



# PhD in ARCHITETTURA, INGEGNERIA DELLE COSTRUZIONI E AMBIENTE COSTRUITO / ARCHITECTURE, BUILT ENVIRONMENT AND CONSTRUCTION ENGINEERING - 40th cycle

**PNRR 630 Research Field: MICROWAVE REMOTE SENSING: AN INNOVATIVE METHODOLOGY IN TESTING AND HEALTH MONITORING OF INFRASTRUCTURES AND CULTURAL HERITAGE BUILDINGS**

Monthly net income of PhDscholarship (max 36 months)
<b>€ 1400.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
<p><b>Motivation and objectives of the research in this field</b></p>	<p>Microwave remote sensing is the most recent experimental technique suitable to the non-contact measurement of deformations on large structures, in static or dynamic conditions. The main ideas of the microwave-based measurement of deflections are: (1) to employ a radar to take consecutive images of the investigated structure; (2) to evaluate the displacement of each target detected in the images from the phase of the back-scattered electromagnetic waves collected at different times (microwave interferometry).</p> <p>In the non-contact radar-based measurement of deflections, each discontinuity of a structure (such as the "corner zones" corresponding to the intersection of girders and cross-beams in the deck of bridges) represents a potential source of reflection of the electromagnetic waves generated by the radar: hence, an echo can be generated and the corner zones act as a series of virtual sensors. The results of the currently available microwave interferometer, developed by the Italian company IDS (Ingegneria dei Sistemi, Pisa), were validated by the team involved in the present research by assessing the equipment performances in ambient vibration testing of full-scale structures.</p>



	<p>The currently available radar interferometer, although providing with excellent performances in several tests, exhibits drawbacks preventing its use in long-term applications and structural health monitoring (SHM). Beyond the issues related to the high cost (that should be solved by changing the radar architecture), the main drawbacks are related to the real-time extraction of deformation time series from raw radar data and the use of such data within a statistical pattern recognition (SPR) process. Furthermore, the radar has only 1-D imaging capabilities, i.e. different targets can be individually detected if they are placed at different distances from the radar.</p> <p>On the other hand, the availability of a technology allowing the non-contact long-term monitoring of the displacement responses should represent an important step forward in Experimental Dynamics and especially in the SHM application to bridges and Cultural Heritage buildings.</p> <p>It should be observed that the team involved in the research has a wide experience in vibration-based SHM of structures and examples of permanently monitored structures currently managed include several bridges and historical monuments.</p>
<p><b>Methods and techniques that will be developed and used to carry out the research</b></p>	<p>Multi-disciplinary skills are required in the development of the present research program: a solid background on radar technology (i.e., range resolution, microwave interferometry, Stepped Frequency Continuous Wave techniques, etc.), signal processing in both time and frequency domain, operational modal analysis and experimental testing of full-scale structures.</p> <p>In order to provide the candidate with the requested skills especially in the field of radar technology, 6 months of internship in the offices of IDS (Ingegneria dei Sistemi, Pisa) has to be provisionally scheduled. It should be noticed that the Italian company IDS is world leader in the design and manufacturing of radar sensors and supports the present research with funding.</p> <p>It is further noticed that IDS is interested both in the practical application in SHM of the currently available microwave interferometers and in the validation of a new</p>



	<p>sensor coupling the capabilities of microwave interferometry and vision systems. In summary, after the acquisition of the basic required skills, the research program includes:</p> <ul style="list-style-type: none"> <li>•learning to use the two available radar sensors (with the first one being directly available in the Lab of Politecnico di Milano and the new one being made available from IDS);</li> <li>•using the equipment available in Politecnico in dynamic testing of full-scale structures (at least one bridge and one historical tower) to learn the basics of signal analysis, extraction of deformations and estimation of normal modes from deflection time series;</li> <li>•development of a methodology to extract in (nearly) real time the deformation time series from raw radar data (the storage of raw radar data requires huge mass memory and is hardly consistent with long-term monitoring) and to perform the feature extraction from deformation signals and the statistical modelling for feature classification (according to a SPR process). It should be noticed that the feature extraction stage conceivably involves the estimation of modal parameters;</li> <li>•using the radar equipment - newly developed by IDS - in both short- and long-time monitoring of full-scale structures to assess the performance of the new sensor and to validate its results by comparison with the data collected using conventional techniques;</li> <li>•applying both the new sensor and the developed methodologies of data analysis in the monitoring of bridges and historical buildings. It is worth mentioning that, during the PhD period, it is assumed that the candidate will spend 6 months of internship in a foreign University: the destination will be definitely decided after the first year of doctoral activities and in dependence on the status of the research.</li> </ul>
<b>Educational objectives</b>	During the PhD period, the applicant will become expert in



	During the PhD period, the applicant will become expert in the following fields: microwave-based methods of remote sensing, design and management of monitoring systems involving the use of microwave remote sensing, experimental dynamics and operational modal analysis, vibration-based novelty (damage) detection, scientific software development (Matlab and Phyton), non-destructive assessment of bridges and Cultural Heritage structures.
<b>Job opportunities</b>	Non-destructive testing, remote sensing and monitoring Assessment and management of bridges and infrastructures Preservation and management of Cultural heritage buildings Development of state-of-art software
<b>Composition of the research group</b>	1 Full Professors 1 Associated Professors 0 Assistant Professors 2 PhD Students
<b>Name of the research directors</b>	Prof. Carmelo Gentile

#### Contacts

email: [carmelo.gentile@polimi.it](mailto:carmelo.gentile@polimi.it)

#### Additional support - Financial aid per PhD student per year (gross amount)

<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

#### Scholarship Increase for a period abroad

<b>Amount monthly</b>	700.0 €
<b>By number of months</b>	6

#### National Operational Program for Research and Innovation

<b>Company where the candidate will attend the stage (name and brief description)</b>	IDS GeoRadar S.r.l.
<b>By number of months at the company</b>	6
<b>Institution or company where the candidate will spend the period abroad (name and brief description)</b>	to be defined
<b>By number of months abroad</b>	6



**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

**Additional support:**

**Budget for the research activity (only for positions supported by scholarship):**

total amount Euro 5707.20 per student

In detail:

- 1st year Euro 1902.40
- 2nd year Euro 1902.40
- 3rd year Euro 1902.40

**Additional information about the organization and regulations of ABC-PhD programme can be found in the Regulations for the 40th Cycle of ABC-PhD:**

download is available at link:

<https://www.dottorato.polimi.it/corsi-di-dottorato/architettura/architettura-ingegneria-delle-costruzioni-e-ambiente-costruito>

**Additional information about ABC department and ABC-PhD programme:**

available at link:

<https://www.dabc.polimi.it/>

**Desk availability:**

The ABC department provides non-permanent desks to be temporarily booked in common PhD rooms.