Settlement measurements in unloaded conditions of turnouts in Swedish railway infrastructure

a part of the project “Improved availability and reduced life cycle cost of track switches” (FUD project, Trafikverket)

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Objective

- Evaluate current measurement equipments which are used to measure vertical track irregularities effecting unloaded track geometry (twist, longitudinal - and cant level) on switches and crossings (S&Cs).

- Provide and analyze field data on vertical geometric measurements of rails in S&Cs when not affected by passing trains.

- The long term objective for the overall project is to increase the knowledge of how to design future S&Cs regarding stability and maintenance needs.

Measurement equipments used today for loaded and unloaded track condition.

Loaded track, measurment with track geometry car (STRIX)

Method used by: Trafikverket for scheduled control of track geometry quality, 2-6 times annually.

Technology: Vertical position on track is determined by the ratio of the output from inertial systems (consisting of accelerometer and gyro) in the body of the vehicle, with output from an optical system.

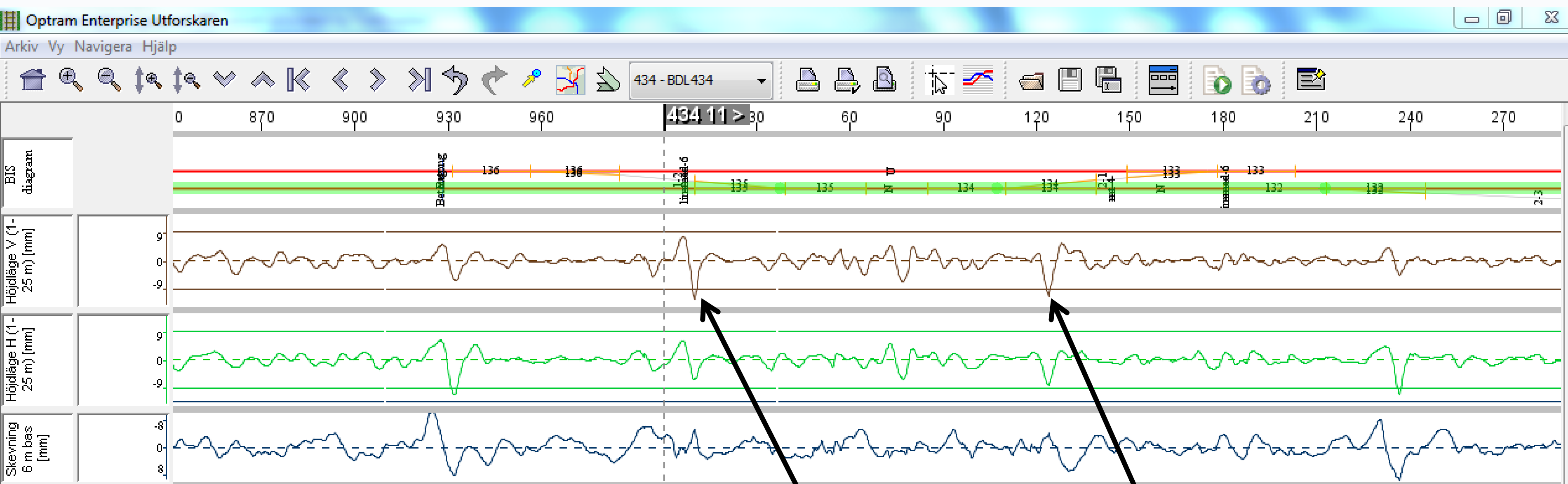


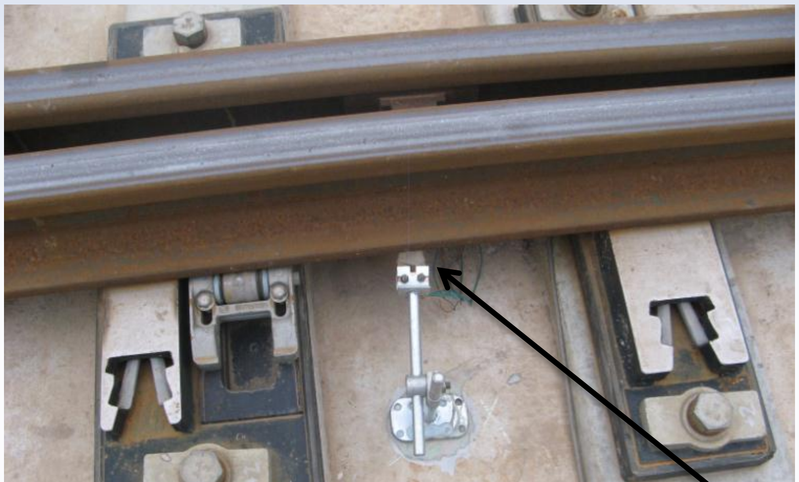
Fig. Picture retrieved from Optram which is a web application that allows data from STRIX to be displayed and analyzed maintenance contractors.

Limits in height +/- 9 mm

Crossing Srv 135

Crossing Srv 134

Loaded track, measurements with strain gauge



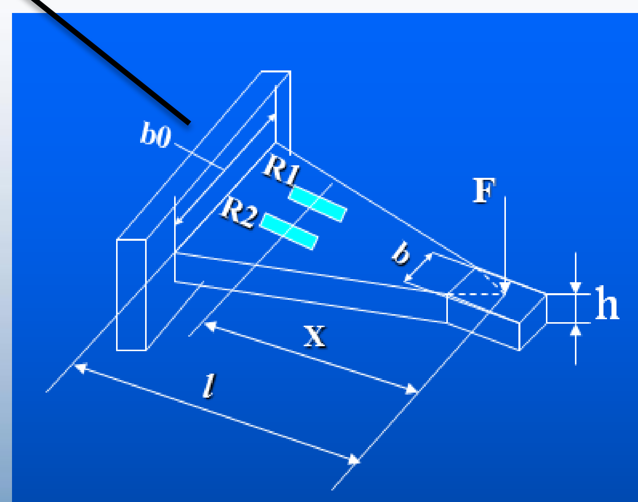
Method used by: chinese railway researcher used method for dynamic measurement on S&Cs on slab track.

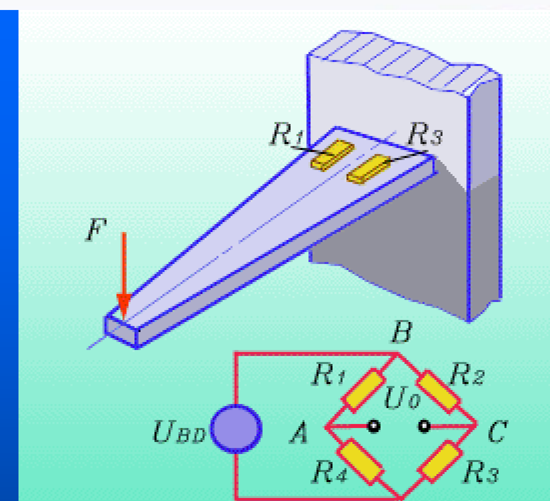
Technology: Using Wheatstone bridge on field measurements as to measure strain gauge effected by the force of the rail and derive vertical displacement.

<u>Alt technology</u>: Accelerometers mounted along the rail.

Fig. Set up for field study of dynamic vertical deformation measurements of S&Cs using strain gauge measurements on foot of rail(fixed in slabs).

$$\varepsilon = \frac{6lF}{b_0 h^2 E}$$





Unloaded track, measurements with geometry recording trolley

Method used by: Maintenance contractors in Germany as a measurement tool on S&C, but do not included level and alignment.

Technology: Mechanical measurements, rolling elements on rail.

Cons: Distance between rolling elements limits longer wavelength measurements

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Issues and challenges when measuring geometry change over time of rails in S&Cs

- There is no fixed points in the infrastructure that can be related to measurements and hold the desired accuracy.

- Longterm geometry change on rail in S&Cs due to change in subgrade requires followup measurements with longer intervals. Similar measurement setup can thus be difficult to achieve.

- Position of measurement points can be shifted e.g. when recording track irregularities with recording cars (STRIX). The infrastructure is moving which creates problems when identifying longitudinal position of follow up measurement on vertical geometry.

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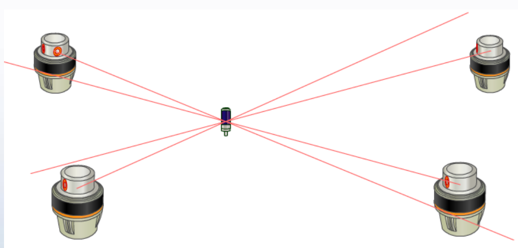
Alt. light-weight measurement equipment

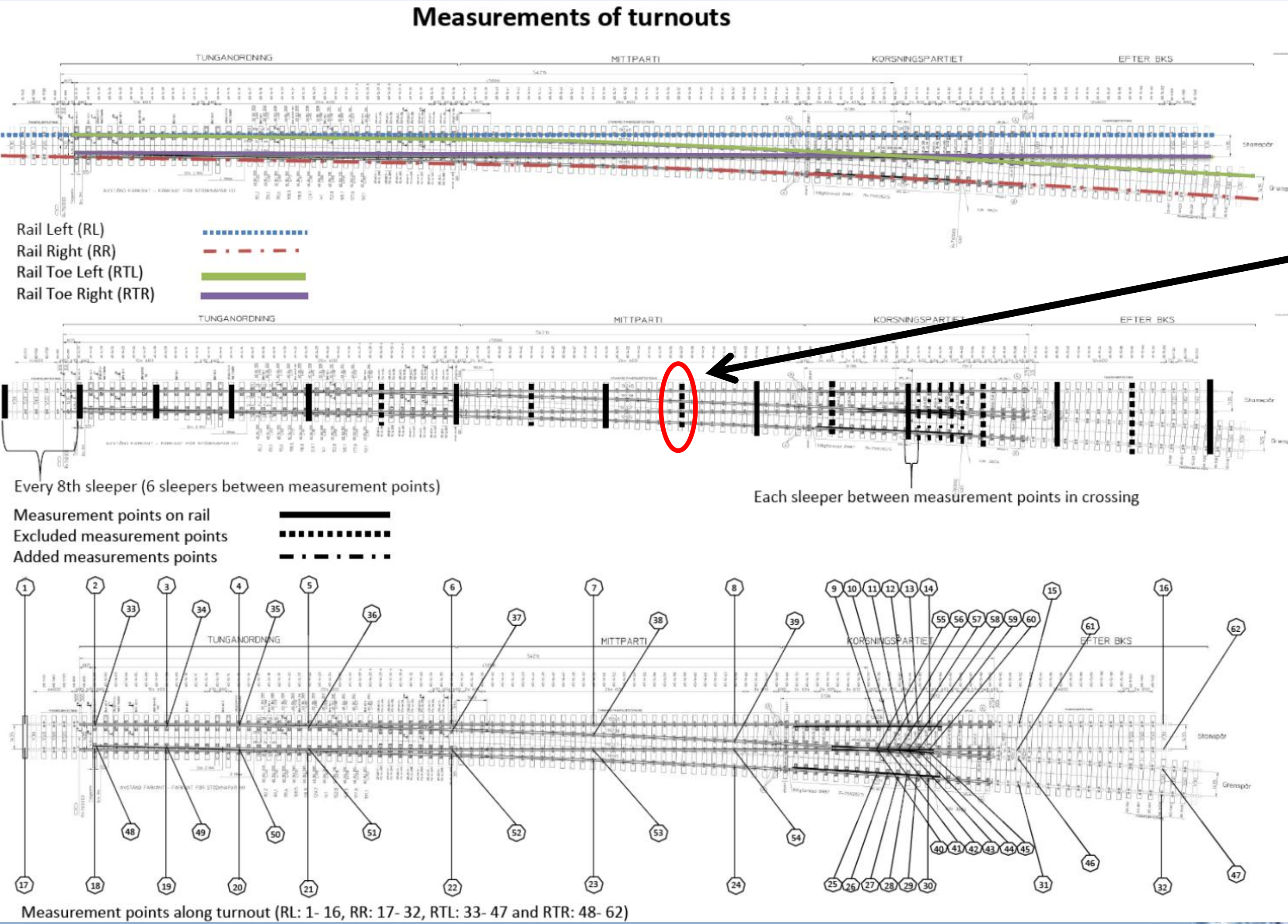
evaluation of alternative equipments for measuring S&Cs



Selection of equipment was based on the criteria's, repeatability (±0,3mm) and usability (practical use and time in track).

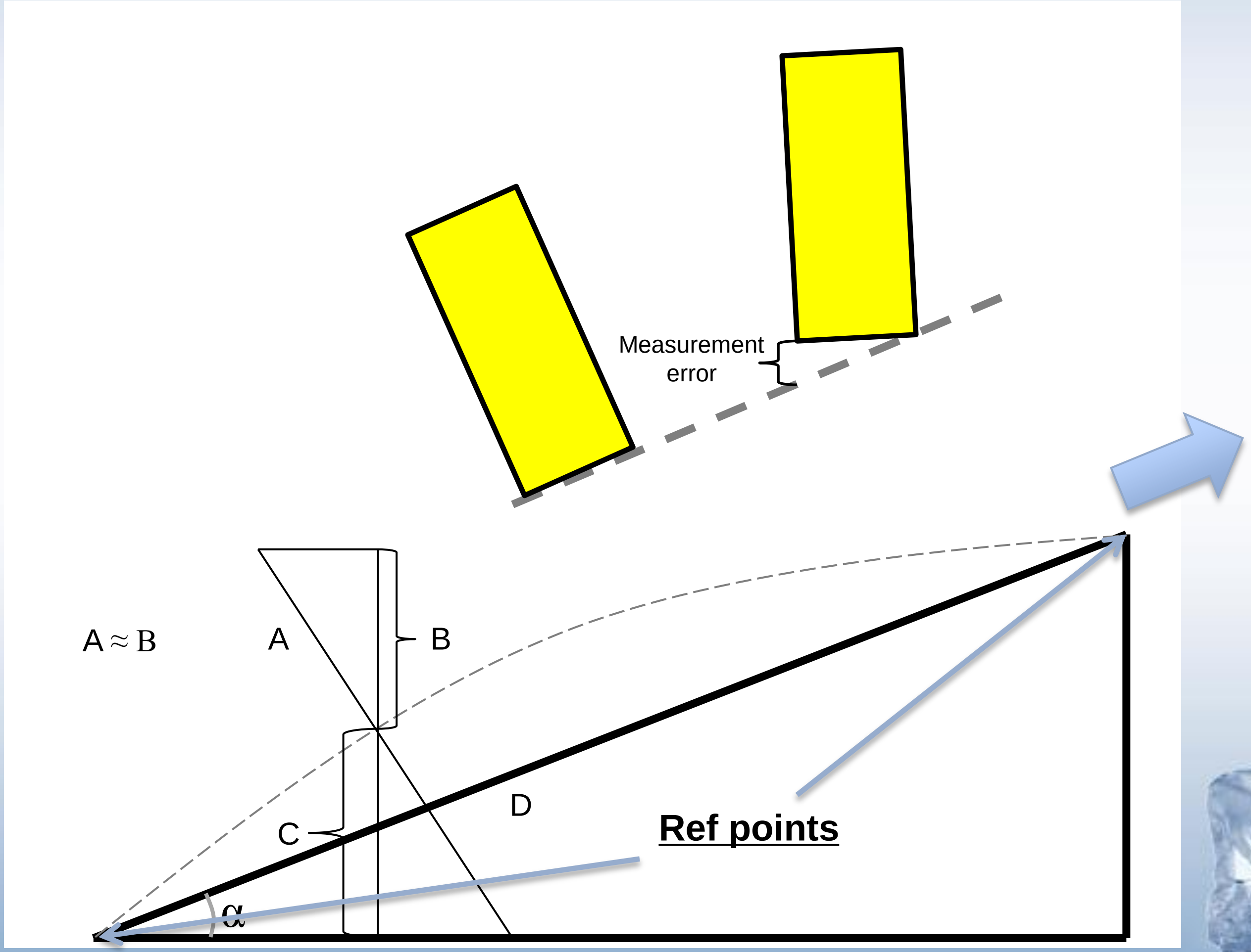
	Repeatability	Time to measure	Range for measurements	Users measuring
Rotating laser	±1 mm	40 min	35m	1
Total station	±1.5 mm	30 min	80 m	2
Local GPS system	± 3.0mm	60 min	< 100 m	2
Levelling instrument	± 0.3 mm	30 min	80 m	2

Measurements setup



- Follow-up measurements 2 times/ year on 13 selected S&Cs.
- Relative measurements over time.

Establishment of ref. points, compensation for slope and measurement error



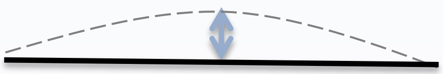


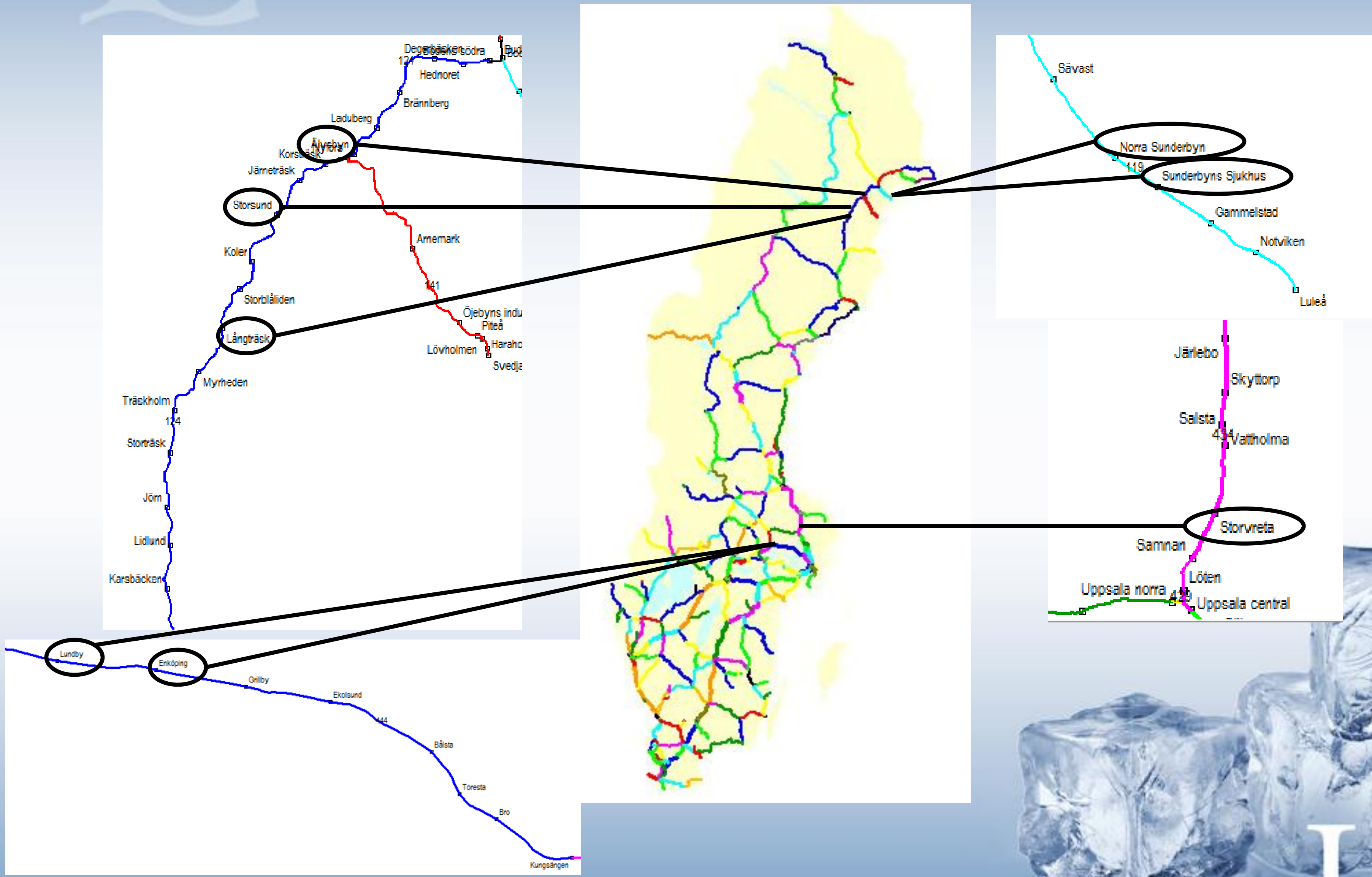
Fig. The measurement was shifted to compensate for the slope. Points in the beginning and after the S&C was the reference points.

Selection of measuring objects

- Common S & Cs model in Swedish railway infrastructure was chosen (EV-UIC60-760-1:15)
- Fixed manganese frogs
- Ballasted main track
- Grouped in two main areas
  - S & C on track section affected by passing freight and ore trains.
  - S & C on track section affected by mixed traffic and passenger trains

Track section	Station	S&C nr	Max speed, ore train	Max speed, freight train	Max speed, passenger train	MGT/year	Ambient conditions	Track section type
	Sunderbyn Sjukhus							
119	Sus	1	70	100	140	18.5		Ore line
119	Sus	2	70	100	140	18.5	Level crossing	Ore line
	Långträsk							
124	Ltk	1		100	135	11		Freight line
	Storsund							
124	Sts	1		100	105	11	Curve in main track and on bridge	Freight line
	Nyfors							
124	Nyf	2		100	140	11	Curve in main track and on bridge	Freight line
	Storvreta							
434	Srv	135		100	200	5.3		Mixed traffic
434	Srv	134		100	200	5.3		Mixed traffic
434	Srv	104		100	200	5.3		Mixed traffic
434	Srv	101		100	200	5.3	On bridge	Mixed traffic
	Enköping							
444	Ep	131			180	3.1		Passanger traffic
444	Ep	102			180	3.1		Passanger traffic
	Lundby							
444	Lub	131			200	3.1		Passanger traffic
444	Lub	102			200	3.1		Passanger traffic

Location of S&C selected



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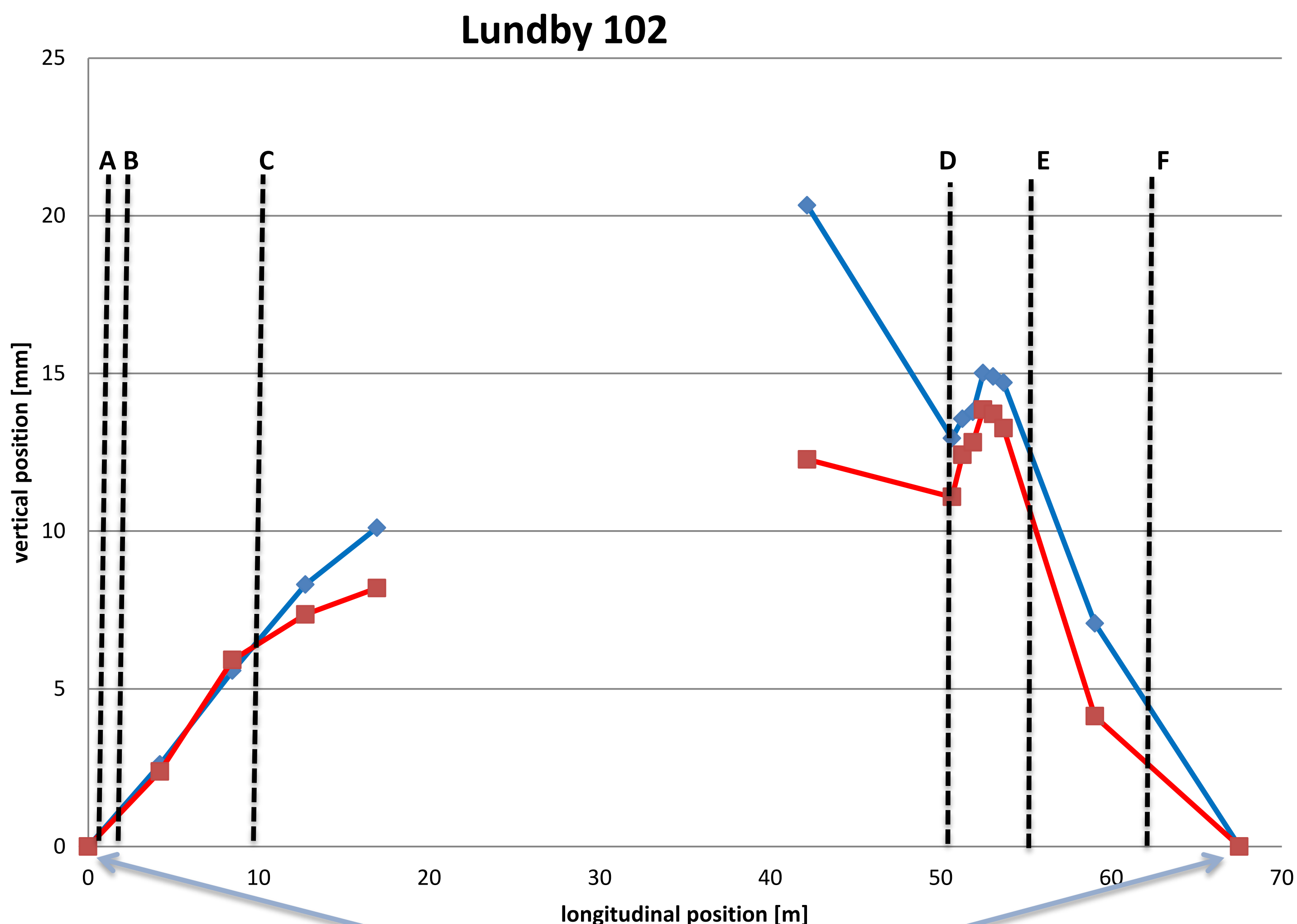
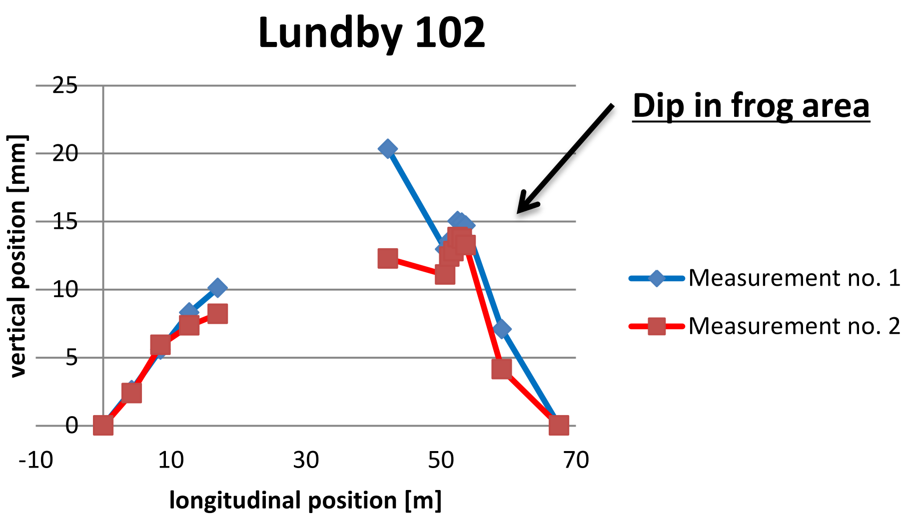
Vertical position as a function of longitudinal position

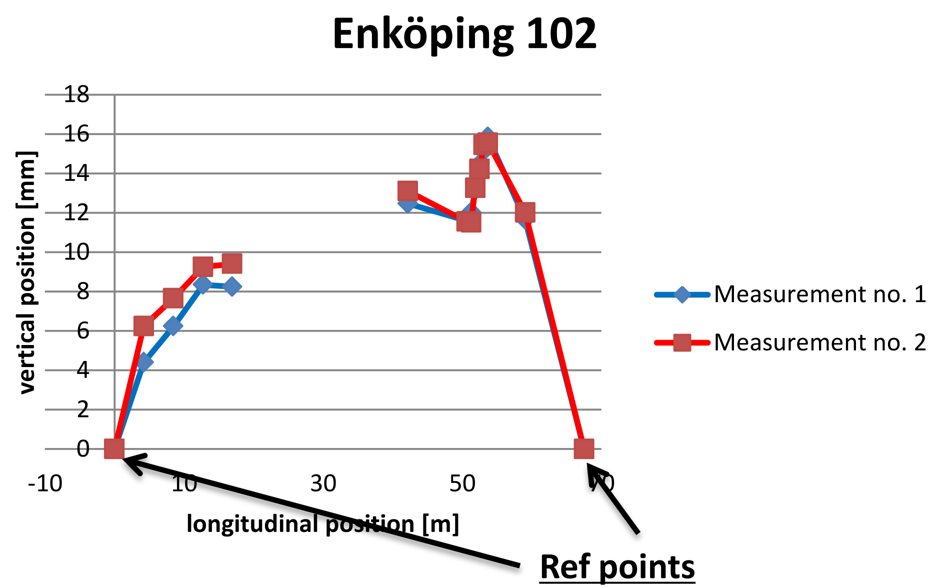


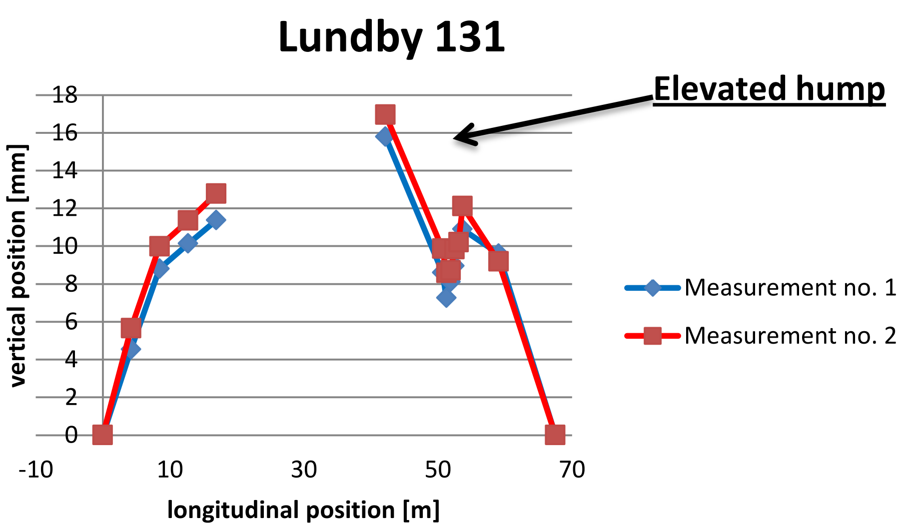
A	Front support rail joint
B	Point machine 1
C	Point machine 2
D	Crossing
E	Back support rail joint
F	Long sleepers

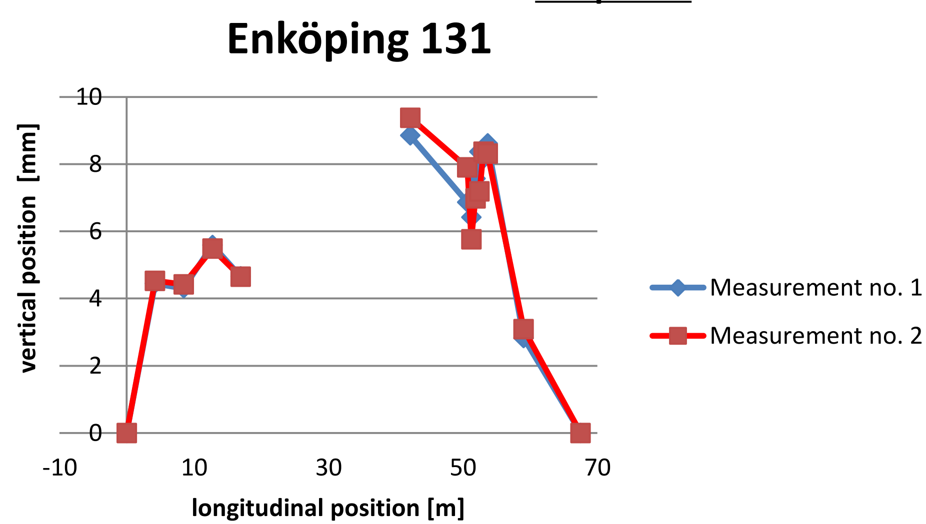
Ref points

Results of vertical geometry measurements on S&C (Track section 444 and ca 2 month duration)

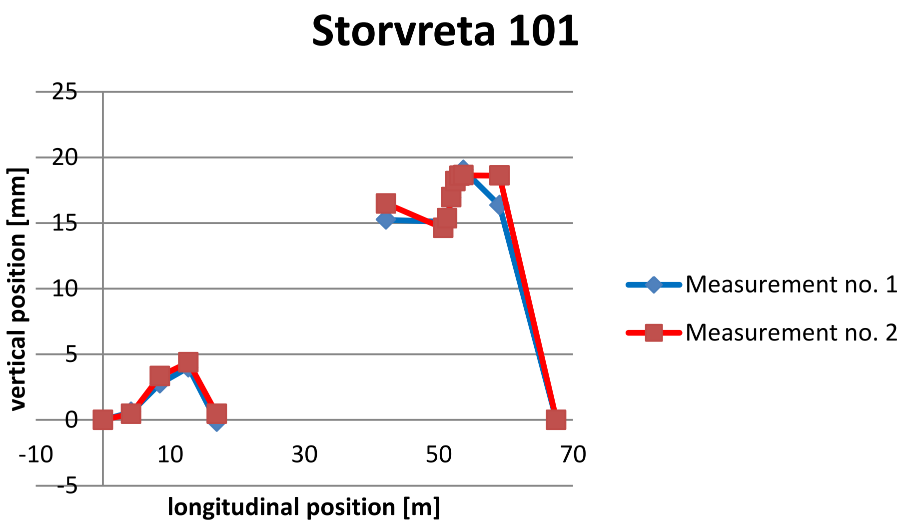


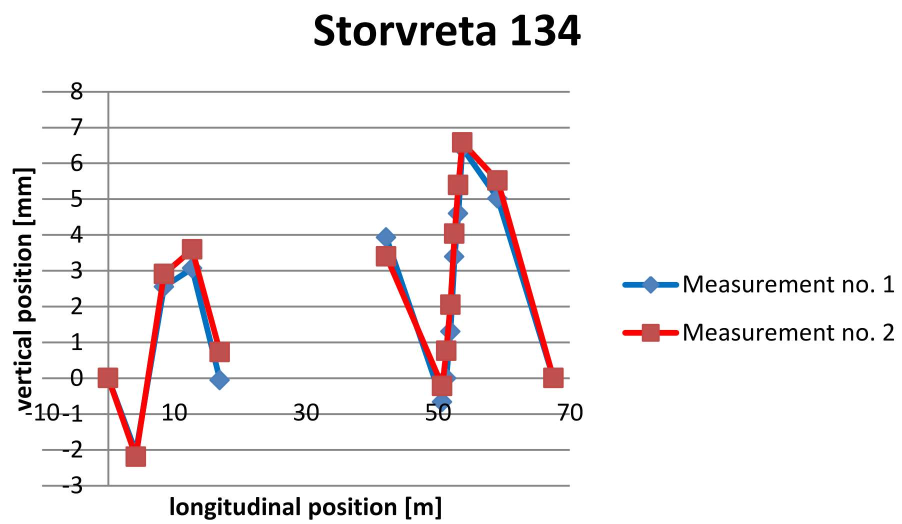


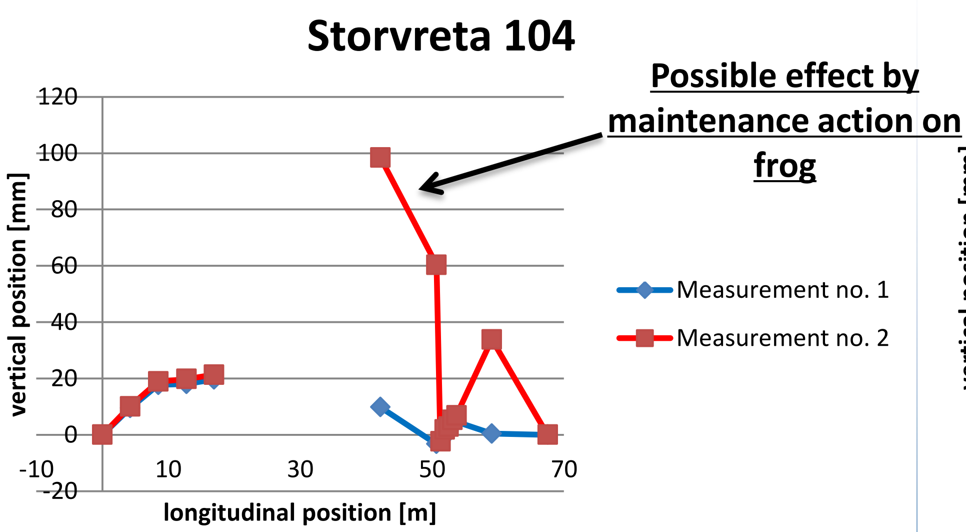


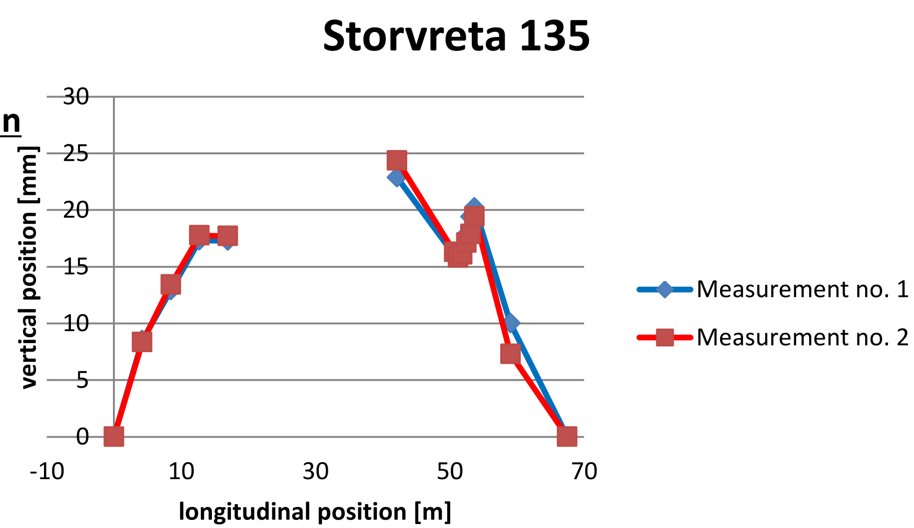


Results of vertical geometry measurements on S&C (Track section 434 and ca 2 month duration)



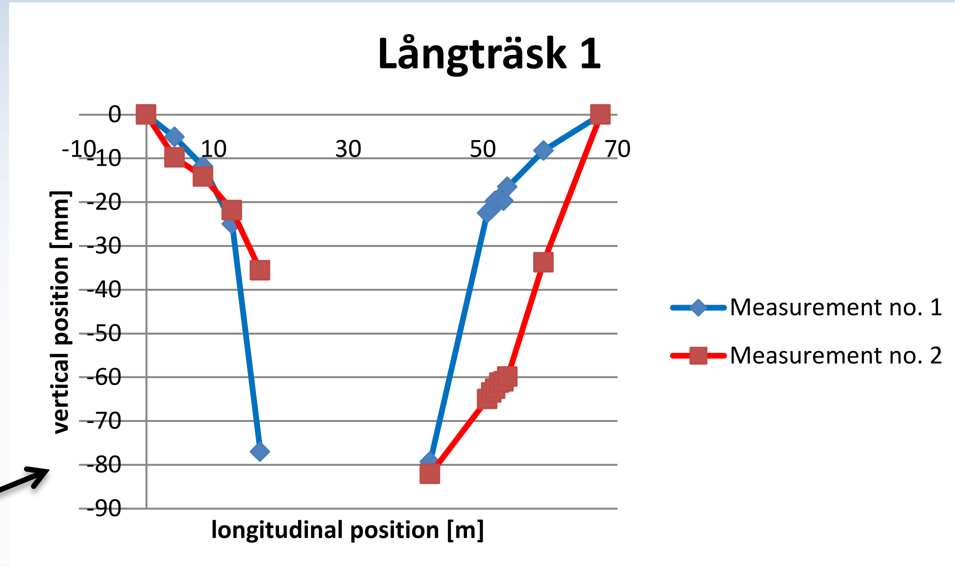




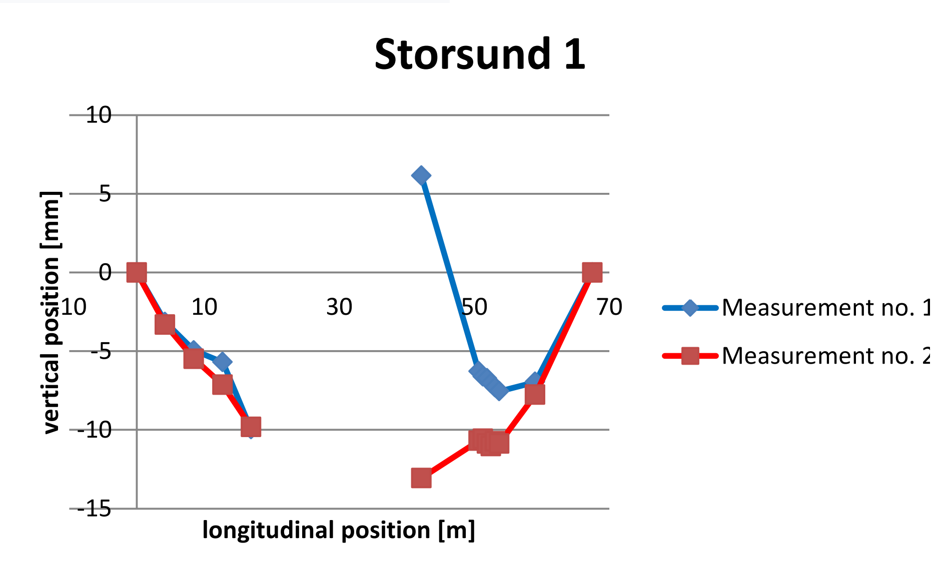


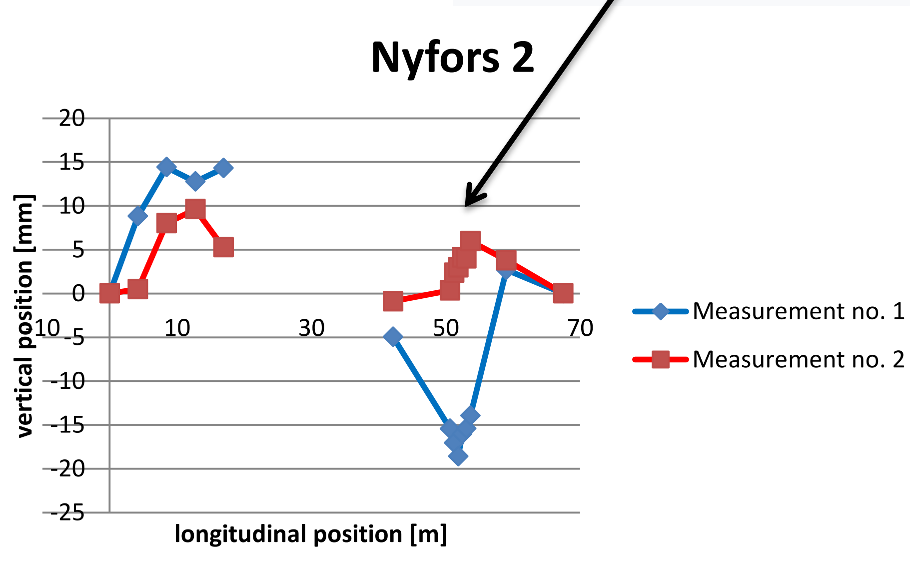
Results of vertical geometry measurements on S&C (Track section 124 and ca 4 month duration)

Cant compensation due to curve

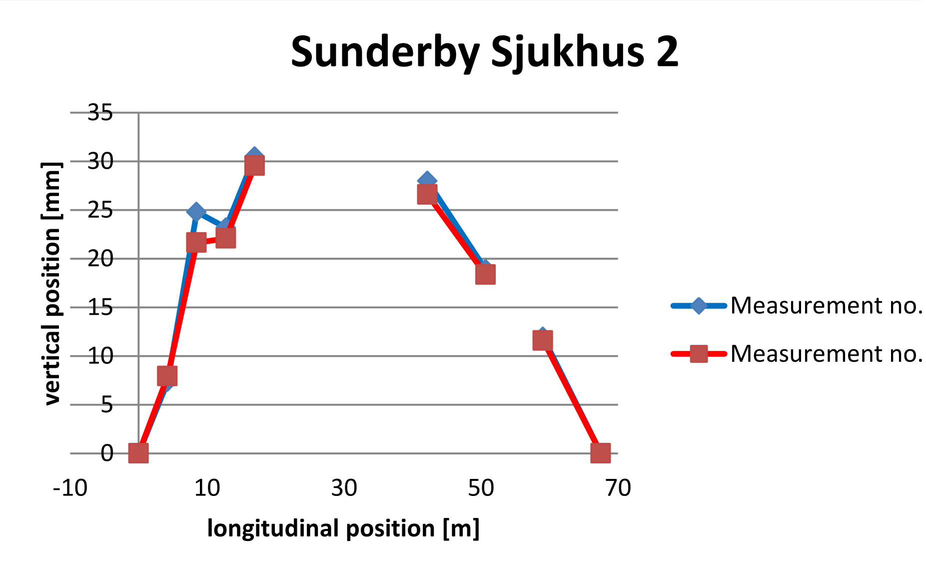


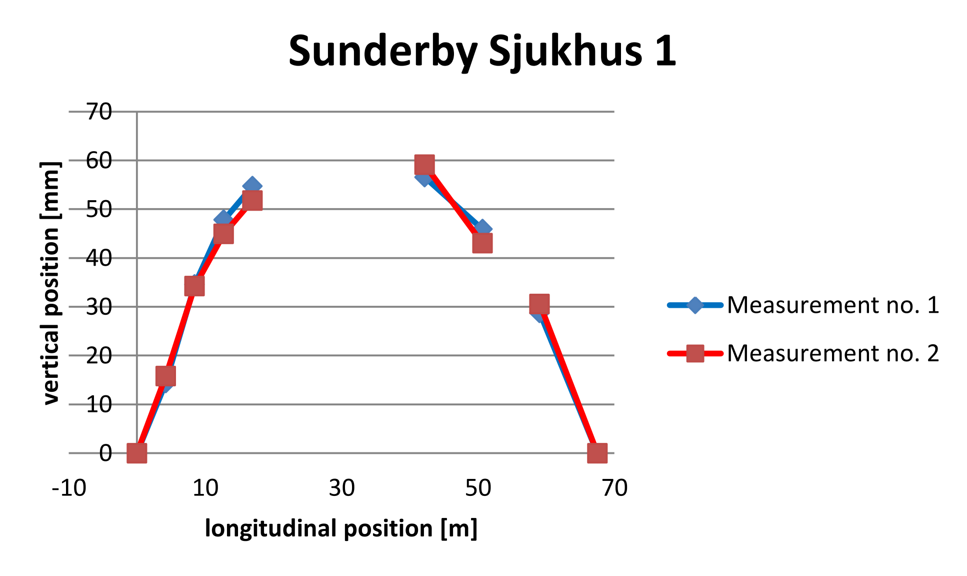
Replaced left toe rail can have effect on measurements of left rail





Results of vertical geometry measurements on S&C (Track section 119 and ca 5 month duration)





Conclusions

- Measurements has shown that it is possible to use a leveling instrument to determine vertical track geometry with a sufficient accuracy of (±0,3mm).
- Method using reference points outside the S & C area can give indication of existing geometry and geometry variation overtime that affect track geometry quality.
- It was surprisingly found that majority of measurements showed that the S&Cs were located on a elevated hump.
- Gap in the crossing point was often observed relative to the basic shape.
- 5 months period is not sufficient to see a general trend of long-term effects of vertical geometry change on S&Cs.

Thanks for your attention

Questions