37TH INTERNATIONAL NO-DIG FLORENCE 2019

Fortezza da Basso • FLORENCE (Italy)

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INNOVATIVE MONITORING OF RAILWAY TRACKS DURING TRENCHLESS CROSSINGS

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1 AN OVERVIEW OF THE FRENCH RAILWAYS NETWORK AND POLICY

A few figures will help understand the importance of the subject. The EU railway networks amounts to 300.000km long. French railway accounts for 10% (i.e 32 000 kilometers and accommodates 14 000 trains every day which puts it in second place in the European Union

Over 500 No Dig crossings under railway are done every year under the French rail network, 95% of these are under 1500mm in diameter.

A large number of utilities owners are concerned (Electricity and gas, water and sewers, telecom..).

It is accepted that trenchless technologies are more suitable if not the only solution concerning railway constraints. But these also carry some risk likely to upset railway tracks' stability and therefore have an impact on the traffic safety and regularity.

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This led to prescribe a set of rules for the No-Dig crossings of railway tracks which are found in section 1 « trenchless technology » of rule IN 1884 (2001 Edition).

A wide scope of preventive measures and compulsory dispositions is set from engineering stage to works stage as well as third party relations. These apply to any trenchless technology operation across or near railway tracks.

The main risks and incidences detrimental to the tracks structure are:

1. Collapse of a subsurface void instant or delayed
2. Upheaval of tracks
3. Drill fluid breakouts (contaminated ballast)
4. Buckling of but welded rails

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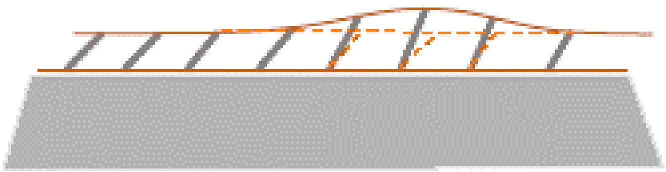
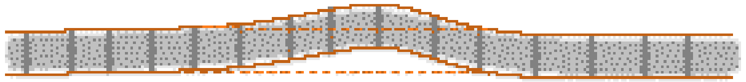
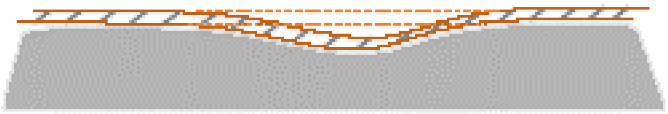


Crossward gradient default « Warp »
Figure 1



Rail dressing
Figure 2



Longitudinal gradient default
Figure 3

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Figure 4

Figure 5

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Figure 6

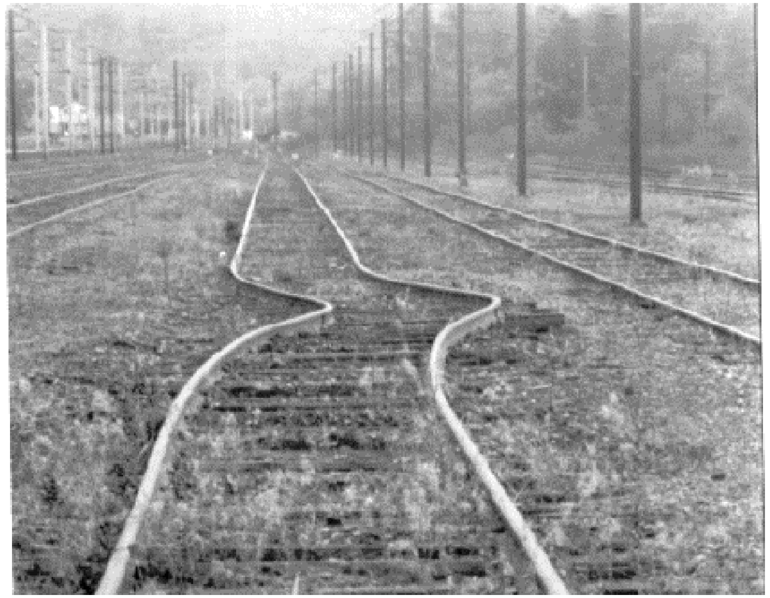

Figure 7

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Figure 8

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The railway safety measures may consist in **slowing trains down** or **interception**, **monitoring** and **supervision** of tracks and works. Subsidiary measures can also be applied such as **strengthening** rails or track **supporting**.

A strong requirement for SNCF is the monitoring of possible deformations of the track and platform in order to detect disorders, warn and take protective measures and adapt site management accordingly.

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The state of the art

Figure 9 OPTICAL Motorized Total stations

Figure 10 SENSOR Tilt meters

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The state of the art

OPTICAL Motorized Total stations

SENSOR Tilt meters

1_ INNOVATIVE LYNX + ARIANE TECHNOLOGY:

- aims to address a maximum of unresolved issues affecting optical methods
- maximize the speed of measurement cycles
- reduce installation time and costs
- Ensure uninterrupted monitoring

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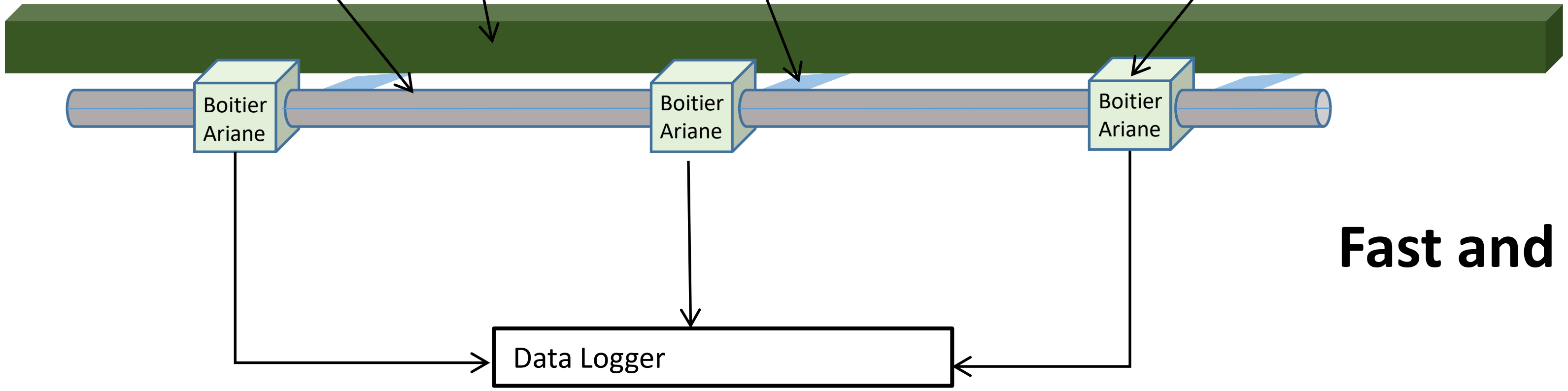
Système Ariane clipped on the rail

Ariane sensors boxes

rail

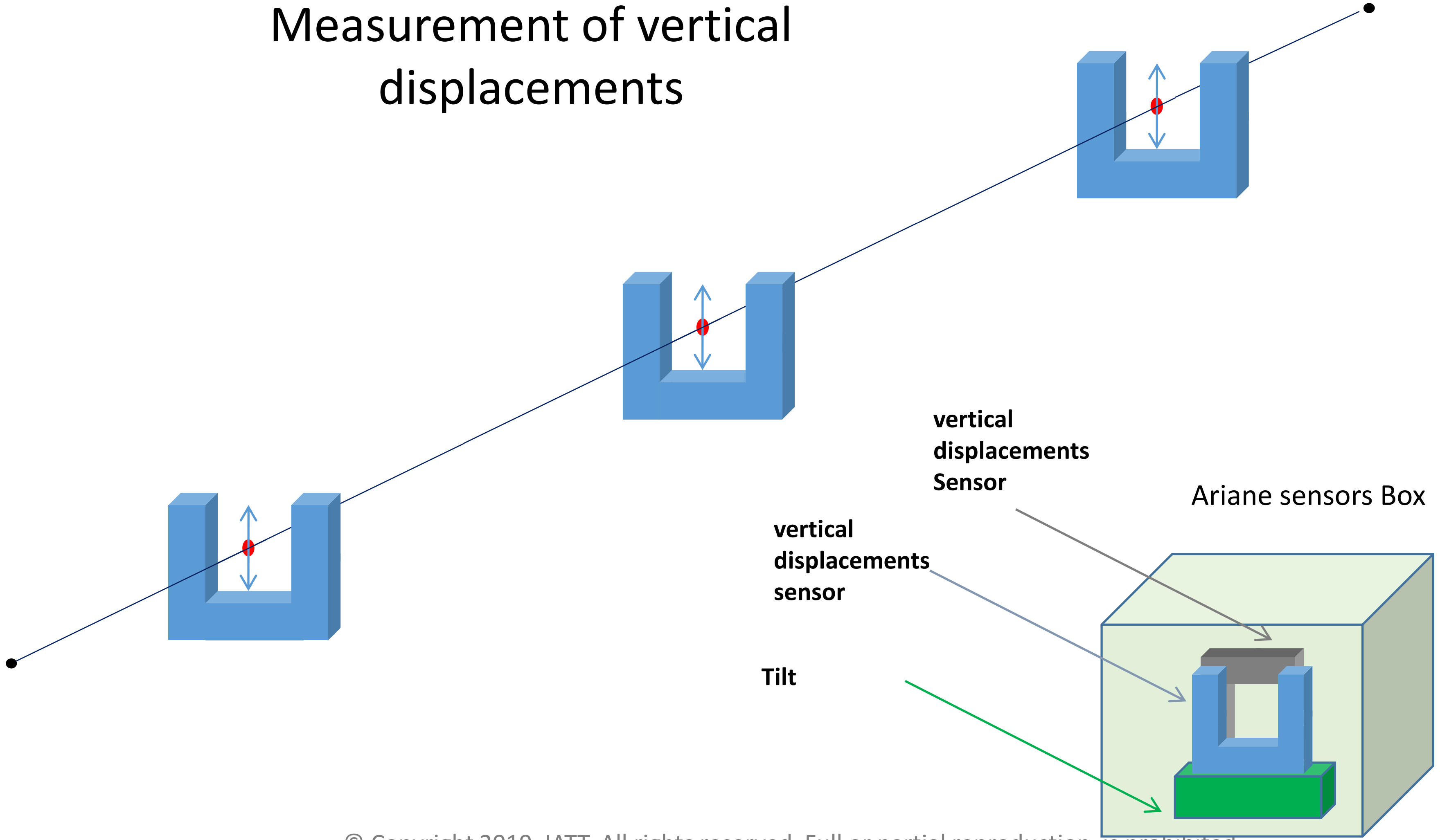
Kevlar line and protection



Fast and efficient implementation of the system

INNOVATIVE MONITORING OF RAILWAY TRACKS DURING TRENCHLESS CROSSINGS

Measurement of vertical displacements



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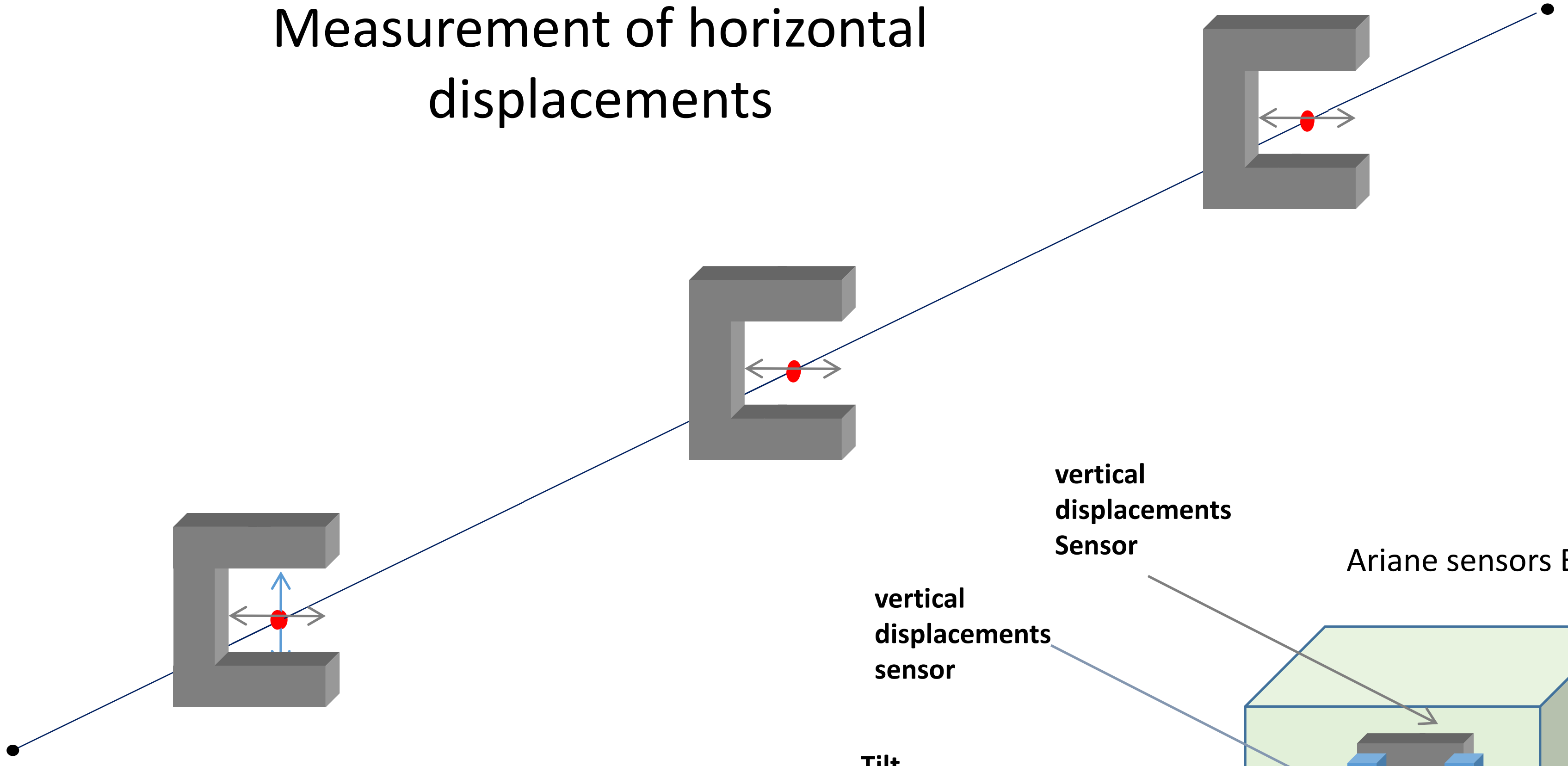
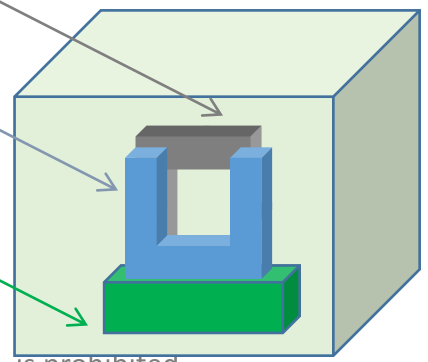
Measurement of horizontal displacements





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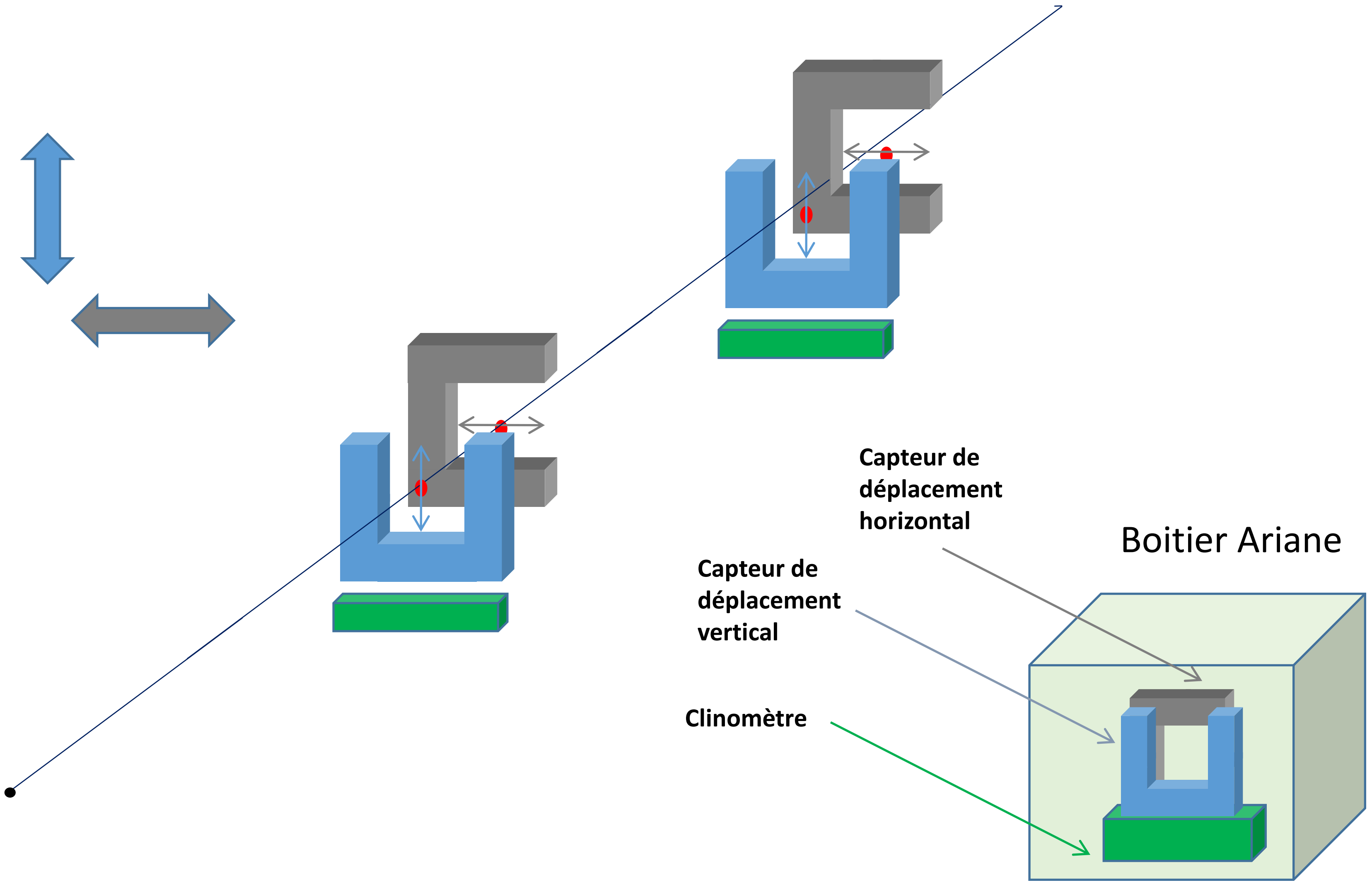

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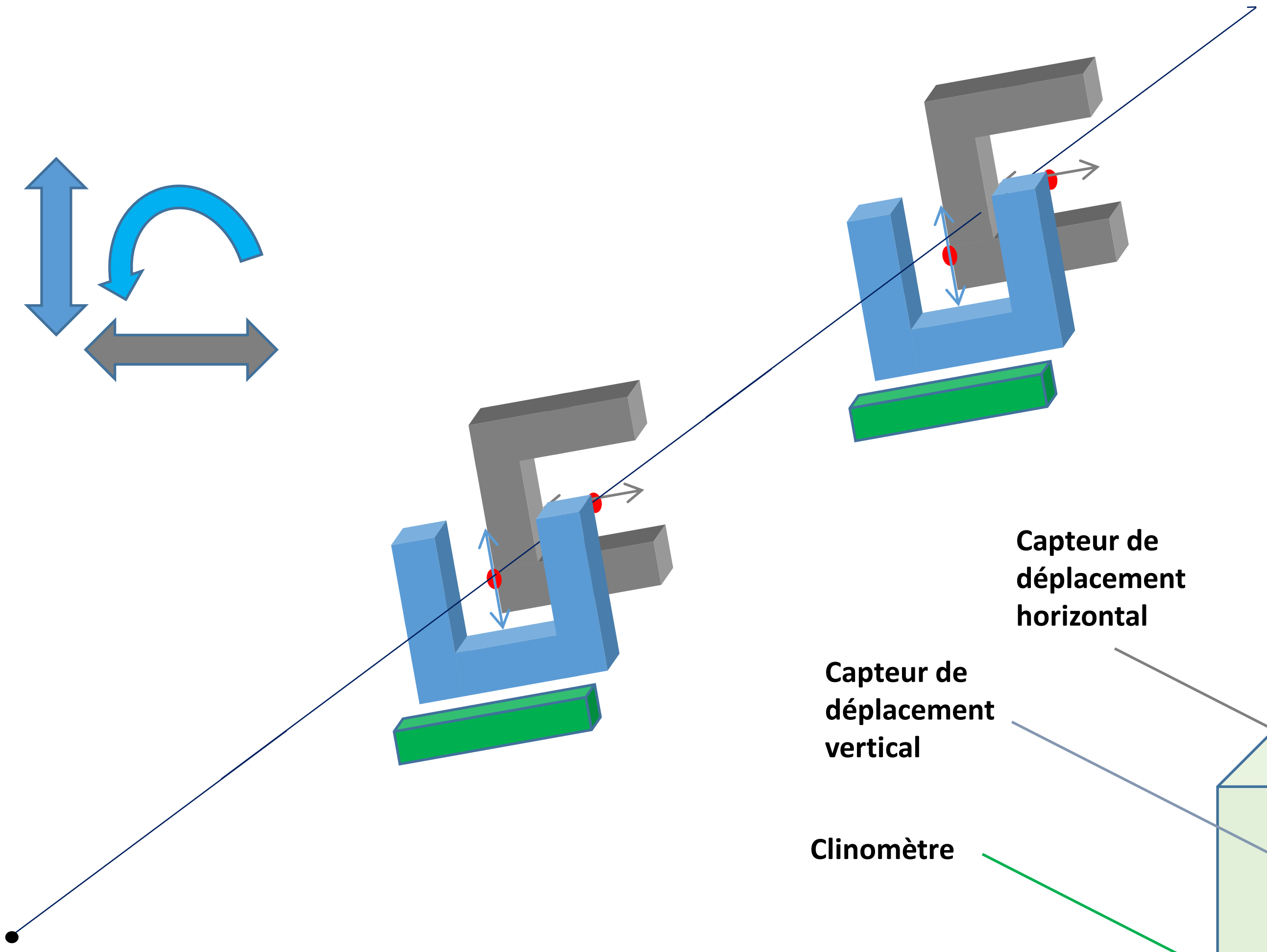
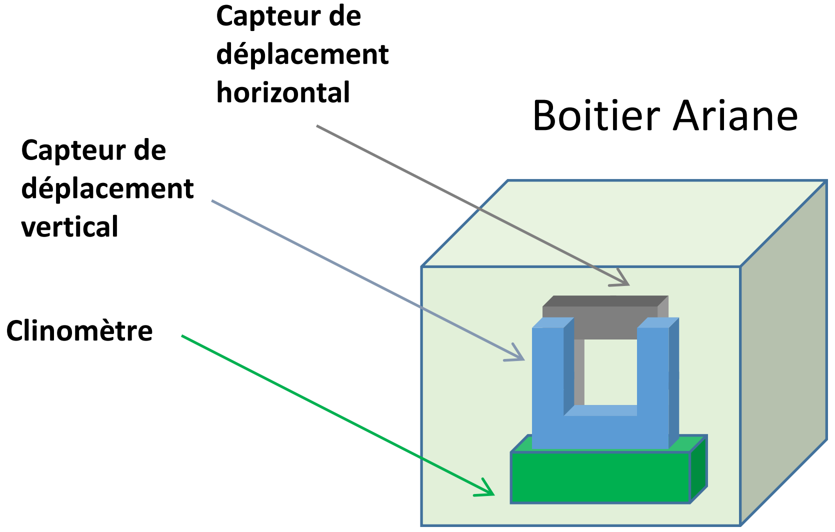
Measuring vertical, horizontal and rotation displacements





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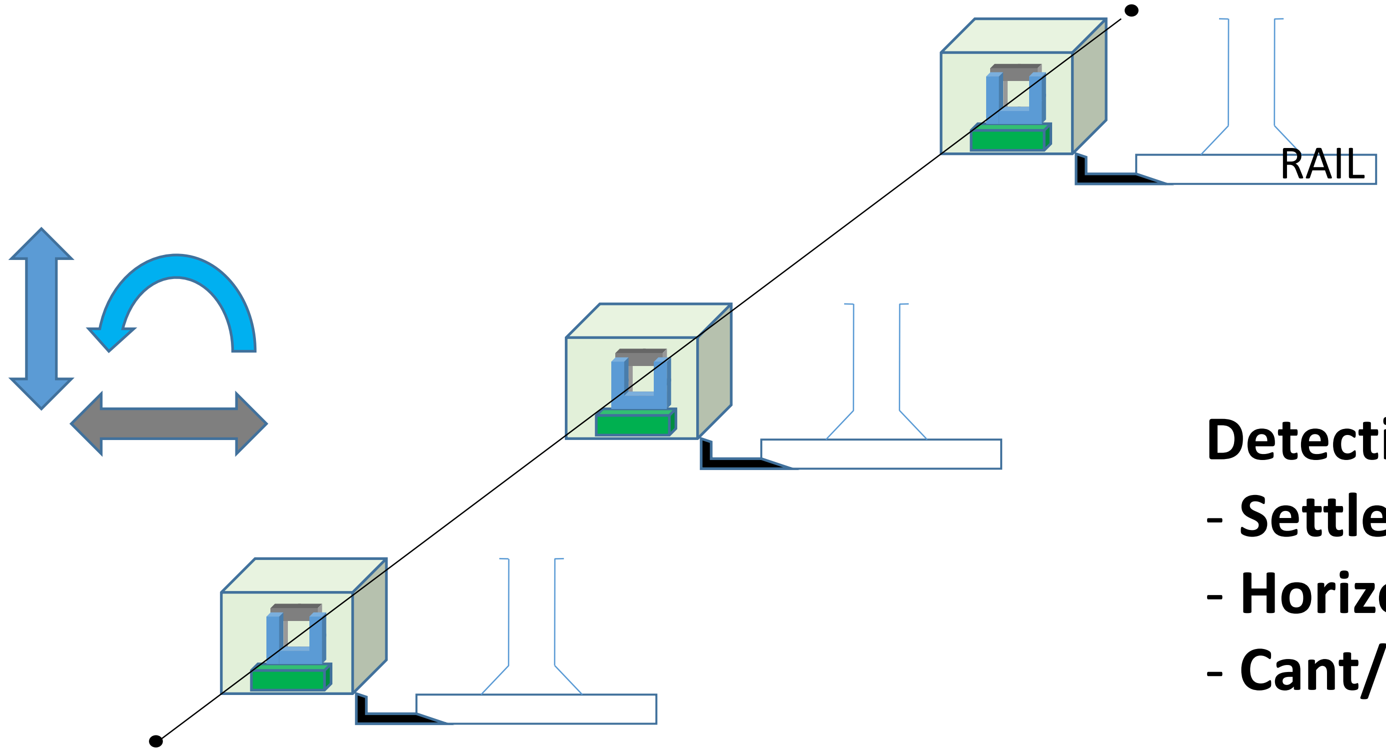

Detecting & measuring :

- **Settlements/Uplifts**
- **Horizontal/vertical Displacements**
- **Cant/ Warp *(dévers/Gauches)***

INNOVATIVE MONITORING OF RAILWAY TRACKS DURING TRENCHLESS CROSSINGS

APPLICATION CASES

Railway platform monitoring
Retaining wall monitoring
Loading tests

ADVANTAGES

far superior to optical systems resolution (0.1 mm).
Protected from outside influences (rain, wind, fog, snow ...) by a suitable housing
high measurement rate 1-5 minutes
Fast and efficient installation thanks to adapted fixings
Low energy consumption system allowing significant autonomy
Discrete system

LIMITS

- The measurements cannot be be obtained during the passage of a train. It is necessary to wait until the end of the induced vibrations in the Kevlar line, a delay of a maximum of 20 seconds.

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References

- Moissy Cramayel (France), Main contractor BIR France 38 Rue Gay Lussac, 94430 Chennevières-sur-Marne, owner RTE Réseau Transport Electricité
  The prototype system underwent testing over a period of 5 months from November 2015 to March 2016. This resulted in SNCF asking to increase the measurement range from the original 25mm upto 60mm.

- Monitoring tracks at Aiserey (France), Main contractor PPS Pipeline Systems GmbH Owner GRT Gaz (France) July/August2017

- Monitoring tracks at Vannes (France), Owner GRT Gaz (France) May 2018

Monitoring an HDD gas pipe Rock crossing in Brittany

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Specifications			
Photoelectric sensor		Mechanical	
Resolution	0.1mm	Waterproofness	IP 66
Reproducibility	±0.3mm	Body	Cast aluminium or Polyamide
Linearity	±0.36mm		Tension measurement of the reference line
Measurement range	60mm	Protection tube	ABS and/or GRP
Timing			
Response time	Min 12ms		
Delay before start-up	≤ 300ms		
Environmental data			
OperatingTemperature	-20°C, +50°C		
Tilt Electronic sensor			
Measuring range:	±10 Deg		
Resolution :	< 2 arc seconds		
Accuracy :	+/-0.1 mm/m		
Repeatability :	+/-0.1%		
OperatingTemperature	-40°C, +85°C		

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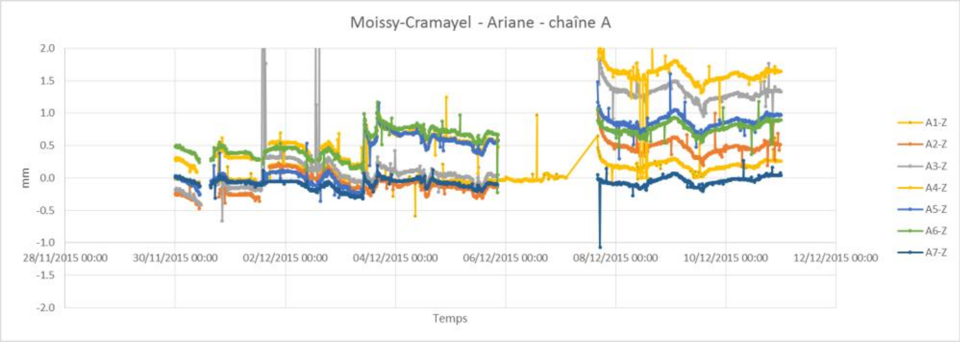

Figure 11 Data from 7 profiles Ariane

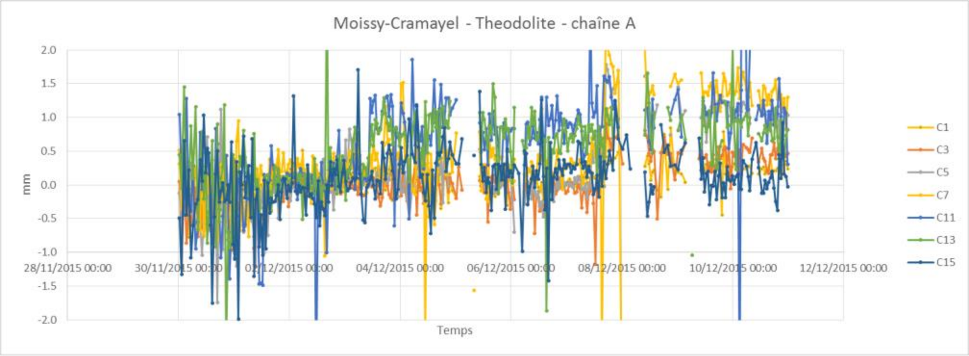

Figure 12 Data from 7 profiles Total Station

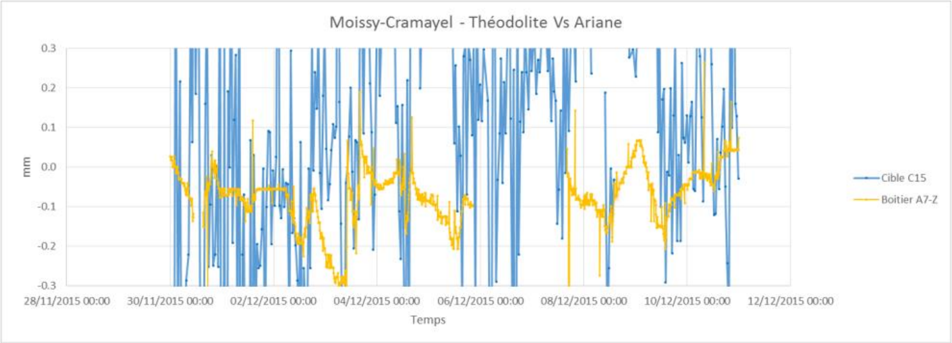

Figure13 Data comparison Ariane sensor VS Automated Total station

References

- Moissy Cramayel (France), Main contractor BIR France 38 Rue Gay Lussac, 94430 Chennevières-sur-Marne, owner RTE Réseau Transport Electricité
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2_ INNOVATIVE LYNX + BOOGIE TECHNOLOGY:

Dynamic measuring of rail deflation under wheel impact

2- INNOVATIVE LYNX + BOOGIE TECHNOLOGY:

Dynamic wheel–rail contact loading and variations in support conditions may result in differential settlement of ballast and subgrade, leading to severe irregularities in track geometry. Poor quality of track geometry induces higher dynamic wheel–rail contact forces and increases the degradation rate resulting in further track settlement, and possibly to increased wear, plastic deformation and rolling contact fatigue of the rails.

In France some 1200 to 1500 areas some of them over 100 meter legnths need to be monitored permanently. Which in return means 20.000 spots need monitoring

INNOVATIVE MONITORING OF RAILWAY TRACKS DURING TRENCHLESS CROSSINGS

State of the art:

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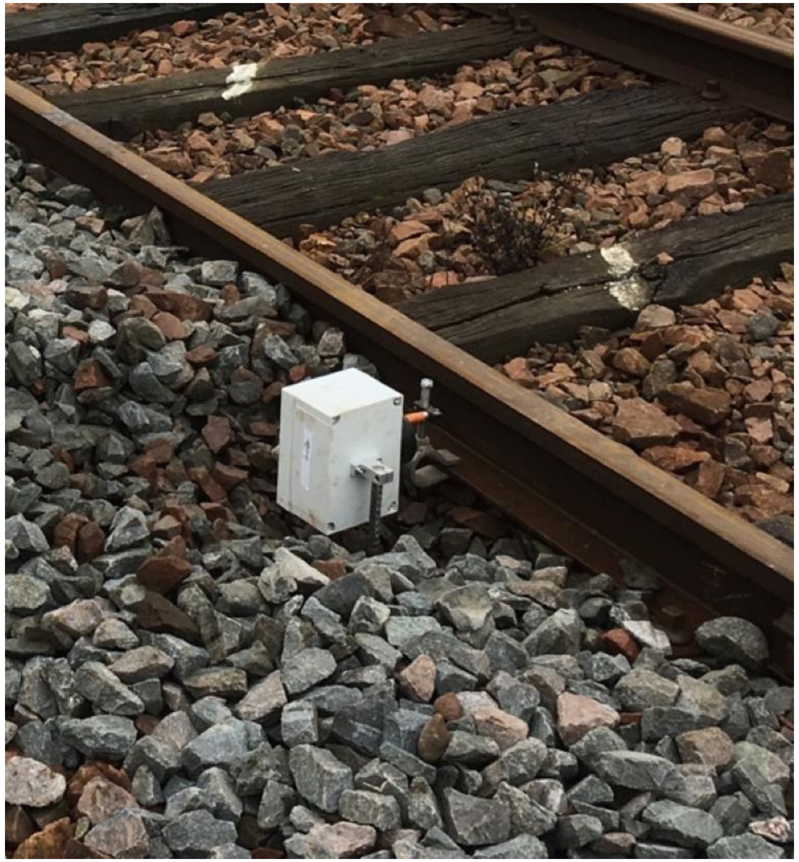

1/ The vertical deformation of the rail is transferred via a horizontal rod to the measurement sensor inside the box.

2/ The measuring box is not in contact with the rail and 10 / 20cm away.

3/ It is not placed on the ballast unlike the manual meter. It is fixed to a vertical rod anchored in the ground below the ballast

The main features of this technology are:

- - no contact between the measuring sensor and the rail so no damaging impact
- - the reference guaranteeing the stability of measurements in time is transferred below the ballast
- the measurements are direct avoiding any error strewn calculations
- no data logger is needed
- no wires along the rails
- direct transmission of data to a database via IT
- 6 months to a year autonomy

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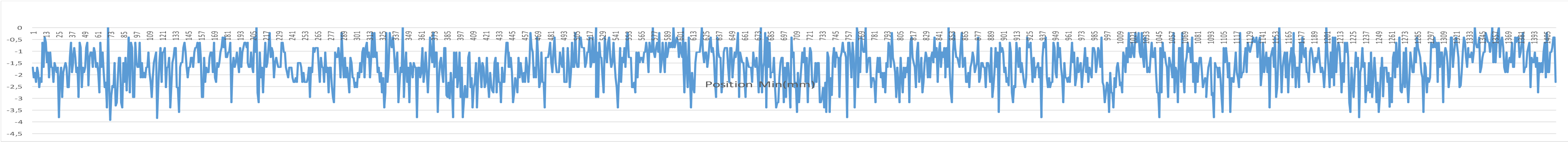

Figure 1 Graph of the deformation induced by1256 passenger trains on the Paris subway in May 2019 recorded by one Boogie sensor

References

A test of 10 different prototypes was completed near Paris for the regional subway (RATP) over a 3 weeks period.

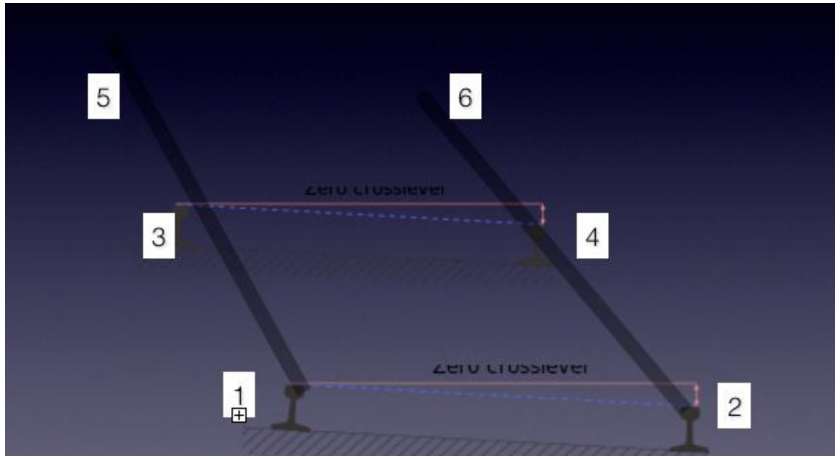

Figure 2 Boogie sensor monitor 3 cross levels to measure Cant and Warp under load

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Specifications			
Photoelectric sensor	5V	Mechanical	
Supply Voltage	0.1mm	Waterproofness	IP 66
Supply current	27mA		
Output frequency	300KHz	Body	Cast aluminium or Polyamide
Resolution	0.2mm	Fixation	Drill attachment system 600 to 800 mm deep at through the ballast
Reproducibility	±0.3mm		Dissociated measuring device from the trains' wheels impacts
Linearity	±0.3mm		The sensors are all independent and not dependent on a data logger
Measuring range	90mm		
Data Transmission Mode	LoRa 868Mhz		
Environmental data			
OperatingTemperature	-30°C, +100°C		

INNOVATIVE MONITORING OF RAILWAY TRACKS DURING TRENCHLESS CROSSINGS

Both these technologies can be combined in order to measure with great accuracy any possible rail deformations during trenchless crossings thus bringing an important safety factor

Thank you for your attention