# Scientific Report

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| Nationality | Spanish |
| Name of the *Host Organisation* | Norges teknisk-naturvitenskapelige universitet – NTNU |
| First Name / family name of the *Scientific Coordinator* | U. Peter Svensson |
| Period of the fellowship | 1/09/2013 to 31/08/2014 |

# I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

The ERCIM fellowship provided me with the opportunity to work in the field of room acoustics, in particular, in diffraction modelling together with a reference researcher on the field, Prof. Peter Svensson.

The acoustic scattering from a rigid body can be modeled as a superposition of geometrical acoustics components (specular reflections) and edge diffraction components. Prof. Peter Svensson developed a recent edge source integral equation (ESIE) formulation to compute multiple-order of diffraction by using secondary-edge sources. Comparisons with reference results have been shown that formulations of secondary-edge-source methods, in particular Svensson's formulation, lose accuracy in some important cases like the case of non-convex bodies. An opening in a thin screen is considered as an example of non-convex body. As explained by J. E. Summers in his paper *Inaccuracy in the treatment of multiple-order diffraction by secondary-edge-source methods* published in the Journal of the Acoustical Society of America, this lose of accuracy comes from the fact that the current formulations of secondary-edge-sources methods neglect the phenomenon commonly called *slope diffraction* that is a well-known phenomenon from the high-frequency asymptotic methods known as the geometrical theory of diffraction (GTD) and uniform asymptotic theory of diffraction (UTD).

Slope diffraction occurs when a thin edge is hit by a zero-pressure field, but the gradient of the field violates the boundary conditions on the wedge, i.e., is a non-zero gradient wave. The current formulation of P. Svensson's method assumes that if any order of diffraction vanishes, i.e., the diffraction wave hitting a second edge has the amplitude zero, then the higher orders vanish as well. Therefore, the diffraction arising from a zero-pressure but non-zero gradient wave is neglected by the ESIE method.

The scientific activity during the ERCIM fellowship has been to exploring possibilities to introduce complementary (directional) edge sources of different types, in addition to the (directional) edge sources of monopole type, to complete the ESIE formulation. In particular, edge sources of dipole type have been introduced to cover the cases of non-convex bodies such as a thin plate with an opening.

The first step has been to derive diffraction expressions for a wedge that is hit by a dipole, rather than the monopole used in previous diffraction expressions. The acoustic dipole has been represented by a monopole doublet of opposite polarities taking benefit of its property of generating zero pressure and non-zero gradient in the plane perpendicular to the direction of the monopoles alignment. These sources of dipole type seemed, a priori, to be appropriate for modelling the slope diffraction phenomenon. The second step has been to derive the gradient of the diffracted field from a first edge point. Then, these two steps has been combined so that the first edge is replaced by a distribution of equivalent dipole edge sources.

The derivations have shown that a directional dipole distribution along the first edge can indeed model correctly the diffracted field in the zero-diffracted-pressure directions, but is only asymptotically correct for high frequencies, that is, when $kr >> 1$, where $r$ is the distance between two parallel edges and $k$ is the wavenumber.

In order to reproduce the gradient field across the hole in the baffle, that is, the gradient field which subsequently hits the second edge and generates slope diffraction waves, another approach has been suggested and opened to further developments.

## II – PUBLICATION(S) DURING YOUR FELLOWSHIP

Martin S.R., Svensson U.P., *Double diffraction models: a study for the case of non-convex bodies*. 7th Forum Acusticum, Krakow 7-12.09.2014

The work for the last publication was done as part of the ERCIM project but the actual conference presentation is done after the ERCIM period.

## III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

- 3rd ABCDE seminar
  From 31st October to 1st November 2013
  Athens, Greece

- 37th Scandinavian Symposium on Physical Acoustics
  From 2nd to 5th February 2014
  Geilo, Norway

- 7th Forum Acusticum
  From 7th to 12th September 2014
  Krakow, Poland

## IV – RESEARCH EXCHANGE PROGRAMME (REP)

- EPFL, Laussanne, Switzerland
  From 8th to 15th March 2014
  Local scientific coordinator: Martin Vetterli

  During the stay at EPFL, I had the chance to present my work to the members of the visiting group leaded by Martin Vetterli. It was a very interesting exchange of knowledge, where I could appreciate a strong motivation on the topic. I had also different discussions with the researchers concerning the projects that the group was making at the time.

- SOTON, Southampton, United Kingdom
  From 7th to 11th April 2014
  Local scientific coordinator: Filippo Fazi

The visit to the University of Southampton was a very enriching experience where I could meet and discuss with both PhD students and postdoctoral researchers. It was a chance to strongly recommend the ERCIM fellowship to the finishing PhD students and talk about its benefits and application procedure. The group in Southampton is a very strong and reference group in my filed and I appreciated the possibility to visit the current researchers and facilities.