IMT Nord Europe
École Mines-Télécom
IMT-Université de Lille

UDS Université de Sherbrooke

GC gE Laboratoire Génie Civil et géo-Environnement Lille Nord de France

9th International Conference on Sustainable Solid Waste Management

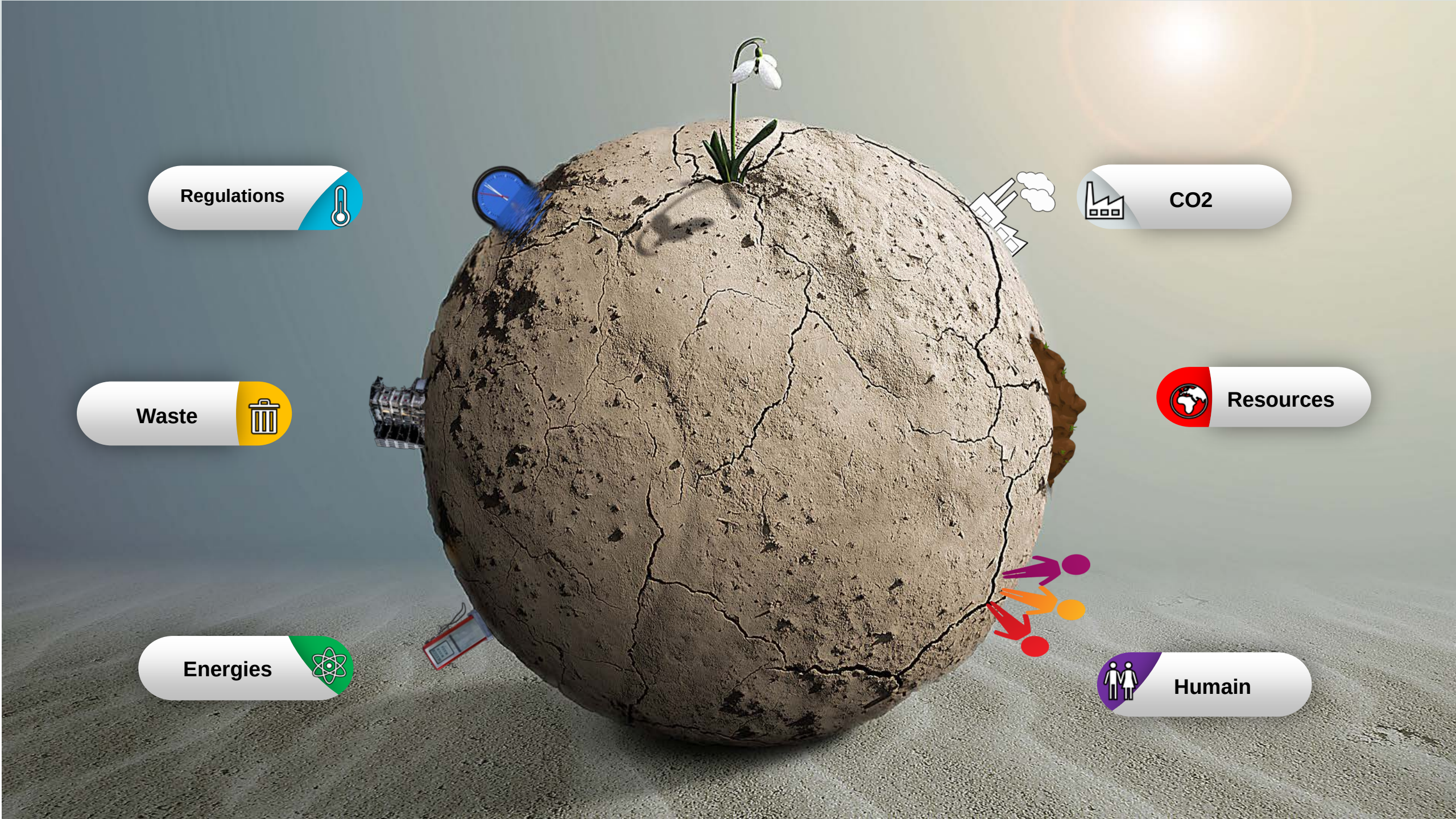
MANAGEMENT OF WASTE IN CIVIL ENGINEERING: A NEW DECISION SUPPORT SOFTWARE FOR THE REUSE OF SEDIMENTS

PR. MAHFOUD BENZERZOUR

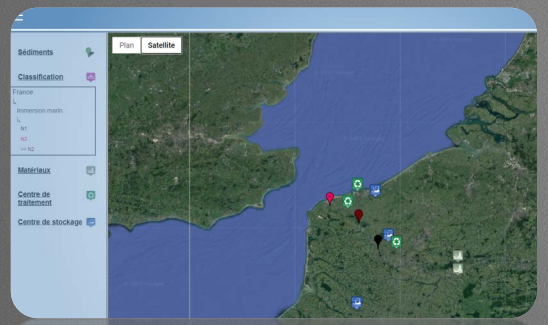
SURICATES PROJECT

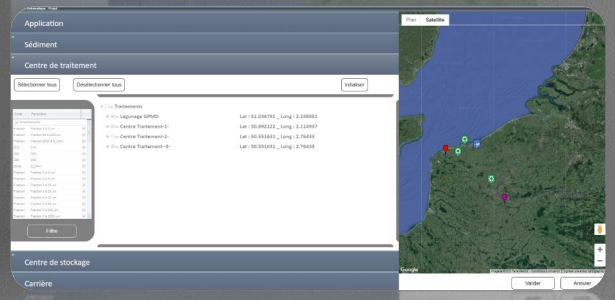
Université de Lille · CORK INSTITUTE OF TECHNOLOGY · Deltares · University of Strathclyde · Port of Rotterdam · UCC · ixsane · brgm · Scottish Canals · ARMINES · IMT Lille Douai · team2

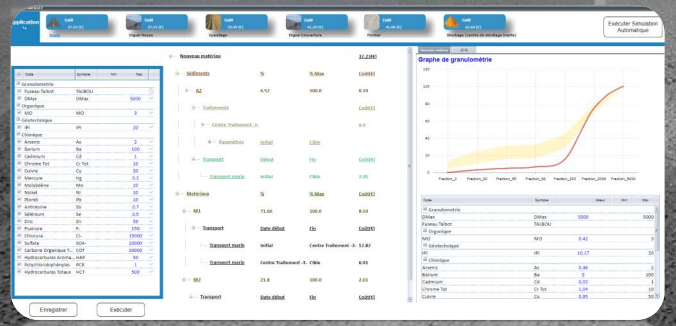
IMT Atlantique Bretagne-Pays de la Loire École Mines-Télécom · IMT Lille Douai École Mines-Télécom IMT-Université de Lille · IMT Mines Albi-Carmaux École Mines-Télécom · IMT Mines Alès École Mines-Télécom · Institut Mines-Télécom Business School · MINES Saint-Étienne Une école de l'IMT · TELECOM ParisTech Une école de l'IMT · TELECOM SudParis Une école de l'IMT · EURECOM · InSIC · MINES ParisTech · MINESnancy · ensiie · ARMINES · La recherche CARNOT pour l'innovation des entreprises


Regulations
CO2
Waste
Resources
Energies
Humain

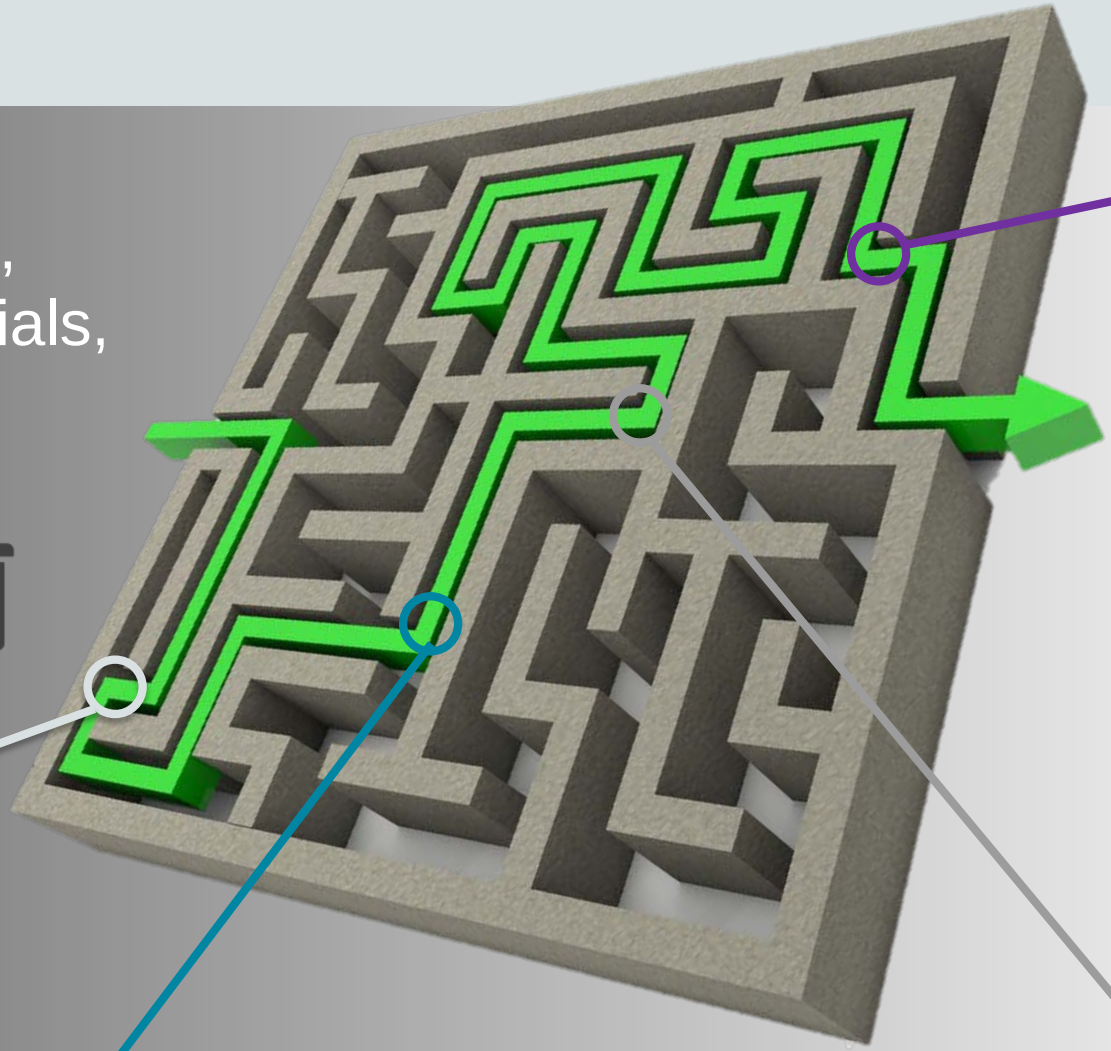
Development of operational digital tools for the optimization of the recovery of alternative materials,..., waste



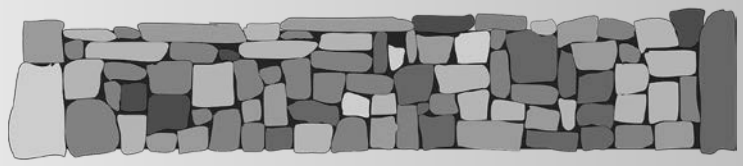




Waste
Industrial by-products,
Secondary raw materials,
Alternative materials,



Regulations

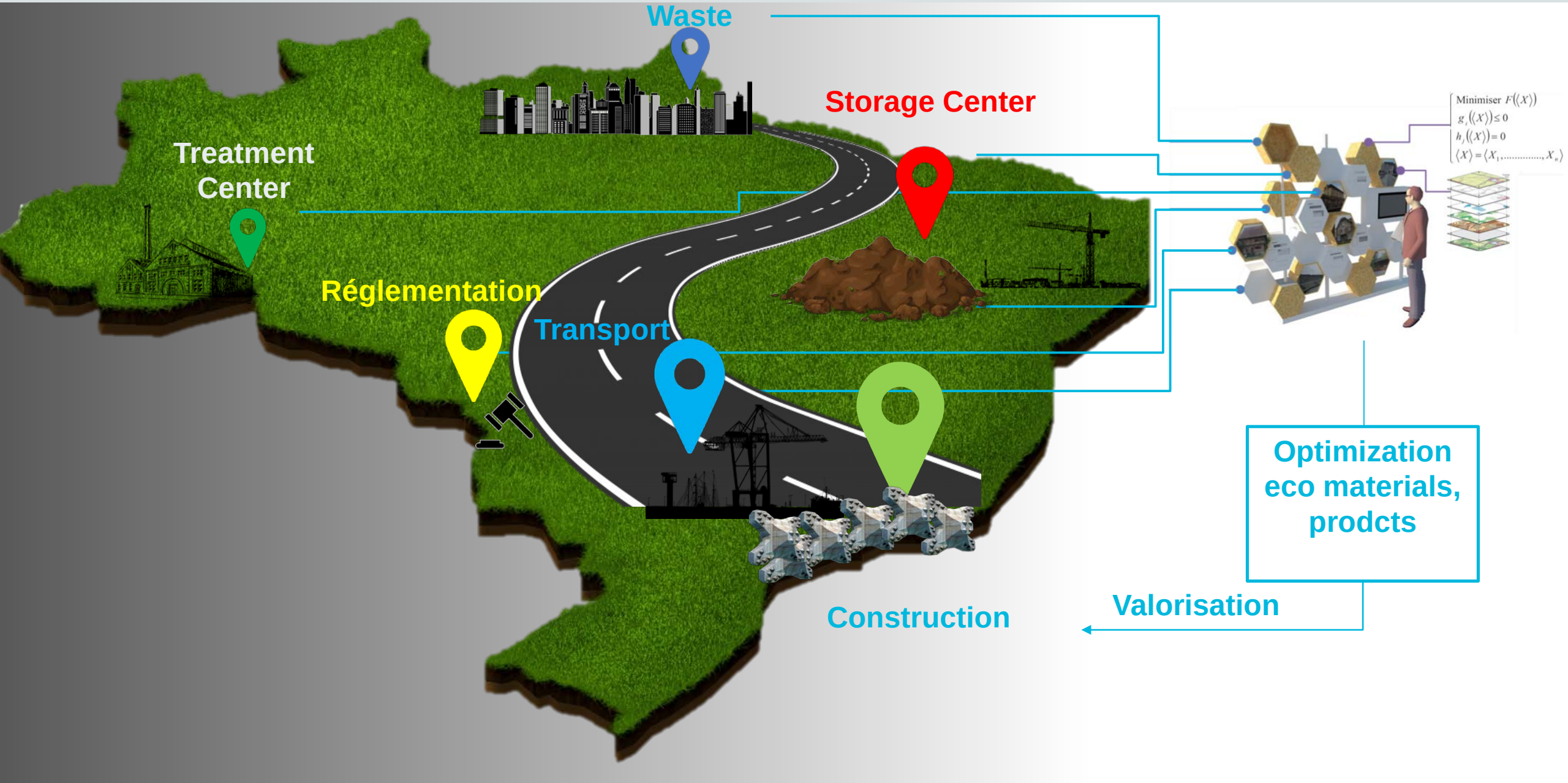


Materials, Products:
Usable

Feasibility

Costs

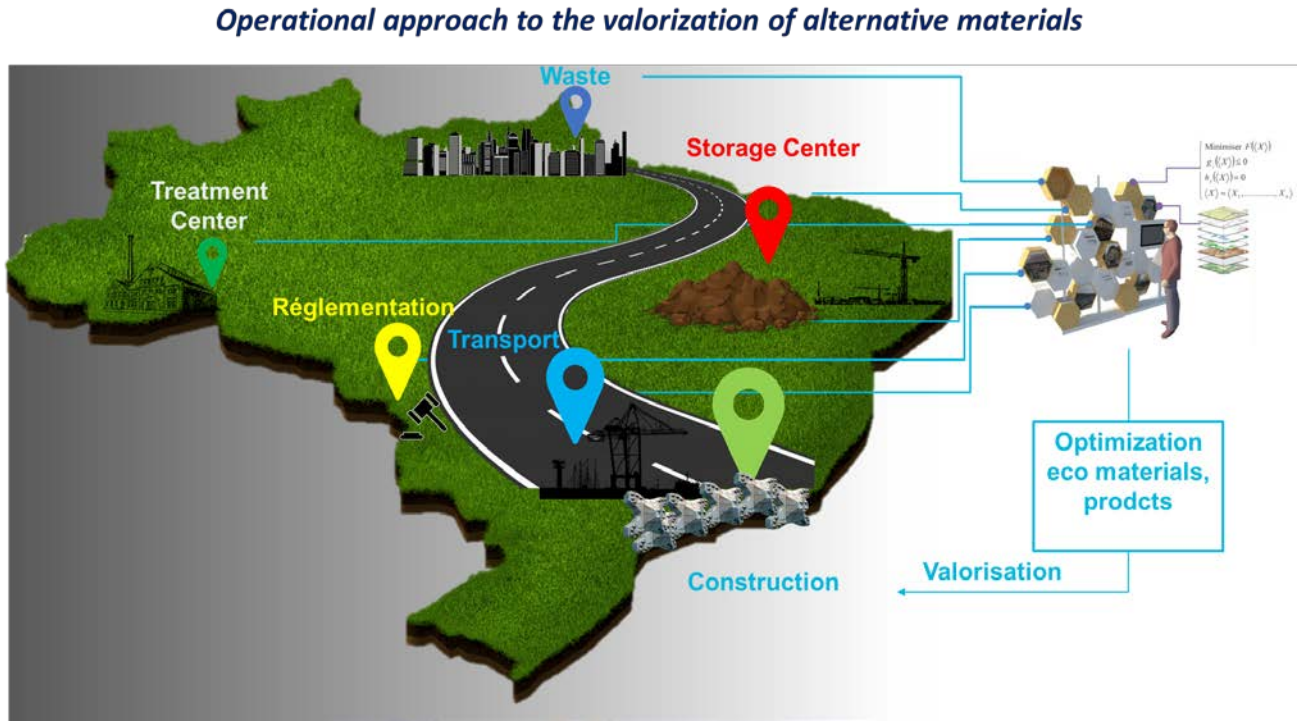
Environment


Waste
Storage Center
Treatment Center
Réglementation
Transport
Construction
Valorisation
Optimization eco materials, prodcts

Operational approach to the valorization of alternative materials

Mathematical Model: Objective Function

$$Min\left(\sum_{i=1}^{n} C_i x_i + \sum_{j=1}^{m} C_j S_j + \sum_{i=1}^{n}\sum_{t=1}^{|T|} C_{ti} T_{ti}\right)$$



With:

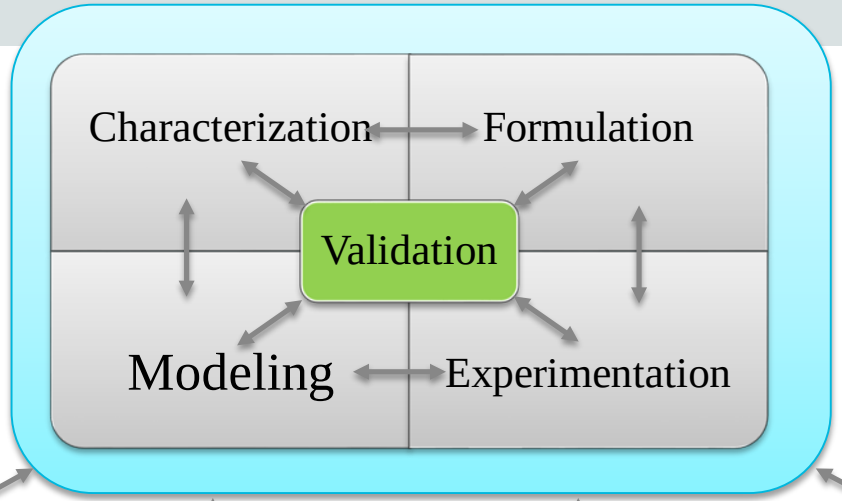
C_i : Operating cost of sediment *i* (dredging)

C_j : Purchase cost of the material *j* and transport cost (T/Km)

C_{ti} : Cost of treatment *t* applied to sediment *i* and sediment transport cost (T/Km)

Operational approach to the valorization of alternative materials

Complex
decision
Multi parameters

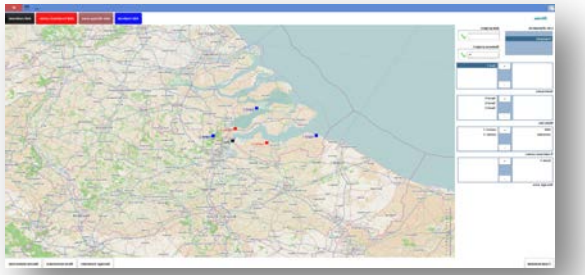


Treatment | Durability | Environment | Cost

Sediment | Tires | Fibers VP | HF Slag | Bauxaline | Mâchefers | Rubble

Digital approach

Materials Approach



[Benzerzour & co 2014-2020]

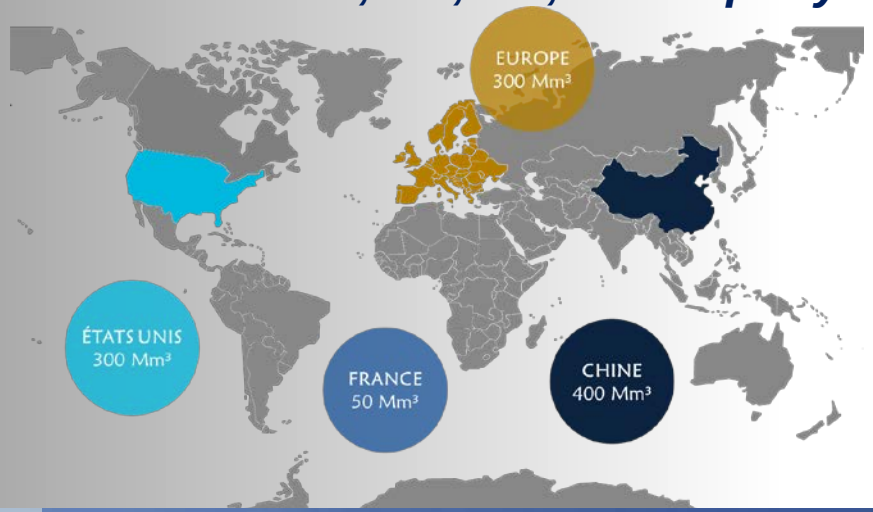
Institut Mines-Télécom

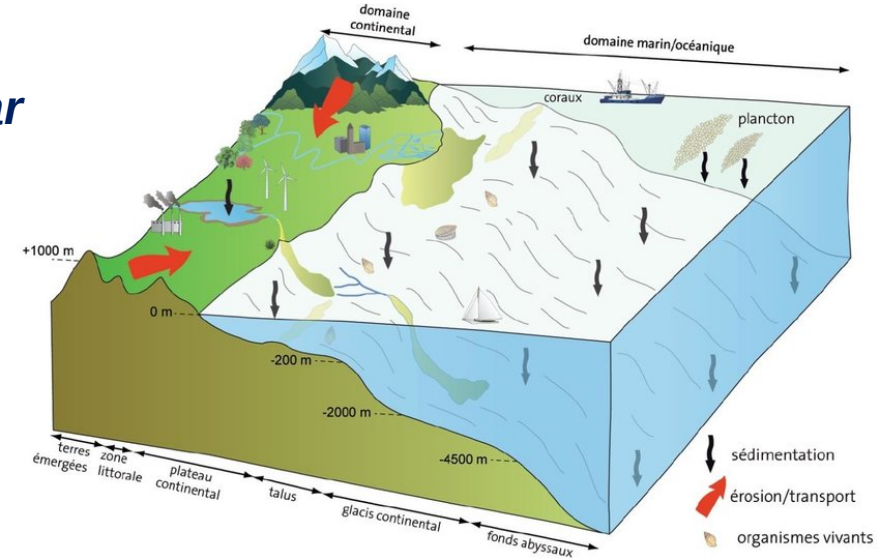
The sediment problem

Needs:
Transport, (reduction C02),
Maritime and river activity,
Urban activity (ditches),

Interviews:
Dredging, cleaning
Storage
Dips

More than 1,000,000,000 m³ per year





Operational approach to the valorization of alternative materials

Mathematical model : Constraints

Environmental constraints : Heavy metals

$$e_{si}\left(1-\sum_{t=1}^{|T|}\hat{e}_{sit}T_{ti}\right)\leq e_s+(1-x_i)M$$

Environmental constraints : Organic matter

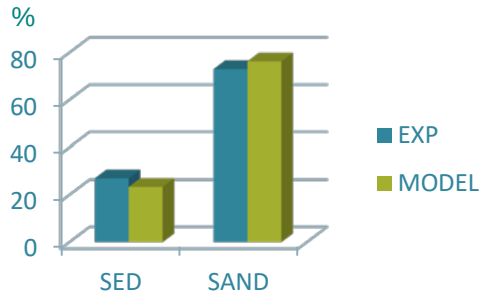
$$e_{Mi}\left(1-\sum_{t=1}^{|T|}\hat{e}_{Mit}T_{ti}\right)\leq e_M\left(1+\sum_{j=1}^{m}S_j\right)+(1-x_i)M$$

Mechanical constraints

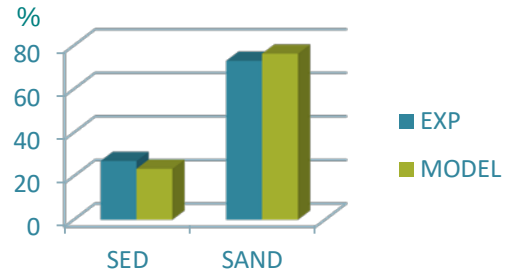
$$\hat{P}_d^{0.4}\left(\sum_{i=1}^{n}x_i+\sum_{j=1}^{m}S_j\right)\leq\sum_{i=1}^{n}(P_{id}\times x_i)+\sum_{j=1}^{m}(P_{jd}\times S_j)\leq\hat{P}_d^{0.25}\left(\sum_{i=1}^{n}x_i+\sum_{j=1}^{m}S_j\right)$$

$P_{id}\,(P_{jd})$: associated percentage to the diameter *d* in sediment *i* (material *j*)

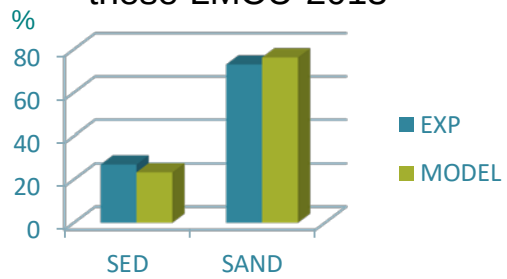
Validation modèle
sur résultats de la Biblio



thèse GPMD 2012



thèse LMCU 2013



thèse PRISMA 2016

Simulation Manuelle : Projet

Application

FRANCE | Route | test Mahfoud

⇧ | Editer Projet |

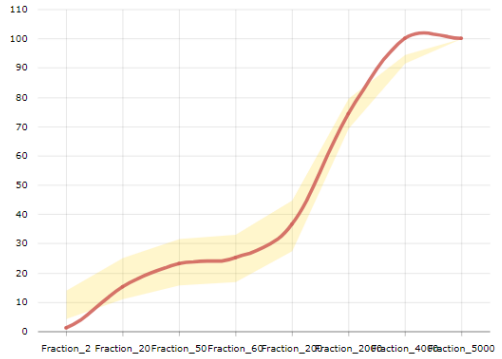
Code	Symbole	Min	Max
Granulometrie			
DMax	DMax		5000
Fuseau Talbot	TALBOU		
Organique			
MO	MO		3
Géotechnique			
IPI	IPI		20
Chimique			
Molybdène	Mo		10
Nickel	Ni		10
Plomb	Pb		10
Antimoine	Sb		0.7
Sélénium	Se		0.5
Zinc	Zn		50
Fluorure	F-		150
Chlorure	Cl-		15000
Sulfate	SO4-		20000
Carbone Organique T...	COT		30000
Hydrocarbures Aroma...	HAP		50
Polychlorobiphényles	PCB		1
Hydrocarbures Totaux	HCT		500
Arsenic	As		2
Barium	Ba		100
Cadmium	Cd		1
Chrome Tot	Cr Tot		10
Cuivre	Cu		50
Mercure	Hg		0.2

Enregistrer | Exécuter

Nouveau matériau				33.9(€)
Sédiments		%	% Max	Coût(€)
A2		5.0	100.0	0.15
Traitements				Coût(€)
Centre Traitement-1				0.0
Paramètres		Initial	Cible	
Transport		Début	Fin	Coût(€)
Transport marin		Initial	Cible	1.28
B2		25.65	100.0	0.76
Traitements				Coût(€)
Centre Traitement-1				1.28
Paramètres		Initial	Cible	
Transport		Début	Fin	Coût(€)
Transport marin		Initial	Centre Traiteme	1.32
Transport marin		Centre Traiteme	Cible	5.34
Matériaux		%	% Max	Coût(€)
M1		24.46	100.0	2.93

Nouveau matériau | GTR

Graphe de granulométrie



Code	Symbole	Valeur	Min	Max
Granulometrie				
DMax	DMax			
Fuseau Talbot	TALBOU			
Organique				
MO	MO	1.09		3
Géotechnique				
IPI	IPI	14.08		20
Chimique				
Arsenic	As	0.37		2
Barium	Ba	0		100
Cadmium	Cd	0.03		1
Chrome Tot	Cr Tot	0.88		10
Cuivre	Cu	0.8		50
Mercure	Hg	0.04		0.2
Molybdène	Mo	0		10
Nickel	Ni	0.52		10
Plomb	Pb	1.91		10

Sédiment

Centre de traitement

Centre de stockage

Carrière

Valider | Annuler

Chaire

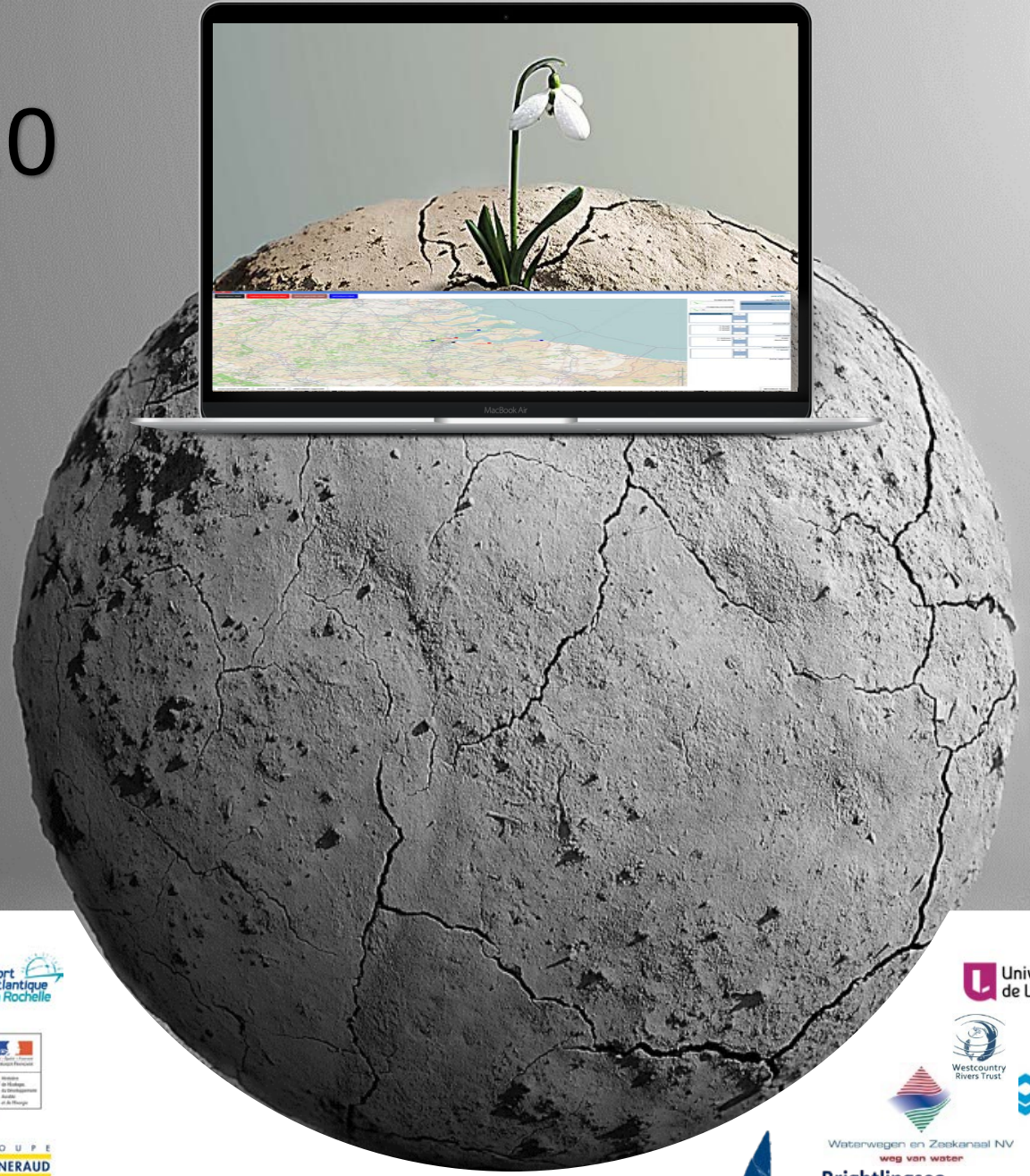
ECOSED–D4.0

2019 – 2024

Titulaire: Pr Nor Edine Abriak
IMT Lille Douai

Démarche
Sédimatériaux

Région
Hauts-de-France



2015 – 2023

Interreg
2 Seas Mers Zeeën
USAR
European Regional Development Fund

Interreg
North-West Europe
SURICATES

DunKerque Port
Institut Mines-Télécom
IMT Lille Douai
Fondation Mines-Télécom
Port Atlantique La Rochelle
COLAS
Nord Asphalte
Baudelet Environnement
vnf
EQIOM
GUINTOLI
neo-eco Recycling
Nord le Département
Jean Lefebvre Nord
BIOSYNERGIE
MEL Métropole
Groupe Gagneraud
Région Hauts-de-France
BDS Bathy Drone Solutions
Agence de l'Eau Artois-Picardie

Université de Lille
CIT Cork Institute of Technology
Deltares
University of Strathclyde
Westcountry Rivers Trust
Port of Rotterdam
UCC University College Cork, Ireland
ixsane
brgm
Waterwegen en Zeekanaal NV
weg van water
Brightlingsea Harbour Commissioners
Scottish Canals
ARMINES
IMT Lille Douai
team2
Hoogheemraadschap van Schieland en de Krimpenerwaard

Operational approach to the valorization of alternative materials
Ongoing development and prospects

Modélisation des contraintes opp de la valorisation des sédiments

Interreg 2 Seas Mers Zeeën USAR

Thèse
A. ZERAOUI

OSMS……..

C: Cement

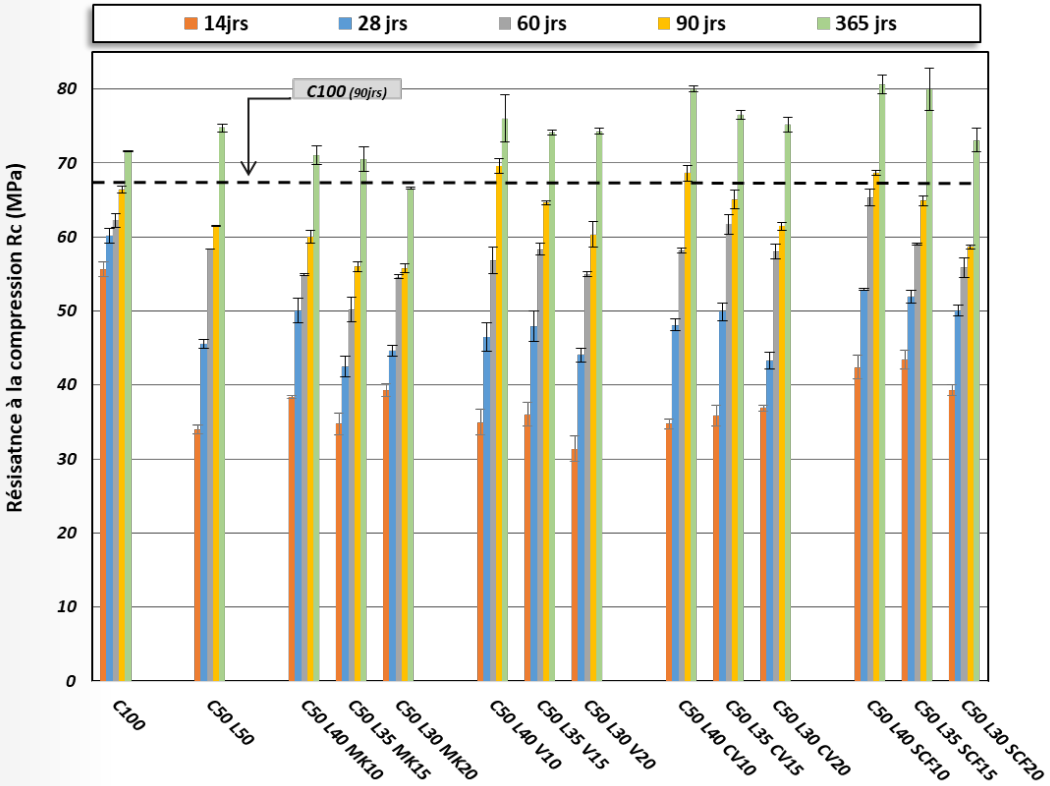
L: Slag

MK: Metakaolin

V: Glass

CV: Fly Ash

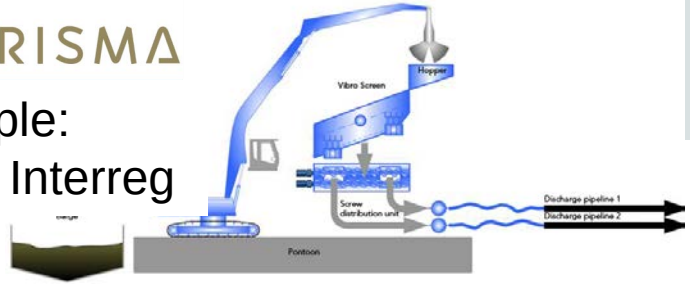
SF: Sediment treated by flash calcination

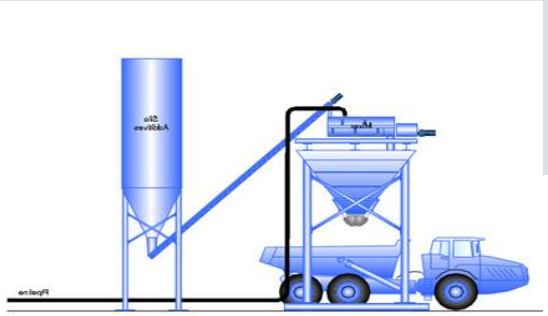


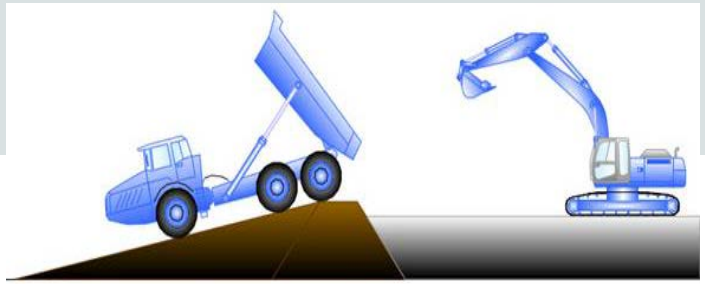
Formulation	Résistance moyenne prédite (MPa)	Intervalle de confiance à 95 % (MPa)	Résistance à la compression moyenne mesurée expérimentalement (± écart-type) (MPa)
C50 L35 MK15	57,82	[56,14 – 59,50]	56,01 (0,69)
C50 L35 V15	64,52	[60,54 – 68,49]	64,66 (0,25)
C50 L35 CV15	64,69	[61,24 – 68,15]	65,08 (1,32)
C50 L35 SFC15	63,83	[60,75 – 66,91]	64,90 (0,70)

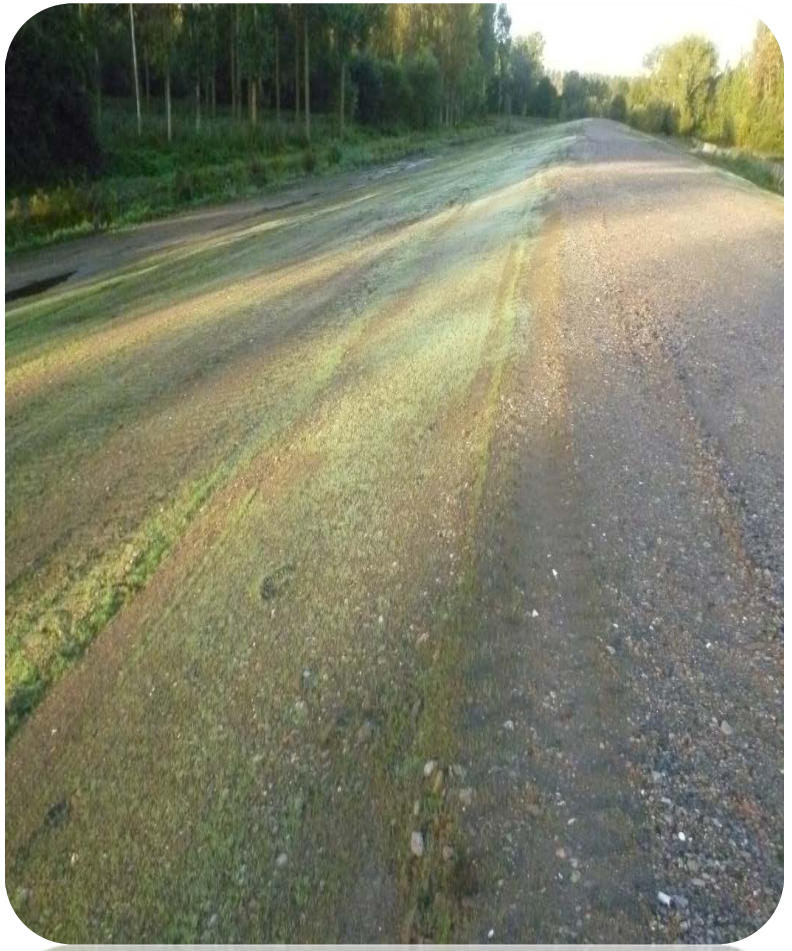
PRISMA

Exemple:
Projet Interreg









PRISMA

Valorization of river sediments in the construction of dike

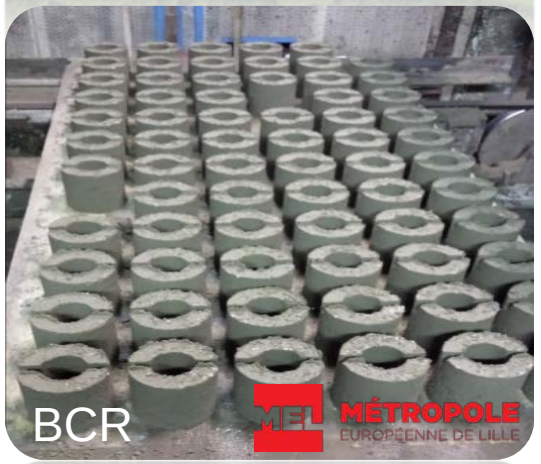

Road


Erosion protection


Géotunnel UK


Dike Antwerp


Géotube



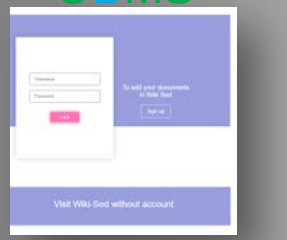

Artificial aggregates


Street furniture


Self-compacting concrete

Operational approach to the valorization of alternative materials
Ongoing development and prospects

OBMS



OGMS

ORMS

OPLASTMS

Durabilité des matrices cimentaires à base de sédiments de dragage

Thèse
A. Safhi

Formulation expérimentale par la méthode DMDA

Thèse
P. OUEDRAOGO

Valorisation Matrices polymériques

Thèse
I. ENNAHAL

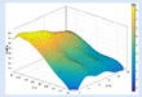
Modélisation des contraintes opp de la valorisation des sédiments

Thèse
A. ZERAOUI

Valorisation du verre dans une matrice cimentaire

Thèse
A. BOUCHIKHI

Modélisattion de la compacité granulaire



P. Doc
S. Benturkia

Impression 3D Covlorisation sed – A. lin- FVPR

PHD
J. Daher

Valorisation terres excavées en industrie cimentaire

MAA
J. Kleib

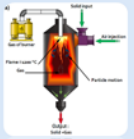
Traiment déchets: approche environnementale

P. Doc
A. Mahmat Ahmet

Covalorisation béton célulaire

thèse
H. El mouaden

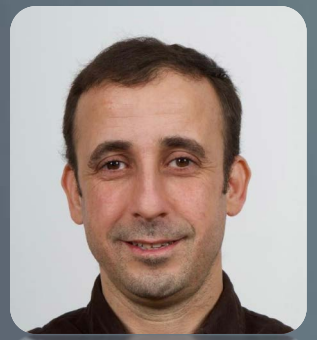
Valorisation par calcination et flash calcinantion



thèse
C. Duc Chinh

thèse - post doc (2020 2022)

Contact:
mahfoud.benzerzour@imt-nord-europe.fr



Merci

Laboratoire Génie Civil et géo-Environnement Lille Nord de France

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École Mines-Télécom
IMT-Université de Lille

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UdS Université de Sherbrooke