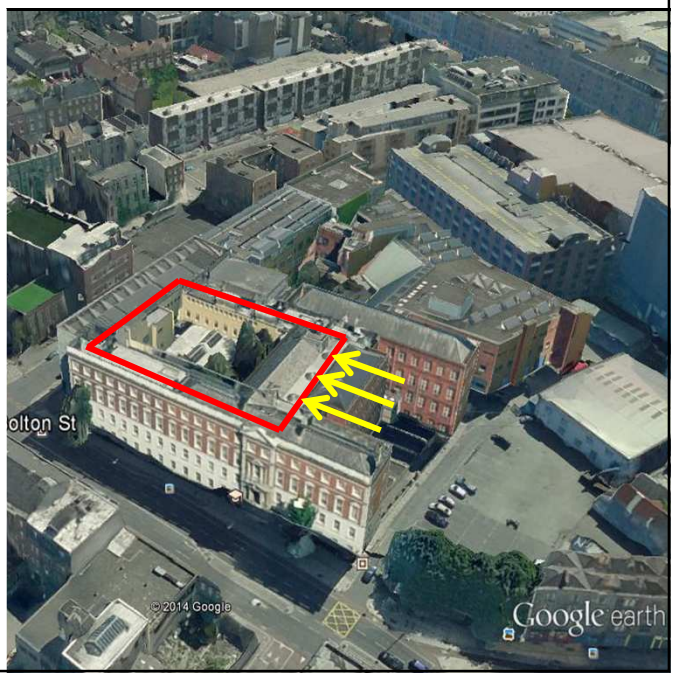


Cross-section - Point Cloud



ZEB1 test area at DIT

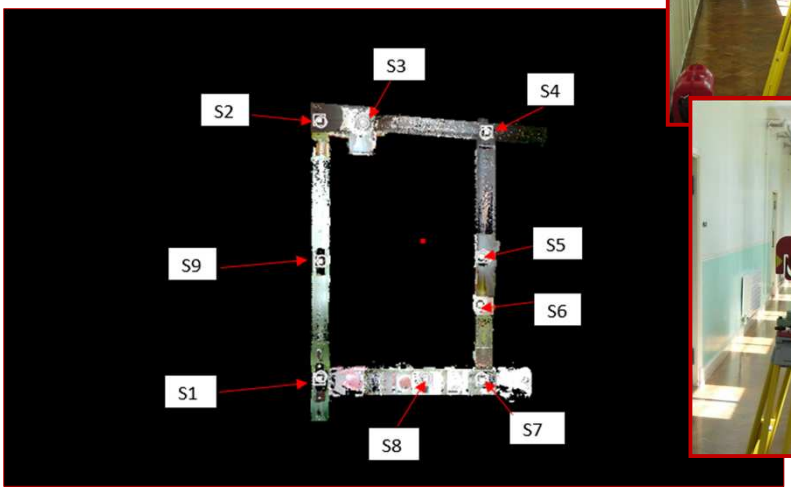
c. 160 m



Survey Control

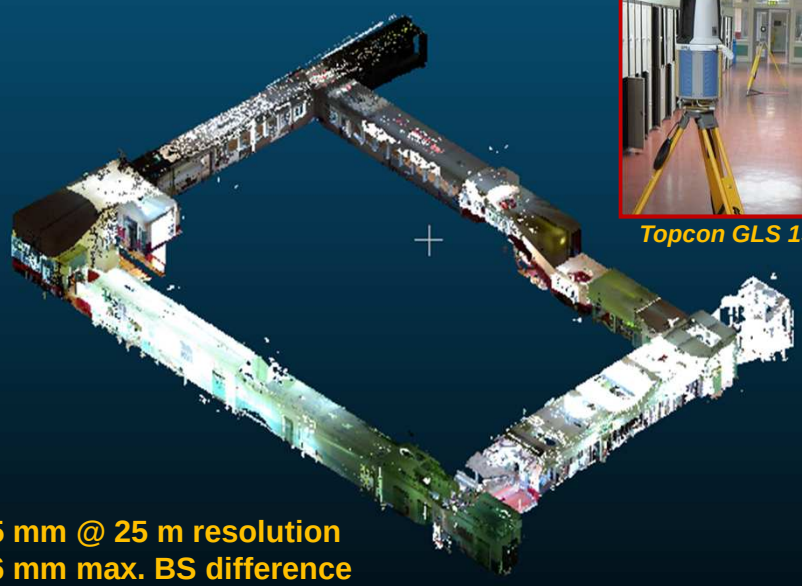
- *9 Stations*
- *Leica 1201+*
- *Topcon ES103*

Misclosure 1/10,000

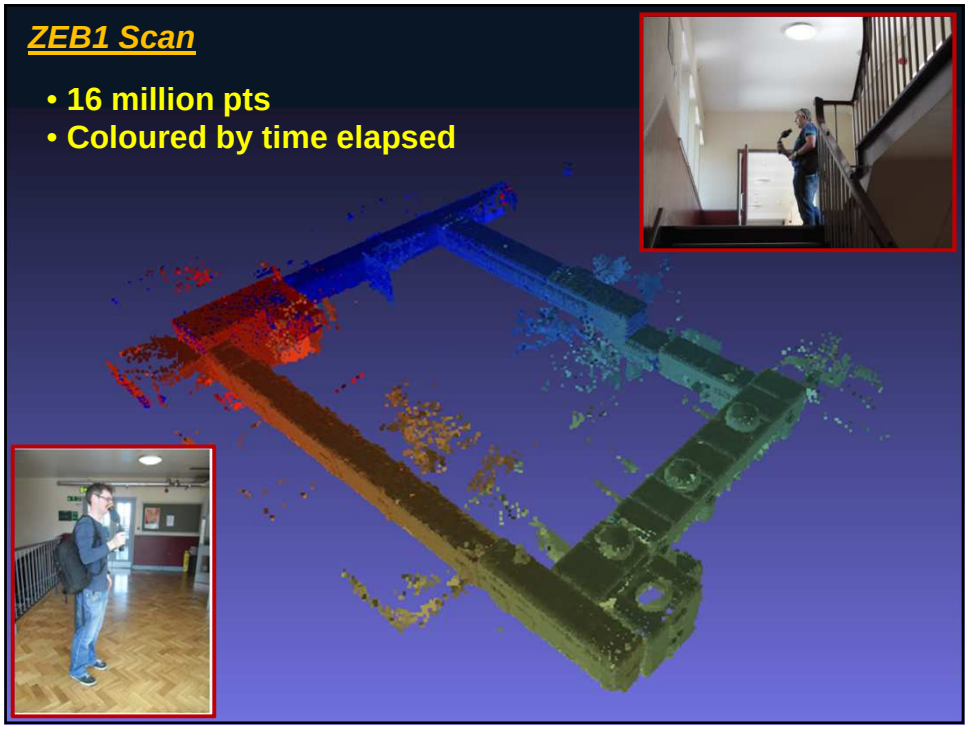


Static Scan

Topcon GLS 1500



- 5 mm @ 25 m resolution
- 6 mm max. BS difference
- 216 million pts.



Results

Horizontal Offsets at 5 m intervals from Ref. Line.

	ZEB1 Closed (m)	ZEB1 Open (m)
Mean	-0.022	-0.025
St. Dev.	0.057	0.064

Chainage (m)	Offset for ZEB1 Closed (m)	Offset for ZEB1 Open (m)	Rmks.
0	0.000	0.000	Corridor 1
5	0.000	0.000	
10	0.058	-0.022	
15	0.053	-0.031	
20	0.032	-0.024	
25	0.011	-0.042	
30	-0.066	-0.093	
35	-0.068	-0.108	
40	-0.060	-0.100	
45	-0.109	-0.161	
50	-0.178	-0.205	
55	0.041	0.091	Corridor 2
60	-0.003	0.054	
65	-0.020	-0.005	
70	-0.063	0.018	
75	-0.088	0.048	
80	-0.103	-0.043	
81	-0.114	-0.044	Corridor 3
86	-0.088	-0.024	
91	-0.032	0.001	
96	-0.042	-0.001	
101	0.008	0.010	
106	0.022	0.039	
111	0.025	0.032	
116	0.036	0.009	
121	0.019	-0.042	
126	0.014	-0.140	
127	0.013	0.031	Corridor 4
132	-0.009	-0.012	
137	-0.007	-0.020	
142	0.000	-0.012	
147	0.023	-0.003	
152	0.002	0.002	
157	0.000	0.000	

Results

Vertical Offsets at 5 m intervals from Ref. Line.

	ZEB1 Closed (m)	ZEB1 Open (m)
Mean	-0.008	0.022
St. Dev.	0.029	0.023

Chainage (m)	Vertical Offset for ZEB1 Closed (m)	Vertical Offset for ZEB1 Open (m)
0	0	0
5	0.003	0.014
10	0.005	0.028
15	0.009	0.043
20	0.012	0.057
25	0.017	0.011
30	0.003	0.013
35	-0.002	0.019
40	-0.006	0.026
45	-0.01	0.031
50		
55	-0.043	0.041
60	-0.045	0.026
65	-0.047	0.01
70	-0.048	-0.005
75	-0.049	-0.019
80	-0.051	-0.035
85		
90	-0.042	0.004
95	-0.044	-0.002
100	-0.046	-0.009
105	0.036	
110	-0.027	0.009
115	0.018	0.054
120	0.02	0.046
125	0.022	0.038
130	0.024	0.031
135		
140		
145	0.01	0.039
150	0.012	0.04
155	0.014	0.041
160	0.016	0.043

Conclusions

- Versatile
- Fast
- Processing is automated
- Accuracy is rel. good (~ 25 mm)
- Variability is high (~ 60 mm)
- Z is more accurate than XY and variability is reduced
- Loop closure is effective
- Results are in line with other researchers

Thank you for your attention