University of Antwerp
EMIB | Energy and Materials in Infrastructure and Buildings

eurobitume

Une riche mémoire collective permettant une compréhension approfondie de la construction routière durable en 2050.

Journée du Bitume et de l'Enrobé 2022

Wim Van den bergh – UAntwerpen

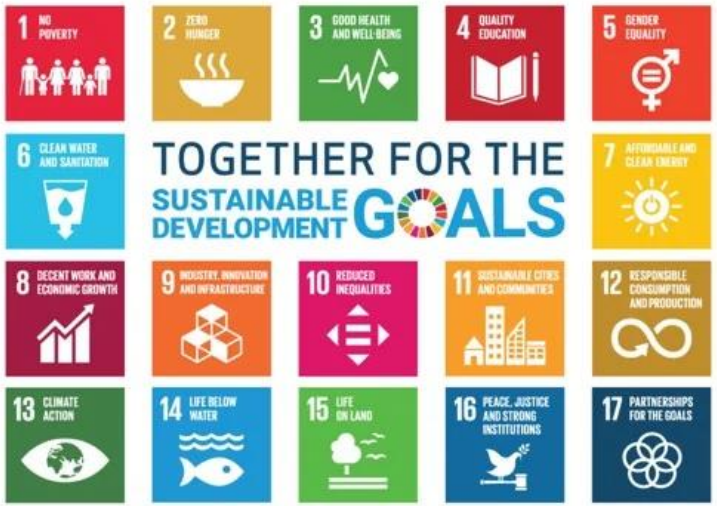
Contenu

- Introduction – Durabilité
- UAntwerpen : Data-Driven Research : pour aujourd'hui et pour la prochaine génération
  - SSMARAGD
  - Modèle optimisé de déformation de l'enrobé ME
- Quelques cas
  - ROAD_IT
  - FBG
- Conclusions

Les routes de l'avenir

Durabilité

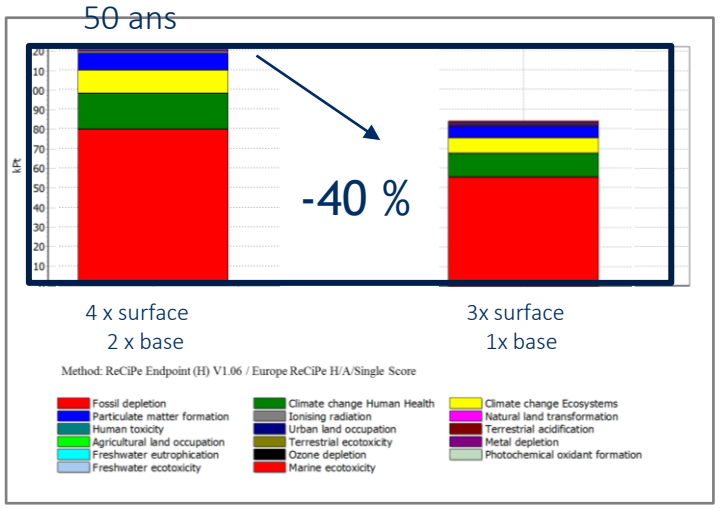
- Qu’est-ce que la durabilité, qu’entend-on par là ?
- *FHWA (2014) : A sustainable pavement is one that achieves its specific engineering goals, while, on a broader scale, (1) meets basic human needs, (2) uses resources effectively, and (3) preserves/restores surrounding ecosystems. Sustainability is context sensitive and thus the approach taken is not universal, but rather unique for each pavement application*
- Quelques beaux exemples déjà :
  - Sur le papier : EAPA, PIARC, EU,…
  - Outils : Edgar, Dubocalc
  - Cas : Programme Impulse, RejuveBIT,...



Durabilité (2)

- Comment rendre les revêtements bitumineux plus durables ?

  - Concept : modèles mécaniques-empiriques améliorés
  - Innovation matérielle : nouveaux matériaux <u>et</u> leur impact environnemental.
    - Life Cycle (Cost) Analysis
    - Remarque : durability versus carbon footprint versus sustainability !
  - Processus de construction
    - Performance – qualité
    - Énergie



Increase quality

Increase service life

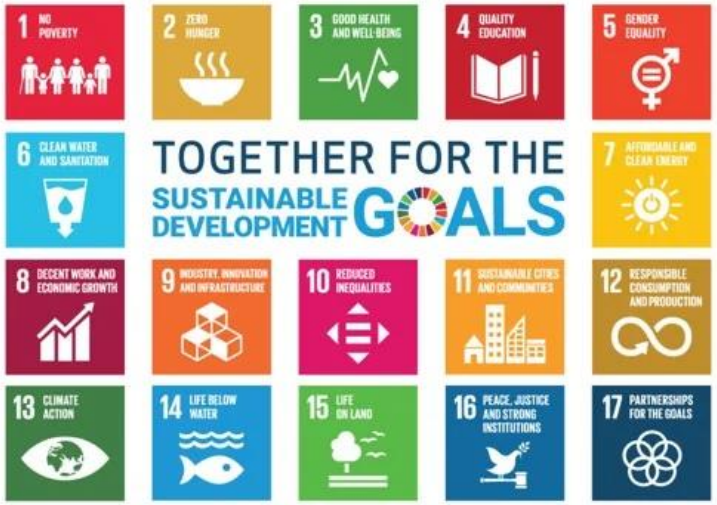
Increase recycling

Decrease transport

Durabilité (3)

Un effort supplémentaire ?

- Inverser l'approche :
  - Où voulons-nous aller ? Où devons-nous aller ? Pourquoi ?
  - Et comment allons-nous y parvenir ?



Durabilité (4)

Interaction rapide, maintenance, visibilité des flux de matériaux, flow,...

Changements dans les :
Perspectives
Technologie
Matériaux
Société

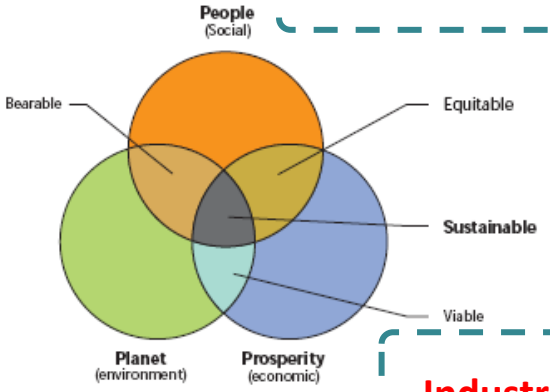
LCA
LCCA…
LCI
Mise à jour continue

Modèles mécaniques
PMS

Prendre les bonnes décisions pour les défis d'aujourd'hui et de demain pour des routes durables

Données historiques et actuelles
Modèles prédictifs

Société



Industrie

Où est l'aiguillon ?

- **Pouvons-nous calculer quel est le meilleur paramètre, avec le plus d'impact ?**
  - Outils
  - Inventaire des variations
  - Analyse d'impact
  - Durée – compréhension approfondie ?

  - Données ?
  - Où sont-elles ?

  - Que voulons-nous en théorie ?

- L'utilisation des données numériques permet toujours plus de prendre des décisions « intelligentes/smart ».
  - Machine learning
  - Neural networks

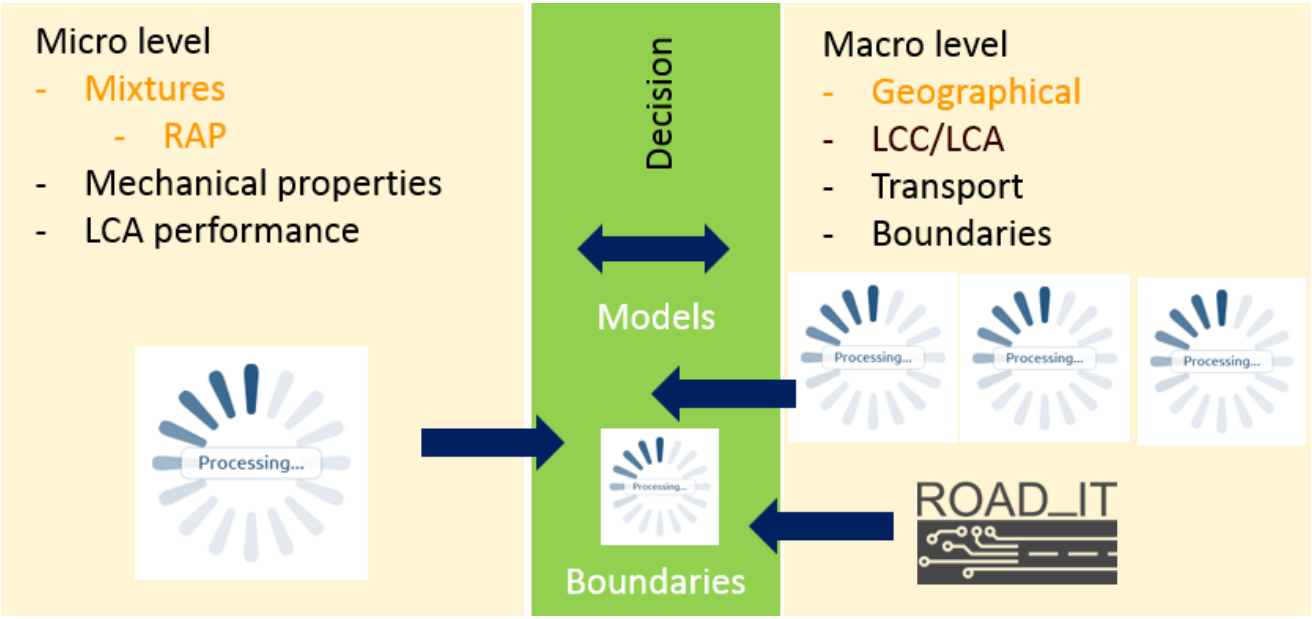
- Possibilités :
  - Détecter les tendances dans la masse des données
  - Simulations et prévisions

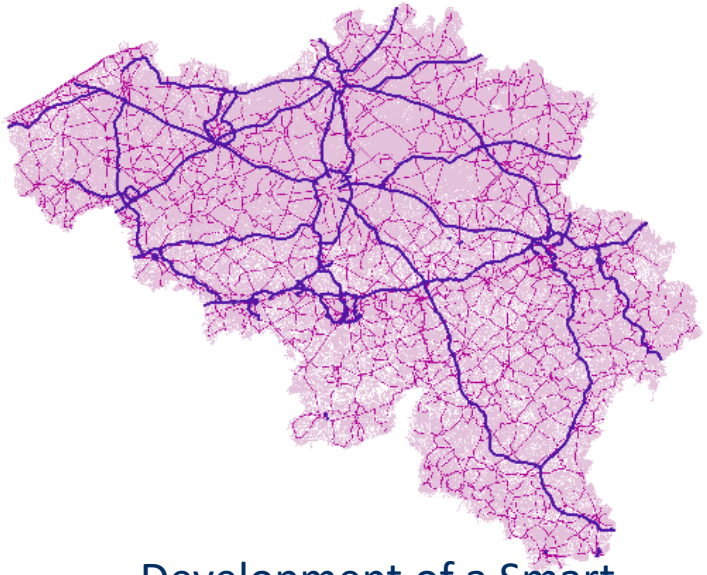
Regardons vers l'avenir : UAntwerpen

- Recherche innovante sur les matériaux et les technologies
- Data-driven analytic modelling from nano to meta scale (SSMARAGD)
- Performance model asphalt

SSMARAGD

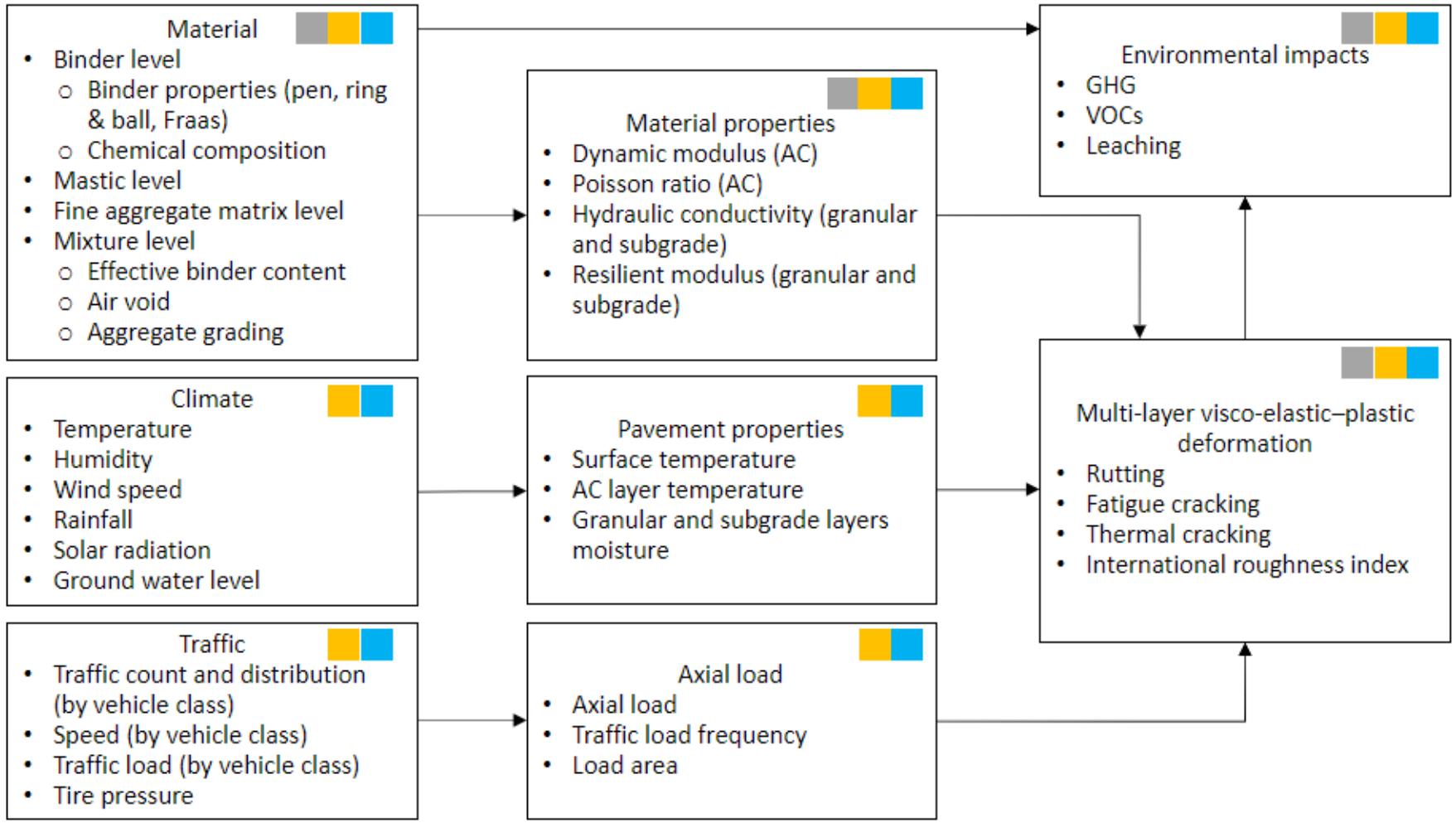
- **Data-driven analytic modelling from nano to meta scale (SSMARAGD)**
  - LCCA, LCA – social, econ, env impact (e.g. VOC)

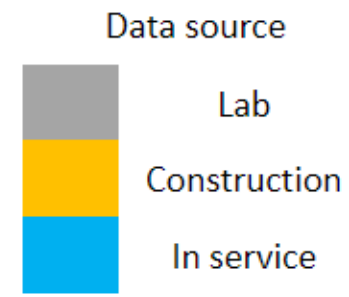




Development of a Smart Selection Model for innovative Application of Reclaimed Asphalt Granulate in road Design SSMARAGD

Historical and actual data





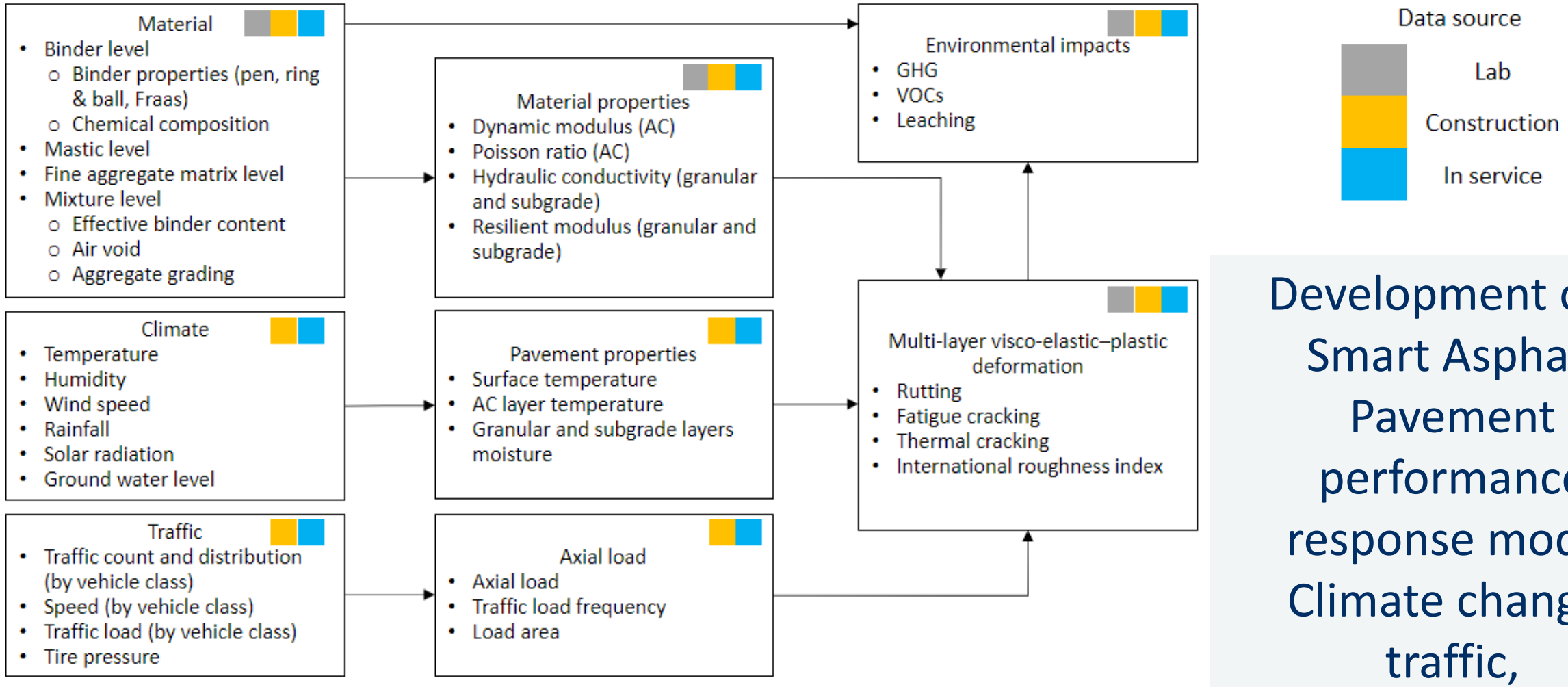
GIS & Machine Learning

Objectives and Research Needs

- Objectives: (1) evaluate data sources and accessibility and (2) discuss legal aspects for further research and valorization
- Research at UAntwerp: (1) model the behavior of the road infrastructure (visco-elastic plastic deformation model); (2) correlate actual performance/service life with predicted performance/ service life; (3) evaluate impacts of climate change on road structures; (4) assess sustainability and circularity (Green Public Procurement)

Material passport

Location Lifetime Material Performance



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Development of a Smart Asphalt Pavement performance response model
Climate change, traffic, ageing, healing, fatigue,…
Historical and actua data

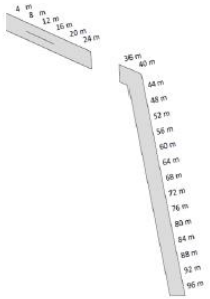
Premières étapes

CyPaTs: Demonstrating novel technologies

CyPaTs
DEMONSTRATING NEW ASPHALT TECHNOLOGIES

100 m Test track at UAntwerpen – Sept 2017

- PQI density device
- Alu plates for thickness
- Construction of a solar heat exchanging asphalt layer (tubes in asphalt layer)
- Fibre-reinforced asphalt surface layer
- ROAD-IT: track and trace, Infraredlinescanner, reporting
- Fibre Bragg Grating Sensors
- Warm mix asphalt



https://www.uantwerpen.be/en/research-groups/emib/projects-publications/road-engineering/cypats/

https://youtu.be/2DKTinDCea4

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ROAD_IT

ROAD_IT
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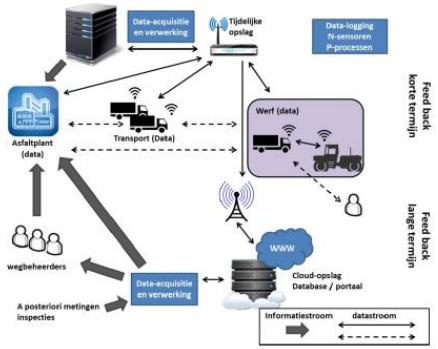
Opzoekingscentrum voor de Wegenbouw
imec IDLab

Improving management process for road construction by implementation of IT tools (2015-2017-...)



to **develop and demonstrate** an integrated and coherent IT process **control system** (*not*) for the entire Flemish asphalt sector whereby all existing sensors and actuators with their own operational data processing system, communicate with one another, in a workable way and storing data for real time and later purpose.

Quality and transport improvement by
- Track and Trace
- Infrared linescanner
- Digital report
- Data Storage

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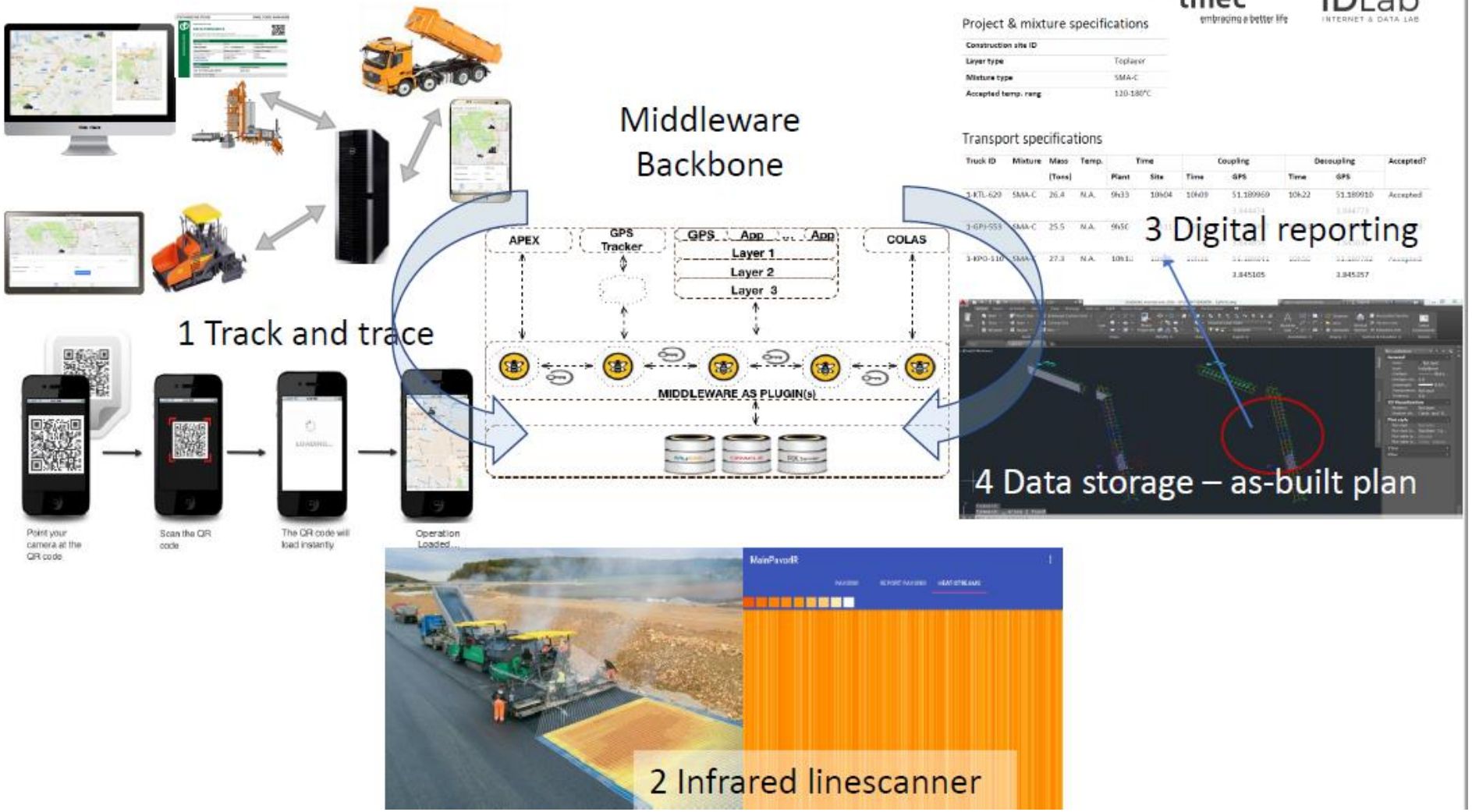
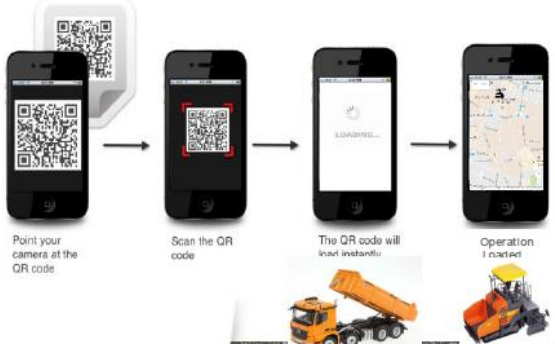
WAWEBO · HOOGMARTENS · WIRTGEN GROUP · DECKX · STADSBADER · TOPASFALT · Confederatie Bouw · THUNDERBUILD · bam · COPRO · NORRÉ-BEHAEGEL · imec · BOUWUNIE · ASWEBO · GRIZACO · BOMAG · De Bruycker · Port of Antwerp · COLAS · AGENTSCHAP INNOVEREN & ONDERNEMEN · IDLab

4 Case studies



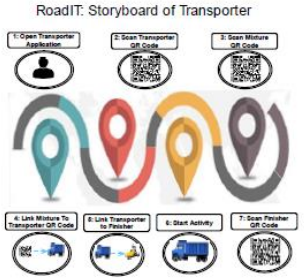
ROAD_IT: Case 1

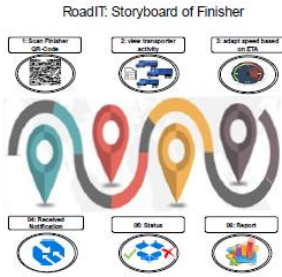
Optimizing logistic process of asphalt production and constructing process



ROAD_IT: case 1 (2)

Optimizing logistic process asphalt production and constructing process



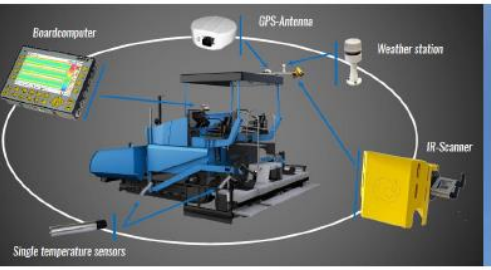


Result: location and time relation between lorry and finisher
Calculate efficiency, truck management, temperature
Mixture verification: go/no-go on site
Speed of finisher can be adopted to truck arrivals

Technical and transport data are gps-related and stored in a database of the road manager.
Each paved quantity from one truck is located and described (material passport and laying parameters)

ROAD_IT: Case 2

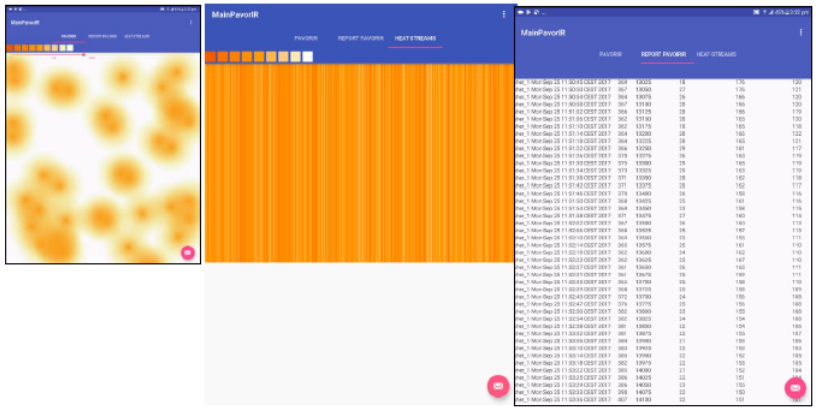
Using infrared camera for continuous temperature measurements



- Infrared camera is linked to GPS-system
- Measurements width of road
- One or more measurements per 25cmx25cm
- Accuracy 1 – 2°C
- Heat maps

ROAD_IT: Case 2 (2)

Continuous monitoring homogeneity after the finisher



During asphalt laying and compaction process:

- direct impact on durability of the compacted asphalt: intervention for rollers is possible

After asphalt construction:

- data-analyse: evaluation, tender specifications, area with good/bad compaction

ROAD_IT: Case 3

Data reporting of a construction site

Project & mixture specifications

Construction site ID	
Layer type	Toplayer
Mixture type	SMA-C
Accepted temp. rang	120-180°C

Totals today

# Trucks	Mixture	Total mass	Avg. mass/truck
3	SMA-C	79.2	26.4

Transport specifications

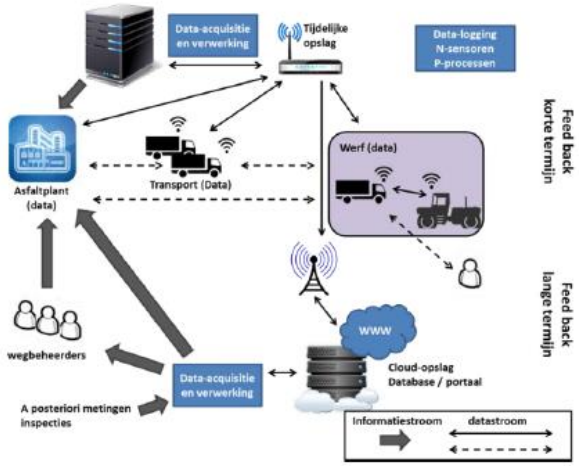
Truck ID	Mixture	Mass (Tons)	Temp.	Time		Coupling		Decoupling		Accepted?
				Plant	Site	Time	GPS	Time	GPS	
1-KTL-629	SMA-C	26.4	N.A.	9h33	10h04	10h09	51.189969 3.844474	10h22	51.189910 3.844773	Accepted
1-GPJ-553	SMA-C	25.5	N.A.	9h50	10h11	10h25	51.189897 3.844858	10h34	51.189857 3.845037	Accepted
1-KPO-110	SMA-C	27.3	N.A.	10h10	10h35	10h38	51.189841 3.845105	10h50	51.189782 3.845357	Accepted

For a whole or a part of a construction site:
Quantities, period, number of trucks, ID of trucks, mixture verification
Contractor, suppliers and road manager

ROAD_IT: Case 4

Data storage for a road or network

- Database to store all data of the job site
- Demonstrated by CyPaTs



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Défi

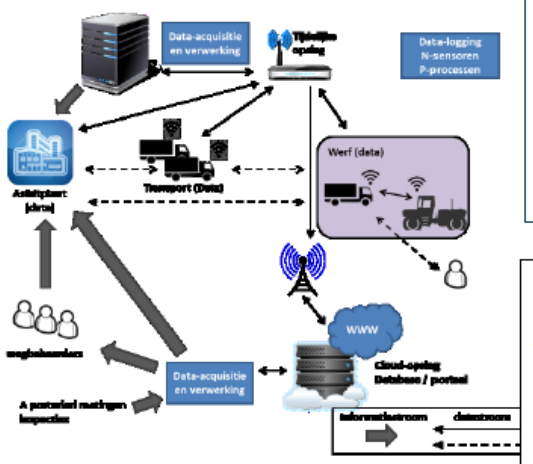
Asphalt process : production – transport – service – renovation – recycling

ROAD_IT: combining all tools and steps into one system chain with short term and long term archive output

Materials
Energy
Safety
Efficiency

Homogeneity
Temperature
Production
Transport
Processing

Research



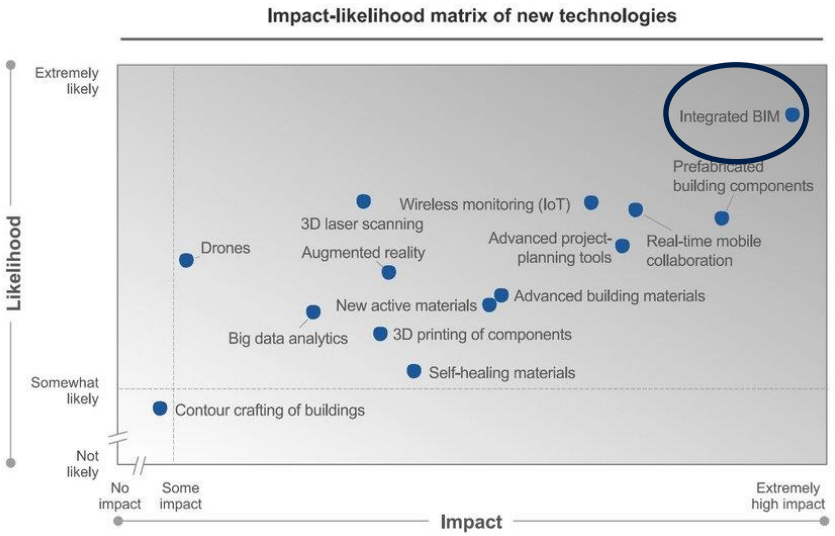
Short term data use

Long term data archive

Quality Controll
intern
extern

Assisting
personnel

Improve
Process
Quality during
construction
service
recycling
Safety at work
Environmental impact
LCA / CO2 Calculation

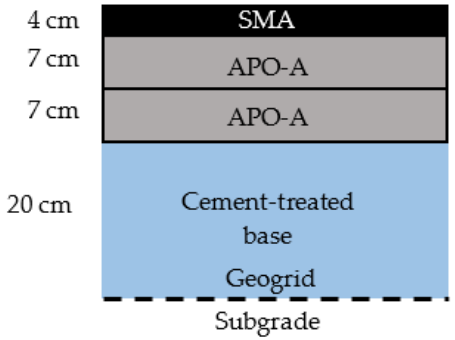


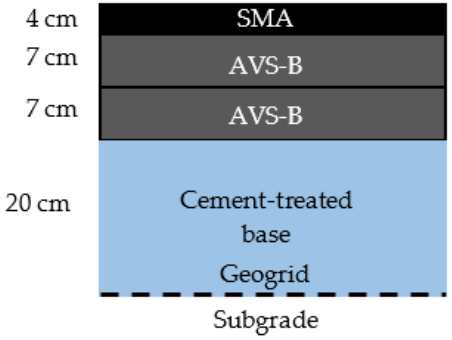
Source : Shaping the Future of Construction

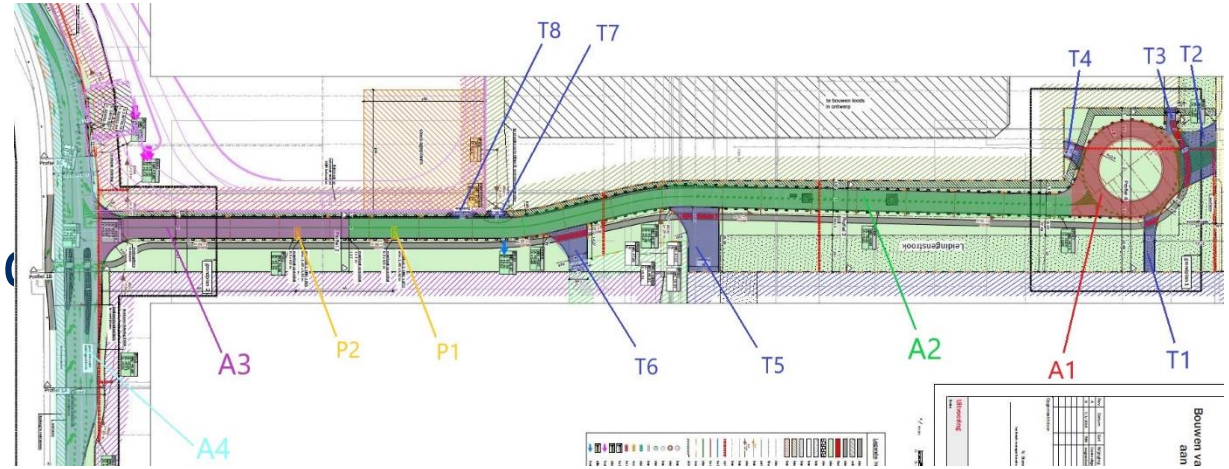
Le défi des données : enregistrement, stockage, utilisation, modélisation

Exemple : Autoroute d'Anvers

- AC-20 versus EME AC-14
  - Lab tests
  - FWD
  - FBG : monitoring de la déformation des couches d'enrobé bitumineux
- ROAD_IT for QA/QC
  - Track and Trace
  - Mesure de l'épaisseur des plac
  - IR-linescanner
  - Smart compaction
  - PQI

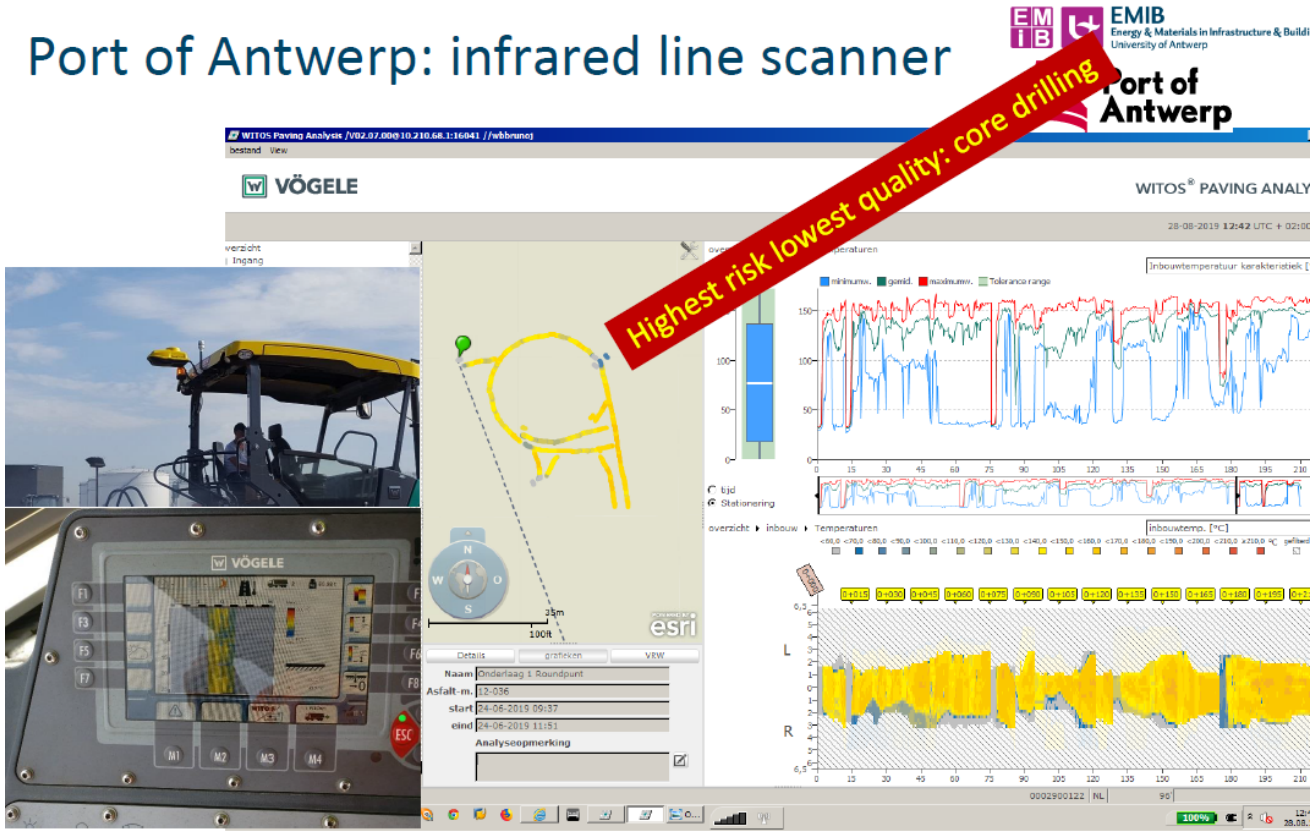






Premières étapes

Port of Antwerp: infrared line scanner



Analyses of quality: impact of temperature on durability

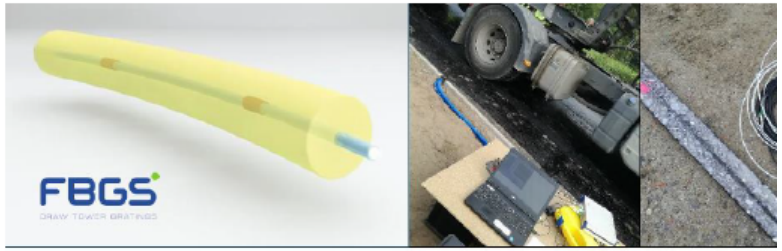
Port of Antwerp: Compaction Degree

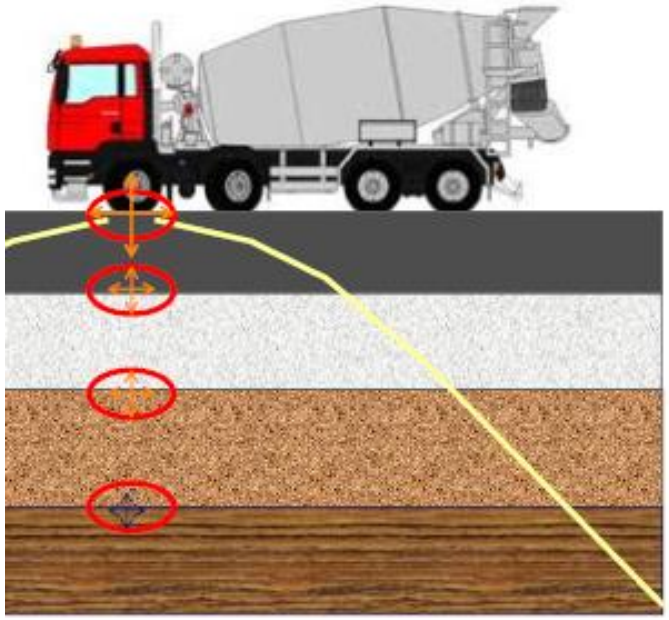
Bomag Compaction Management

Plug in systeem

Analyses of quality: impact of compaction degree on durability

Fibre Bragg Grating





Technology:

- Glass fibre light polarization
- Embedded in asphalt (geogrid)
- Measuring strains (µm)

Objectives of FBG:

- Analysis of strains
- Monitoring the deformation of the structure (and each asphalt layer)
- Implementation of ageing in asphalt response model

Fibre Bragg Grating

Fibre Bragg Grating

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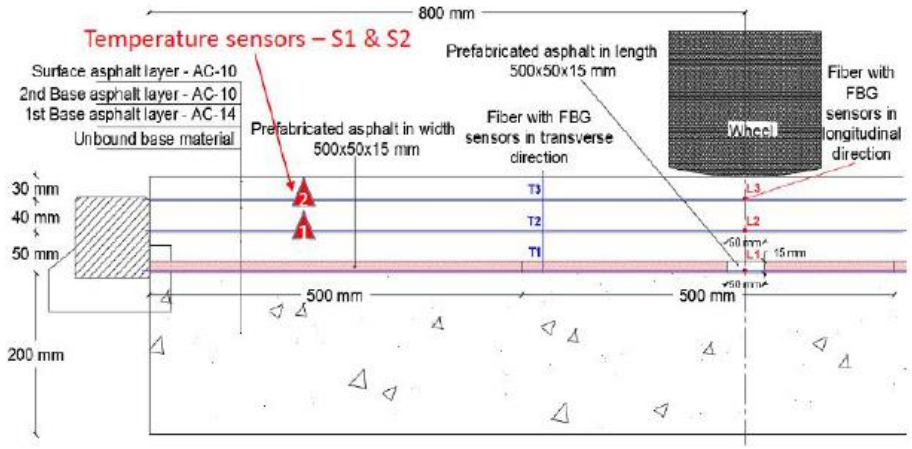
1. FBG monitoring system prototype at CyPaTs

[Phd P. Kara De Maeijer (ongoing)]



The installed FBG monitoring system is based on the in-situ pavement sensors: FBG chains of 30 DTG® (2 fibers), 5 DTG® (4 fibers) and two temperature sensors embedded in three asphalt layers with a cross section configuration (width - 4 m and length - 3.2 m). In total: 82 sensors

YouTube CyPaTs: Demonstrating New Asphalt Technologies

Monitoring des charges/déformations actuellement et durant leur
→ durée de vie attendue
→ Maintenance

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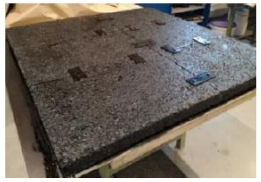
Fibre Bragg Grating

(c) (d)



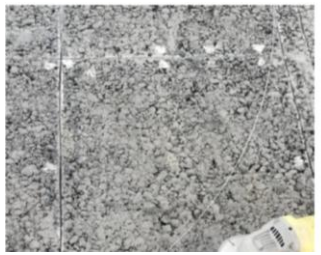


Figure 28: Reference truck used for preliminary measurements in Antwerpsebaan

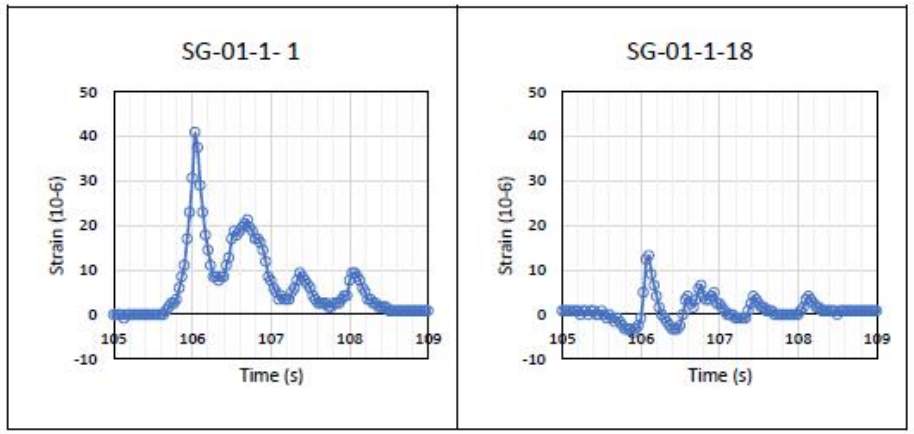
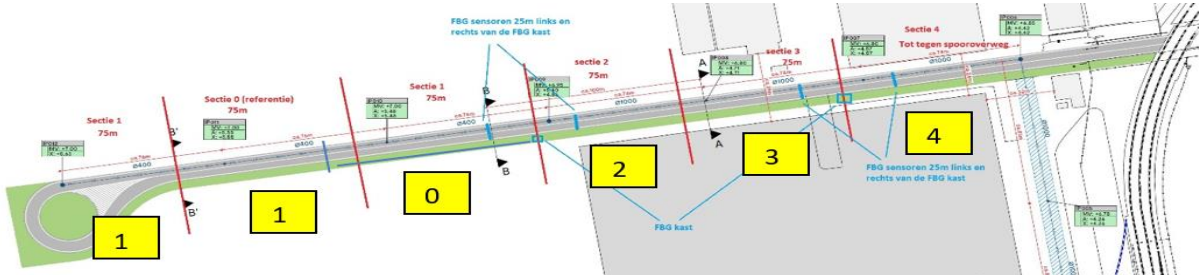
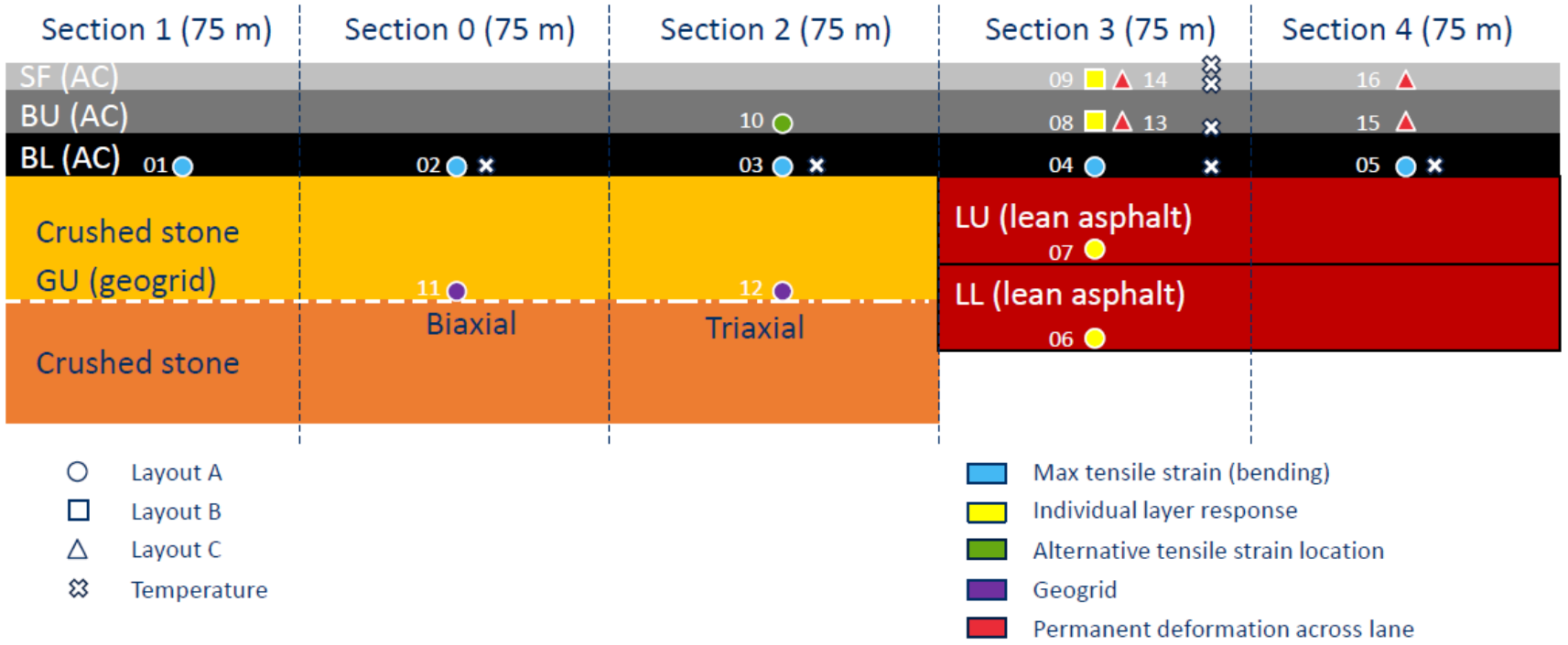


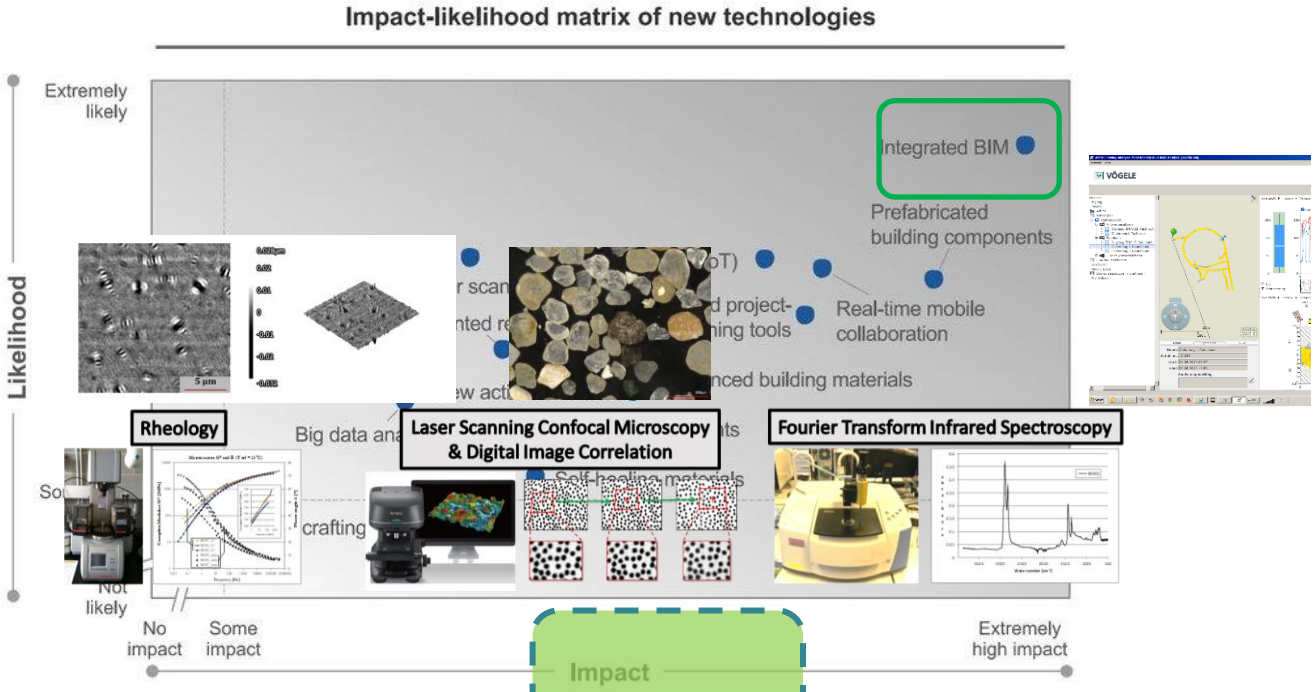
Figure 29: Strain response measured when driving the reference truck at 30 km/h and a sampling frequency of 30

Port d'Anvers





Retour à notre rêve

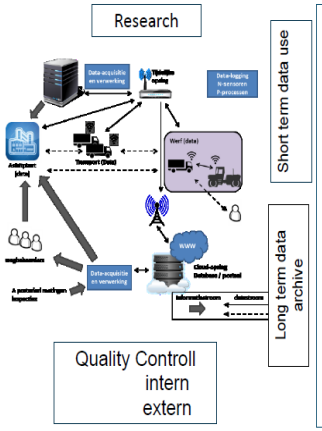


Asphalt process : production – transport – service – renovation – recycling

ROAD_IT: combining all tools and steps into one system chain with short term and long term archive output

Materials
Energy
Safety
Efficiency

Homogeneity
Temperature
Production
Transport
Processing



Assisting personnel

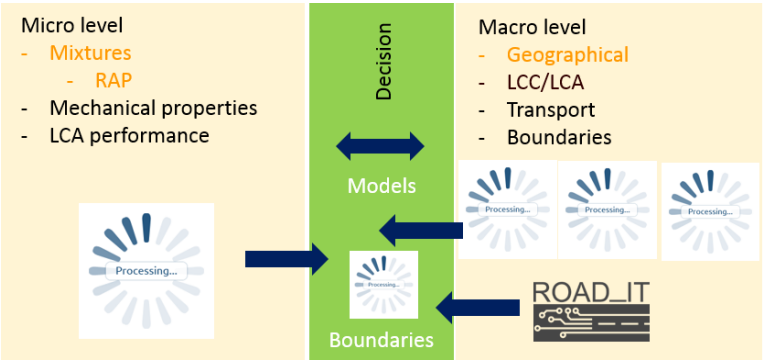
Improve
- Process
- Quality during
  - construction
  - service
  - recycling
- Safety at work

Environmental impact
- LCA / CO2 Calculation

Development of a Smart Asphalt Pavement performance response model
Climate change, traffic, ageing, healing, fatigue,…
Historical and actual data

FED by Data Knowledge

Development of a Smart Selection Model for innovative Application of Reclaimed Asphalt Granulate in road Design
SSMARAGD
Historical and actual data



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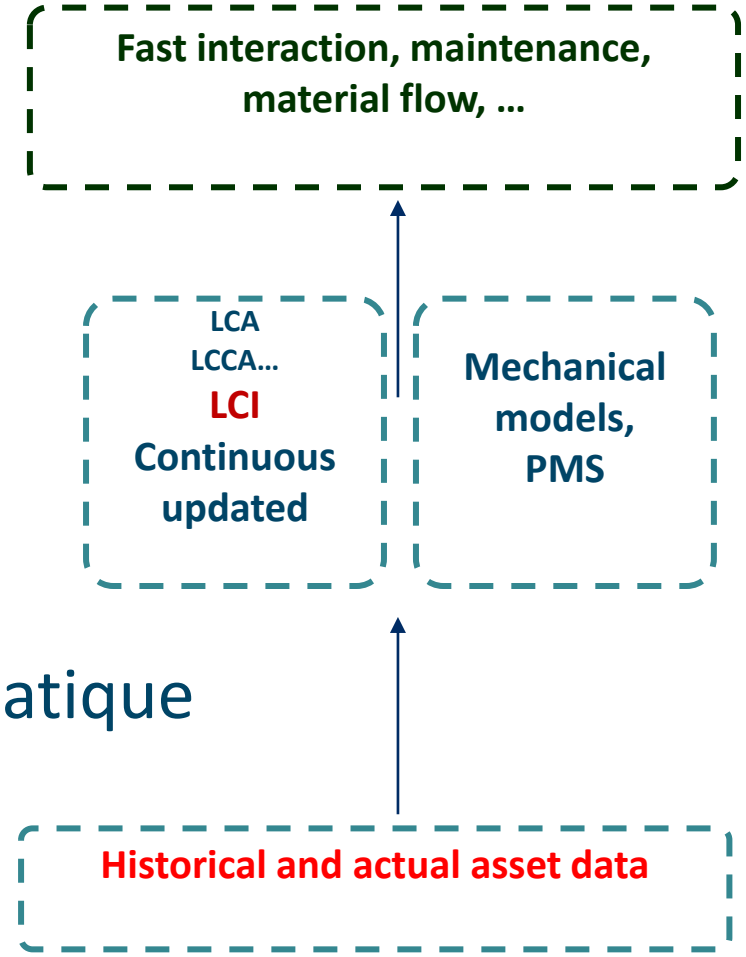
Task Force Data-driven Research (2022)

- **UAntwerpen, AWV, CRR, COPRO**
- **Inventaire des données**
- **Stratégie d'utilisation des données**

  - Mechanical asphalt response model
  - GPP (également fondations)
  - PMS : état actuel et impact du changement climatique



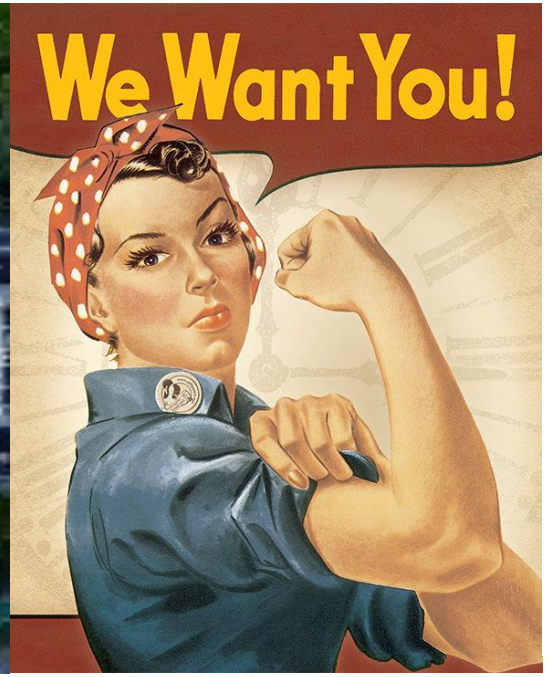
Conclusions

- Durabilité vs Sustainability
  - De nombreuses initiatives importantes : évaluation et fondements
  - Qualité : Longévité et Formation
  - Optimisation du transport, de la consommation d'énergie et du flux de matériaux
    - Recyclage in situ, proximité
- Nouvelle étape « outil » : LCA-LCCA
- Nouvelle étape : utilisation des données → accroître la numérisation
  - Aujourd'hui et demain :
    - ROAD_IT – FBG → Asphalt Response Model
    - Création d'une base de données → informations sur les enrobés utilisés sur les tronçons de route
- **Collaboration entre tous les acteurs**

SSMARAGD Meets BIM

Conclusions

- **Collaboration entre tous les acteurs**

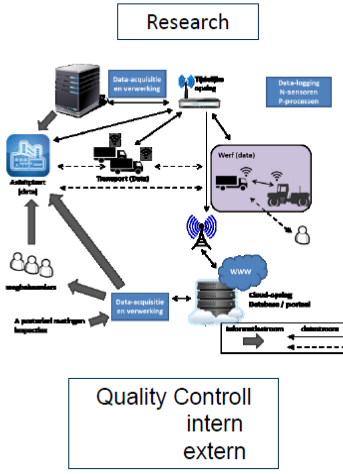


Asphalt process : production – transport – service – renovation – recycling

ROAD_IT: combining all tools and steps into one system chain with short term and long term archive output

Materials
Energy
Safety
Efficiency

Homogeneity
Temperature
Production
Transport
Processing



Assisting personnel

Improve
Process
Quality during
construction
service
recycling
Safety at work
Environmental impact
LCA / CO2 Calculation

Merci !