L'exploitation
et la maintenance
des infrastructures

PN - ANR MOVE
DVDC
DURÉE DE VIE DES CHAUSSÉES

IREX
Institut pour la recherche appliquée
et l'expérimentation en génie civil

THEME 2
CHARACTERISATION OF THE STATE OF THE NETWORK

In situ measurements

MINISTÈRE
DE LA TRANSITION
ÉCOLOGIQUE
Liberté
Égalité
Fraternité

Public presentation of results
7 November 2023, ENTPE, Vaulx-en-Velin

AGENCE NATIONALE DE LA RECHERCHE
ANR

Automatic measurements and treatments

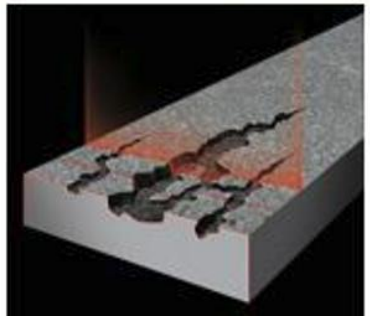
Visual surveys

On foot

By car with computer

Automatic acquisition but analysis in the laboratory

RUPTURE



► Complementary simplified visual method 38-2

- Modernisation of the current method
  - 3 procedures depending on the network
  - 1 procedure dedicated to studies
  - 1 specific procedure for concrete road pavements
- Appendices
  - Appendix 1 - Information on the quality, repeatability and reproducibility of visual and semi-automatic measurements
  - Appendix 2: specifications for collecting information and qualifying surface deterioration (excluding concrete slab road pavements)
  - Appendix 3 - Help for managers in preparing measurements
  - Appendix 4: Possible additional options for deterioration measurements

Type de réseaux et objectifs de l'étude	Chaussées souples, semi-rigides, bitumineuses, inverses, mixtes, BAC			Dalles béton
	Rase campagne et voies rapides urbaines (RN, RD, etc.)		Réseau urbain hors voies rapides urbaines, réseau communal (communes, communautés de communes)	Tous sites
	Réseau structurant (en et hors agglomération)	Réseau secondaire		
Programmation, évaluation, surveillance	**MO1**	**MO2**	**MO3**	**MO5**
Diagnostic - renforcement Suivi de sections témoins	**MO4**			

Tableau 1 : Domaine d'emploi des Modes Opératoires de relevés visuels

2: Visual evaluation of road pavement conditions

► Limits encountered

- Conditions for carrying out deterioration surveys
- Supports one to 2 channels simultaneously
- Lane geometry,
- Luminosity, dry pavement, etc.
- Insertion into traffic at low speeds.

► Human factor

- Training - qualifications,
- Accuracy on where information is located,
- Attention, fatigue, etc.
- Inter-operator consistency.

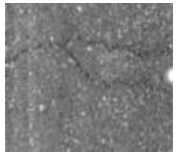


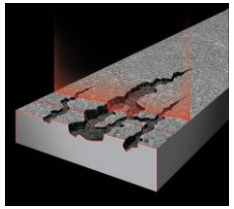
▶ Automatic measurement technologies

- Since the 90s, technological developments have enabled us to move towards increasingly effective means of monitoring

- Developments in laser technology have enabled:
  - First generation from 2001
    - LRMS - LRIS (AMAC® - Road Eagle Colas)
  - Second generation from 2010
    - LCMS (AIGLE 3D - DIAGWAY 2 - EVALIS 3D - SYMAN)
    - PPS+
  - Third generation from 2017 (?)
    - LiDAR with high density of measurement points
    - Mobile mapping device (LiDAR + immersive imaging)



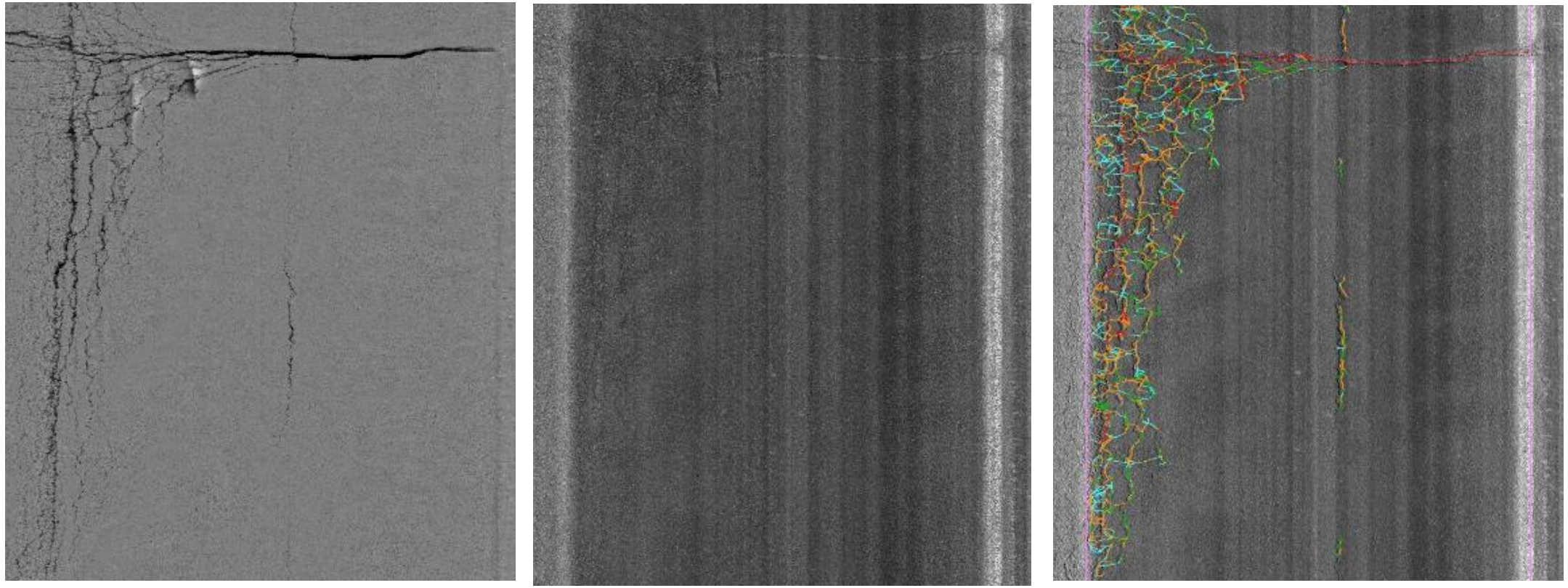








› Towards a surface evaluation approach

- LCMS (laser crack measurement system) study



Range **Intensity** **3D**

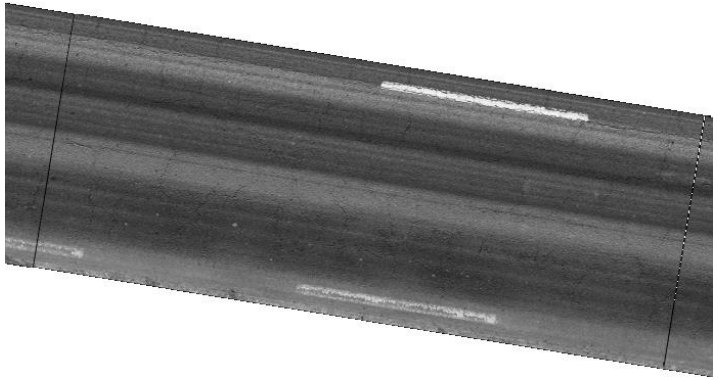
▶ Development of a surface approach: principles

- Quantification of deterioration by basic meshes
  - Using a mesh (matrix) to divide up the road pavement
- Severity calculations based on the information contained in the basic meshes
- Basic meshes grouped to produce aggregated data
- "Per image" synthesis (in 10 m increments) in the form of:
  - road pavement surface affected (m^2)
  - volume of material leaving the site (cm^3)
  - a count, by severity, of the number of sporadic points of deterioration

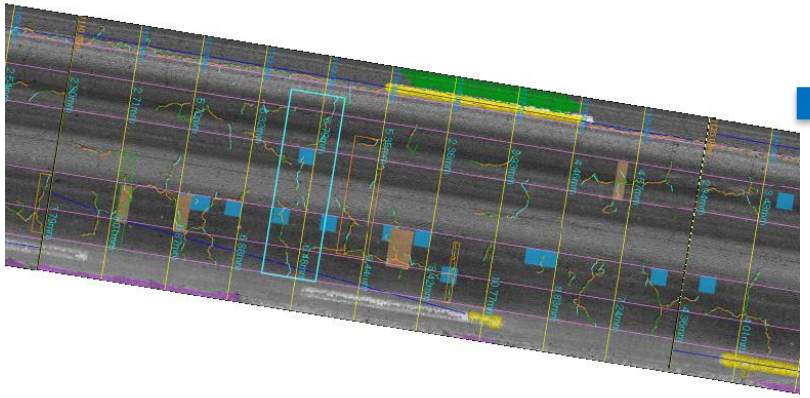


4: Surface Evaluation: Deterioration descriptors

- Based on the establishment of a mesh made up of 25 cm squares

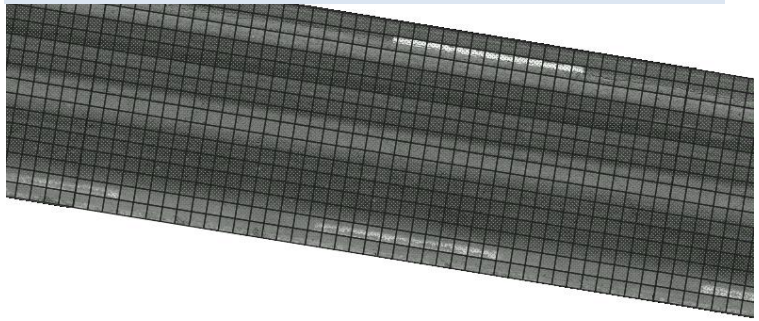


3D LCMS image

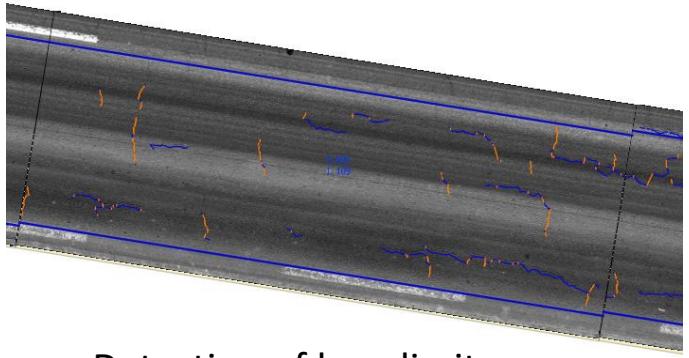


Gross detection of deterioration

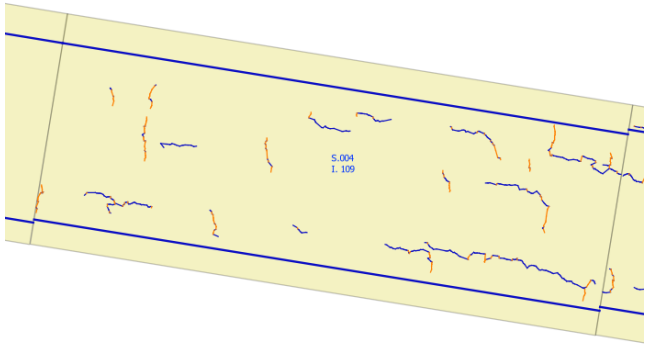
Mesh positioning process



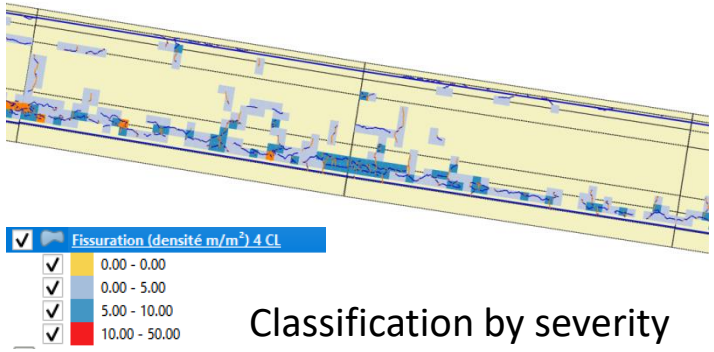
0.25m x 0.25m mesh



Detection of lane limits



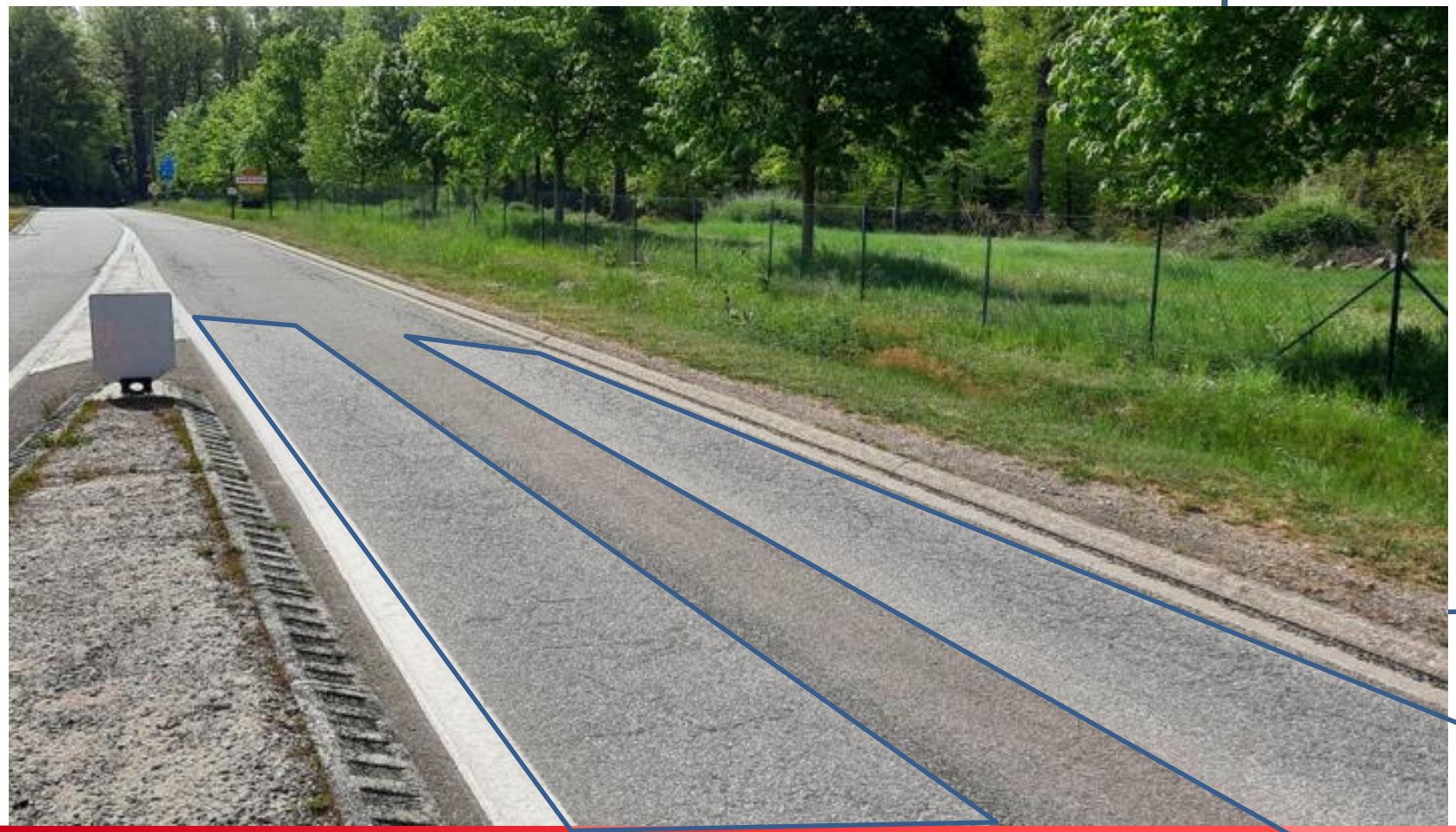
Calculations performed within lane limits

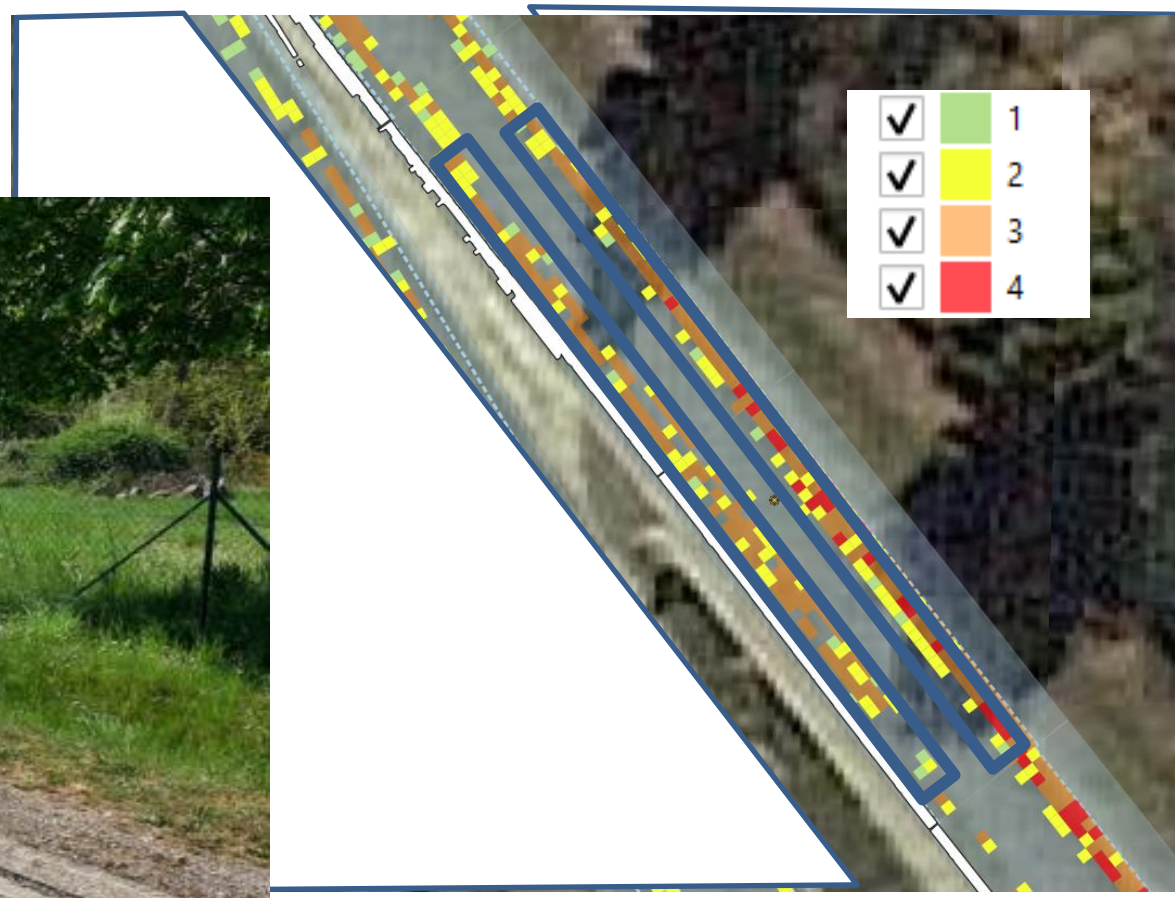


Classification by severity



- Application on DC27 roadbeds
  - Characterisation of cracking





4: Surface Evaluation: Deterioration descriptors

Documented in the DVDC project

- Cracking
- Bridged cracking
- Bridged longitudinal cracking
- Bridged transverse cracking
- Surface erosion of materials
- Sealing/bleeding
- Cavities

Possible extension

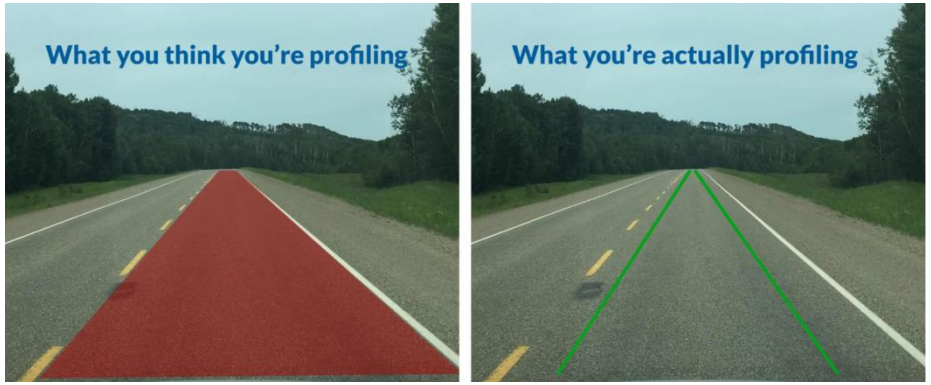
- Transverse cracks
- Alligator cracking
- Longitudinal cracks
- Other cracks

	Famille de dégradation	Descripteurs		Paramétres supplémentaires / remarques
		Base	Complément	
Niveau 1 Informations extraites depuis les mailles élémentaires	Fissuration	Surface totale (m²) Surface totale G1 (m²) Surface totale G2 (m²) Surface totale G3 (m²) Surface totale G4 (m²)	Surf totale en BDR (m²) Surf totale Hors BDR (m²) Répartition FT/FL (%) Longueur totale de fissures BDR (m) Longueur totale de fissures HBDR (m)	Pour chaque gravité 1, 2, 3 et 4 (calculée en fonction de la densité et de l'ouverture moyenne par maille) : - surf BDR (m²) / surf HBDR (m²) / long fissures BDR (m) / long fissures HBDR (m) Les gravités 3 et 4 sont relatives à des concentrations de fissures élévées : les paramétres disponibles permettent de quantifier les zones faiençées
	Fissuration pontée	Longueur (m) Surface de chaussée affectée (m²)	Surf en BDR (m²) Surf Hors BDR (m²) Répartition FTP/FLP (%)	
	Fissuration longitudinale pontée	Longueur (m) Surface de chaussée affectée (m²)	Surf de chaussée en BDR (m²) Surf de chaussée HBDR (m²)	
	Fissuration transversale pontée	Lg trans. de chaussée affectée(m) Surface de chaussée affectée (m²)		
	Départ superficiel de matériaux	Surface totale (m²) Surface totale G1 (m²) Surface totale G2 (m²) Surface totale G3 (m²)		Exploitation de l'indicateur "Ravelling Index"
	Glaçage /Ressuage"	Surface totale (m²)	Surf G1 (m²) Surf G2 (m²) Surf de chaussée en BDR (m²) Surf de chaussée HBDR (m²)	Exploitation de l'indicateur "Glacage"
	Cavités	Nombre Surface totale(m²) Volume total (cm3)	Nombre en BDR Volume total en BDR (cm3) Nombre HDR Volume total HBDR (cm3)	Création de classe de gravité et pour chaque gravité 1, 2, ou 3 - nombre / surface (m²) / volume (cm3) / nombre en BDR / nombre HBDR / volume en BDR (cm3) / volume HBDR (cm3)
Niveau 2 Informations recalculées à partir de regroupement préalables de mailles élémentaires ZONAGE	Fissures transversales	Nombre FT Ouverture moyenne (mm) Taux de ramification (m/m²)	Lg trans. de chaussée affectée(m)	Création de classe de gravité (recalculée en fonction de la densité et de l'ouverture moyenne sur la zone) et, pour chaque gravité 1, 2, ou 3 : - nombre / surface (m²) / longueur trans. de chaussée affectée (m)
	Faiençage	Surface totale (m²) Nombre de zones Densité (m/m²) Ouverture moyenne (mm)	Surf en BDR (m²) Surf Hors BDR(m²)	Création de classe de gravité (recalculée en fonction de la densité et de l'ouverture moyenne sur la zone) et, pour chaque gravité 1, 2, ou 3 : - nombre de zones / surface (m²) / surf en BDR (m²) / surf HBDR (m²)
	Fissures longitudinales	Nombre de zones Surface totale (m²) Longueur totale de fissure (m²)		Création de classe de gravité (recalculée en fonction de la densité et de l'ouverture moyenne sur la zone) et pour chaque gravité 1 2 ou 3 : - nombre / surf (m²) / surf BDR (m²) / surf HBDR (m²) / long fissures (m) / long fissures BDR (m) / long fiss
	Autres fissures	Surface totale (m²) Longueur totale de fissure (m²)	Surf G1/ G2/ G3/ G4 (m²)	Correspond aux fissures n'ayant été classées dans aucune catégorie (Faiençage, fissuration Traitement sur la base de l'exploitation des mailles élémentaires : possibilité de les gérer en gravité G1 à G



› Surface reading of deformations

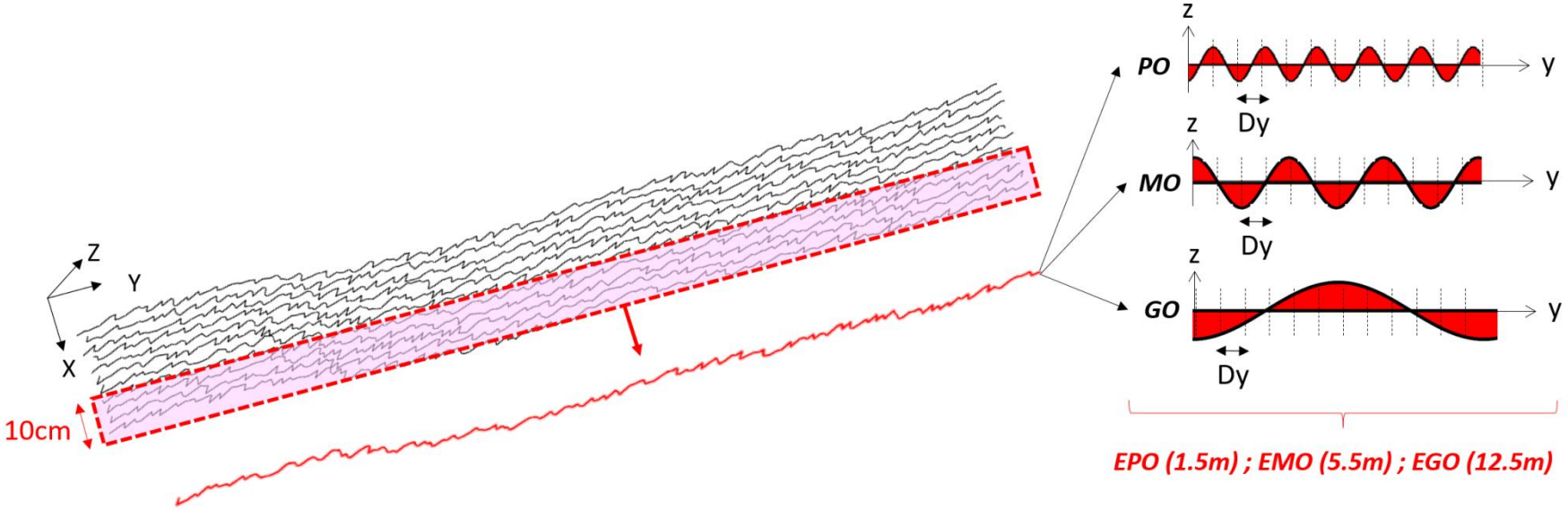
- Different perception and analysis of defects
- New uses
  - Characterisation of surface/structural condition
  - Specific maintenance assistance
  - Road safety assistance (?)

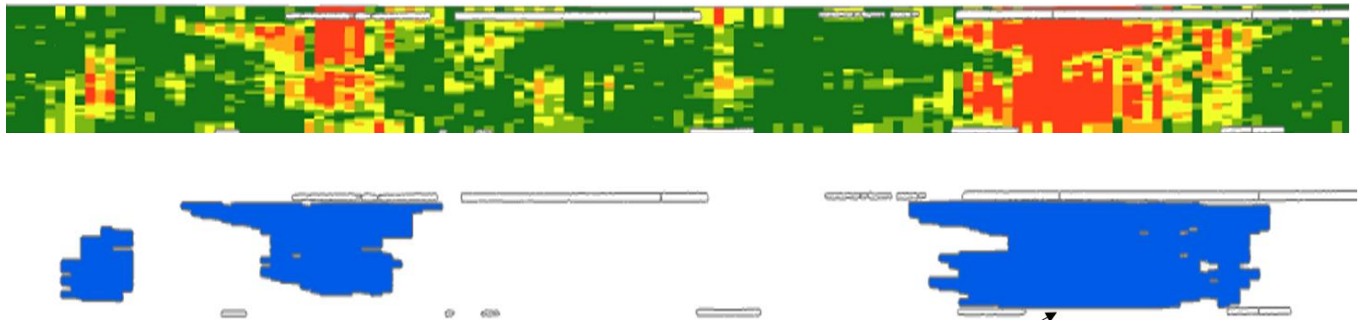


› Methodological approach to be built / developed / validated:

- Method initiated in DVDC
- More advanced Cerema method

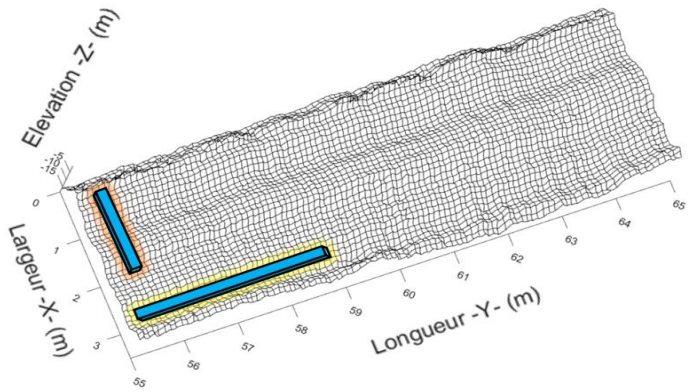
Cerema method based on a network of longitudinal profiles (extended EBO)

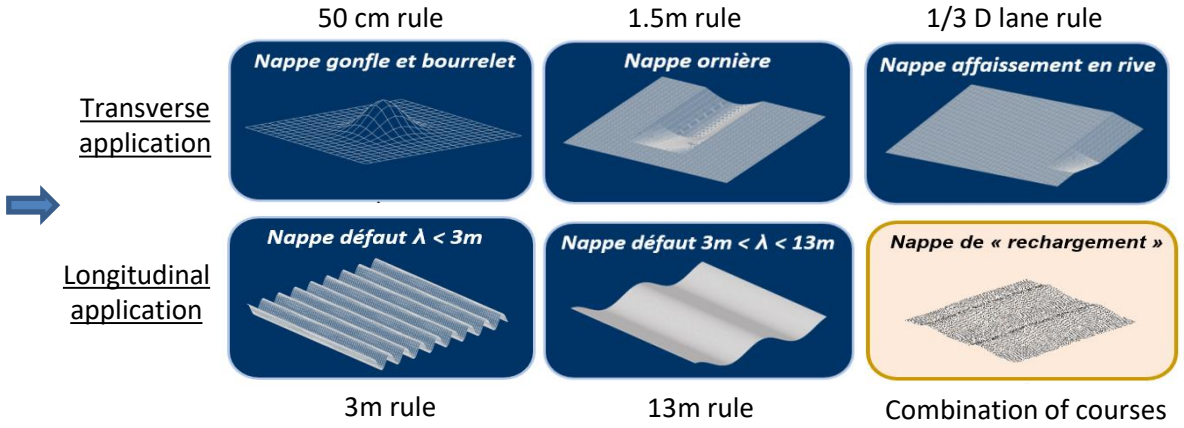


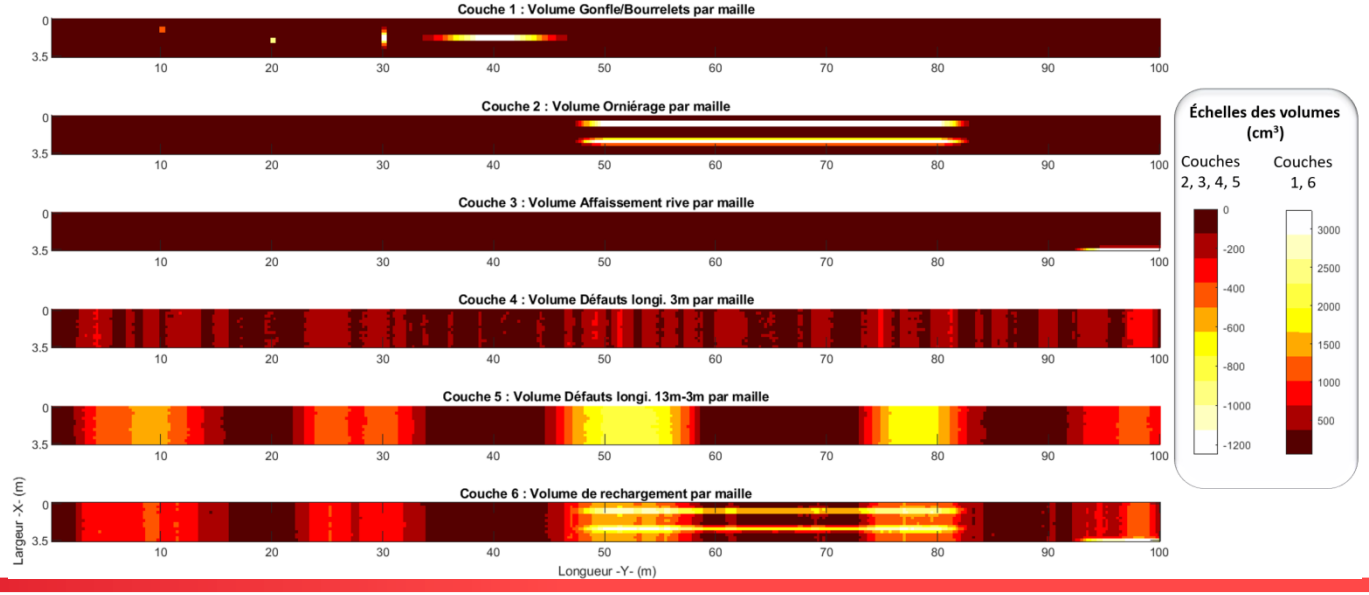


Sliding rules method

3D layer







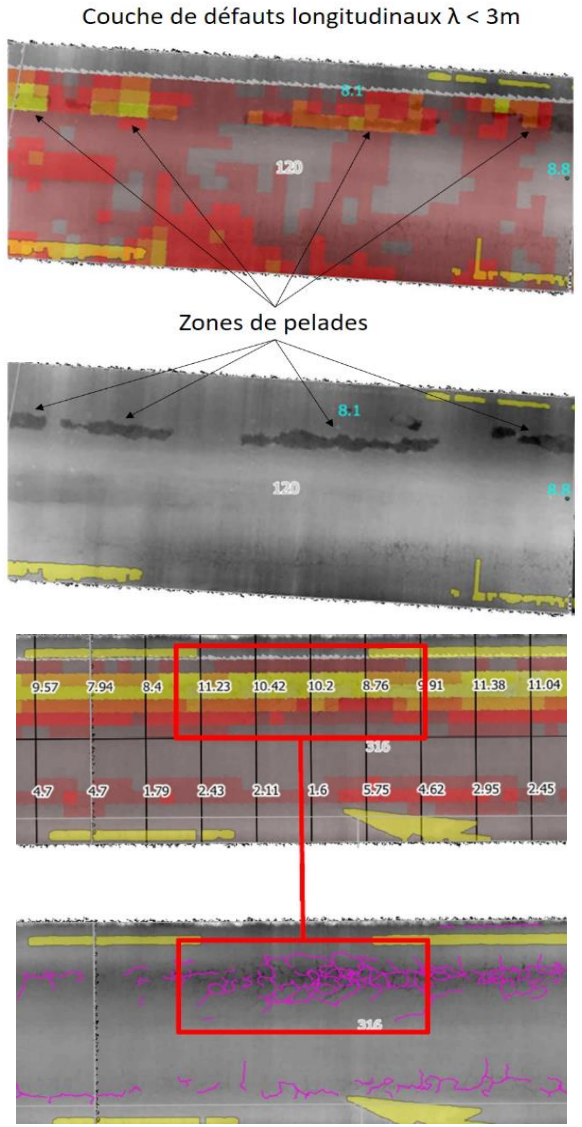


4: Surface evaluation: deformation descriptors

- Cross-referencing with deterioration descriptors

- Contribution to structural state indicators
  - Aggregated deformation indicators (10m section?)
  - Notion of "actually used" traffic lanes
  - Method of linking deteriorations & deformations

- Possible uses
  - At time *t*: road pavement condition, work to be done
  - Over *Δt*: Spatial monitoring of deformation trends
    - Worsening of a defect
    - Detection of specific phenomena (e.g. earth movement)



5: Surface Evaluation: Conclusions

- Surface evaluation based on automatic measurements represents a new way to manage road pavement assets
  - Better evaluation,
  - Better understanding of phenomena,
  - Promotes a preventive approach to road pavement maintenance.

- Towards a new testing method
  - Finalise deterioration descriptors,
  - Evaluate the 3D deformation approach in situ,
  - Cross-reference deformation-deterioration descriptors to improve the structural evaluation's relevance.

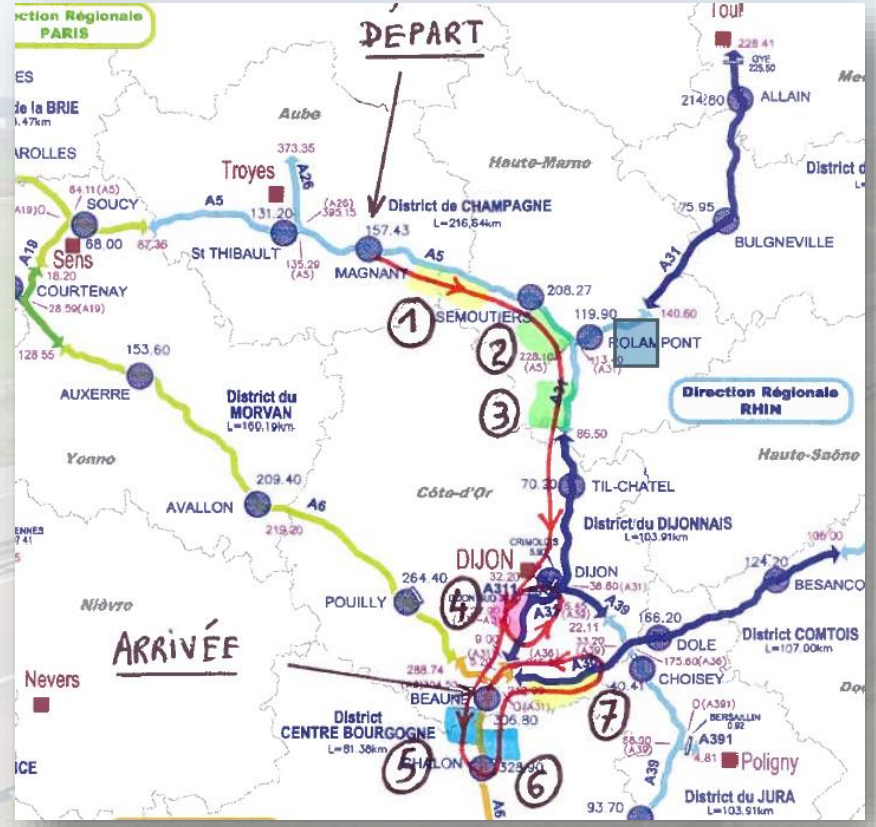


▶ Organisation of ASFA round robin tests

- Led by APRR
- 5 operators:
  - Cerema, Diagway, Ginger CEBTP, Nextroad, TN,
- Conducted in convoy on 7 roadbeds
  - Opening vehicle + closing vehicle,
  - Prevention plan and operating mode framework,
  - Announcement of the convoy's passage on VMS + 107.7.

6: LCMS® ROUND ROBIN TESTS - RESULTS AND PROSPECTS

- Circuit selected:
  - 7 sections of 10 km
    - 1 run per section,
    - 3 runs on section 4 to assess repeatability and reproducibility.
- Different characteristics of the sections:
    - Visual condition,
    - Type of surface.





▶ Definition of 3 levels of deliverables:

Standard report

- Descriptors provided by Pavemetrics® processing libraries

DVDC methodology

- New methodology for surface assessment of deterioration developed as part of the DVDC project.

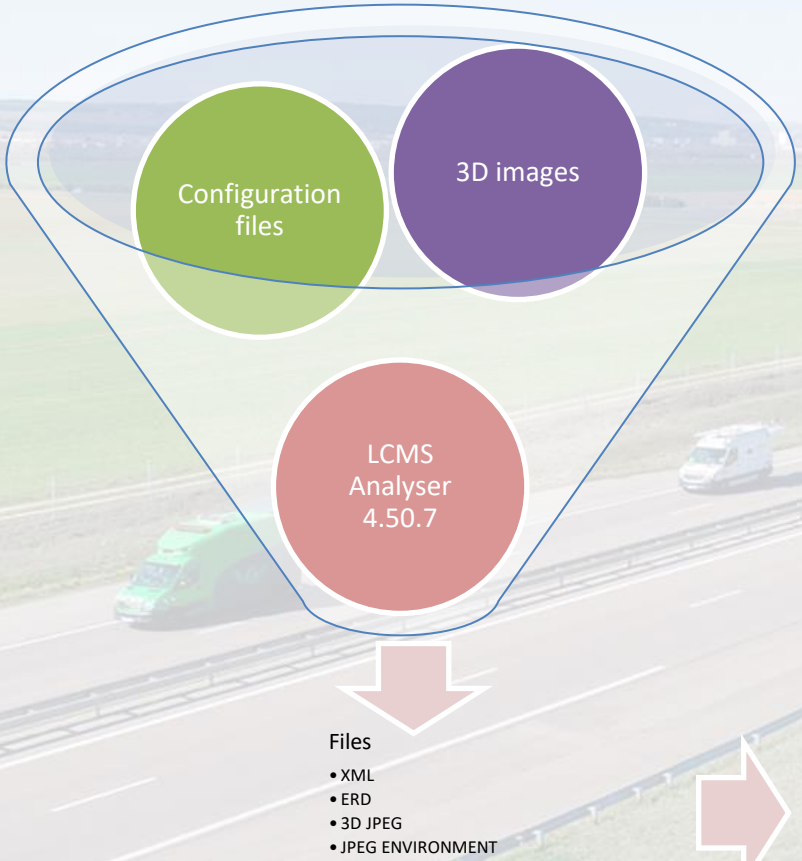
ASFA specifications

- 15 Indicators measured according to standard methodologies (LPC method)



► Analysis and comparison roadbed (Cerema).

- Common configuration file sent to all participants
- Parameter description file to be extracted from XML files



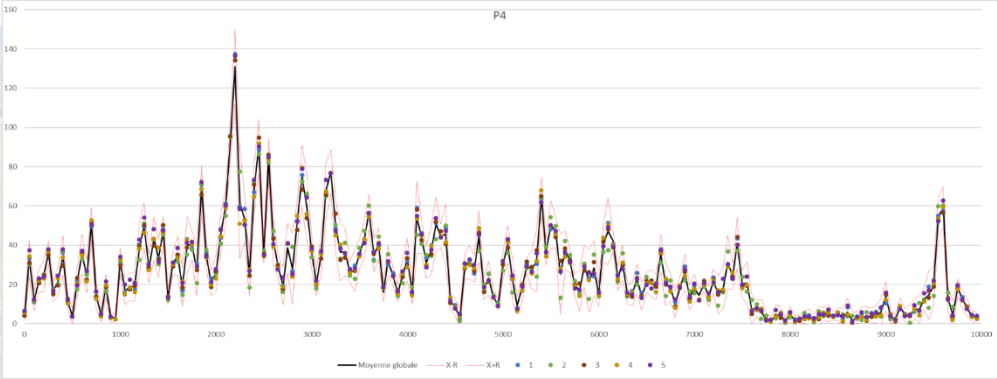
- 10 m intervals
- 2000 profiles
- 1 profile every 5 mm

- Common version provided by Pavemetrics

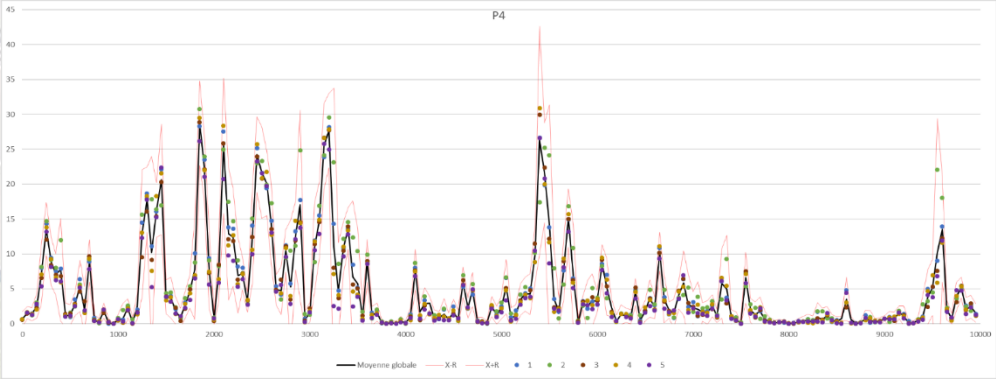


▶ Standard report: Example of cracking for P4 roadbed

- Total crack:
  - Average = 26.1 m (min = 24.9 - max = 26.7 m)
  - Repeatability = 6.0 m (23%)
  - Reproducibility = 7.9 m (30%)



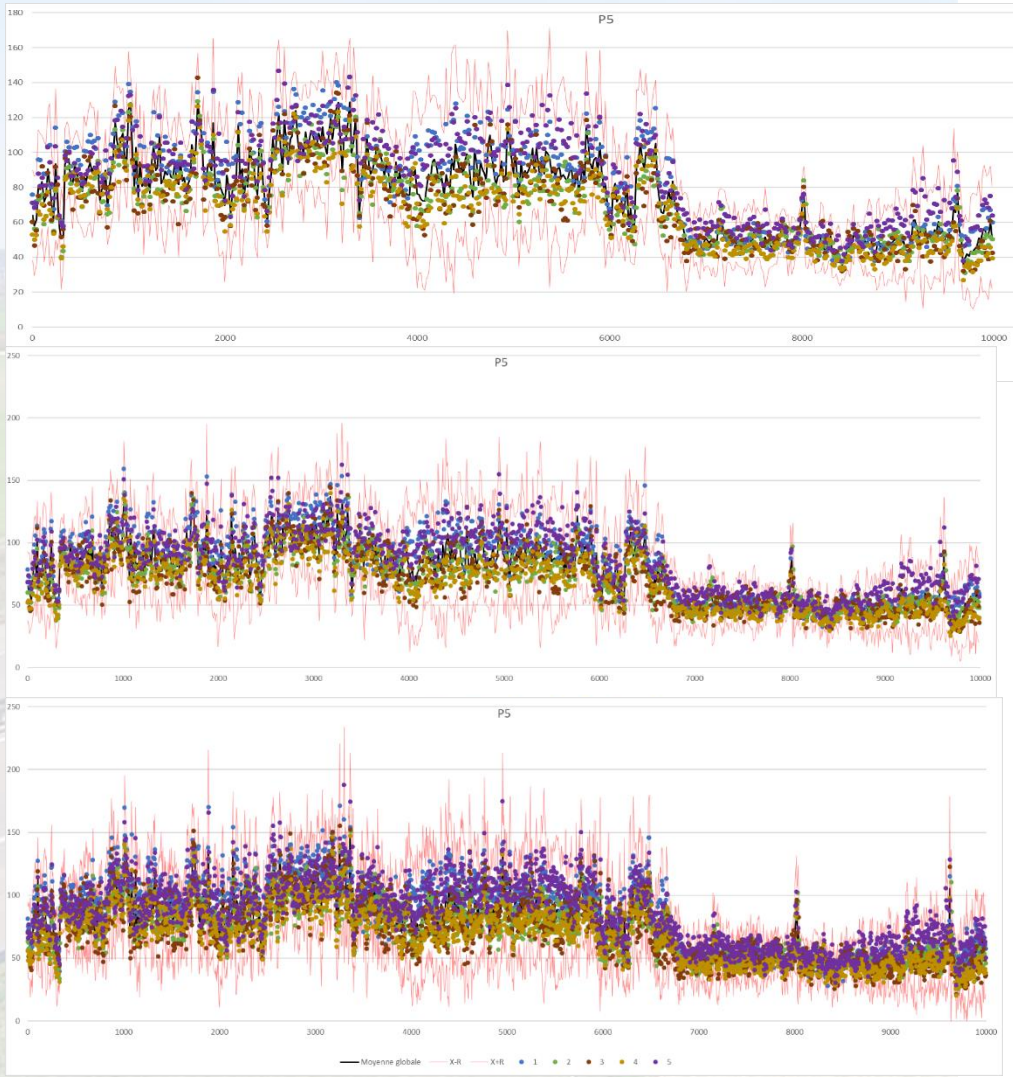
- Medium and severe crack MTQ:
  - Average = 4.8 m (min = 4.2 - max = 5.7 m)
  - Repeatability = 2.0 m (41.7%)
  - Reproducibility = 3.0 m (62.2%)



6: LCMS® ROUND ROBIN TESTS - RESULTS AND PROSPECTS

► Standard report: Example of Tearing

- Same averages for all roadbeds
- The greater the interval, the greater the improvement in repeatability (roadbed 4) and reproducibility
- Example on roadbed P5:
  - Average over 10,000 metres = 76.9 cm^3/m^2
  - Minimum value = 69.1 cm^3/m2
  - Maximum value = 86.9 cm^3/m^2
  - Reproducibility of
    - 27.4 cm^3/m^2 (20 m)
    - 29.4 cm^3/m^2 (10 m)
    - 31.5 cm^3/m^2 (5 m)



▶ Conclusions (1/2)

- **An innovative and collaborative approach** that brought all the operators to the table!
- **First evaluation of the dispersion** (repeatability, reproducibility) of the results obtained with different LCMS-type monitoring devices,
  - Better understanding of the behaviour of this new generation of sensors,
  - Better consideration given to the management of ASFA's road pavement assets,
  - An approach to standardising the processing of testing results in the event of a change of operator.

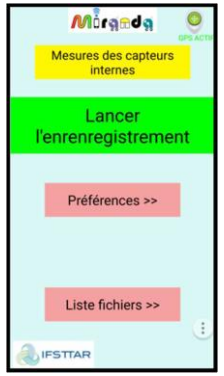


► Conclusions (2/2)

- The results obtained are **generally of good quality**
- **The appearance of the curves is close** for all operators even if some vertical offsets are sometimes observed
- **Some aggregated descriptors** (necessary step) examined show **lower reliability** than others (judged solely on repeatability and reproducibility values)
- The **sections** measured are **generally in good condition** , which **may limit statistical interpretation** for some descriptors.

► Objective:

- Gain **knowledge of the longitudinal uniformity of a road network** using **onboard sensors** in a fleet of vehicles



- **Phase 1**: Testing using data from a **smartphone**

- **Phase 2:** Testing using data from a **sensor** mounted on a vehicle called a **"Uni wheel"**

- Testing carried out with the Eure department on its road network using the following methodology:
  - Data acquisition
  - Calculations of NMO, NGO and IRI type indicators
  - Comparison with reference values



7: Miranda Project

Figure 1 - Synoptique général du démonstrateur



► Results:

- Phase 1: Smartphone Testing:
  - **Reliability of operating tools**,
  - The indicators calculated on a pseudo longitudinal profile **correctly reflect the level of deformability of the network**, particularly the secondary network, as perceived by the operator
  - Comparisons before and after the work have shown that the **indicators are sufficiently discriminating** to highlight the uniformity gains made
  - **Initial comparisons** with reference measurements on the main network are **encouraging** in terms of Miranda's ability to estimate deformations

- Phase 2: UniWheel testing
  - The UniWheel **delivers all the usual uniformity indicators** (NBO and IRI) with levels of precision very close to those of the reference equipment, whatever the network category
  - **Only small defects in small waves** (PO scores > 8) **can be attenuated** by the UniWheel due to the smoothing power of the vehicle wheel
  - The UniWheel is totally unaffected by the weather, especially damp or wet surfaces, unlike optical devices