COST Action
TU 1402

Quantifying the Value of Structural Health Monitoring

Chlorides induced corrosion on TMDC5 Wharf - St Nazaire

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Industry Innovation Days – Workshop hosted by BRISA Group in Lisbon, 19th and 20th April 2018

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Global overview

- Role of wharves and societal value

- 80% of the world overseas trade (99% in USA) passes through ports
- Key role in European defence
- 3 millions people are employed in the maritime transport sector in Europe

- Stakes for maintenance

- In France: 106 km of wharves, among which 64 km are built with a reinforced concrete platform
- In a concrete platform: 350 m in length means 1,6 km of beams
- In France: €13 millions per year are spent for curative maintenance
- In USA: plan to spend $154.8 billion from 2016 to 2020

- *Source: [Boero et al, 2009] [2017 USA Infrastructure Report Card]*

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The structure and the partnership

Existing video on youtube:
https://www.youtube.com/watch?v=h9u6l0aT9Ys
220 views (6 months)

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The structure and the monitoring

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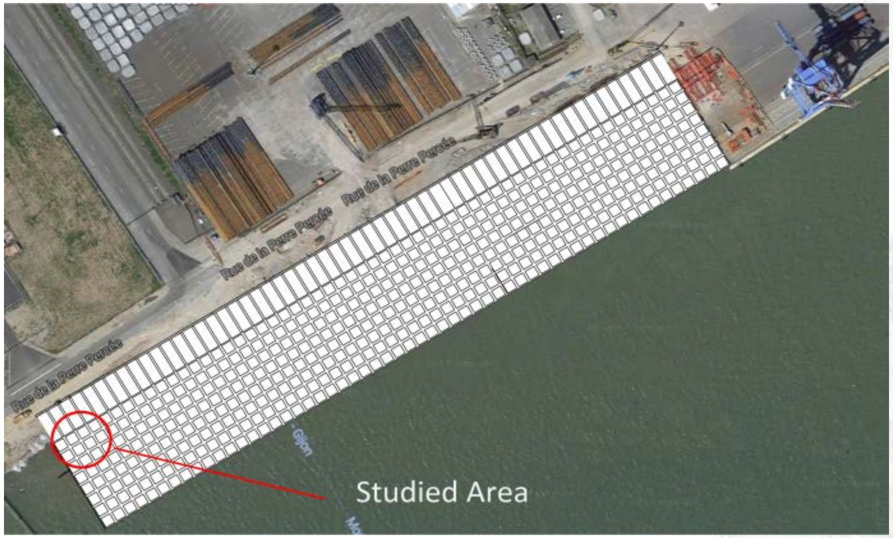
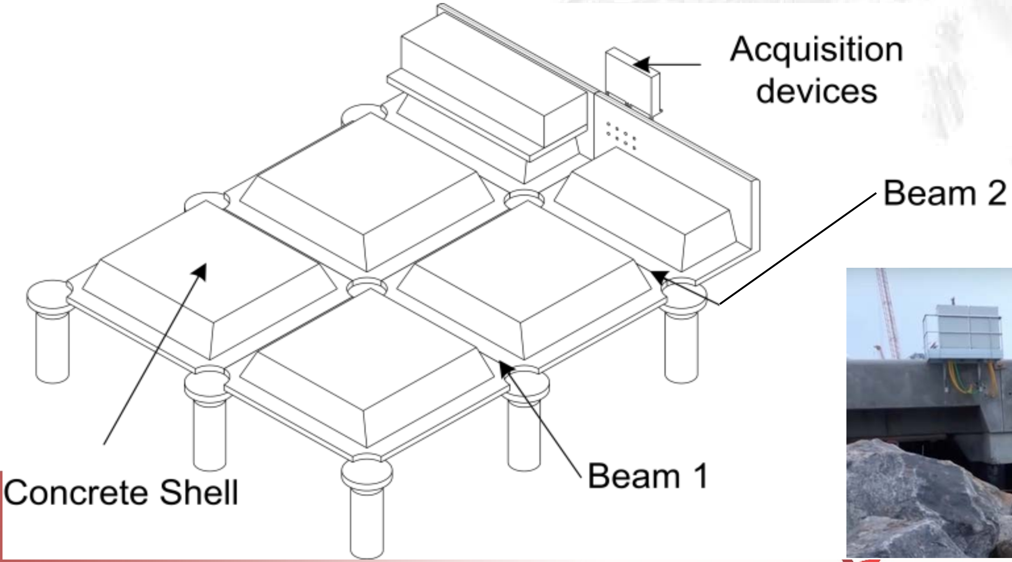
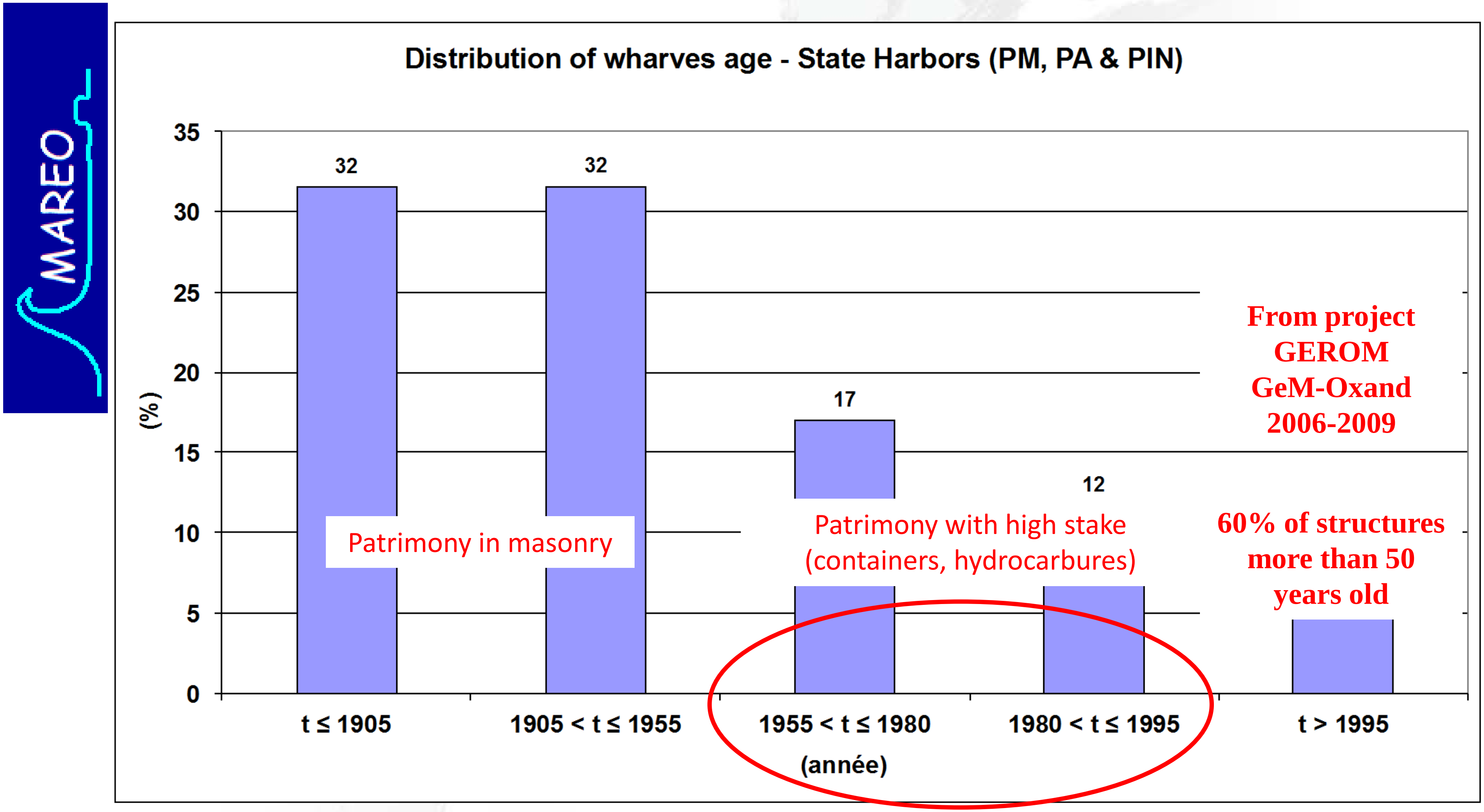
The structure and the monitoring





Access >> additional costs of inspection and repair

Prior knowledge about coastal infrastructures



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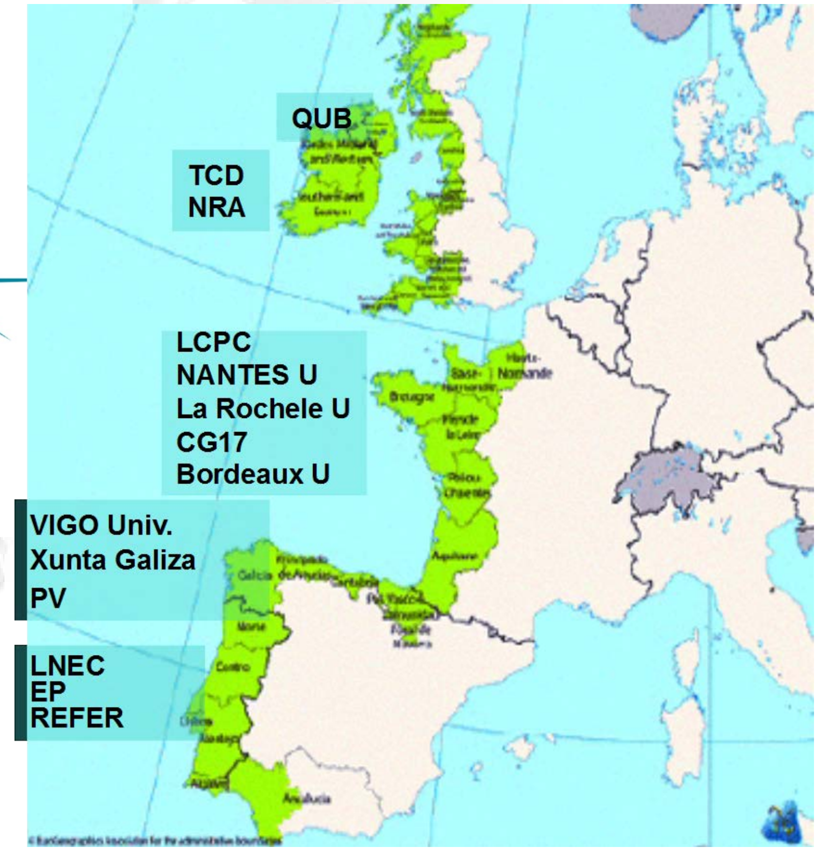
Prior knowledge about coastal infrastructures

duratiNet

Durable **T**ransport **I**nfrastructures in the Atlantic Area **Net**work



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European Regional Development Fund

Investing in our common future

ATLANTIC AREA
Transnational Programme

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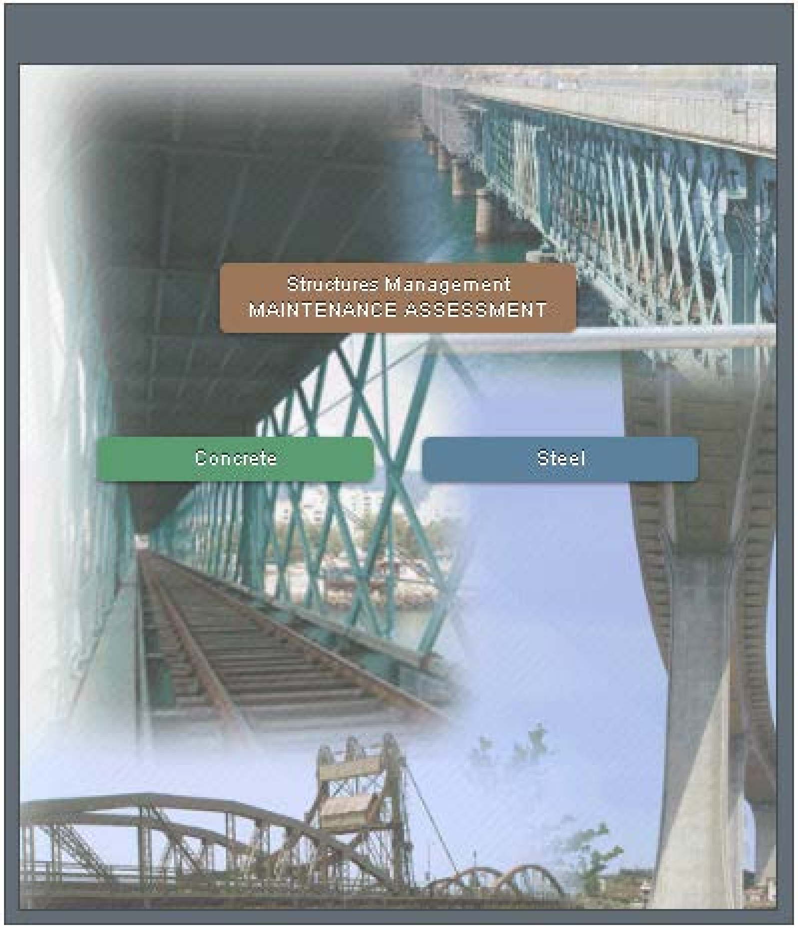
Prior knowledge about coastal infrastructures

DuratiNet Technical Guide – Web



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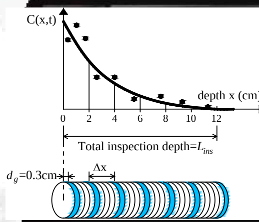
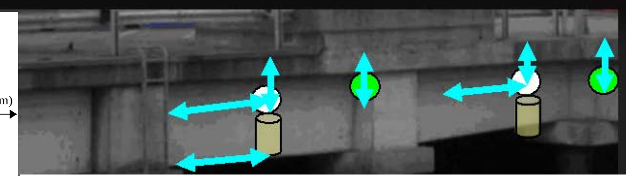
1. Decision scenario: preventive maintenance based on condition assessment

1.1 Decision based on which indicator What do we detect ?

- **Indirect** measurement of Chlorides near the rebar or in the whole thickness
- **Threshold** (large uncertainty) => chloride induced corrosion
- Spatial distribution

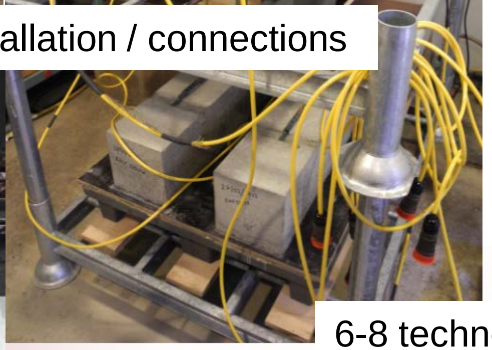
SDT





Complex multi-stages process with large uncertainties

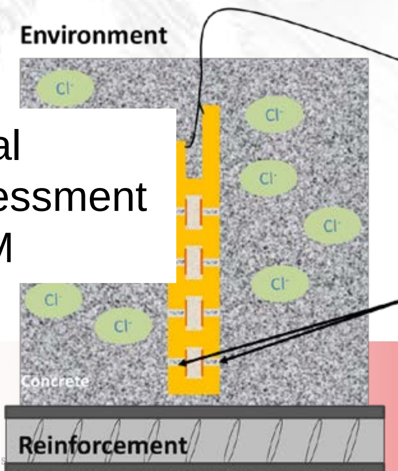
Complexity of manufacturing / installation / connections



Global assessment SHM

6-8 technologies

Local assessment SHM



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1. Decision scenario

MAREO

1.2 What decision ?

- Inspect (Semi Destructive Testing tools)
- Monitor (SHM – limited life time)
- Maintenance Md (concrete removing) with several methods (d: depth)
- Preventive Mdi with several techniques
- Curative repair: change the steel rebar

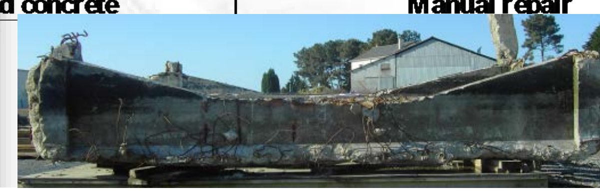
Partial concrete removing and replacement with 3 methods (cost/efficiency)

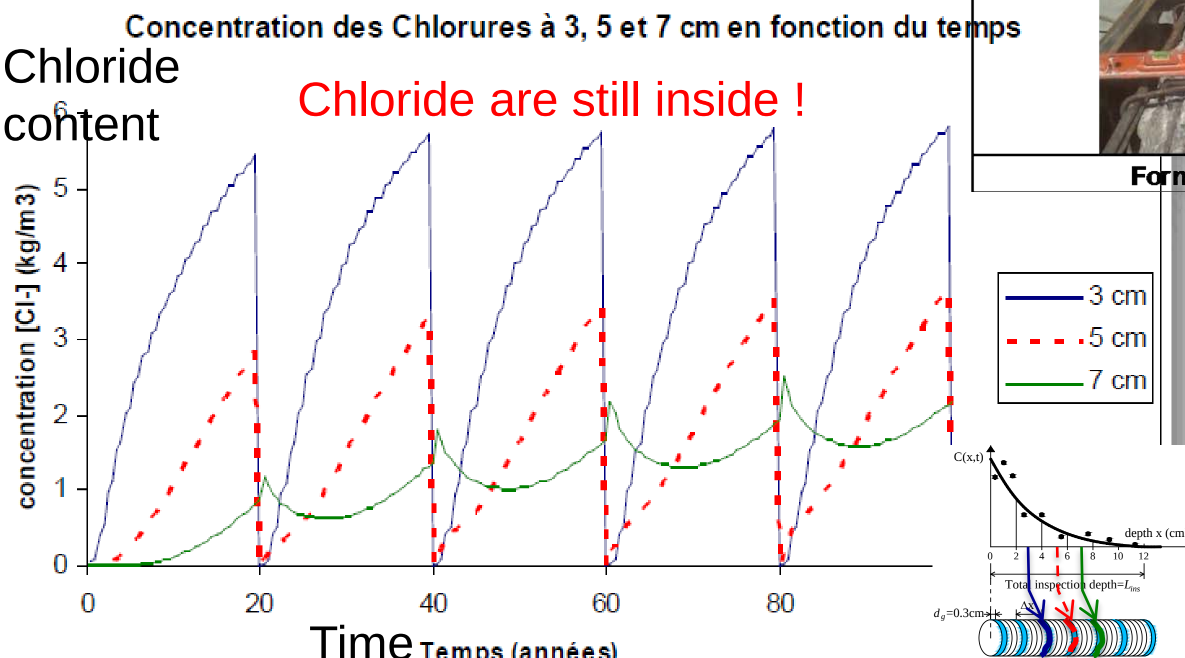
Beam after hydrodemolition

Wet/(dry) shotcrete

Formed concrete

Manual repair





Non perfect repair and **more complex after repair** (material changes and resilient chloride content) >> added value of SHM

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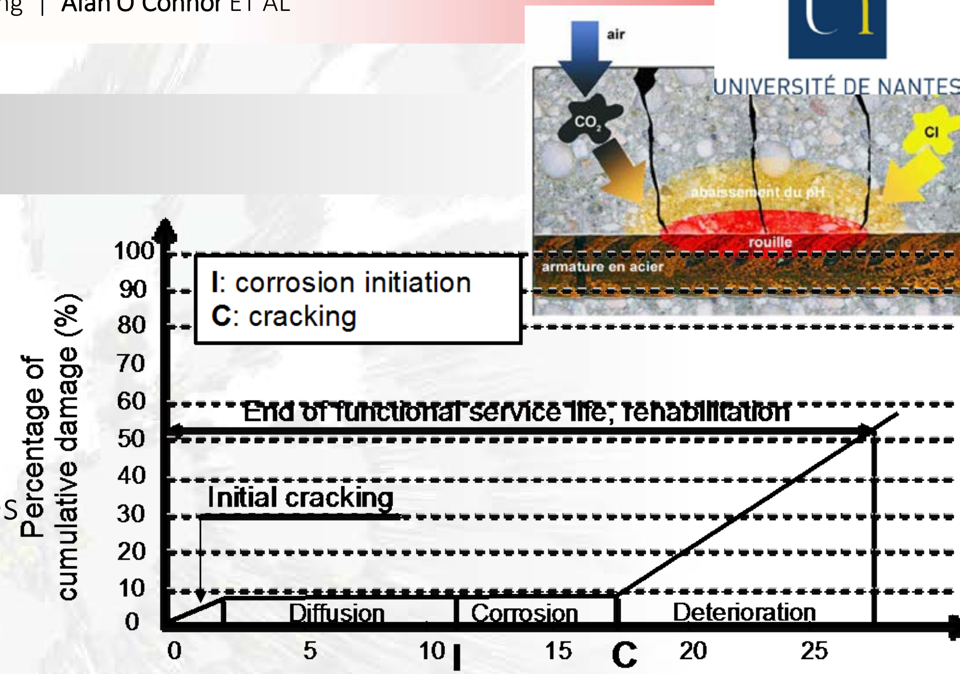
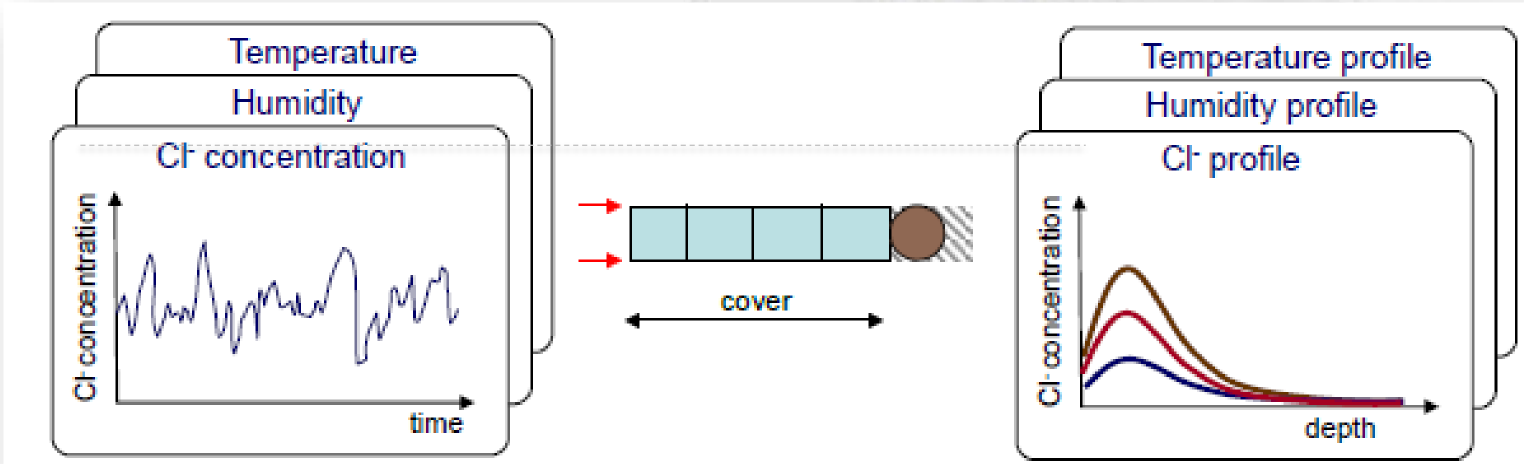
2. Methods applied

2.1 Simulate an hidden process

- Gama processes
- Bayesian networks
- Use key properties: stochastic properties of uncertainty of measurement and degradation processes are different





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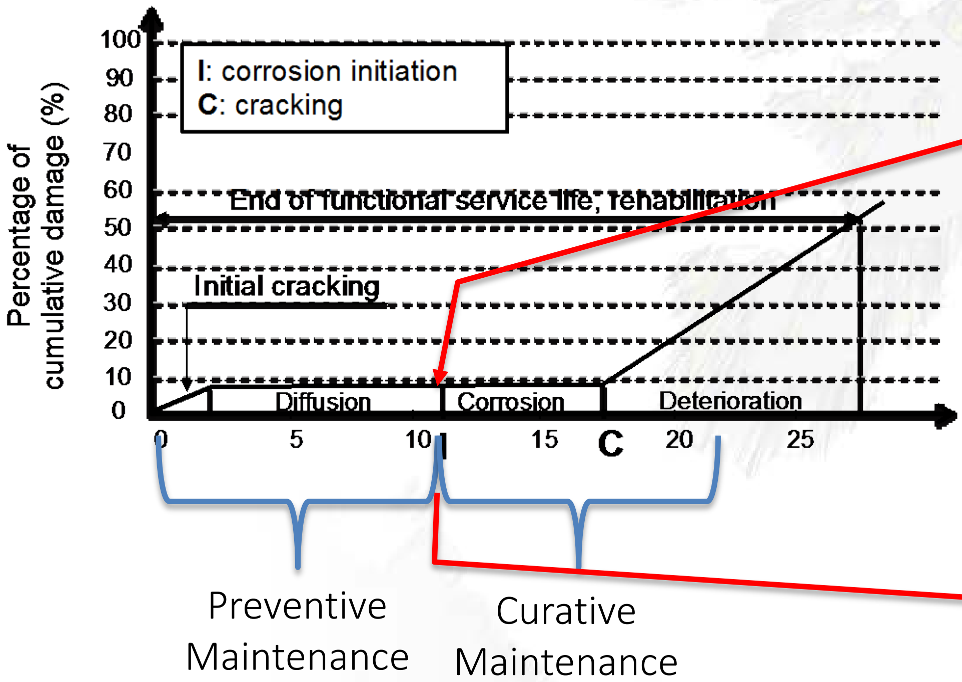
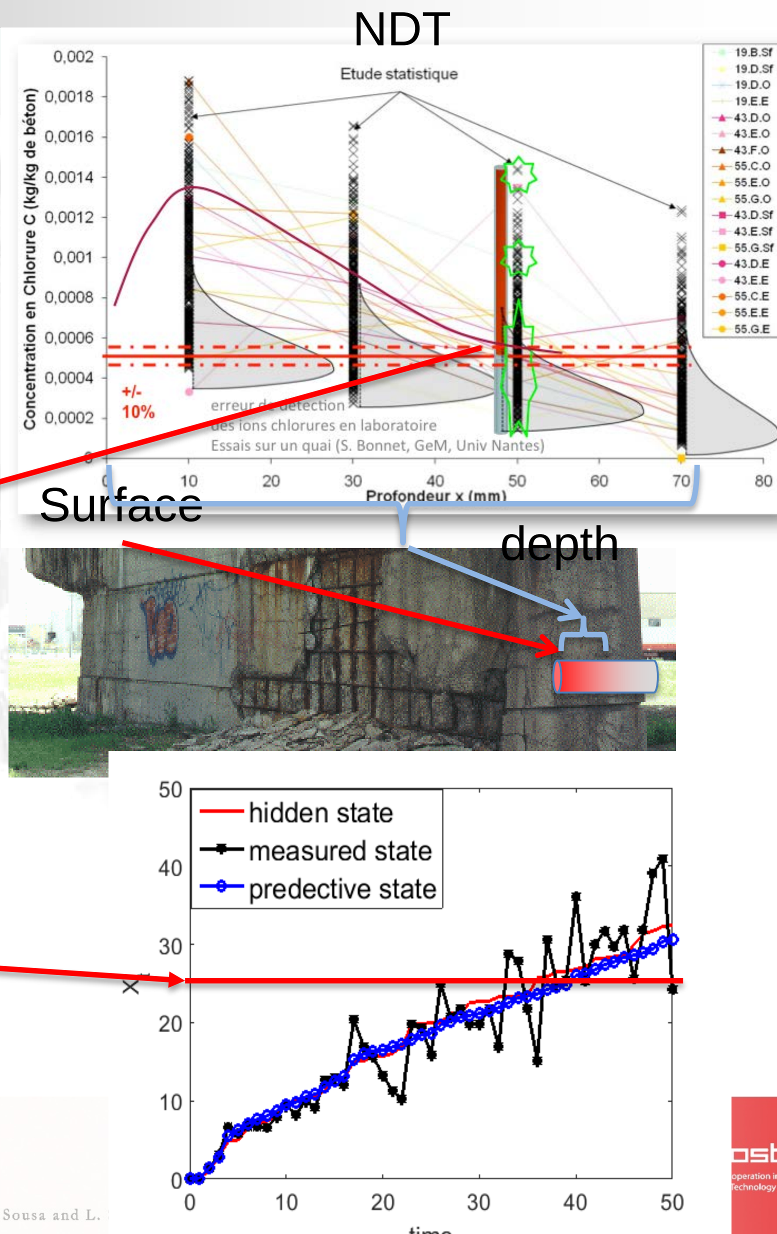
2. Methods applied

2.2 Simulate the actions with their uncertainties

- Gama processes
- Bayesian networks





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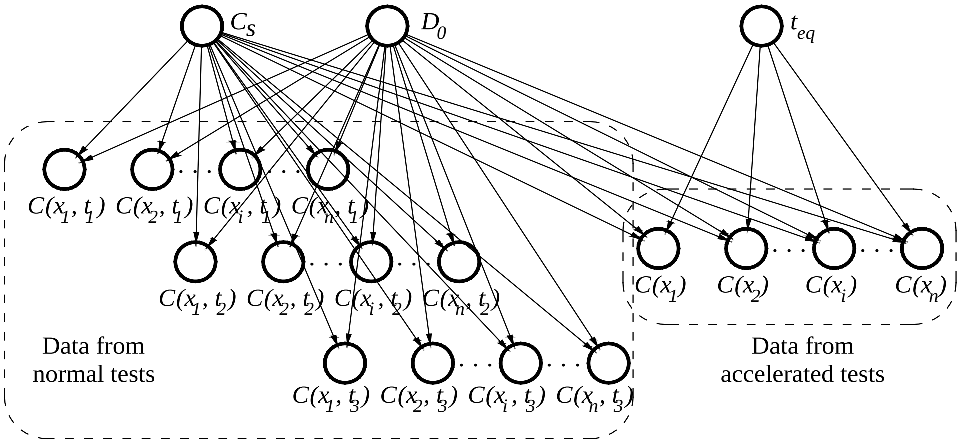
2. Methods applied

2.3 Improve the prediction with accelerated tests



BN: Advantages

Accounting for Uncertainties

Reduce time computational cost

>> computation of time scales from accelerated and natural ones onsite) -> acceleration factor

> better predictive model

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3. Results obtained

3.1 Assumptions

- Realistic costs from pas experience

Phase

bedding censors, tools and cabling

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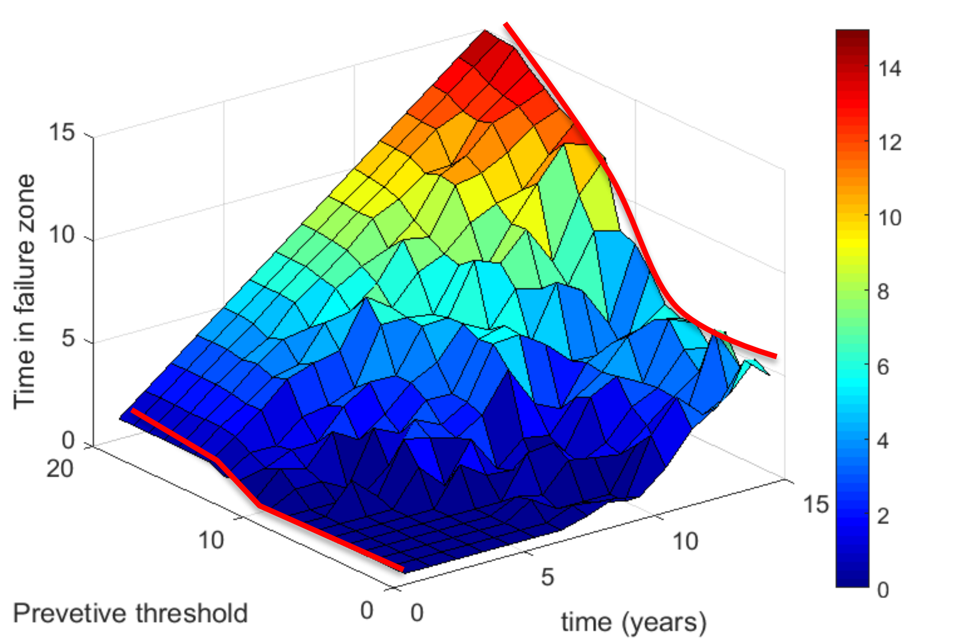
3. Results obtained

3.2 Optimization with SDT and NDT

- Find the time interval of inspection that reduces the total expected cost
- Find the repair threshold (not necessary initiation of corrosion threshold) that reduce the cost or **time in failure zone**



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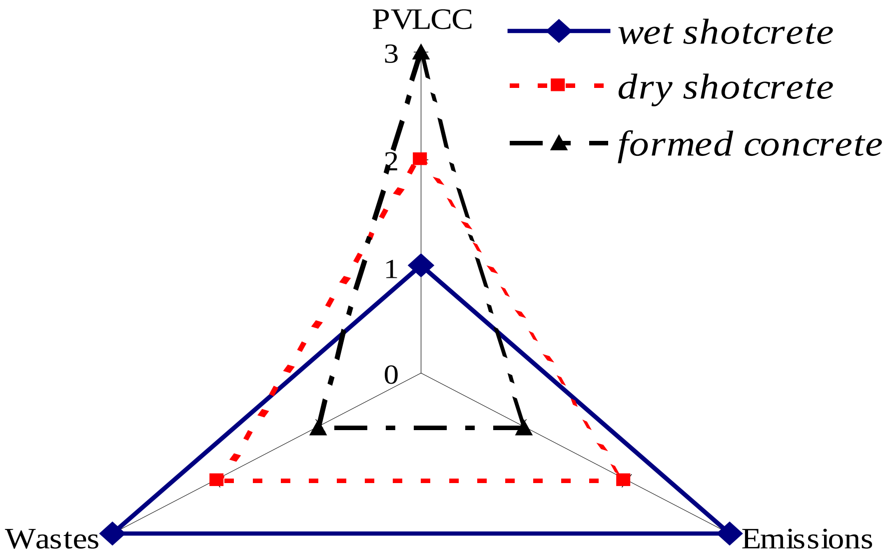
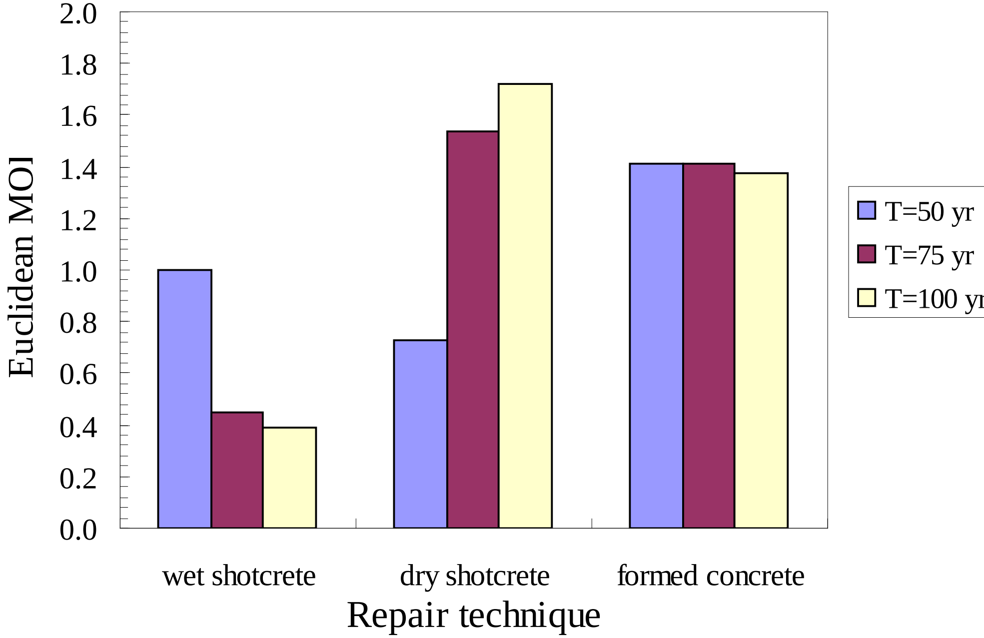
3. Results obtained

3.3 Comparison of repair techniques after cost optimization

- Include all the costs
- Analyze several required life-times





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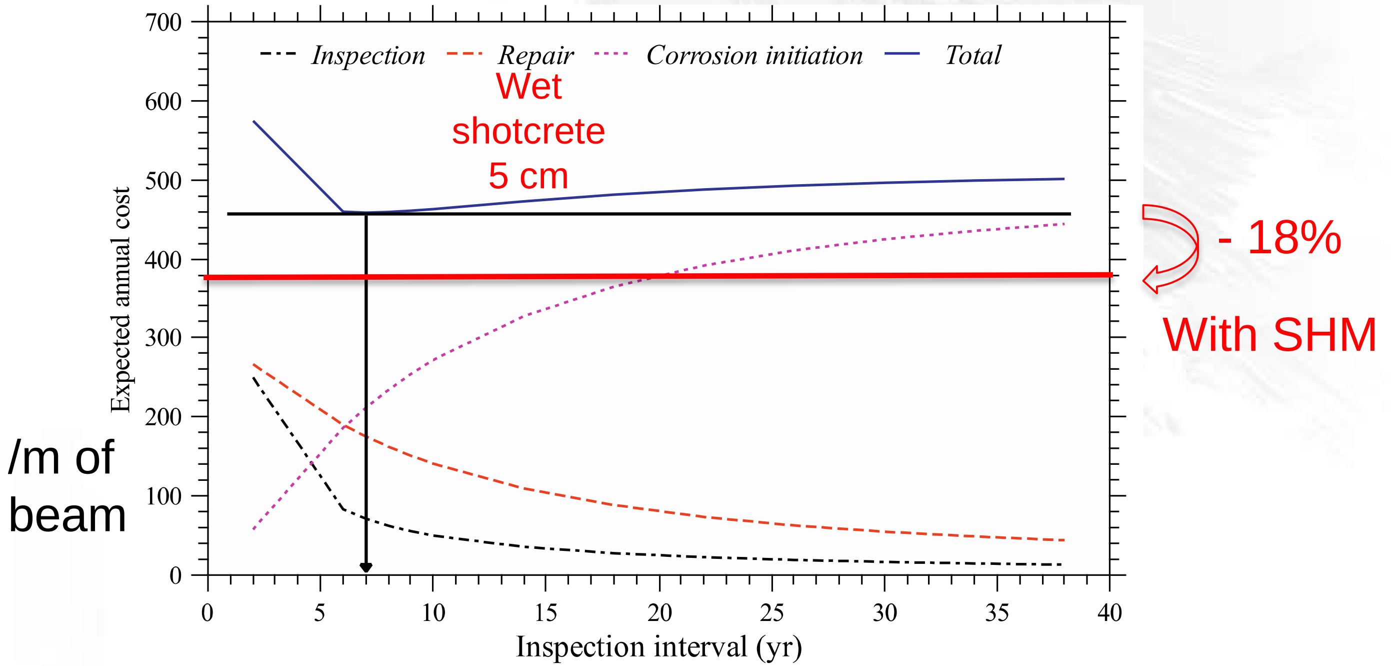
4. Value of the SHM information for the owner/concessionaire

4.1 Added value od SHM

- Computation of minimum maintenance expected cost with SDT
- Computation of minimum maintenance expected cost with SHM (10 years SLT global assessment)

1st results



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5. Open question addressed to decision makers

Is it acceptable for stakeholders to support accelerated tests during the 3-5 first years?

Is it acceptable to pay for sensors with 5-10 years lifetime? Do you need certification ? What type ?

Should we add sensor maintenance and maintainability of sensors ?

It there any feedback for existing chloride sensors?

Is it feasible to introduce monitoring early in the design process?

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Thank you for your attention

http://www.cost-tu1402.eu/

Activity 2: Problem Definition