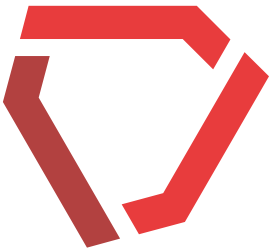


COST Action TU 1402

Quantifying the Value of Structural Health Monitoring

cost
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

www.cost-tu1402.eu

SHM
... just value it.

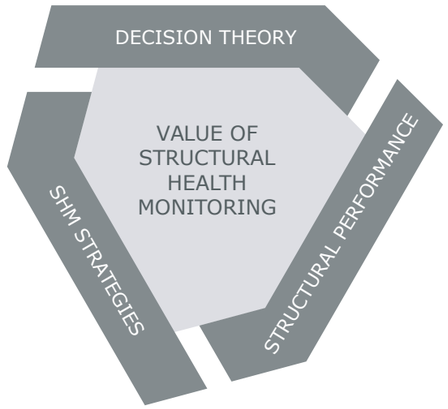
Structural Health Monitoring is good. But it can be much better.

We build upon decades of Structural Health Monitoring (SHM), structural risk and reliability research and development grown into a comprehensive research community and an important part of today's infrastructure engineering. Our network incorporates expertise of SHM technologies, SHM data analysis, structural performance, applied utility and decision analysis and infrastructure operation.

We want to enhance the benefit of SHM by novel utilization of applied decision analysis on how to assess the value of SHM – even before it is implemented. We know already that the value of SHM can be tremendous. We just have to quantify it.

Knowing the value of SHM, we can improve the decision basis for design, operation and life-cycle integrity management of structures and facilitate more cost efficient, reliable and safe strategies for maintaining and developing the built environment to the benefit of society.

And we mean it.



Grant Holder:

DTU
Technical University of Denmark
Lyngby, Denmark

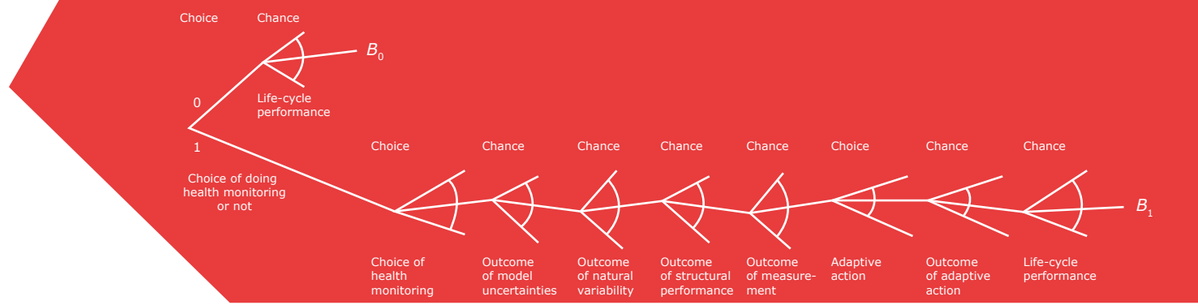
Sebastian Thöns / Chair of the Action
Technical University of Denmark

The COST Action TU1402 is unique world-wide

Ana Mandic Ivankovic / Vice-Chair of the Action
University of Zagreb, Croatia

TU1402: a COST for a VALUE

1 WG1: Theoretical Framework

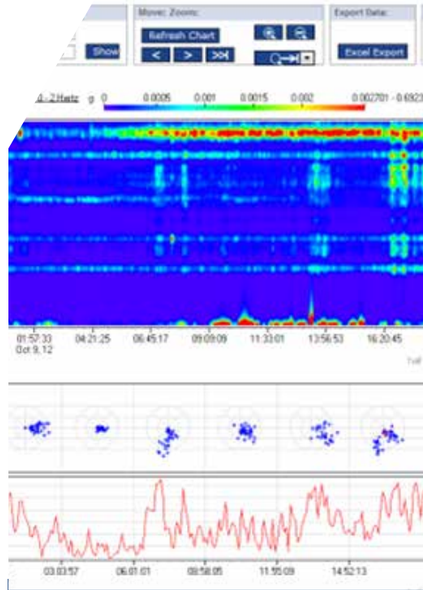


To put a value on structural health monitoring (SHM) strategies even before they are implemented may sound mind bubbling since, due to very clear reasons, nobody is capable to guess precisely what the monitoring strategies will bring in terms of new information.

The good news is, however, that this problem is relevant not only in the area of SHM but also in a wide range of other areas – in fact, in all contexts involving the planning of acquisition of new knowledge – and that is a lot. Driven by the practical relevance of this class of problems, the so-called Value of Information (VoI) analysis was formulated within Bayesian decision theory as a special case of the pre-posterior decision analysis.

Principally, the VoI analysis greatly facilitates the optimization of SHM strategies; however, this cannot be achieved without substantial efforts. It has been recognized that there are major gaps of knowledge which must be bridged before the VoI for SHM can be put to practical use. Generally, SMH experts and structural engineers do not know what VoI really is and also do not have the required formal training to appreciate this easily. This gap must be closed or at least narrowed down significantly. Another challenge concerns the development of special knowledge about how to represent and embody in the decision analysis the various SHM techniques and the information they collect.

The team of Working Group 1 of COST Action TU 1402 is dedicatedly engaged in helping to resolve these challenges. In particular, the team is collecting, assessing and recompiling the mathematical framework of VoI analysis to facilitate its targeted and efficient use for optimizing SHM strategies. In addition, a task of Working Group 1 is to examine and describe how the performances of SHM techniques should be quantified and documented to allow for an assessment of their value and for a full utilization of their potential in the optimization of SHM.



Michael Havbro Faber / Leader of WG1
Aalborg University, Denmark

May your SHM be informative and your forecast strong

Dimitry Val / Co-Leader of WG1
Heriot-Watt University, U.K.

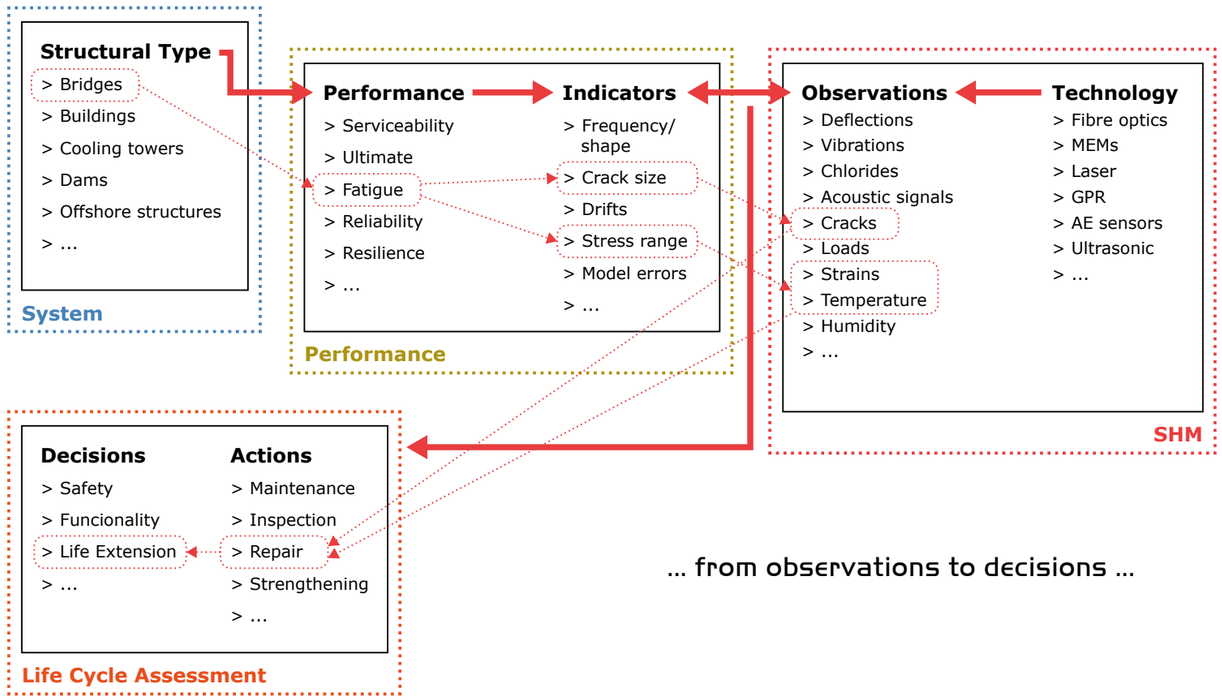
Pre-posterior analysis: knowing before measuring

2 WG2: SHM Technologies and Structural Performance

Francisco Piqueiro,
www.fotoengenho.pt

The value of SHM lies in the information it provides on structural performance as required by owners and infrastructure managers to make informed decisions on appropriate actions. Any SHM strategy should therefore encompass engineering knowhow and judgment, sensor technologies as well as methods/tools for data processing, jointly implemented in an asset management decision framework.

For a given type of structure and structural performance, a selection of suitable SHM strategies can be made by qualitatively screening alternatives through knowledge and experience. Increasingly, there is a plethora of SHM technologies that can be deployed on civil engineering structures and significant research is undertaken on diverse methods/tools for data interpretation. Building on participants' experience, a framework has been proposed to structure the different concepts involved and to illustrate how alternatives may be considered systematically. This framework also facilitates the classification of uncertainty sources and their potential impact on the asset management process.



... from observations to decisions ...

Marios Chryssanthopoulos / Leader of WG2
University of Surrey, U.K.

SHM: measuring performance for managing the life-cycle

Michael Döhler / Co-Leader of WG2
Inria, France
Geert Lombaert / Co-Leader of WG2
KU Leuven, Belgium

3 WG3: Methods and Tools

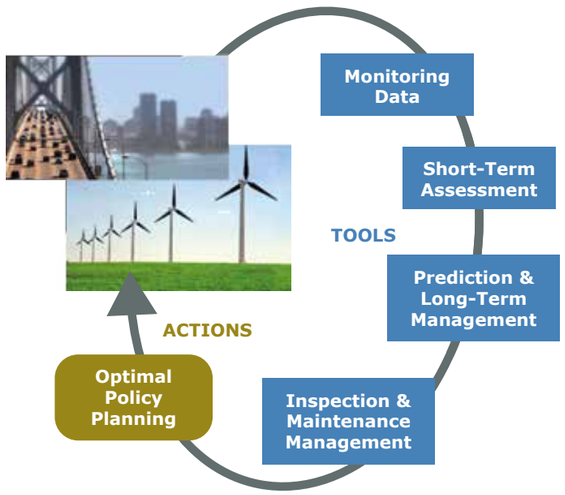
Beyond availability of raw data, as ensured by state-of-the-art monitoring technologies, it is of the essence to develop novel methodologies, able to fuse the resulting Big Stream of data and to convert the underlying Information into effective Knowledge. The Value of Information (VoI) analysis is a recently surfaced concept, dealing with this pursuit, in various stages of a structure's life-cycle.

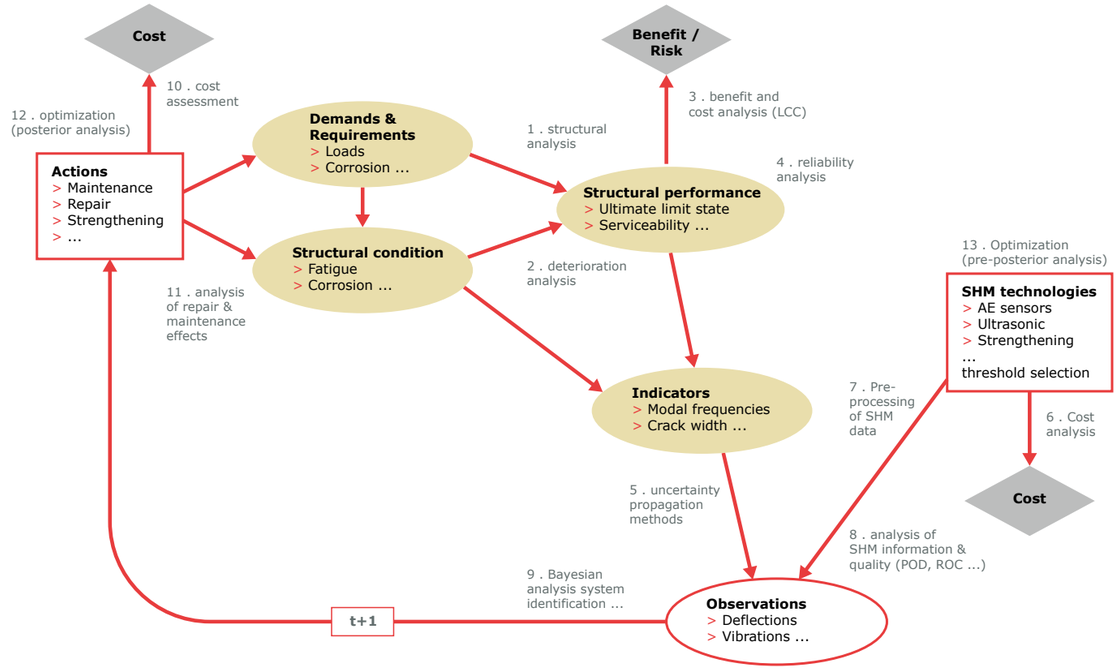
Working Group 3 aims to establish guidelines on the use of available methods and tools for harvesting the VoI, with the aim of optimizing operation and maintenance of infrastructure systems.

Value of Information models and associated probabilistic computations are often interlinked with considerable computational costs, due to the need for considering a large set of possible scenarios and decisions. While many methods and tools exist for the individual components of the VoI approach, these have seldom been put together for a complete VoI analysis. Considering the multiplicity of methods involved, successful incorporation into actual Operation and Maintenance schemes necessitates standardization of the models and methods undertaken and, ideally, development of corresponding software tools.

To foster the application of VoI to assess SHM strategies, WG3 aims to:

- provide engineers and researchers with databases and toolboxes that facilitate VoI modelling, and
- collect and further advance the algorithms available for efficient computation.





Daniel Straub / Leader of WG3
Technical University of Munich, Germany

SHM – Providing Value by Informing Decisions

Eleni Chatzi / Co-Leader of WG3
ETH Zürich, Switzerland

Turning Data into Knowledge

4 WG4: Case Studies Portfolio

The alignment of the developed insights of WG 1-3 to practical cases and applications is of utmost importance to demonstrate the potential and practical relevance of Value of Information (VoI) analysis. In this working group relevant application cases are identified and analyzed throughout the progress of the Action. Here, it is built upon a substantial portfolio of previously performed case studies within the Action network.

The case studies will highlight which combinations of techniques of SHM can be expected to be feasible under which conditions with respect to the precision and instrumentation of the monitoring techniques. In selecting them, the Action will review carefully the problems faced by the various European infrastructure sectors, in order to focus attention in those areas where societal requirements and expectations are affected. Engagement with infrastructure owners/managers will be actively pursued in this respect.

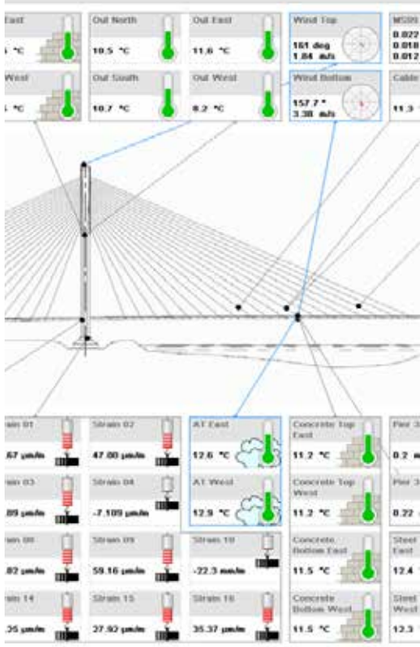
It is envisaged to cover the following relevant application areas:

- Bridges
- Wind energy convertors
- Offshore structures
- Dam structures

The case studies should encompass a model to quantify the infrastructure functionality (such as e.g. power production for a wind park), component failure and/or structural collapse in conjunction with strength deterioration mechanisms, such as e.g.:

- Metal fatigue
- Corrosion
- Overload
- Timber decay

The case studies will be classified and disseminated in fact sheets. Selected case studies will be published in relevant scientific journals.



Jochen Köhler / Leader of WG4
Norwegian University of Science and Technology, Norway

From theory to practice using the network

Helmut Wenzel / Co-Leader of WG4
VCE Vienna Consulting Engineers, Austria

From Monitoring to Decision Making

5 WG5: Development of Guidelines

Guideline documents are needed to facilitate the implementation of the principles and methods developed.

The guidelines focus on practical applications based on the example cases.

A guideline will serve as background document for a chapter in the JCSS probabilistic model code (PMC).

The application guidelines will ensure that the benefits especially in regard to the applications are obtained.

The guidelines are developed based on and with interaction through the network of the action members to standardisation activities such as e.g. JCSS, EUROCODES, ISO, IABSE, RILEM, fib, ECCS, CIB and an international SHM standardisation initiative as well as several national codes committees.

John Dalsgaard Sørensen / Leader of WG5
Aalborg University, Denmark

Standardisation: a joint effort

6 WG6: Dissemination

A major challenge of COST TU1402 is to disseminate the idea of and the framework for assessing the value of SHM before its implementation among stakeholders. The team of WG6 is actively engaged in dedicated activities aimed to continuously and promptly ensure the public diffusion of the progresses and results of the Action.

Internet and social media are today one of the most effective outreach mean for the general diffusion of information. They are exploited in COST TU1402 through the creation of a website, a Linkedin and a Facebook group and a Youtube video for the diffusion of the Action purposes and contents.

The Action website is constantly updated with video streams of keynote presentations from the Action workshops and from highly recognized and visible international conferences where Special Sessions focused on VoI for SHM are organized. In the website the written material produced within the Action is available for consultation together with general information about the Action and its participants.

Peer-reviewed journals are still the main device for the communication of the results of high quality research. In order to diffuse the major findings of the Action, the publication of a Special Issue of a peer reviewed scientific journal on VoI for SHM will be solicited together with the organization of training courses directed to young researchers and practitioners.

… and right now you are getting all these information in a 'capsule format' because you are reading this brochure …

Maria Pina Limongelli / Leader of WG6
Politecnico di Milano, Italy

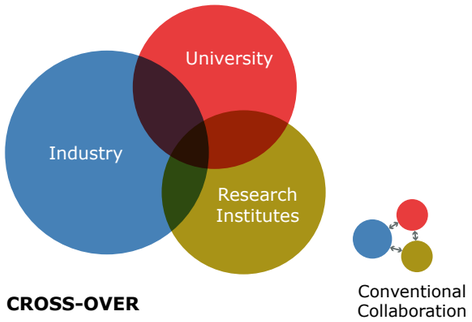
Don't ask what monitoring COSTs, ask how monitoring adds VALUE

STSM
Short Term Scientific Mission

Short Term Scientific Missions (STSM) are exchange visits aimed at supporting individual mobility, strengthening existing networks and fostering collaboration between researchers.

VISION:

- To promote mobility within the Actions scientific objectives.
- To facilitate Innovation within the Action.
- To enable knowledge transfer, knowledge sharing and potential exploitation of developed IP.
- To facilitate the sharing of knowledge between host and home institution.
- To facilitate the creation of networks between researchers and industry
- To increase the participation of SME's in the Action by targeting topics of specific interest to industry.
- To demonstrate/increase the TRL of emerging/existing.



CROSS-OVER

Conventional Collaboration

Alan O'Connor / STSM Coordinator
Trinity College Dublin, Ireland

STSM: exchange, share, innovate

Innovation Committee

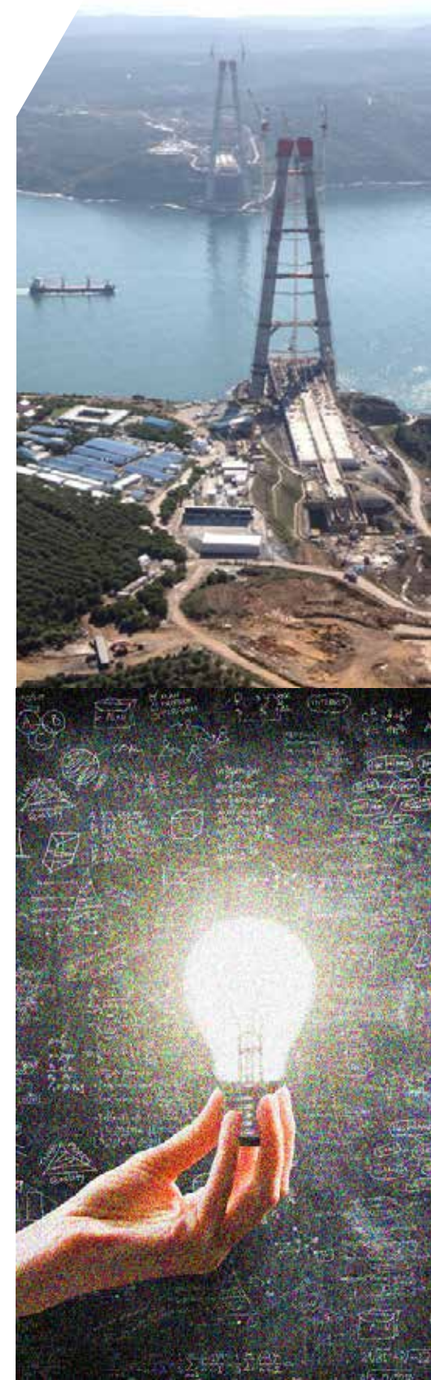
Innovation refers to the creation of new or significantly improved:

- Products
- Processes
- Marketing
- Organisation that add value to markets, governments and society

Innovation, i.e. innovative thinking, is a process that has, as a starting point, an idea/invention/opportunity (generating ideas) through which a product/service/business model is developed (implementation) and validated/commercialized by the market (dissemination). After that, there is a monitoring phase that assesses the market behaviour, which will lead to new ideas, opportunities (strategic thinking) and therefore a new cycle begins.

Within the COST Action TU1402, an Innovation Committee exists with the mission to foster:

- Innovation, by stimulating a creative process between people in the COST Action based on recommendations related to activities that are able to promote the sharing of ideas towards the quantification of the value of SHM.
- Entrepreneurship, by favouring an effective engagement between researchers and industrial partners. This will enhance the creation of high-qualified jobs for young researchers (e.g. by STSM) and the submission of consortium project proposals, which is definitely the most successful path for the next generation of SHM-based solutions.
- Dissemination, by guaranteeing the effective wide spread of all outcomes of the work developed during the COST Action. Dissemination of knowledge, monitor knowledge use and evaluate impact is particularly focussed by using proper channels of communication.



Helder Sousa / Leader of the Innovation Committee
BRISA S.A., Portugal

Innovation is a way of thinking

Members

We are glad to welcome new members throughout the entire duration of the Action. For more information contact the leader of the working group you are interested to join. You find the email addresses on the website of the Action.

DTU – Technical University of Denmark
Denmark

VCE Vienna Consulting Engineers ZT-GmbH
Austria

Politecnico Milano
Italy

ETH Zürich
Switzerland

COWI – Leading Consulting Group

UCG – University of Montenegro
Montenegro

TNO innovation for life

Eracons – Engineering Reliability
Germany

KU Leuven – Katholieke Universiteit Leuven
Belgium

Bundesanstalt für Materialforschung und -prüfung
Germany

Universitat Politècnica de Catalunya
Spain

University of Catania
Italy

Queen's University Belfast
U.K.

SP Technical Research Institute of Sweden
Sweden

Universidade do Porto
Portugal

BRISA – Concessao Rodoviaria
Portugal

Ramboll Holding GmbH
Germany

Reykjavik University
Iceland

University of Surrey, U.K.

ITU – Istanbul Technical University
Turkey

ATKINS
U.K.

University G. d'Annunzio
Italy

Heriot-Watt University
U.K.

Matrisk GmbH
Switzerland

Technical University of Munich, Germany

Spanish National Research Council
Spain

LNEC - Laboratório Nacional de Engenharia Civil
Portugal

Royal Institute of Technology
Sweden

Irstea – National Research Institute
France

The University of Newcastle
Australia

French Institute of science and technology for transport, development and networks, France

University College Dublin
Ireland

University of Thessaly
Greece

Bundesanstalt für Straßenwesen
Deutschland

STU – Slovenská technická univerzita
Slovakia

University of Nantes
France

Universiteit Gent
Belgium

University of Minho
Portugal

Ecole Polytechnique Federale de Lausanne
Switzerland

University of Belgrad
Serbia

Aalborg University
Denmark

Klokner Institute
Prague
Czech Republic

Trinity College Dublin
Ireland

inria
France

Cracow University of Technology
Poland

Universität für Bodenkultur Wien
Austria

Ss. Cyril and Methodius University in Skopje
Macedonia

Slovenian National Building and Civil Engineering Institute
Slovenia

AIMEN Technology Centre
Spain

Vilnius Gediminas Technical University
Lithuania

University of Zagreb
Croatia

Boğaziçi Üniversitesi
Turkey

University of Genua
Italy

University of Aberdeen
U.K.

University of Ljubljana
Slovenia