Forecasting Impact of Technology Developed in R&D projects: the FITMAN Approach

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***Abstract*—A typical two- or three-year research project has an impact that is only really visible after the project has come to an end, at a time when there are no resources to monitor that impact. As a consequence, projects need to estimate/predict their future impact before they end. In this paper we describe the impact activity monitoring method in the FITMAN project. This method addresses the problem by accounting for actions to raise impact during a project and the planning for such actions after a project has ended. We also describe the socio-economic impact assessment methodology created in FITMAN, showing how this links to the impact activity monitoring method. Key to both is the assessment and monitoring of impact in three different areas: industry, society and the scientific community. Each area represents different challenges and we discuss their relative value to the overall assessment. We also report on our early experiences of applying this to ten industry-led use case trials in the FITMAN project. The insights gained by applying these methodologies can be more widely applied across domains related to technology management.**

Keywords—impact; forecasting; impact monitoring; socio-economic impact assessment

I. Introduction

Multi-year projects, such as typical EU-funded research and development (R&D) projects involving software development, usually see a time horizon for production of benefit and impact that begins during the project and continues well beyond its end. During the lifetime of a project, it is possible to continuously assess the outcome of the work done, and methodologies for this purpose are characterised by a structured assessment of the software quality and business indicators.

The impact creation process, however, takes a very long time to unfold: consider the timescales involved in effects on industry, citizens and society as a whole. This timeframe is much longer than the duration of an average research and development project, meaning that the major part of the impact achieved through project activities will take place well after the completion of the work. After the project, no resources remain to measure impact. Impact depends on the results and promotion activities of projects, with valuable results and high quality promotion actions increasing the likelihood of high impact.

It is possible to monitor these features and activities during a project, including activities to maximise post-project impact. For that purpose, the EU-funded FITMAN project [1] developed an impact activity monitoring methodology that can be deployed in on-going projects. FITMAN is a Future Internet Public-Private Partnership (FI-PPP) project, developing and applying Future Internet (FI) technologies to manufacturing industries. The FI-PPP is a European programme for Internet-enabled innovation: it is particularly focused on advancing the development and adoption of Future Internet technologies in Europe, advancing the European market for smart infrastructures, and increasing the effectiveness of business processes through the Internet. As such, the FI-PPP is more concerned with impact than the average European research programme.

As an R&D project, FITMAN is focused on creating impact by bringing new technologies into commercial organisations. To achieve this, the FITMAN project comprises 10 industry-lead use case trials from different manufacturing industries. Reflecting the goals of the FI-PPP, FITMAN's trials are greater in number and scope than trials in an average European project validation case study.

The impact activity monitoring methodology in FITMAN is based on the idea of impact creation as a series of "waves". The impact process is described through impact waves that advance over time from the start of the project, through the project's duration, and after its end. To secure optimal impact, the activities and quality of the results needed from each wave must be assessed and assured. A detailed view of the impact process is necessary to achieve this goal. The process (waves) can be broken down into semi-independent streams for the different types of impact, e.g. industrial, scientific and social.

Complementary to the impact activity monitoring methodology, a methodology for conducting Socio-Economic Impact Assessment (SEIA) has also been created in the FITMAN project. The purpose of the SEIA methodology is to analyse and measure potential social and economic impacts of new technologies and business models. In FITMAN, this is done on each use case trial with respect to the potential impact on the respective enterprise, its customers, suppliers and wider

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society. This helps to identify the potential long-term costs and benefits for the different stakeholders associated with each respective manufacturing industry.

Section II of this paper reports on existing work in this area. Section III describes the models and methodologies that were brought together to create the greatest possible future positive impact. Thereafter, Section IV describes the experiences and lessons learned from applying these approaches within the FITMAN project. Section V provides a summary and discussion, emphasising the link between the two methodologies and their impact to the overall impact monitoring and assessment. Section VI provides conclusions.

II. Relation to Existing Theories and Work

Forecasting impact and assessing impact is a broad topic involving e.g. environmental impact, innovation impact and policy impact assessment. Consequently there is also a multitude of pre-existing work available. In this paper we focus on research impact forecasting.

According to the International Association for Impact Assessment [2], impact assessment is *"the process of identifying the future consequences of a current or proposed action"*. The University of Manchester, SEED [3] delivers a slightly broader explanation of impact assessment, remarking that it is *"the process of identifying the anticipated or actual impacts of a development intervention, on those social, economic and environmental factors which the intervention is designed to affect or may inadvertently affect"*. The impact assessment can take place before an intervention (ex ante), after completion (ex post), or at any stage in between. In this paper we focus on ex ante assessment forecasts. SEED [3] makes a distinction between two separate but interlinked assessment levels: *internal monitoring and evaluation* through the integration of specific impact indicators into existing management information systems and *external impact assessment*, often involving independent investigators producing reports for specific purposes, such as poverty impact assessment, regulatory impact assessment, social impact assessment or health impact assessment.

Considering the research perspective, one can consider the definition of research impact by the Research Councils UK (RCUK), which is "*the demonstrable contribution that excellent research makes to society and the economy*" [4]. They go on to state that it contains all the diverse ways that research-related skills benefit individuals, organisations and nations.

The EU funded SIAMPI Project (2009-2011) [5] developed indicators to assess social impact of research projects, research programmes and research funding instruments. According to SIAMPI, assessing the scientific quality of research is common practice, but the question how to assess the impact of research on society is still largely unanswered. SIAMPI developed indicators for social impact in three categories of Productive Interactions between researchers and relevant societal stakeholders; 1) direct interactions, in the sense of personal interactions involving direct contacts between humans; 2) indirect interactions through some kind of material "carrier" (publication of texts, exhibitions, models, films) and 3) financial interactions occurring when potential stakeholders engage in an economic exchange. In the SIAMPI project, Productive Interactions is understood as exchanges between researchers and stakeholders in which knowledge is produced and valued that is both scientifically robust and socially relevant. Although the project is already finished, the project website[1] contains an updated list of publication, articles, reports and guidelines related to social impact assessment. The majority of the papers address ex post analysis of research impact on society.

There exists many method for different forms of socio-economic impact assessment: examples include the Delphi Method (a hybrid of focus groups and an approach to 'the wisdom of the crowds') [6], SEQUOIA (used to assess the impact of research projects in the area of Software as a Service) [7], and the Measuring Impact Framework (designed to help companies understand their contribution to society) [8]. Each method has its own particular focus, but none of them address the monitoring and prediction of technology's impact.

In summary, we observe that there is a multitude of existing theories and work in the area of environmental impact assessment, ex poste impact analysis of research funding instruments and research programmes as well as general policy recommendations. No papers addressing the monitoring and prediction of impact in on-going research projects have been identified, however.

III. Research Approach

The first part of this section discusses the post-project impact creation method, which uses a wave-based approach to modelling and managing impact both during and beyond a project's duration. The second part of this section describes the FITMAN socio-economic impact assessment methodology created to identify and estimate potential long-term impacts the technologies developed in the project has on the European industry, society and the scientific community.

A. Post Project Impact Creation Model

As mentioned in the Introduction, the impact activity monitoring methodology used in the FITMAN project is based on impact creation in waves, which is illustrated in Fig. 1. The first impact wave contributes to the advancement of knowledge in the domain and to improving RTD building capacity among the partners. During this stage, the results of the FITMAN project are also developed and evaluated in the use case trials in a realistic manufacturing context.

The second impact wave occurs during and after the trials, when project partners get immediate experience of the achievements in the project. By further developing and increasing the usage of the tools, the stakeholder could have early take-up of the FITMAN results already before the end the project.

In the third wave, the software providers commercialise new products and services based on the results of the FITMAN project, and offer them to lead customers in relevant industries. In this stage, the dissemination activities are expected to have

[1] http://www.siampi.eu/

created interests among end-users in the manufacturing domain, i.e. among manufacturing enterprises outside the FITMAN project. The interest is also expected to result in concrete applications of the results and products from the FITMAN project. This wave will already start close to the end of the project, when all the final technical results are available and published. Relevant industrial associations and similar can contribute to the constituency for this wave.

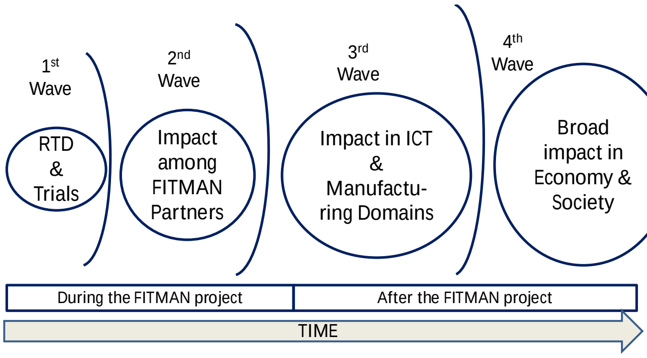

Fig. 1. Impact process illustrated as impact waves.

In the fourth wave, exploitation of the results is supported by industry-wide standardisation and policy-making. Naturally, the quality and availability of commercial solutions built upon the FITMAN results are the main prerequisites for a successful impact. However, the efficiency of the dissemination and the exploitation activities in the project is vital in order to promote and create awareness of the solutions among potential end-users.

In Fig. 1, the impact process is described through the impact waves that advance over time from the start of the project, during the project, and after the end of the project. To secure optimal impact, the activities and quality of the results needed from each wave must be secured and assessed. The waves could be further amplified during the project to get a larger wave front after the project. In order to be able to assess that the results from each wave are sufficient, it is important to have a detailed view of the impact process.

The process (waves) must be broken down into semi-independent streams for the different types of impact, e.g. industrial, scientific and social. The precise approach to assessment, and the weighting of the different types of impact, varies with the individual project and its aims: for example, in some projects (or waves), commercialisation is the primary factor, but in other projects (or waves) the social impact may have a heavier weighting, even if it does not have an associated large financial return.

When considering economic and social impact, we apply indicators and monitoring appropriate to each of the scales indicated by the impact waves of Fig. *1*. The approach is slightly different when measuring scientific impact, as follows: in Wave 1 we monitor uptake of scientific results across trials (i.e. direct use of results, publication of papers); in Wave 2 we monitor uptake of scientific results among FITMAN partners (i.e. direct use of results or publications in other projects); in Waves 3 and 4 we monitor broader impact of direct results and publications (i.e. adoption of results in wider industry, publication impact in terms of citations as well as adoption or adaptation of results to broader contexts).

To monitor the factors and activities needed for the impact objective, an impact model is needed. The identification of high level impact objectives can be drawn from sources such as EU research Work Programme objectives and details in the project's Description of Work.

We formulate the impact model as a structure called a 'success tree', a device that describes in a top-down structure the factors needed to achieve success (the defined goal). A success tree can be seen as a complement to a fault tree, in which an undesired state of a system is analysed using Boolean logic such as AND and OR statements to combine a series of lower-level events. The analysis of factors and activities needed to achieve the impact objective is performed in a hierarchical way by detailing the sub-goals or steps and the factors needed to achieve them. In general, in a success tree, logical gates such as AND and OR can be used to describe whether all sub-factors (tree branches) are needed to achieve the goal (AND) or whether there are alternative routes for achieving it (OR).

For sake of simplicity, the denotation is left out in the example in Fig. 2. The interpretation should be that all the impact success tree branches contribute to the R&D project impact, and in order to achieve the maximum all the factors are needed. The success tree, "Contribution to IT industry success and business expansion", presented in Fig. 2 is a simplification of one of the overall success trees elaborated in the FITMAN project.

B. *Socio-Economic Impact Assessment Methodology*

The FITMAN Socio-Economic Impact Assessment (SEIA) methodology includes three components: the assessment of impact on industry, society and the scientific community. These three components are closely linked: for instance, impacts on industry engendered by the new technologies may in turn have knock on effects on society and the environment.

Fig. 3 summarises a multi-stage process for the SEIA. For each individual stage, all three issues – industry, society and the scientific community – would theoretically be covered. Here, we will describe only the industry level analyses. Each stage focuses on a different subdivision of the domain: the business environment as it is today of the manufacturing subsector as defined in [9]; a cost-benefit analysis for a typical exponent of that subsector, based on one of the FITMAN trials; and finally, these two aspects coming together to predict what the industry level impacts would be like in the future.

1) Socio-economic Megatrends

One of the aims of the FITMAN project is to ensure that the European manufacturing industry remains competitive and to improve its business processes through Future Internet (FI) technologies.

The Factories of the Future 2020 Roadmap [11] outlines a set of long-term societal objectives to recover the European manufacturing industry in terms of employment, environment and economic growth.

Fig. 2. A simplified success tree representing contribution to IT industry success and business expansion.

The technologies developed in FITMAN can help to achieve these objectives through improved business processes. The methodology presented here has been used to assess the potential impact of the FITMAN manufacturing trials across three categories:

- Employment: Effect of technology on individual employees, enterprise staffing requirements, health & safety, conditions of work, job satisfaction and staff training.
- Environment: Direct or indirect effects of technology on the environment (e.g., improved energy efficiency, reduced waste, improved product development leading to more environmentally friendly products).
- Economic Growth: Economic impact of the technologies for the whole manufacturing ecosystem; the enterprise itself, its suppliers, the wider manufacturing industry and the economy as a whole.

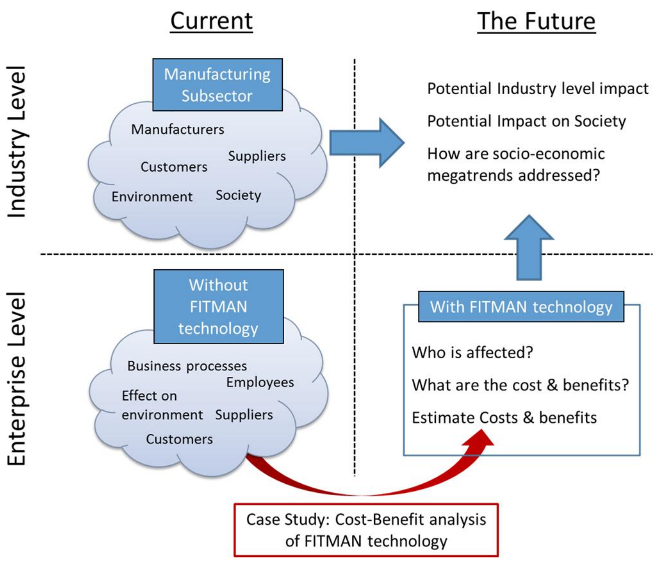

Fig. 3. The FITMAN Socio-Economic Impact Assessment Methodology.

2) Step 1: Establish the status quo of the manufacturing subsector

The first step in the SEIA methodology is to establish the current status quo in the manufacturing subsector. This is done considering the manufacturing subsector with respect to the three separate categories discussed above: importance to the European economy, employment in the industry, and effects on the environment.

3) Step 2: Cost-benefit analysis of FITMAN trials

In this step, the FITMAN use case trials provide the basis to analyse the potential impacts of the FI technologies applied in the manufacturing subsector. By drawing on the actual manufacturing trials, it is possible to quantify some potential costs and benefits to parties involved in the manufacturing ecosystem (including customers, suppliers, other manufacturers and society more widely). This insight can then be used in step three to assess the potential long-term socio-economic impacts of the new technologies.

To do this a cost-benefit analysis of affected parties is undertaken. This involves:

- Identification of affected parties (stakeholders) and construct a value network of the business model.
- Identification of the costs and benefits for affected parties and identify performance indicators that can be used to estimate them. Costs and benefits will cover the full spectrum of possible socio-economic impacts.
- Estimation of the costs and benefits for the affected parties. This should include, where possible, the quantification of the costs and benefits by scaling up the performance indicators.

This step provide a tangible basis to understand (and estimate where possible) the potential socio-economic impacts of the new FI technologies developed and adopted in the FITMAN project.

4) Step 3: Business impact assessment

The final step is to assess the business impact of the new technologies, which uses the analysis in steps 1 and 2 to draw together the potential socio-economic impacts across the three socio-economic megatrends discussed above.

The FITMAN technologies are also be considered with respect to the specific traits of the manufacturing subsector identified in step 1. Finally, each subsector will again be considered with respect to its interactions with the socio-economic megatrends, and the potential of the FITMAN technologies to help the manufacturing ecosystem address the socio-economic megatrends is then discussed.

IV. Findings: Application of the Socio-Economic Impact Assessment Methodology

This section reflects on the application of the research approached described in Section III, considering firstly the process for building the success tree based on the wave approach to modelling impact, and secondly the approach for modelling the impact of a trial on industry.

A. Building the success tree and collecting information

The post project impact creation model is used to monitor if project activities are sufficient (i.e. if the factors in the success tree 'leaves' have been realised). Project activities should be performed throughout all impact waves, starting from year one of the project. In FITMAN, the first monitoring checkpoint was at the end of project year 1.The focus was on the factors (i.e. leaves) that should have been performed by the milestone. Examples of such factors include the definition of trial requirements with end user involvement, the use of the ECOGRAI method [10] to define Business Indicators, and the availability of FITMAN technologies known as 'Specific Enablers'.

The timing, assessment, and data collection methods were defined and applied for all factors (i.e. leaves) in the impact hierarchy in order to identify any potential insufficiencies.

The construction of the tree structures is based on a variety of sources and knowledge, including the FI-PPP programme and projects [12] [13], FInES cluster activities, workshops, roadmaps and position papers [14] [10], literature in the manufacturing research domain [15], the European Union FP7 Work Programme[16], the FITMAN project itself [1], and expert workshops conducted by the authors.

In all, twenty project impact objectives where identified, for example: *FITMAN IT providers access new markets or create and use new software products*. Based on the impact objectives the success trees could be built, taking into account the three dimensions of impact (industry, society, the scientific community). The most complicated dimension, impact on the manufacturing industry, requires a tree structure of 5 levels, 15 leaves and 11 nodes, spanning three waves. It should be noted that impact monitoring is a continuing activity: the tree structure will be modified and updated further during the project according to new needs and observations.

To assess the status of factors (i.e. leaves) in the success tree, 13 assessment and data collection methods were identified and applied at the lowest level of the impact hierarchy, for example: *Quantitative assessment of dissemination activities*. Also, the data sources for monitoring and assessing the potential target value were identified, for example project activity reports, project deliverables or project performance indicators. Only impact creation waves 1 and 2 were considered because impact creation activities during waves 3 and 4 cannot be monitored during the project.

The factors relating to the first-year milestone were collected together into a table including the main monitoring data source, potential target value and status. The status is presented using three levels: OK (sufficient), OK- (minor shortages or lack of clarity), and not OK (not sufficient). Colours of the tree structure boxes, shown in Fig. 4, can be used to indicate the status: a green box refers to 'OK', a yellow box refers to 'OK-', a red box refers to 'not OK', and a blue box refers to a term that has not yet been assessed.

The status at the first-year milestone was visualised using the coloured success tree. For the first milestone the main part of the required activities had been performed but some minor insufficiencies were identified: for example, not all external components (‘Generic Enablers’) were 100% implemented by the FIWARE software provider. This information was used to generate recommendations for the next period, with the goal of ensuring impact both by correcting the identified insufficiencies, and by emphasising the important actions in the next period. These included, for example, ensuring sufficient collaboration and end user involvement.

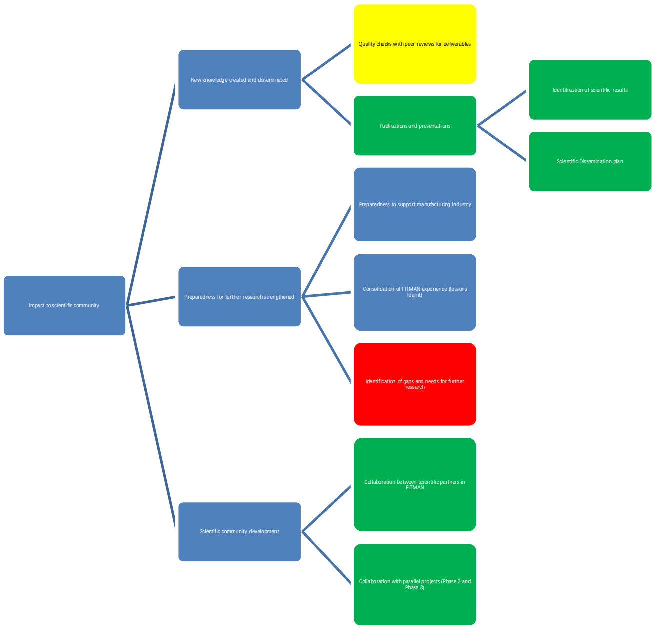

Fig. 4. Impact tree, with colours indicating status.

The next step is corrective actions: Based on status and looking further into the next project phase, a number of recommendations were given, for example: *To strengthen the scientific community, collaboration between scientific partners are encouraged to write more joint journal papers between FITMAN scientific partners.*

The recommendations were further refined to actions, including due dates and responsibilities, to be implemented during the second period. The objective was to ascertain that all possible success tree factors were considered so as to maximise impact.

B. *Impact on Industry*

It is clearly a goal of FITMAN that its technologies will impact business models in manufacturing, with downstream impacts on the customers and suppliers of those manufacturers. The FITMAN project drew on the Factories of the Future 2020 Roadmap[11]. As previously stated, this focuses on areas such as employment, the environment and economic growth with a view to encouraging benefits across all three and without detriment to any one of them.

FITMAN technologies can help achieve the objectives of the Factories of the Future roadmap through improved business processes. The Factories of the Future 2020 vision identified various socio-economic megatrends, which were analysed and expanded to three tangible areas of impact for FITMAN technologies, as follow:

1) Demographics and consumption
2) Globalisation
3) Sustainability

As discussed in Section III.B, three categories were identified as targets for trial-by-trial analysis of the FITMAN business cases: employment, environment, and economic growth. Table 1 shows an analysis of those three categories alongside the socio-economic megatrends to identify key questions of relevance in these scenarios.

In Section III.B we noted that the precise approach to weighting different types of impact varies according to project priorities (i.e. commercialisation, social impact, etc.). Similarly, in Table 1 we can consider the relative value of the different aspects such as industrial impact, societal impact, and impact on the scientific community. It is not uncommon, for example, for conflict to be inherent when trying to achieve both positive environmental impact and strong economic growth. In FITMAN’s ten trials, a number of different weightings exist, but it is typical for any given trial to consider a number of factors, from efficiency savings (where reduction in materials used leads to positive impacts in both the environmental and economic areas) to improved levels of health and safety in the workplace.

The analyses showed a wide-ranging potential for trial technologies to have impact across the manufacturing business ecosystem and wider society. The three categories allowed coherent analysis of the impacts of the new technologies on a trial-by-trial basis. With an understanding of the areas of

TABLE 1. MAPPING THE THREE ASSESSMENT CATEGORIES WITH FACTORIES OF THE FUTURE SOCIO-ECONOMIC MEGATRENDS.

	Employment	**Environment**	**Economic Growth**
Demographics & Consumption	How do we ensure generic benefits across the value chain as employment patterns change?	How can we ensure environmental benefits to all stakeholders?	How can we establish changes which lead to steady growth?
Globalisation	What effects will collaboration beyond the enterprise as well as beyond borders have?	Can we establish mutual benefits for all partners and not just put the burden on less strict countries?	How do we establish and maintain on-going growth and success for all?
Sustainability	How will changes to employment patterns and working practices affect medium and long term employment?	What can be done to ensure common benefits in the long term for all partners?	How do we maintain success and growth in the long-term?

impact across these categories it was then possible to link these impacts back to the socio-economic megatrends to identify how the new technologies address them.

To assess FITMAN's socio-economic impact, a quantitative framework was built to assess impacts in the three categories, looking particularly at macro-economic and societal impacts of FITMAN technologies. As described in Section B, this process involved three steps:

1. Establish the status quo of the manufacturing subsector
2. Cost-benefit analysis of FITMAN trial
3. Business impact assessment

In step one of the process, FITMAN partners generated a value network of the parties involved with the particular trial in question, considering the businesses and their customers as well as suppliers and sub-contractors. A value network diagram was generated to describe this, with Fig. 5 giving an example of what this looks like.

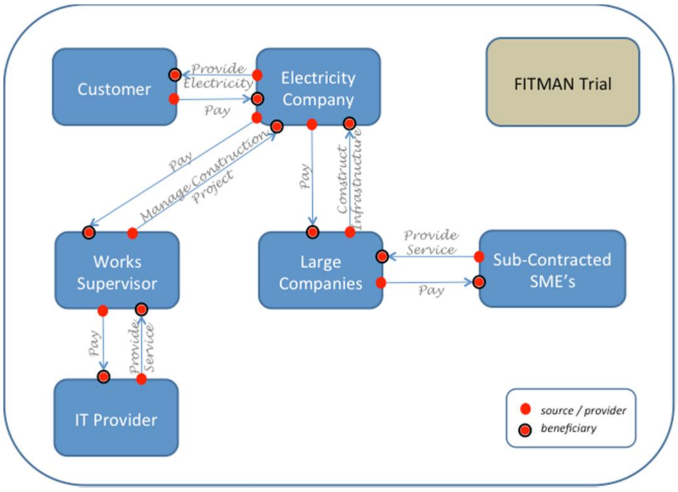

Fig. 5. An example of a value network diagram.

In step two of the process, the cost-benefit analysis is conducted. Tables are used to collect this information, with Table 2 showing how this is presented.

TABLE 2. EXAMPLE COST-BENEFIT ANALYSIS.

Actor	**Cost or benefit?**	**Cost / benefit**	**Related trial Performance Indicator (PI) measurement**
Actor 1	Benefit	Reduced project management overhead	**PI1**: Average lead-time to perform, record and analyse test results.
Actor 2	Cost	Cost of system implementation	None
Actor 3	Benefit	Reduced resource usage	**PI2**: Average amount of resource used before and after change implementation.

As can be seen, the fourth column describes which Performance Indicators (PIs), if any, are relevant to the identified cost of benefit. The PIs are typically at a very low level (i.e. impact on average % of a resource used, or on average time to perform a task), and hence a certain amount of extrapolation is required to understand the potential cost or benefit at the enterprise level. Nonetheless, the PIs are the measurements that outline the impact of the new technologies and are the only means by which the real costs and benefits can be quantified. In consequence, there is a close dependency between PI – a measure taken as part of monitoring activities – and the socio-economic assessment methodology. The one provides the required data to populate and understand the other.

In step three of the process, the business impact assessment is conducted, in which the individual costs and benefits identified in step two are assessed. This assessment typically involves an analysis of each row in the cost-benefit table from step two, discussing the impact of each row, related evidence from research and practice, and providing detail about any PIs. For example, if a PI involves a reduction in the costs of paper usage, it is important to establish a base level of paper costs, which can be done as follows:

Estimated cost of paper per sheet = 0.5EUR[2]

The associated PI can then measure the ratio of the number of pages used before and after the introduction of the new Future Internet technologies. By making some assumptions regarding the total paper usage across the project lifetime, the benefit to the project supervisor can then be gauged: see TABLE 3.

TABLE 3. ESTIMATED COST SAVING IN A PROJECT THROUGH REDUCED PAPER USAGE

Paper usage through project lifetime (no. of pages)	**Total cost saving (EUR)**
10,000	5,000*PI
100,000	50,000*PI
1,000,000	500,000*PI

This data can then be used to provide a quantified estimate of the benefit to the trial of the technology.

The kind of analysis to be done in step three can involve deep investigation of aspects including, but not limited to: the average salaries of people working in specific roles in specific countries; research findings about the frequency and impact of delays in projects in specific sectors; the average cost of specific resources.

After the above three steps have been completed, a final analysis can be conducted to drawn together the findings to explore the potential long-term benefits of FITMAN solutions in the sector in question. This kind of analysis works best when grounded in the specific traits of the manufacturing subsector under consideration (considering aspects such as average timeframes, impact on society, influence by government and commerce, etc.). Bringing these inputs together allows comment on the three key areas of employment, environment and economic growth.

Of particular value in this process is the use of PIs as an underlying resource by which the impact assessment is informed. Assessments can be updated throughout the project as the trials progress by simply revisiting the latest values of

[2] http://www.signinghub.com/datasheets/The_Real_Cost_of_Paper_based_Signatures.pdf

the identified performance indicators and updating the related analyses accordingly.

V. Summary and Discussion

The role of impact monitoring activities is not to assess the impact itself, but to monitor the activities needed to achieve that impact, including actions taken during the project and planning for actions after the project. The constant, cyclical monitoring of key indicators forces continued engagement between stakeholders that in turn provides an invaluable source of feedback into the project and its self-assessment. As discussed earlier, the challenge of R&D projects is that the actual impact of the project results cannot be measured during the lifetime of the project itself. However, it is possible to estimate what the potential impact could be, which is the role of the socio-economic impact assessment methodology discussed above.

In Section IV.B, we discussed the trade-offs between industrial impact, societal impact and impact in the scientific community. It is clear that sometimes the goals of a trial or technological rollout may favour one or two of these areas at cost to another such area (i.e. increasing economic growth and employment with some negative environmental impact), but there are clear examples of times when a goal is beneficial to several of the areas without having a negative impact elsewhere (i.e. reducing usage of a particular resource, with positive economic and environmental impact and no negative impact to the third area considered, the scientific community).

It is of course the case that the leaders of trials and other rollouts of technology will need to consider the bigger picture when weighing up these goals and their areas of impact: modelling post-project impact creation and using socio-economic impact assessment to quantify this work hand-in-hand to provide that holistic view and aid in decision-making.

Primary FITMAN outputs described in this paper are the wave-based post project impact creation model, formulated as a 'success tree', and the socio-economic impact assessment methodology, in which industrial impact, societal impact, and impact on the scientific community are weighed, considering socio-economic megatrends and extrapolating from performance indicators. By applying these models and methods, we have learned the following:

1. Success trees are a useful way to structure multi-faceted requirements. They can cope with complex scenarios (i.e. FITMAN used one with 5 levels, 15 leaves and 11 nodes).
2. As described in Section IV.B, structured analysis of any trial, experimentation or other rollout of technology facilitates taking a holistic view that can simplify the task of weighting different and sometimes conflicting factors.
3. It is possible to use low-level Performance Indicators (PIs) as inputs into a larger impact forecasting process. This involves extrapolating from the PIs, and has the advantage of enabling the update of assessments by revisiting the latest PI values at any time.

Use case trials in projects such as FITMAN are important for being able to do this kind of impact assessment and monitoring. Such trials typically represent the first real-world application of cutting-edge technologies, and so the objective measuring of their current and future impact is crucial. It can be the case that technology projects can be very focused on the technologies in question, sometimes at cost of this kind of impact monitoring and assessment.

We argue that by broadening a project to incorporate these aspects, vital lessons can be learned, not only about the project's impact (as a whole and in terms of each individual technology that is deployed), but also about a) how the project might increase its impact before it finishes and b) about the best ways to measure impact in the project's industrial sectors in general (by identification of related work, relevant trends, and appropriate resources that are used in generation and update of Performance Indicators).

VI. Conclusions

In this paper we have presented an analysis of the impact management and forecast approach used by the EU FITMAN project, a project that has close ties with industry as well as goals to influence that industry in a positive way.

We have described both theoretical and practical outputs. Theoretical outputs include the wave-based post-project impact creation model and the socio-economic impact assessment methodology. Practical outputs concern the approach to and lessons learned from the real-world application of these theories, both at the level of the FITMAN project overall (impact creation model) and at the level of specific trials within FITMAN (socio-economic impact assessment methodology).

By describing the underlying theory as well as the practical approach and lessons learned, we believe that these insights – which continue to prove useful as the FITMAN project continues to progress – can be more widely applied across domains related to technology management.

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