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Department of Civil, Environmental & Geomatic Engineering (CEGE)
↳3D Imaging, Metrology, Photogrammetry Applied Coordinate Technologies (3DIMPact)

Optical non-contact railway track measurement with static terrestrial laser scanning

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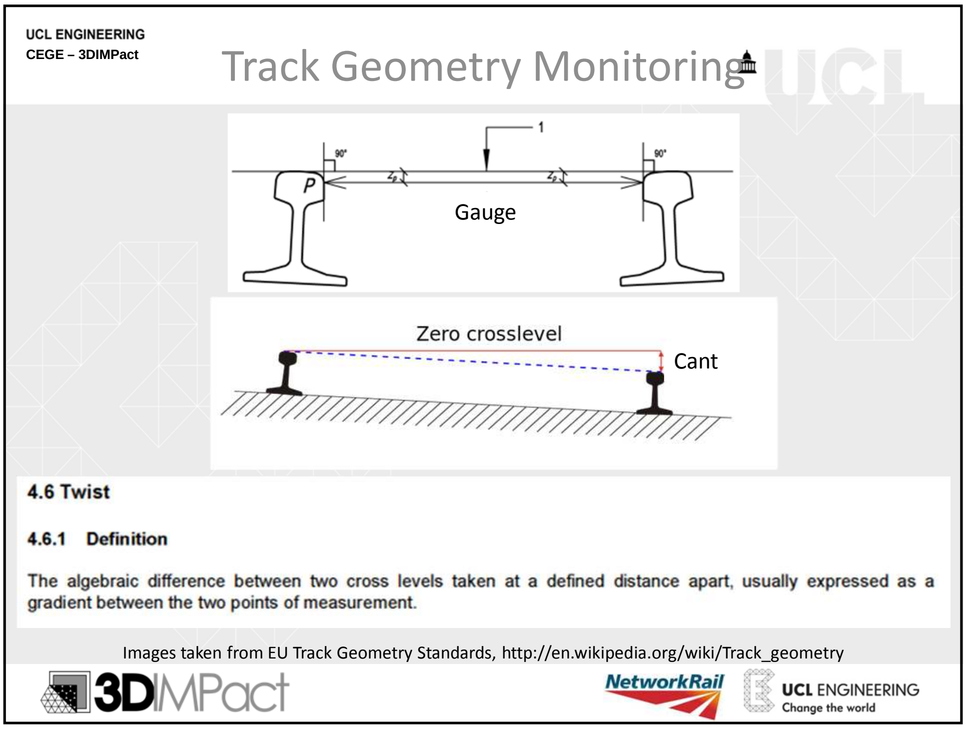
3D Imaging, Metrology & Photogrammetry
Applied Coordinate Technologies

Example of Monitoring Requirement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Track Geometry Monitoring
Gauge
Zero crosslevel
Cant
4.6 Twist
4.6.1 Definition
The algebraic difference between two cross levels taken at a defined distance apart, usually expressed as a gradient between the two points of measurement.
Images taken from EU Track Geometry Standards, http://en.wikipedia.org/wiki/Track_geometry
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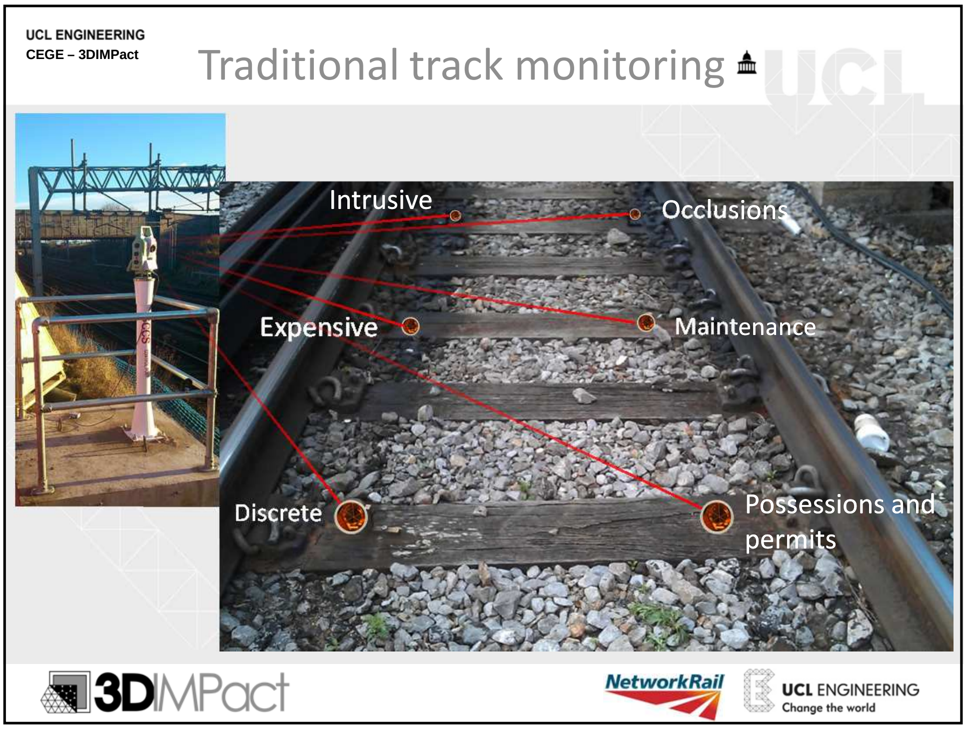
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Traditional track monitoring
Intrusive
Occlusions
Expensive
Maintenance
Discrete
Possessions and permits
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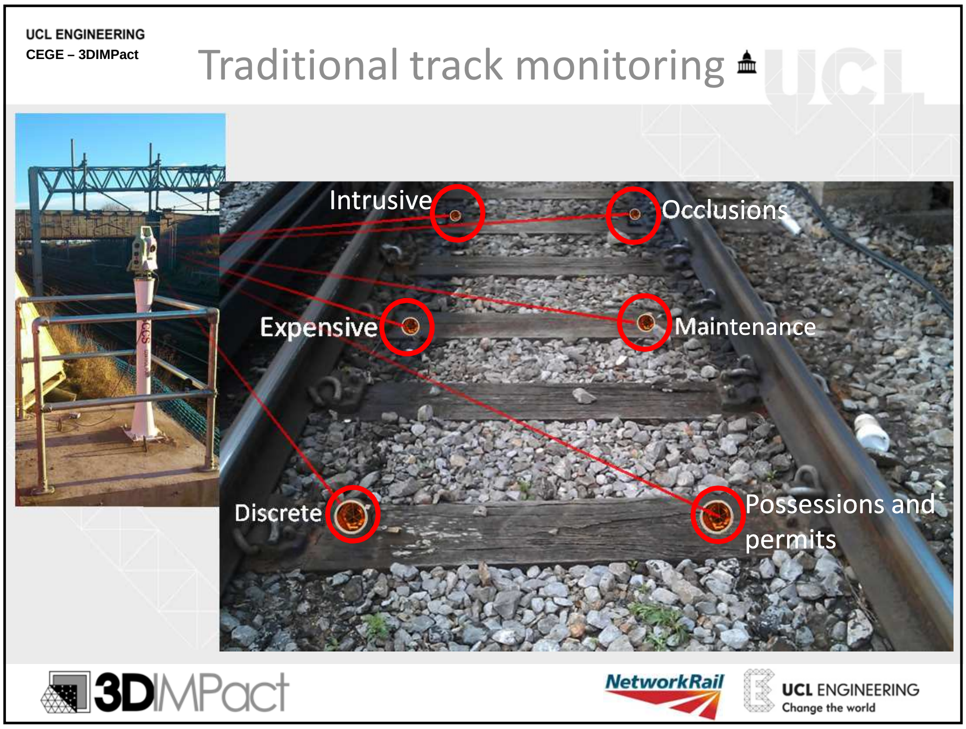
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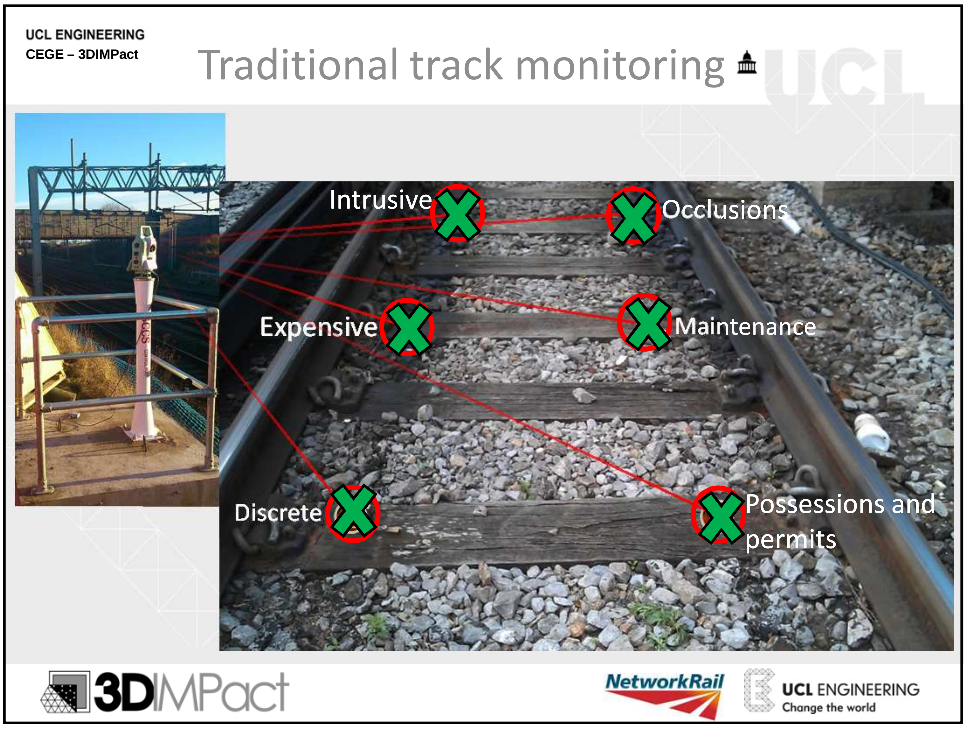
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Traditional track monitoring

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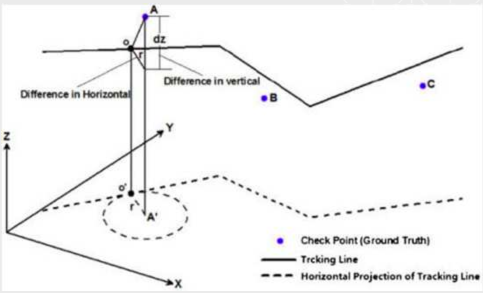
Previous Work: Meng et al (2014)

- Extracting track from static TLS data of lab track
- Edge detection algorithm (vertex normal approximation) to produce trajectory line from 3D mesh
- Accuracy of trajectory line compared to ground truth
    - 2mm in Vertical
    - **3mm** Horizontal



Accuracy determination of extracted track with ground truth points. Image taken from Meng et al (2014)

- Uncertainty if model conforms to physical form of track

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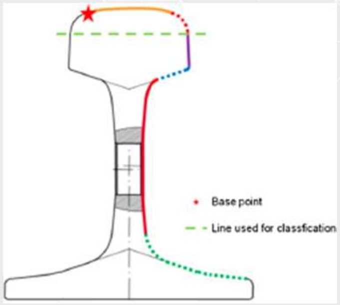
Previous Work: Liu et al (2013)

- Static TLS to extract track geometry for deformation of high- speed rail
- 1mm cross-sections track extracted
- Classification using curves and lines
- Gauge and cant accuracy better than **3mm** compared to precise levelling/track inspection car
- Accuracy affected by sampling interval + laser/track interaction



Classification of track
Image taken from Liu et al (2013)

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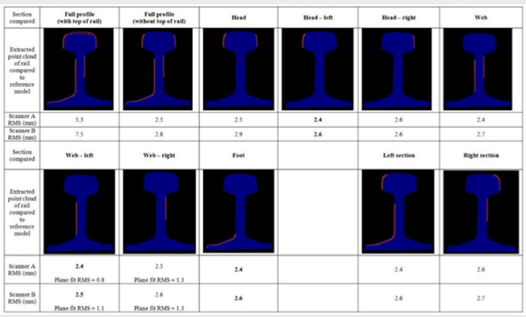
Previous Work: Soni et al (2014)

- Extraction and Classification method for measuring track geometry
- Registering different sections of track profile (head, web and foot) to design rail model
- Better than **3mm** RMS registration for Time-of-Flight and Phase Based Scanners



Section compared	Full profile (with top of rail)	Full profile (without top of rail)	Head	Head – left	Head – right	Web
Extracted point cloud of rail compared to reference model						
Scanner A RMS (mm)	5.3	2.5	2.5	**2.4**	2.6	2.4
Scanner B RMS (mm)	7.5	2.8	2.9	**2.6**	2.6	2.7
Section compared	Web – left	Web – right	Foot		Left section	Right section
Extracted point cloud of rail compared to reference model						
Scanner A RMS (mm)	**2.4** Plane fit RMS = 0.8	2.5 Plane fit RMS = 1.3	**2.4**		2.4	2.6
Scanner B RMS (mm)	**2.5** Plane fit RMS = 1.1	2.6 Plane fit RMS = 1.3	**2.6**		2.6	2.7

Summary of RMS values of fitting point cloud to modelled track.
Image taken from Soni et al (2014)

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Case Study: London Bridge Station

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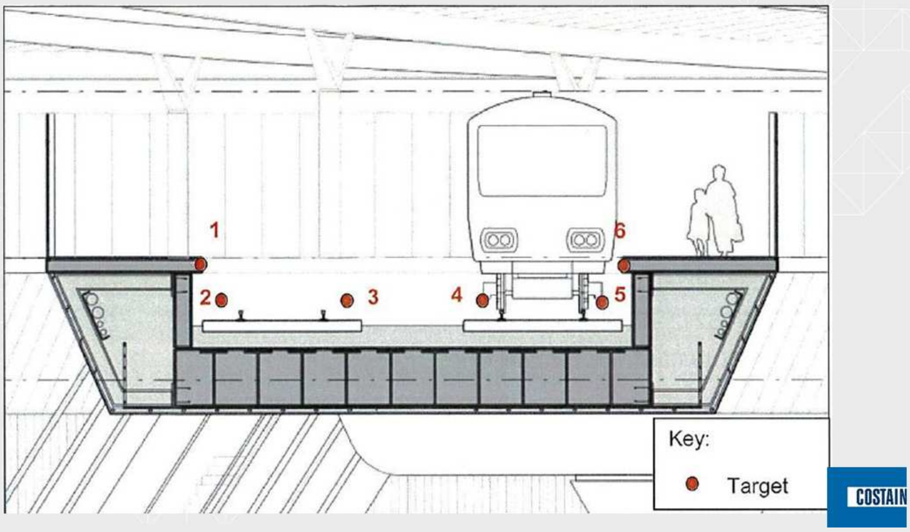
Prism Monitoring



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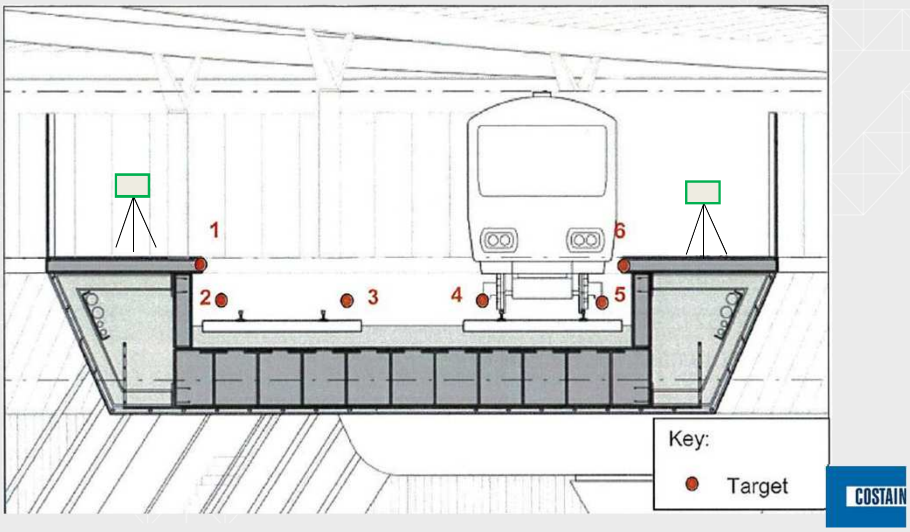
TLS Data Capture



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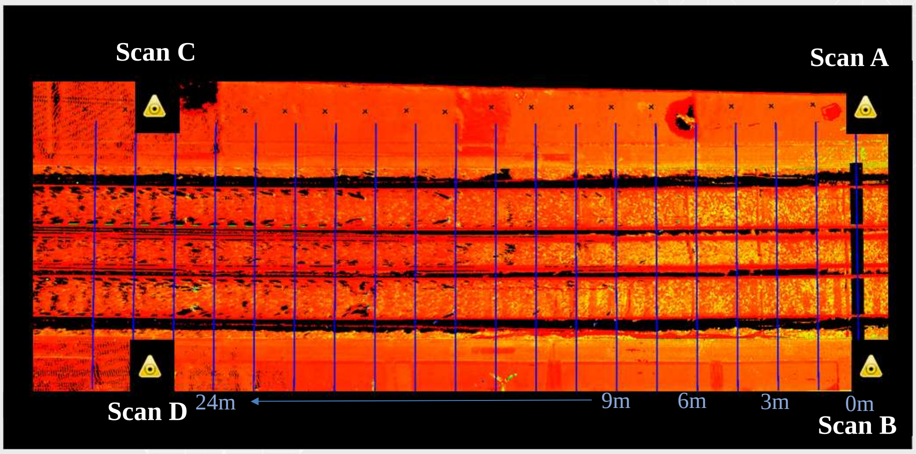
Data Capture



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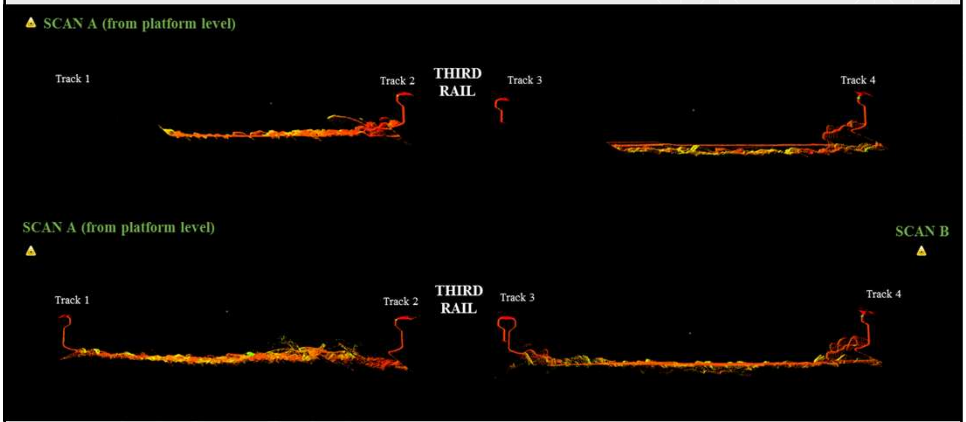
Profile of Track from TLS



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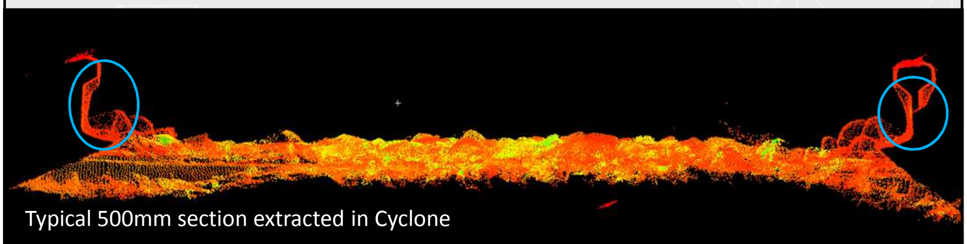
Output Sections


Typical 500mm section extracted in Cyclone

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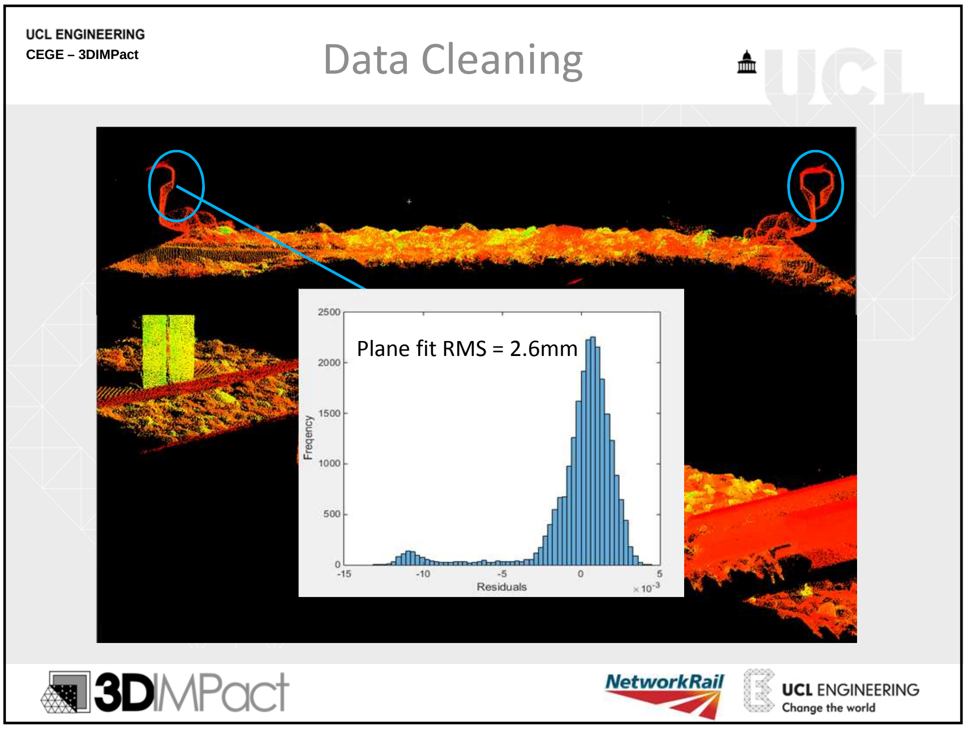
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Data Cleaning
Plane fit RMS = 2.6mm
Freqency
Residuals
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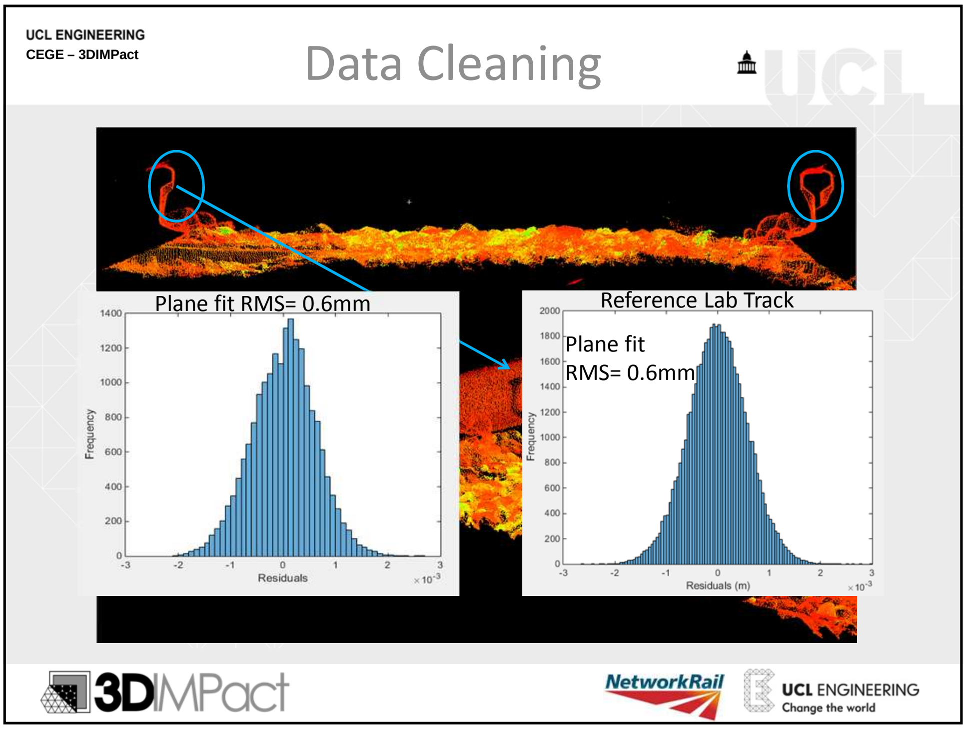
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Data Cleaning
Plane fit RMS= 0.6mm
Frequency
Residuals
Reference Lab Track
Plane fit
RMS= 0.6mm
Residuals (m)
3DIMPact
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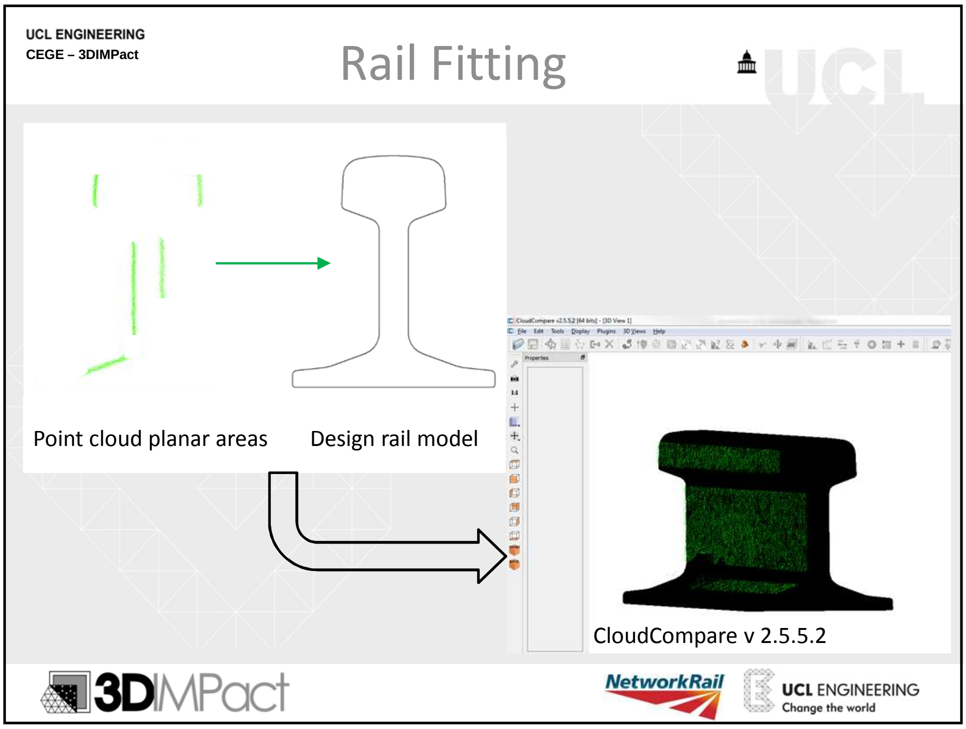
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Rail Fitting
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Point cloud planar areas
Design rail model
CloudCompare v 2.5.5.2
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Rail Fitting Results
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Scan C
Scan A
1
2
3
4
Scan D
24m
9m
6m
3m
0m
Scan B
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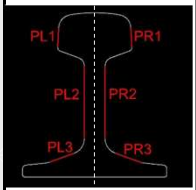
Rail Fitting Results



Rail Fitting from Scan A&B							
	Local plane fit RMS (mm)						Combined plane fit to rail RMS (mm)
	PL1	PL2	PL3	PR1	PR2	PR3	PR1,PR2,PR3 or PL1,PL2,PL3 (i.e. left or ride side of track)
Track 1				1.1	1.0	1.4	1.2
Track 2	0.6	0.9	0.7				1.2
Track 3				0.7	1.3	0.8	1.5
Track 4	1.1	1.3	1.1				1.5

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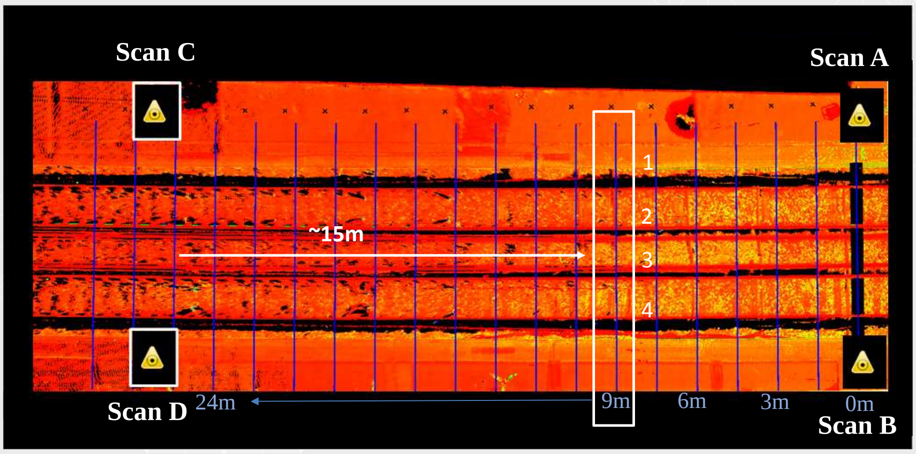
Rail Fitting Results



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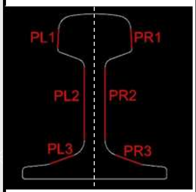
Rail Fitting Results

Rail Fitting from Scan C&D							
	Local plane fit RMS (mm)						Combined plane fit to rail RMS (mm)
	PL1	PL2	PL3	PR1	PR2	PR3	PR1,PR2,PR3 or PL1,PL2,PL3 (i.e. left or ride side of track)
Track 1				1.0	1.1	1.2	1.3
Track 2	0.8	1.0	1.0				1.2
Track 3				0.7	1.1	0.8	1.3
Track 4	1.1	1.5	1.2				1.5

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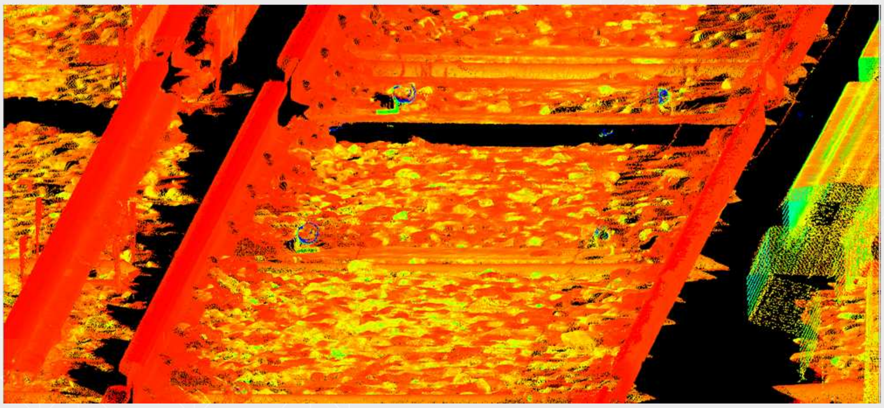
Track Geometry for Engineers



Monitoring method	Cant values (mm)
Monitoring Contractor (prisms)	5.3
Rail Fitting method	5.1

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Conclusions

- Complexity of the physical and logistical environment for data capture
- Improved quality of rail fitting a point cloud of track to UK standard design model to **1.5mm**
- Scans of track from 9m & 15m range produce comparable results (local and combined registration processes)
- Narrows gap between engineering requirements for deformation monitoring + TLS capabilities
- Local plane fitting and analysis of histograms provide mechanism for removal of track artefacts
- Automation of the method is possible through local plane fitting and analysis of histograms provide mechanism for removal of track artefacts
- Ongoing work - performance of geometry calcs for engineers

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Further Work

- Investigation of the systematic bias in the spread of the residuals
  - Physical interaction of TLS + track
  - Develop robust statistical testing procedures for artefact removal
- Application to mobile rail mounted system for asset management