Postdoctoral position in nonlinear dynamics

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Project overview

- **Title: L**imitation of offshore windturbines **O**scillations using a tra**CK NES** [***L****imitation des* ***O****scillations d'éoliennes offshore au moyen d'un tra****CK NES***] — **LOCKNES**
- **Duration:** 1 year, start between 01/01/2026 and 01/09/2026
- **Funding:** ANR — institut Carnot MERS

Scientific context and objectives

Energy production is a critical challenge for modern society. In France, offshore wind power stands out as one of the most viable solutions, given its high production capacity, the number of exploitable sites, and the relatively rapid deployment of wind farms [1]. As wind turbines grow in size to maximise efficiency, their increasingly slender structures become more susceptible to vibrations. Effective vibration control is essential to prevent stress levels that could disrupt operations, trigger shutdowns, or, worst of all, shorten the structure's lifespan. It is therefore necessary to develop more efficient vibration absorbers to protect wind turbines from the many stresses they endure [2]. An example of a wind turbine equipped with a vibration absorber is illustrated in Fig. 1.

Wind turbines are complex systems, subject to excitation from wind and waves. Their structural properties (mass and stiffness) are influenced by aero-hydrodynamic interactions, rotational speed, material or structural wear, and, in the case of monopile or fixed-bottom turbines, interactions with the seabed [3, 4]. These properties can change over time, altering the natural frequencies at which the turbine is most sensitive [4, 5]. This renders conventional vibration absorbers ineffective, as they are tuned to fixed frequencies. While active absorption methods can adapt to such changes, their reliance on external power sources is a significant limitation.

Nonlinear Energy Sinks (NES) are essentially nonlinear vibration absorbers which can tune themselves to a wide range of frequencies, making them inherently robust against changes in the primary structure's natural frequencies [6, 7]. When the NES resonance frequency approaches one of the structure's, a locking occurs, triggering an irreversible energy transfer from the structure to the NES, thereby mitigating vibrations. Optimising NES performance, particularly for offshore wind turbines, is an active and evolving area of research [5, 7].

Innovative NES designs are currently under investigation, including track NES, which consist of a mass rolling on two tracks (see Fig. 2a, b). The rolling tracks' geometry dictates the path of the centre of mass, effectively defining the NES stiffness through the action of gravity. This design thus offers a practical way to control and adjust the stiffness of the NES. These promising devices absorb energy from the primary system (in this case, the wind turbine) through pure translational motion. While the absorption performance of these devices scales with mass, much like conventional

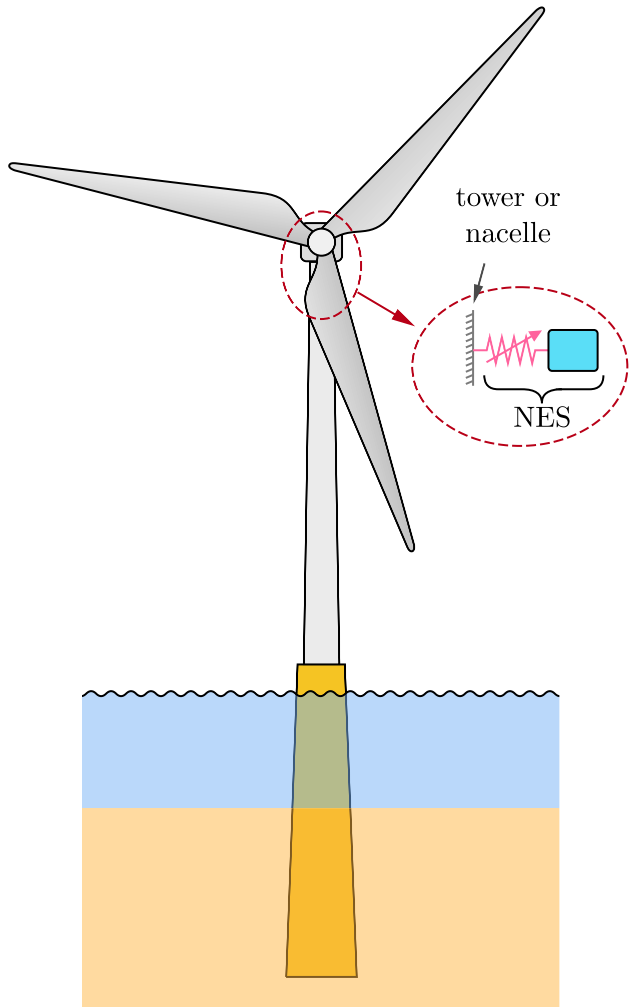


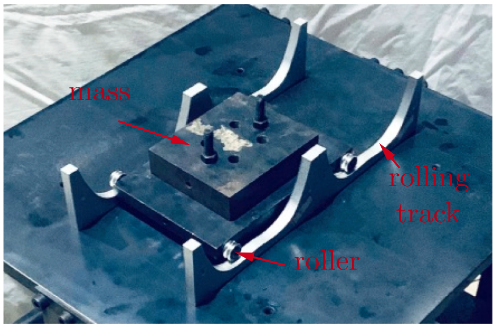
Figure 1: Monopile offshore wind turbine equipped with a NES.

absorbers, practical constraints limit their physical mass. While the absorption performance of these devices scales with mass, much like conventional absorbers, practical constraints limit their physical mass. The design freedom is more on the shape of the rolling tracks. The LOCKNES project will therefore focus its effort on the improvement of the rolling tracks to improve the NES performance, drawing inspiration from other absorbers from the literature [9].

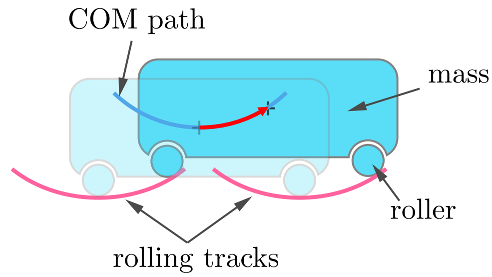
Methodology

The study will begin with a simplified system consisting in a wind turbine model represented as a single degree-of-freedom (dof) oscillator equipped with a track NES. Using this 2-dof model, the following developments are planned:

- Development of a Python code to calculate the rolling tracks' geometry, ensuring the NES's centre of mass follows a prescribed kinematic motion,
- Analytical investigation of the system's dynamics, employing NES-specific tools and an existing formal calculus code for perturbation analysis,



a)



b)

Figure 2: (a) Track NES used to mitigate the vibrations of a building, adapted from [8], (b) track NES principle.

- Establishment of guidelines for the path and rotation law from the analytical results that optimise the NES efficiency,
- Implementation of a finite difference Python code to validate the analytical results against numerical ones.

In the second phase, the effectiveness of the track NES will be validated using a realistic offshore wind turbine model. This phase will involve:

- Modelling the wind turbine and its excitation, drawing on relevant literature for inspiration,
- Creation of a finite element model of the wind turbine, with the NES incorporated as an additional dof,
- Assessment of the track NES's performance under realistic operating conditions.

Contributions

The postdoctoral researcher is expected to make the following contributions to the project:

- Development of a code to design a track NES with controlled mass and stiffness properties,
- Establishment of guidelines to dimensionalise a track NES,
- Evaluation of a track NES's effectiveness using a realistic wind turbine model,
- Publication of research work in a peer-reviewed journal and presentation in a conference.

Skills developed

Through this project, the candidate will have the opportunity to develop expertise in:

- Kinematic computation to design a system with a prescribed motion,
- Analytical tools for the study of (nonlinear) dynamical systems,
- Finite Element Analysis.

Research Environment

Host Institution

Founded in 2004, GeM is a Joint Research Unit of Nantes Université, Centrale Nantes, and the CNRS (UMR-6183). It brings together all the expertise in civil engineering, materials mechanics and processes, and modelling and simulation in structural mechanics from the Nantes Saint-Nazaire metropolitan area within a single laboratory.

Team and Collaborations

The postdoctoral researcher will join the laboratory's structural dynamics research unit, a team comprising 14 permanent researchers, including nonlinear dynamics specialists Vincent Mahé and Mathias Legrand, as well as 6 PhD and postdoctoral researchers.

This project shares strong interests with ongoing work at the École de l'Air et de l'Espace (EAE) on the design of nonlinear absorbers and isolators applied to the vibration control of aerospace structures [10]. As part of this project, a collaboration is planned to build on the expertise of Benjamin Chouvion, particularly regarding the underlying physical phenomena and optimisation techniques for NES design [10, 11].

Location

The campus of Centrale Nantes is located along the Erdre river, close from the centre of Nantes, and is easily accessible with common transportation or by bike. The campus comprises about 3500 persons, including about 2000 students, and offers several cultural activities (sports and others). Nantes is a pleasant dynamic city with a rich cultural scene, a nice historical district and many green spaces along its rivers and parks.

A one week stay at the EAE, in Salon de Provence, is planned as part of the project.

Postdoc position

Candidate Profile

The candidate should fulfil the following requirements:

- PhD in structural dynamics or a related field,
- Proficiency in English and/or French.

The following skills would be an asset:

- Experience in analytical analysis,
- Experience in nonlinear vibrations,
- Familiarity with programming tools, preferably Python,
- Ability to write scientific papers for journal publication.

Position details

- Salary: 60 000€ gross per year
- Contract duration: 12 months
- Start date: between 01/01/2026 and 01/09/2026
- Location: École Centrale de Nantes, Nantes, France

- Benefits: subsidised on-site restaurant, public transportation, cultural activities

Application Process

Applicants should submit the following materials:
- Academic CV,
- Your best journal paper, report, or presentation (according to you),
- Names and contact information of two academic references,
- Any additional supporting materials (e.g., publications, reports, letters of recommendation).

Applications are being accepted immediately and will be considered in the weeks following receipt.

Contact Information

For inquiries or to submit an application, please contact:

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