
BUILDING A WORK PLAN


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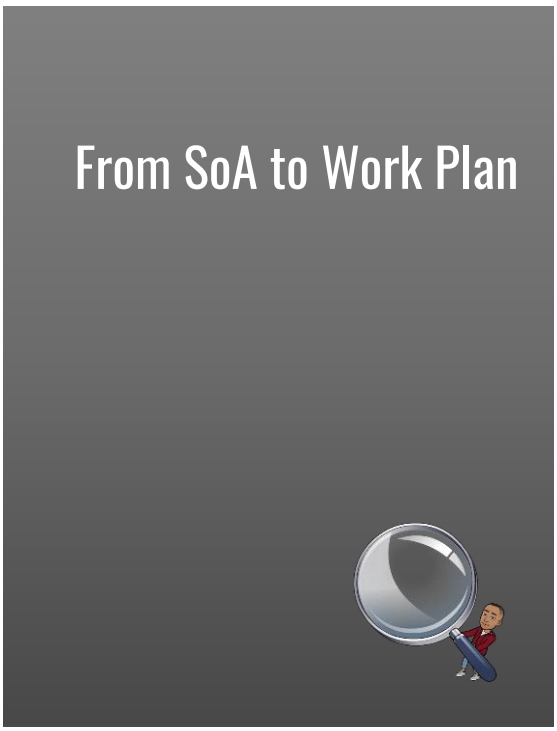
From SoA to Work Plan

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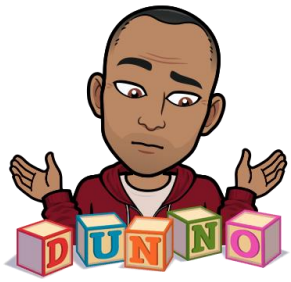
From SoA to Work Plan

- You have a crictical state of the art, what is it useful for ?



Identify what can be used in your project

Identify what is lacking

Build your work plan

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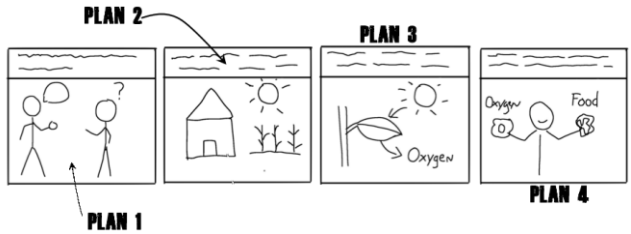
Writing your SoA : telling a convincing story

Make an outline : 1 idea / 1 paragraph



- Are the links between paragraphs logical ?
- Is it easy to understand what your final message is ?
- Could you use graphs/pictures to better illustrate and shorten text ?
- Are your arguments convincing and supported with enough literature ?

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From SoA to Work Plan : Example

A new generation of embedded ultrasonic transducers for real-time concrete structures monitoring

State of the art

- Introduce general context (concrete structures)
- Talk about current maintenance strategies and ultrasonic testing
- Focus on embedded transducers and their advantages
- Discuss their current design
- Discuss importance of coating layers and how to optimize them
- Identify the gap(s) in the SOA (to define your goals)

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SoA : General context and focus on maintenance

Introduction of context

Concrete is the most widely used construction material in the world. It is used in safety critical civil constructions such as bridges, dams, nuclear power plants, nuclear waste containers and skyscrapers, for which a permanent evaluation of the quality of the concrete is necessary to ensure safe and efficient maintenance.

Focus on maintenance and ultrasonic testing

Current maintenance strategies are generally cost intensive and rely on scheduled manual inspections. Among the numerous existing technologies for concrete structures, manual ultrasonic testing using external piezoelectric probes is a current practice (Figure 1a).

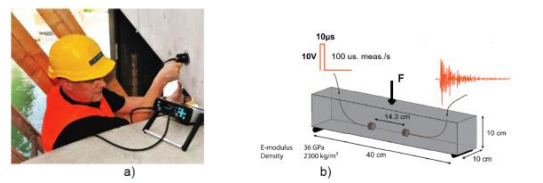

Figure 1: a) Manual ultrasonic testing using external probes. b) automated ultrasonic testing using embedded transducers

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SoA : Focus on embedded transducers and advantages

Focus on the use of embedded transducers

In the last ten years, a few research groups, mainly in the US, in China and in our group at ULB-BATir have proposed to perform ultrasonic testing of concrete using low-cost embedded piezoelectric transducers instead of the bulky and expensive external probes [1-5]. The main advantage of this technique is that the monitoring can be performed on-line (Figure 1b) and in inaccessible locations.

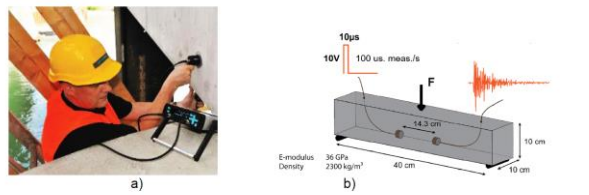

Figure 1: a) Manual ultrasonic testing using external probes. b) automated ultrasonic testing using embedded transducers

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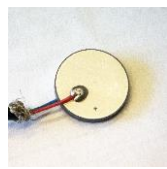
SoA : Discuss current design of embedded transducers

Design of embedded transducers

As the embedded transducers must act both as actuators and sensors, the best choice for the piezoelectric material is PZT (lead zirconate titanate). Some authors have also proposed the use of composite cement-based PZT transducers [6], but as demonstrated in [7] the improvement with respect to bulk PZT is marginal for these types of applications, and the associated costs are prohibitive.



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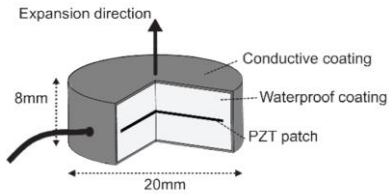
SoA : Discuss current design of embedded transducers

Importance of coating layers

PZT ceramics cannot however be embedded as such in the concrete: the PZT is a brittle material which must therefore be mechanically protected to avoid failure during concrete casting, waterproofing is a necessity, both for durability and to avoid capacitive coupling between the different transducers, and electromechanical shielding is important to avoid interferences. For these reasons, several coating layers are used in the fabrication process (Figure 2).



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SoA : Discuss importance of coating layers

How to optimize the design of coating layers

These layers have an effect on the intensity of the wave which can be measured/sent in the concrete, but this aspect has not been addressed in the literature, until very recently in our team [8]. The proposed approach is based on a multi-physical numerical modeling of the transducer embedded in an infinite concrete medium

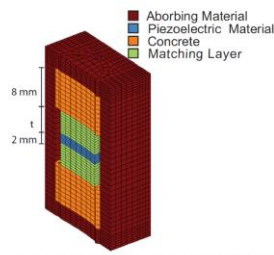

Figure 3: Example of a numerical model of a piezoelectric disk with surrounding layers embedded in an infinite material [8]

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SoA : Identify the gap(s)

So what is missing ?

There are however some limitations to the approach presented, the main one being the fact that the computations are made in the frequency domain considering harmonic excitation, a common approach found in the literature.

Using simple 1D models and time domain computations, we have very recently discovered that for this specific application, approaches based on harmonic excitation are not fully representative of the behavior of the wave under impulse excitation, which is mainly dependent on the transient part of the response, rather than the steady state regime.

This was also confirmed by preliminary laboratory tests on a concrete sample with two ultrasonic transducers

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Defining the objectives

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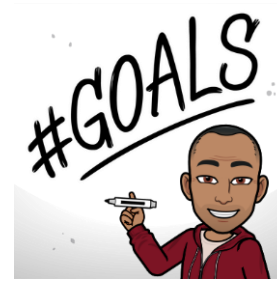
Objectives and means

Define clearly your objectives

Main objective (what ?)

This project aims at addressing the question of the optimal design of embedded piezoelectric transducers for on-line concrete monitoring applications.

The final goal is to design, manufacture, and validate experimentally a new generation of embedded piezoelectric transducers for concrete monitoring.



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Objectives

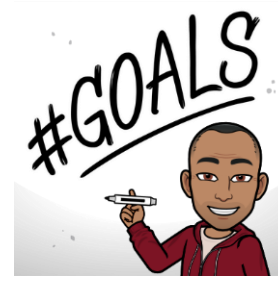
Define how you plan to reach them

Means (how ?)

The approach is based on detailed numerical models of the multi-layer transducers and the host medium (concrete). The aim is to be able to predict accurately in the time domain the wave propagation from the emitter to the receiver, including the effect of the coating layers, the coupling with host medium and the transducer's dynamics.

This requires extending the current approach in the frequency domain to the time domain.

Low computational costs are essential to use such detailed models for design optimization. Efficient model reduction techniques are therefore also developed in this project.



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Building the Work Plan

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Methodology

- Develop a methodology to reach your objectives
  - Divide your work into tasks/work packages (related to objectives)
  - Link the tasks together (Pert chart)
  - Make a provisional timeline (Gantt Chart)

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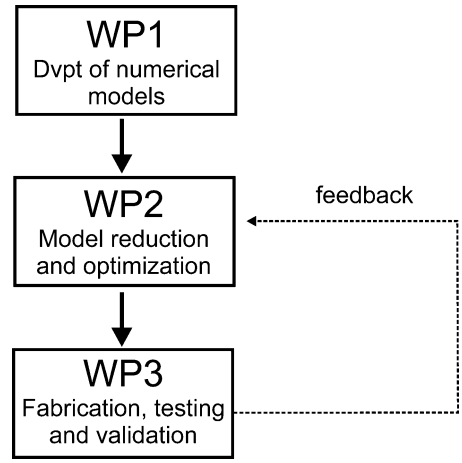
Making a Pert chart : overview of the project

- Define WPs wrt objectives
- Link WPs with arrows



! Do not use general WPs such as « Master thesis writing », or « Preparation of oral defense » in the Pert chart

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WP description : introduction

WP1 : Numerical modelling of embedded piezoelectric transducers in the time domain under impulse excitation

It is of common practice to evaluate the performances of ultrasonic transducers in the frequency domain, which was done in [8]. The model was developed in the Structural Dynamics Toolbox (SDT – http://www.sdtools.com) under Matlab which allows to model the piezoelectric effect in the transducers, as well as the infinite boundary conditions for the host medium [9-10] – Figure 3.

We have recently performed simple one-dimensional simulations that show that harmonic excitation is not fully representative of the performance of the transducer when excited with an impulse signal, where the transient effects play a major role. This calls for an extension of the existing models to perform transient simulations in the time-domain.

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WP description : specific tasks

WP1 : Numerical modelling of embedded piezoelectric transducers in the time domain under impulse excitation

Building on the existing models in SDT, the extension to the time-domain transient simulations can be performed using two main approaches:

- Task 1 : Using time-domain solvers and developing specific infinite boundary conditions elements
- Task 2 : Using frequency domain solvers and the existing infinite boundary conditions elements to compute impulse responses through inverse Fourier transform, and convolution in the time domain (Duhamel's integral approach).

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WP description : detailing tasks and proposing deliverables

For the first approach, literature exists in the field [11], but specific developments need to be made in the SDT software. The second approach is not commonly used and is based on recent unpublished developments of the author of this proposal, and may be of high interest to reduce the high computational costs associated with the first technique.

For both approaches, as efficient implementation of the technique in the SDT architecture is essential in order to lower the computational costs, subcontracting and collaboration with the company SDTools (which develops SDT) is an important ingredient for the success of the project.

Deliverables:
D1: numerical models of piezoelectric transducers embedded in an infinite medium in SDT for time-domain computations.

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Making a timeline : the Gantt chart

	Year 1				Year 2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
WP 1 : Dvpt of numerical models								
WP 2 : Model reduction and optimization								
WP 3 : Fabrication, testing and Validation								

Or more detailed with the different tasks …

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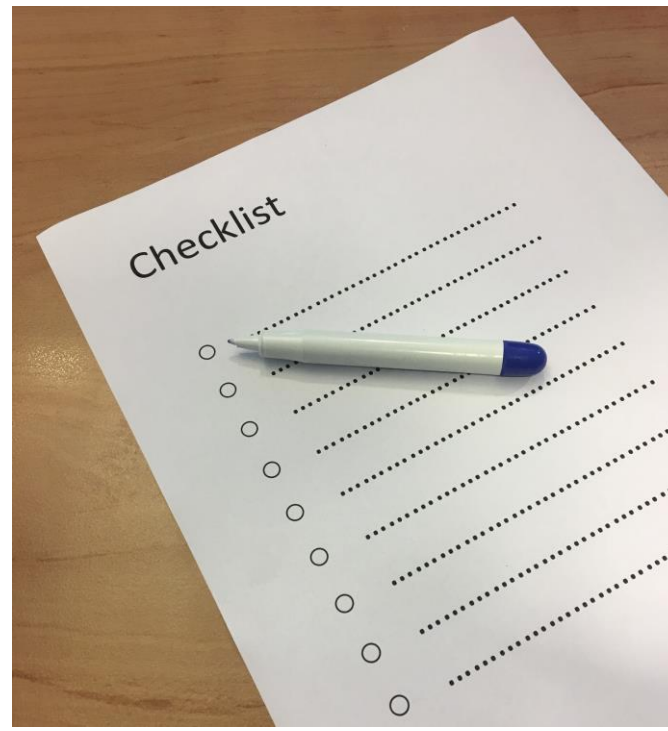
Summary for the report



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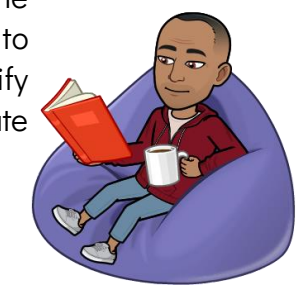
Summary for report

- **A short abstract** (½ page)

- **An introduction** giving the background, context and motivation and general objective of the work (1-2 pages)

- **A critical and structured state of the art** containing the most important references, a description of the relevant information from these publications and their link with the topic of the research, as well as their adequacy or limitations with respect to the problem treated. The state of the art should clearly identify the gaps in the existing methods/applications which motivate the research and define the goals. (2-3 pages)



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Summary for report

- **A clear and structured work plan**. The work plan should be clearly linked to the gaps identified in the state of the art and be aimed at filling these gaps, by proposing specific methods. In doing so, the work should be structured in tasks, which are themselves gathered in work packages. A Pert chart showing the links between work packages and tasks (which output result is used as an input to which task?) should be included (2-3 pages)

- **A tentative schedule**. At this stage it is important to imagine how the tasks defined in the work plan should be arranged in time in order to finalize the research work by the end of the academic year. As always in research, this is only tentative and will be used as an adaptable roadmap during the thesis. (1 page)

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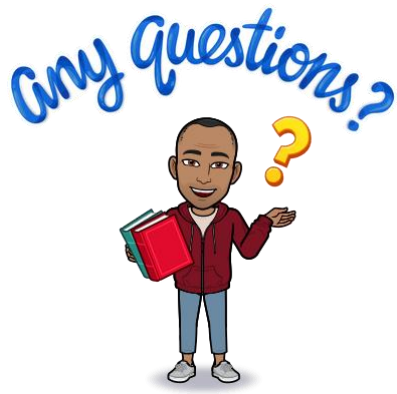

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