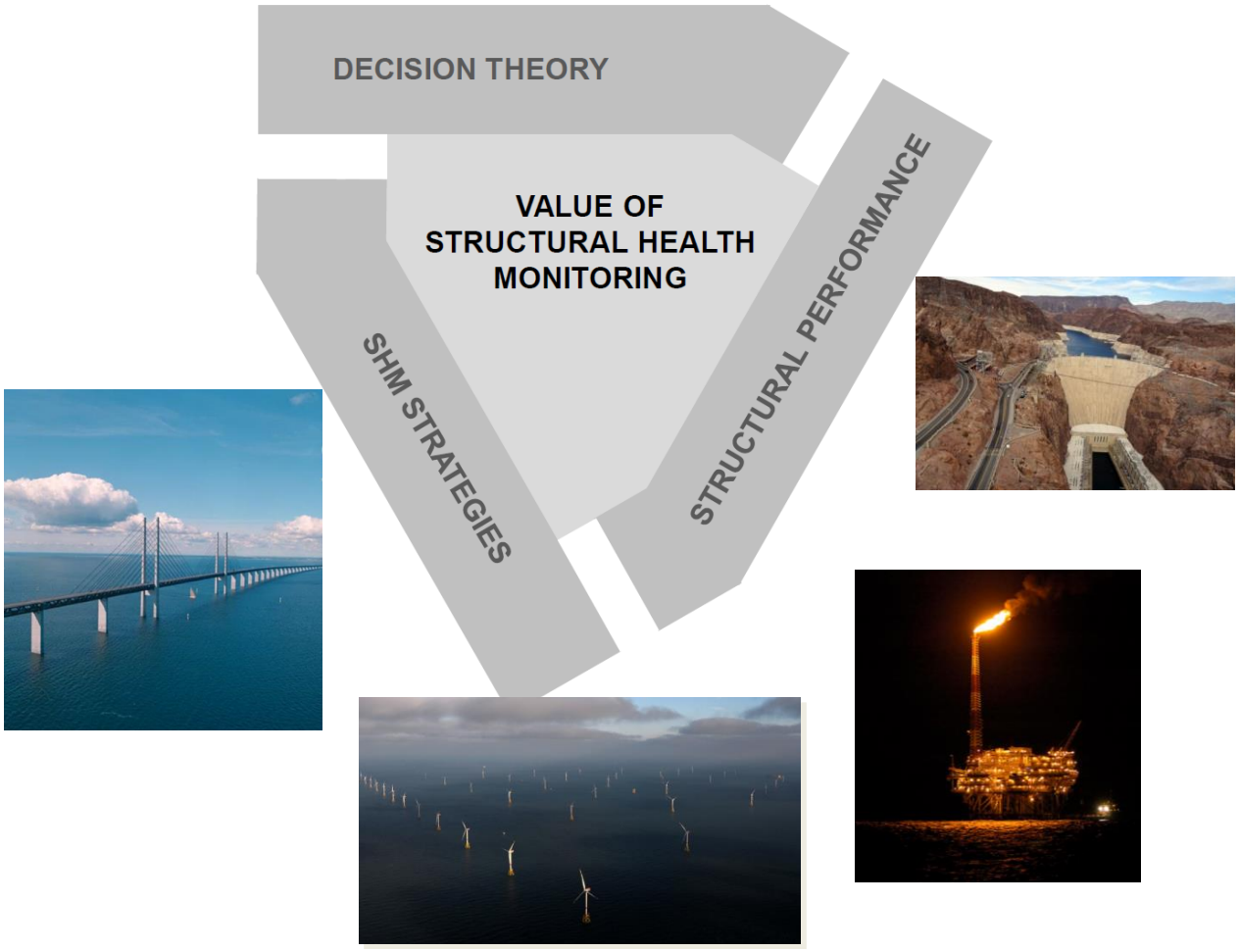
COST Action TU1402 Strategy: 2017 and 2018



Authors	Sebastian Thöns (Chair) Michael H. Faber (Scientific Chair) Dimitri Val (WG1 lead) Marios Chryssanthopoulos (WG2 lead) Geert Lombaert (WG2 lead) Michael Döhler (WG2 lead) Daniel Straub (WG3 lead) Eleni Chatzi (WG3 lead) Jochen Köhler (WG4 lead) Helmut Wenzel (WG4 lead) John D. Sørensen (WG5 lead) Maria Pina Limongelli (WG6 lead) Helder Sousa (Innovation Committee lead)

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Executive Summary

This document contains a strategy for the COST Action TU1402 for 2017 and until the end of the Action in November 2018. This strategy has been developed in a TU1402 Strategy Workshop in the beginning of 2017.
The TU1402 strategy aims at the most comprehensive fulfilment of the TU1402 objective and the development of activities beyond the duration of the Action. The strategical focus in the second half of TU1402 is directed towards (1) impacting industry, science and society and (2) the consolidation and dissemination of the action progress.
Important elements for an industrial impact are the stepwise development of a case study portfolio, of teaching activities and the organisational start of standardisation activities. The scientific impact will be supported by disseminating in scientific journals, by the visibility of TU1402 research and developments at international conferences and extending the network worldwide. A societal impact can then be achieved on the basis of the industrial and scientific impact and by showing the societal relevance by e.g. large scale case studies. The consolidation and dissemination of the action progress relates to the further efforts to comprehensively fulfil the actions objectives in the perspective of the individual Working Group objectives, the network and widening the network to outreach and to impact.

Contents

Introduction

This document contains a strategy for the COST Action TU1402 until the end of the Action in November 2018. The strategy has been developed with a Status and Strategy Workshop where the progress of the first two years has been summarised in conjunction with the Memorandum of Understanding [1], the Action's intermediate report [2] and its assessment by COST. The past TU1402 progress (Section 1) has been the basis for (1) identifying potentials and ideas for further developments and (2) blank spots where efforts need to be directed to. The strategy consists of an overall TU1402 strategy (Section 2), a scientific strategy (Section 3) and aligned Working Group and Innovation Committee strategies (Section 4).

1 TU1402 Progress summary

The TU1402 progress until now encompasses:

1) the creation of a large network across Europe with international links,
2) research according to the Scientific Program,
3) the dissemination of the research results and
4) impacts on science and economy.

The creation of a large network has been achieved by including 130 participants in 27 European countries plus Australia as an International Partner Country (IPC) and establishing links to International External Advisors which are foreseen as MC Observers. The network incorporates researchers, SHM engineers, structural engineers, European and national associations and confederations, authorities and policy makers at regional and European levels, relevant standardization bodies and code writers, teachers, lecturers and students of structural design and engineering schools.
The research of the Action has been organised according to the Scientific Program with active Working Groups on the Theoretical Framework, SHM Strategies and Structural Performance, Method and Tools and Case Study Portfolio (starting phase). A factsheet format has been developed to collect and compile state-of-the-art and relevant knowledge across the network and to allow for the stepwise development of new approaches. The created factsheets associated to the individual Working Groups have been compiled in two comprehensive reports. 7 Scientific Missions focussing on Early Stage Investigators (ESIs) and participation of female researchers have been performed.
In order to motivate the generation of innovative and relevant research, an Innovation Committee and Advisory Board has been organised. A scheme for developing research proposals has also been created. The research results have been disseminated in 3 special sessions at international conferences, 5 dedicated Workshops across Europe targeting Inclusiveness Countries amounting to 2 comprehensive reports and about 30 peer reviewed publications. Scientific impacts have been achieved (1) in the development of the scientific field for quantifying the value of SHM and (2) by the provision of scientific evidence for an improved economic efficiency in the operation and maintenance and asset management of structures and infrastructure systems. The action has also partially impacted industry by making the scientific field more accessible with the disseminated research results.

2 TU1402 Strategy

The TU1402 strategy aims at the most comprehensive fulfilment of the TU1402 objective and the development of activities beyond the duration of the Action.
The TU1402 objective is to enhance the benefit of Structural Health Monitoring (SHM) by novel utilization of applied decision analysis on how to assess the value of SHM - even before it is implemented. This improves decision basis for design, operation and life-cycle integrity management of structures and facilitates more cost efficient, reliable and safe strategies for maintaining and developing the built environment to the benefit of society. The MoU objectives are accordingly to (1)

provide a newly developed theoretical framework for the quantification of the value of SHM and (2) to work with a multidisciplinary and multifunctional network on the utilisation of the framework for a broad and representative range of applications. The strategy builds upon 2 years of TU1402 work and progress.
The strategical focus in the second half of TU1402 is directed towards (1) impacting industry, science and society and (2) the consolidation and dissemination of the action progress. Important elements for an industrial impact are the stepwise development of a case study portfolio, of teaching activities and the organisational start of standardisation activities. The scientific impact will be supported by disseminating in scientific journals, by the visibility of TU1402 research and developments at international conferences and extending the network worldwide. A societal impact can then be achieved on the basis of the industrial and scientific impact and by showing the societal relevance by e.g. large scale case studies. The consolidation and dissemination of the action progress relates to the further efforts to comprehensively fulfil the actions objectives in the perspective of the individual Working Group objectives, the network and widening the network to outreach and to impact.

2.1 Impacting industry

The main elements for an industrial impact are (1) the stepwise development of a case study portfolio, (2) the development of teaching activities, (3) the continuation of the Innovation Committee activities and (4) the organisational start of the standardisation activities.

The stepwise development of a case study portfolio will be performed on the basis of:

1) Documented and with test cases exemplary described theoretical framework (WG1),
2) Available SHM technologies and models (WG2),
3) Structural performance models (WG2) and
4) Available methods and tools (WG3).

The case study portfolio should include one or more case studies solely performed by industrial participants.
The utilisation of the TU1402 network with calls and for mapping the case study options, the organisation of workshops, STSMs and the acquisition of research and development projects with a strong industrial background are recommended.
The strategic elements for the establishment of the case study portfolio are:

1) Workshop to map and to summarise the WG1, WG 2 and WG 3 inputs with the deliverables of factsheets.
2) Call for “case study STSMs” within the TU1402 network
3) STSM workshop focussing on industrial participants
4) Organisation of Special Sessions at industrial oriented conferences
5) Development and documentation of 10 case study options
6) Five mini-workshops on case studies

The development of teaching activities will include the Working Groups 1, 2 and 3 to comprehensively address the theoretical framework, the relevant SHM and structural performance modelling and the available tools for the quantification of SHM. The teaching activities will target researchers, PhD students, industrial consultants, and infrastructure owners and operators.
The strategic elements for establishing teaching activities are:

1) Organisation of one or more Training Schools addressing researchers and PhD students
2) Organisation of one or more Training School addressing industrial consultants, and infrastructure owners and operators

The organisational start of the standardisation activities should include the mapping of relevant standardisation organisations and the relevant links to experts inside and outside the network. The strategic elements for the start of the standardisation activities are:

1) Factsheets for producing drafts of the envisaged JCSS and practitioner guidelines
2) Factsheets on standardisation organisations, including contact persons and options for standardisation work
3) Three or more Workshops
4) Two or more STSMs

2.2 Impacting science

The scientific impact will be enforced by the organisation of Special Sessions at international conferences in Europe and worldwide, by the initiation of special journal issues (e.g. in relation to the Special Sessions) and by research project acquisition. The strategic elements for impacting science are:

1) Two or more Special Sessions per year
2) Three or more Special Issues of scientific journals until the end of the Action
3) Start of final conference organisation
4) Call for research and development proposals
5) Workshop for research and development proposals
6) Five or more Horizon 2020 applications

2.3 Networking

The TU1402 network will (1) be made more visible, (2) will be extended internationally and (3) will be actively utilised and (4) continuously developed to include relevant partners. More visibility includes the improvement of the website and the provision and continuous updating the dissemination material such as a brochure and flyers.
The international extension means that International Partner Countries (IPCs) such as e.g. China and USA are formally included in the network which then facilitates that STSMs can be performed to IPCs and that the international participants (i.e. MC Observers) can be reimbursed for Training Schools.
The Working Groups will actively seek new relevant research partners given a clear MoU contribution and industrial experts, infrastructure owners and operators. The TU1402 network will be actively utilised to contribute to the WG activities and research and the Working Group interaction will be enforced.

The strategic elements for networking are:

1) Further website and dissemination development to make the network more visible.
2) Include at least USA and China as International Partner Countries (IPCs) with one or more international participants. Consider also Near Neighbour Countries.
3) Calls to the network across the Working Groups to contribute to factsheets.
4) Organisation and alignment of workshops to extend the network - as may be necessary to conduct case studies.
5) Extension of the network should focus on ECIs and industrial experts, infrastructure owners and operators and relevant European associations.

2.4 Exploitation of results and outreach

Planning for the TU1402 exploitation of results and outreach should start and should encompass any activities beyond the end of the Action such as e.g. continuation of Special Session organisation, large research proposals and the collection and editing of a book about TU1402.

3 TU1402 Scientific Strategy

From a methodical perspective, the Action has collected and assessed a very substantial amount of information on available frameworks, strategies, approaches, techniques/tools and example applications. This processed information is already a strong achievement of the Action and an important stepping stone for the further developments.
In the next phase of the Action the collected and assessed information shall be utilized in pursuit of establishing:

1) A categorization of decision problems which might be supported by monitoring results (WG 1)
    a. Suggested to start with integrity management
2) A categorization of structures/components/materials (WG 2)
    a. Suggested to start out with bridges of a few selected different types (steel/concrete solutions of most relevant types)
3) A categorization of deterioration processes which are of relevance for the different categories of structures (WG 2)
    a. Suggested to start out with fatigue and corrosion of reinforcement
4) Providing a categorization of possible measurable indicators of the identified deterioration processes for the different types of structures accounting for their uncertainties (WG 3)
    a. Suggested to include e.g. HCP measurements, chloride profiles, deflections, strains/stresses, crack characteristics, accelerations
    b. Identify models for the quantification of the uncertainty associated with the indicators with respect to the different condition states of relevance for the deterioration processes of significance for the integrity management Fundamentally, this cooks down to assessing type 1 and type 2 errors from hypothesis testing. In this context it must of course be appreciated that the definition of indicators is often associated with selection of threshold values and that this selection in turn might be formulated as an optimization problem.
        i. It is important to account for measurement uncertainties associated with the measurement technique itself but also as it is applied in terms of a strategy e.g. considering different possibilities for sensor placements, sampling locations and mixes of measurement techniques
        ii. If models (like FEM models/fracture mechanical models/chloride ingress models etc) are applied as a means of quantifying the uncertainty associated with the indicators (like in OMA) then the model uncertainties associated with the applied models must be accounted for
        iii. The influence of statistical uncertainty – if present – must be accounted for
        iv. If several possible can explain the measured observations then these must be accounted for
        v. It might be that appropriate models are not available and not easily achievable – but this type of observation is also an important result
5) Identity and categorize relevant measure of (remedial) actions which are or might be relevant to associate with different observed indicators for the considered degradation phenomena and the different structures/components/materials. (WG 2)
6) Providing a categorization of the interaction between the structures/components/materials, the deterioration processes, the possible measurable indicators, the measures of (remedial) actions and the decision problems (WG2 and 3)
7) Formulate the objective functions representing service life performance (benefits/costs/consequences) for the different types of structures/materials/components (WG1)

   a. These objective functions must include models which associate benefits and losses associated with correct positive, correct negative, false positive and false negative indications in the context of the considered decision problem
8) Formulate and categorize appropriate formulations of the pre-posterior decision problem which may quantify the Value of Information achieved from the identified monitoring strategies for the different types of degradation processes and types of structures/components and materials (WG3 and WG1)
   a. Here attention should be directed on the utilization of either the normal or extensive form of the pre-posterior decision analysis – or a combination of the two – as appropriate
9) Identity and categorize uncertainty propagations tools appropriate to solve the pre-posterior decision analysis problems (WG3)
10) Illustrate the approach and quantify the VoI for the most typical monitoring applied in the context of representative cases of the considered categories of structures/components /materials (WG4)

4 TU1402 Working Group and Innovation Strategies

In addition to the TU1402 (Section 2) and the Scientific Action (Section 3) strategies, the Section lists the individual WG strategies.

4.1 WG1: Theoretical framework

Beyond the main activity of WG1, further efforts are directed towards the explanation and description of the theoretical framework. This includes e.g. a further characterisation and classification of the different decision scenarios for utilizing SHM, help for performing case studies and contribution to Training Schools.

4.2 WG2: SHM Strategies and Structural Performance

The next steps for WG2 activities are the completion of the framework of SHM strategies and performance indicators during the next workshop. This includes the following points:

1. Include deterioration processes/defects in scheme to guide users in the selection of the relevant performance indicators and technology, making use of existing catalogues of defects.

2. populating it with case studies from the participants in a bottom up approach

3. including recommendations related to the performance indicators and monitoring techniques for selected structural type and deterioration process in a top down approach, in collaboration with WG1. Focus on typical cases.

4. input from industrial STSM’s for the relevance of SHM strategies

Being a part in the framework of SHM strategies and performance indicators, uncertainty quantification is a topic that is present in all areas. Its classification based on questionnaires from the participants will be completed at the next workshop.

Furthermore, a common simple test case simulation is prepared together with WG3 for the demonstration of the diverse methods and paths in the framework.

4.3 WG3: Methods and Tools

The objectives of the third working group lie in identifying, developing and critically overviewing methods and tools required for the utilization of the theoretical VoI framework in practice. Efficient methods and tools will be developed to facilitate the application of the theoretical framework in practice. Such methods will take basis in modern methods of probabilistic systems analysis including Fully and Partially Observable Markov Decision processes, Bayesian Networks, Monte Carlo simulations schemes, stochastic meshing algorithms, First Order Reliability Methods, and combinations thereof. In supporting these goals:

1. A series of Training Schools, comprising two sessions. The first session will pertain to the theoretical basis of VoI approaches, and will be intended for both the academic and industrial partners of the action. The second session, in collaboration with WG4, will be in the form of a Hackathon, where the methods formerly introduced will be implemented on actual case studies.

2. A set of method-inspired tutorials will be made available by WG3 on the Action's website. A first such example will be on Bayesian Networks and Influence Diagrams for pre-posterior analysis, using the open source GeNIe modeler.

3. WG3 will further introduce guidelines for Instrumentation, as this has been requested by numerous partners of the action. This will be established as an online interactive tool, for members of the action to continually advance. The tool will exploit initial attempts by previous and ongoing actions such as DURATINET and TU1406.

4. Finally, a simulation benchmark will be established, to serve as a reference numerical experiment for members of the monitoring and reliability community at large.

4.4 WG4: Case Study Portfolio

The main objective of WG4 is to illustrate the developed methodology by real engineering examples. This will demonstrate the feasibility of application, but will also help to identify further challenges related to the sound implementation of the methodology.
In the case studies it is directly referred to the results from WG 1-3, in regard to the developed methodology, tools, problem classification scheme and wording. The case studies shall aim at the assessment of VoI, i.e. different possible monitoring or inspection methods shall be ranked according to their cost-efficiency. The case studies are documented by fact sheets with a standardized TOC and a limitation on the number of pages. Further, information and insights concerning the fact sheet can be disseminated via peer-reviewed journal publications and/or reports.
Several typical application areas in structural engineering will be covered.
The envisaged number of different case studies is 10 and they will be identified, selected and initiated by setting up a call for case studies to be distributed among the action participants in the beginning of February 2017. After selection, the case study ideas will be presented at the Action Workshop in March 2017. The case studies will be further developed and discussed on the 2017 Action Workshops. Spring 2018 will be targeted for completing most of the case studies.
For dissemination of the results WG4 is co-organising a special session at the 2018 European SHM workshop to be held in Manchester. Furthermore, a Training School is organised and mini workshops are utilised when required.

4.5 WG5: Standardisation

The objective of WG5 is to facilitate the implementation of the principles and methods developed in WG1 to WG3 into guideline documents. The guidelines will focus on practical applications based on the example cases studied in WG4. Furthermore, a guideline serving as background document will be prepared and published as a chapter of the JCSS probabilistic model code (PMC).

The application guideline will be based on the framework developed in previous WGs and will ensure that the benefits especially in regard to the applications are obtained.
The guidelines are to be 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 by the International Workshop on SHM (IWSHM) as well as several national codes committees.

4.6 WG6: Dissemination

COST Actions supports networking activities aimed to impact both research and industry to strengthen Europe's capacities and to leverage research investments.
Results of the Actions have thus to be disseminated, both in terms of networking (creation of the network and active collaboration on the Action topic) and both in terms of scientific outcomes of the research project.

4.6.1 Dissemination of the Action networking efforts

Dissemination of the networking effort will be carried out through:

- **social media** (Facebook, Linkedin, Twitter, Youtube) will be mainly used to **capture attention** on the Action **and** redirect interested people toward the website. A **trailer** of the Action (2-3 minutes) will be recorded and published on Youtube, to briefly and effectively describe the Action networking and research activities. The trailer will be recorded during the joint Zagreb workshop (jointly organized with COST Action TU1406 and IABSE WG1). The choice of the set in Zagreb meeting will ensure the presence of key persons of the Action (Chair and vice Chair, scientific Chair, leaders of WG1-6, leaders of the Innovation and of the STSM Committees, International observer) and allow the recording of a number of networking activities inside and outside the Action (e.g. the workshop itself, working groups meetings, social activities). In addition, videos related to the STSM will be recorded and published on Youtube in relation with the Action trailer.
- **website** of the Action that will be improved with: information about the rules to join the Action, photos and links to personal websites of co-leaders and action vice-leader (females).
- a printed **brochure** aimed to be distributed at scientific and industrially oriented conferences and other events of the field.

4.6.2 Dissemination of the Action research outcomes

- The **website** of the Action:
    - **will be updated** in order to more effectively achieve a communication of the COST Action outcomes targeting **3 different stakeholder groups**: the **research community** (experts of the Action topic), **enterprises** (industry and SMEs), the **general public** (e.g. citizens, policy makers, not-experts of the Action topic).
    - **will be added information** about the activity of the Innovation Committee, a simplified description of the topic of the Action for the general public, a page with links to papers published in the realm of the Action.
    - **visibility and searchability will be improved** by introducing effective keywords and adding a page either with a repository of experimental SHM data or links to websites where experimental data can be downloaded/ requested. This should attract more the people interest in SHM and also provide the network with data that can be utilized in the research project carried out by the network. The repository will be organized according to the categorization described in the Scientific Action Strategy.
- **Special Session** will be organized at scientific and industrially oriented conferences (e.g. ICOSSAR 2017, EWSHM2018, HeaMES2018)
- A **page for Wikipedia page** on VoI for SHM will be written taking basis on the MoU.

- **Press releases** for the local press will be issued for the future workshops of the Actions and the program circulated among local stakeholders (research and industrially oriented)
- A description of the Action and on how to use the website will be prepared in **Power point format** as a compact tool to present the Action and the network at national conferences and to local organizations.
- **Teaching material** by based on the work developed in the different Working Groups. As aforementioned, the teaching material will target researchers, PhD students, industrial consultants, and infrastructure owners and operators in a first instance. Nevertheless, this would also be a first step in the definition of a course that could be a reference to all universities that envisage SHM as a strategic field and want to implement new courses.

4.7 Innovation Committee

The Innovation Committee activities will continue by addressing recommendations with special focus on industry needs, by taking into account that the COST Action is entering in the two final years. It will be recommended a set of activities favouring the effective engagement between experts in science and stakeholders of structures and infrastructure systems. Indeed, this is in alignment with what is reported in the Green Paper from the European Commission [3]. With this, collaborations between academia and industry will be facilitated and at the same time there will be a potential for the creation of high-qualified jobs for young researchers and project consortiums. Indeed, this might be the most effective strategy to improve the industry engagement in project proposal, i.e. by pushing high-qualified young researchers into industry where they will be responsible, as end-users, of exciting opportunities to implement/show/validate the most recent advances in the field of SHM. The strategic of the Innovation Committee will address recommendations in the following issues:

1) Recommendations on the organization of special sessions in industry-based conferences.
2) Recommendations on the classification of the degree of maturity of the presented case studies (objective TRL4-7)
3) Recommendations on STMSs by pushing young researchers to engage with the industry and building/strengthen links based on possible case studies
4) Recommendations on setting a list of fruitful collaborations and support them in further developments beyond the COST Action period (e.g. consortium projects)
5) Recommendations in the assessment of the degree of the dissemination based on quantitative parameters (e.g. number of visits to the, number of downloads of available material in the website)
6) Recommendations on the evaluation on how the action has changed paradigms in different environments (e.g. lecturing in the university, new products in the market, new/updated departments in companies)

References

[1] European Cooperation in Science and Technology (2014): Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST Action TU1402: Quantifying the value of structural health monitoring. COST 059/14.

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[3] European Commission (2011). GREEN PAPER - From Challenges to Opportunities: Towards a Common Strategic Framework for EU Research and Innovation funding. Brussels. COM (2011) 48.