Extending manufacturing towards service-oriented business models: The T-REX technological levers that support this extension

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Abstract:

The European project (T-REX[1]: Lifecycle extension through product redesign and repair, renovation, reuse, recycle strategies for usage&reusage-oriented business models) is targeting the development of specific technologies and tools (grouped into four different 'levers') that will empower the companies (specially SMEs) in the development of advanced service-oriented business models for new Product-Service Systems (PSS) offering, or in other words, to promote a shift from value in exchange to value in use for customer needs satisfaction.

To support such transition, in the capital goods industries, from the "traditional" business models to the "new" service-oriented business model four different 'levers' will be developed: a platform to develop new service-oriented Business Models (BM), improved design of products considering their lifecycle (Design for X techniques), re-engineering of traditional support services (Services Engineering) and integrated local Condition Monitoring (CM) systems and tools for assets and fleets Prognostic Health Management (PHM), customizable to industry requirements in order to increase availability and reduce Life Cycle Cost.

Therefore, T-REX aims to develop and experiment conceptual tools within three practical case studies focused on industrial partners target sectors, i.e. in the forklift trucks, the machine tools and the robot solutions domains.

Final results will try to reduce operational maintenance service costs, increase reuse of components and extend the life cycle, with a global reduction in the Life Cycle Cost in the range of 25-30%.

Introduction

The current economic downturn and the global economy competitiveness are pushing many sectors related to manufacturing industry to adapt to an ever-changing business environment looking for new ways to diversify their business (Takata, 2013). In particular, there is a trend for manufactures producing and selling durable products towards selling the usage of the product (e.g. renting, pay-x-use) or even selling the product performance (e.g. pay-x-

[1] http://t-rex-fp7.eu

performance). All these emerging new trends fall within the concept of 'servitization' of manufacturing (Vandermerwe and Rada, 1988; Wise and Baumgartner, 1999).

However, these new business, even tough with a low-level of maturity (i.e. renting lacking a more comprehensive perspective), completely change the manufacturer's perspective over the costs and revenues arising during the product lifecycle. The relevance of concepts such as Total Cost of Ownership (TCO), life cycle extension or maintenance management strongly increases (Takata et al, 2014), and thus the reduction of costs related to the product usage and maintenance is mandatory in order to achieve a profitable business, even at the expenses of higher costs related to materials, production processes, and supporting technologies. Over time, this new business led to a more distributed and stable revenues coming from a wider after-sales services portfolio related to the operation and maintenance of the equipments. In addition, such models entail environmental benefits too through increased duration, renovation and reuse of product modules.

This is an important change, and there is today a limited diffusion of new business models, especially on manufacturing SMEs. Despite the expected benefits at a company and societal level, the transition towards such models is slow and mainly concerning large multinationals manufacturers. Smaller firms often lack managerial vision, competence and resources to revolution their Strategy, Organization (internal and inter-firm), Product Design, Maintenance/Repair/Renovation Services and Economic Performance Measurement Systems (towards customer lifetime value). More often than not, capital goods manufacturers act as pure suppliers of pieces of equipment while they neglect the opportunities stemming from a more service-oriented approach. Thus, they tend to lose control over their installed base, and fail to achieve the customer intimacy that is quintessential to devise and offer customized products and services.

One way to overcome this is to empower companies, and specially SMEs, with technologies that can aid them to understand the benefit of each business alternative, as well as to assist in the deployment of these new models. In particular, the main concept is to work on integrated product-service solutions or Product-Service Systems (PSS), promoting the shift from value in exchange to value in use for customer needs satisfaction (Tischner et al., 2002; Tukker, 2004).

As a consequence, we think main stress should be put on reducing the Life Cycle Cost of the Product-Service Systems and extending their lifecycle in order to maximize profits, but also to increase customer utility and the lifecycle value of their offerings.

T-REX project

The points cited above are the main motivation of T-REX[2] project. This project has started in October 2013 to support companies to satisfy current customer needs, enhance the company's performance, enabling to diversify its business and achieve a competitive advantage. In particular, defining and implementing a new Product-Service Systems (PSS) offering is a demanding process that must be supported by four 'levers', the first focused on

[2] Lifecycle extension through product redesign and repair, renovation, reuse, recycle strategies for usage&reusage oriented business models

innovation of new service-oriented Business Model (BM) configuration and the remaining based on products-services lifecycle extension and Life Cycle Cost reduction, with the use of technologies related to Design for X (DfX), Services Engineering (SE) and Condition Monitoring & Fleet Management (CM/FM). The objective of these levers is to support the application of service-oriented business models, especially within SMEs, in a context of a lack of a business model approach that guides companies in the servitization process.

Therefore, T-REX project aims to support such transition by developing and experimenting conceptual tools within three practical case studies in the transportation (forklift trucks), machinery (machine tools) and automation (robot solutions) domains. In order to cope with these objectives it has been required to develop a business platform whose main elements are:

- A Business Model suited for the new landscape that changes the way products are offered and customer relationships managed;
- Product design techniques to extend the lifecycle, to foster upgrading and renovation, and to support serviceability;
- Service design methods for the (re-)engineering of existing services;
- Integrated local condition monitoring capacities and tools for asset Health management, customizable to the industry requirement;

T-REX consortium is composed of 10 partners from 5 different countries. The industrial partners are key players in their European target sectors, and are supported by research universities/centres and technology providers with specific background in each area of this project.

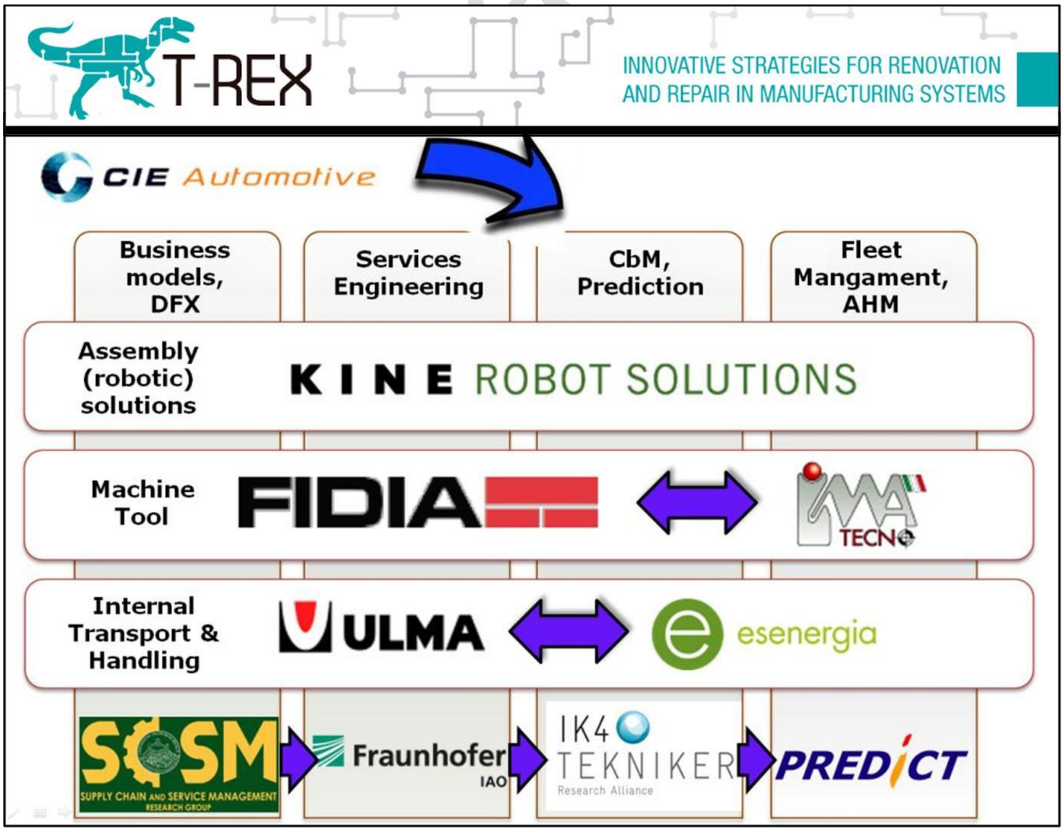

Figure 1 - T-REX consortium and its main activities

Background and preliminary research

Maybe the main characteristic for the proposed new service-oriented business models is that they do not necessarily require the transfer of product ownership from the manufacturer to the customer, with the consequent transferring of business risk from the customer to the manufacturer (Oliva and Kallenberg, 2003; Baines et al., 2009). The customer pays for using an asset, rather than its purchase, and so reduces risks and costs traditionally associated with ownership. In fact, in the new‖ business model all the costs arising in the product‘s lifetime, from early conception to disposal, are suffered by the manufacturer and must be covered by the periodical bills delivered to the user, according respectively to the product‘s usage or its performance in field. This is precisely why pay-x-use or pay-x-performance agreements have to be based on a sound Life Cycle Costing (LCC) or Total Cost of Ownership (TCO) approach. From this standpoint, it is in the manufacturer interest to provide for as long a product‘s lifetime as possible since any product‘s replacement would decrease sales (according to the product‘s unavailability or loss of performance) and increase costs (according to the product‘s production variable costs).

New business models that do not transfer the product ownership offer and opportunity to redesign the products, the (after-sales) services and the (after-sales services) supply chain, as well as manufacturer-customer (ongoing) relationship and (lifecycle) revenue models. The main differences arising from this new point of view have been collected in the following table.

	“traditional” business models	“new” business models
Product design	- Product is designed for the minimum cost - Lifetime should be enough	- Product cost is less important. The relevant is the Total Cost of Ownership. - The product is configured for the application. - Product lifetime is enlarged.
Services, supply chain and customer relationships	- Product developer establishes conservative preventive maintenance policies. Maintenance is made in house or BY third parties - After-sales services, mainly technical assistance and spare parts, are sources of revenue for the manufacturer (or third parties)	- Product developer make extra effort to minimize maintenance cost: leveraging on techniques and tools to optimise preventive and emphasize on prediction - Services allow to increase the product availability

Customer relations and Cash flows	- Product sales as a one-off transaction - In the usage and end-of-life phase interactions between the manufacturer and the customer may not occur - If they occur their monetary value is often negligible compared with the product value - Product developer is not aware of the conditions in which the product is in operation - Dismantling is in charge of the user	- Product-Service Systems provision as a relational, long-term process - Stable and continuous cash flows from customer to manufacturer over the product lifecycle, of a smaller entity compared to product sales - Cash flows cover both the product and service component of the offer - Product developer is aware of operating conditions - Information from the product is collected to increase product availability (e.g. Condition based Monitoring), increase service efficiency (e.g. remote control/diagnosis) and transform the feedback from the field in input to the design of new products and services - End of life is in charge of the producer. Some modules could be re-used

Table 1 – "traditional" vs. "new" business models

To gain preliminary insights in this topic and better understand the level of service orientation of business models in capital goods industries and their actual market strategies, an exploratory survey has been carried out on 95 European companies that operate in three main sectors addressed by T-REX project (Saccani et al., 2014): Transportation (forklift trucks), Machinery (machine-tools), and Automation (robot systems).

For the present study, the Supply Chain and Service Management (SCSM) research group of the University of Brescia has developed a research framework consisting in an extension of the Business Model Canvas (Osterwalder and Pigneur, 2010) as a methodology to define new service-oriented business models. This model has two more variables which take into account contextual factors that influence the business model development and its relations with the company strategy. The model was also enriched with two additional layers (Adrodegari et al., 2014): drivers (e.g. internal or external elements that drive firms to develop new business model) and obstacles (e.g. internal or external elements that slow down the adoption of new business model). The rest of the nine variables considered in the model are the same building blocks of the Canvas, this is, value preposition, key activities, key resources, partnerships, channels, customer relationships, customer segmentations, revenue model and cost structure.

Initial findings and Ongoing work

Descriptive analyses have been performed on collected answers in order to identify existing outstanding gaps/barriers and drivers in the development or adoption of the new service-oriented business models, complementing this research with exploratory partners' case studies analyses in the three target sectors and with a literature analysis of other best-in-class case histories. Gaps were classified in four different categories (i.e. market and business related risks, financial risks, and technological risks, divided into external threats and internal development weaknesses), paying particular attention on how they can affect the development of the 'levers'. Lastly, a set of actions intended to overcome all these barriers were identified, linking them to the corresponding description of the 'lever' that is going to support/solve them. The main findings emerged from the empirical research can be summarized as:

- The adoption of service-oriented business models is low in the studied industries, in particular with regards to the machine tools and robotics sectors; revenue models are dominated by product sales, with a contribution of services close to 20% dominated by corrective maintenance and spare parts sales. Rental or "pay-per-x" contracts are an almost negligible revenue source.
- Service offerings are still mainly anchored to traditional services.
- The transportation industry is a step ahead the machinery and automation one in the journey towards new usage-oriented business models.
- Service is an important part of company's business and its importance will increase in future. However, most companies have not yet formalized the service development activities, with no explicit strategy, responsibilities, budget, formal processes and methods in place.
- Product design practices aimed at modularity and reliability are in place in a number of companies, while products/components reuse, recoverability and serviceability are rarely supported since the product design phase by formal techniques.
- Fleet operation and maintenance practices are carried out by companies on less than 50% of the installed base, generally through direct field engineers.
- Information systems and automation have a great unexploited potential.
- Customer relationships are still dominated by a traditional approach. They are transaction-based, and customers' culture is perceived as an obstacle to develop and offer "pay-per-x" contracts.

The aim of T-REX project is to support such transition by developing and experimenting conceptual tools within three practical case studies focused on industrial partners target sectors, i.e. in the forklift trucks, the machine tools and the robot solutions domains.

Based on these preliminary findings, a revision of the three T-REX case studies has been performed in order to identify the ideal level that each company should achieve in the development of its usage-oriented business model. In addition a General Framework to select, develop, implement and validate these service-oriented business models has been designed considering the particular actions to be deployed by each lever to support products (DfX) and services (SE) design, Condition Monitoring and Fleet Management (CM/FM).

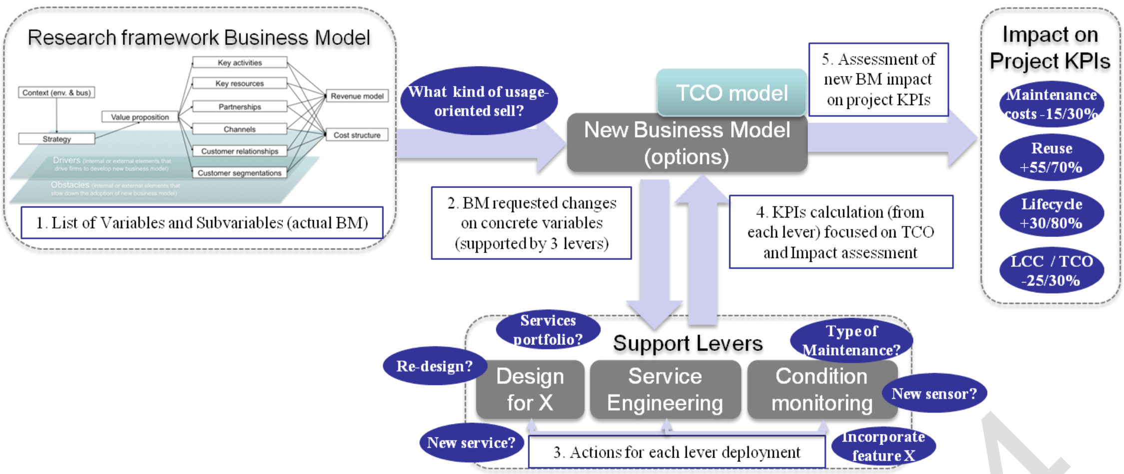

Figure 2 – T-REX General Framework for new service-oriented Business Models deployment

This General Framework states five steps where the collaboration between BM development and technology levers is structured, and that are being handled within T-REX project:

1) List of variables and subvariables: To assess the actual characteristics of the organization (according to the current research findings) and to identify possible needs or chances to develop new business (Business Model design).

2) BM requested changes: Design of the three support levers to cope with new business models needs as well as to plan possible interoperability between all of them.

3) Actions for each lever deployment: To select which are the best alternatives, regarding levers application, and the required actions to be carried out.

4) Key Performance Indicators (KPIs) calculation: To implement selected solution and to calculate indicators that will also be linked to the Total Cost of Ownership (TCO) assessment based on the new business model findings.

5) Assessment of new BM impact on project KPIs: To assess additional project KPIs related to costs reduction and lifecycle and reuse extension.

This framework has more importance as the complexity of the technical systems increases, widening possible scenarios for after-sales services where maintenance, repair, renovation, reuse and recycling of such systems take on growing importance.

Within this framework, the design of products, services and production systems can benefit from the adoption of a modular approach as a lever to enhance the reparability, renovation and upgrade of products and systems. Modularity is enabled itself by specific design methodologies that adopt the Design for X (DfX) approach.

The key role played by services during a product life emphasizes the need to consider their usage since the concept phase. The design of the support processes needs to be developed in parallel with the design of the product. Services Engineering (SE) has emerged as a new research area, which is concerned with the systematic development and design of service products attempting to efficiently utilise existing engineering know-how.

At the very end, the goal is to have a structured framework to deliver project objectives related to the new BMs, which are as high as:

- Decreasing maintenance service costs by 15-30%.
- Increasing reuse of components and modules for 55-70%.
- Extending assets lifecycle on 30-80%.

If such results are achieved, it will be also translated to a global reduction in the Life Cycle Cost (LCC) in the range of 25-30%.

The maintenance lever

Manufacturing equipment maintenance has evolved from breakdown maintenance to time-based and predictive/proactive maintenance, and finally to proactive maintenance based on prediction and prognostics. Condition based Maintenance (CbM) can be only performed when a failure can be predicted by means of Condition Monitoring (CM). CbM capabilities are extended by Prognostic Health Management (PHM) approach, where systems are working to overcome unscheduled maintenance problems by integrating all the condition monitoring, health assessment and prognostics into an open modular architecture, and then further supporting the operator by adding intelligent decision support tools (Bengtsson et al., 2009). This approach is even more significant when considering renovation and reuse within fleet wide dimension (Fleet-Wide PHM).

Partial results arising from the survey study suggests that the practices regarding fleet operation and maintenance (CM/FM) are lower than regarding other levers such as Design for X (DfX) or Services Engineering (SE). This implies a lot of room for improvement, especially in domains such as manufacturing or automation (e.g. robotics), taking also into account the perceived importance of some practices among T-REX use case participants, such as remote diagnostics.

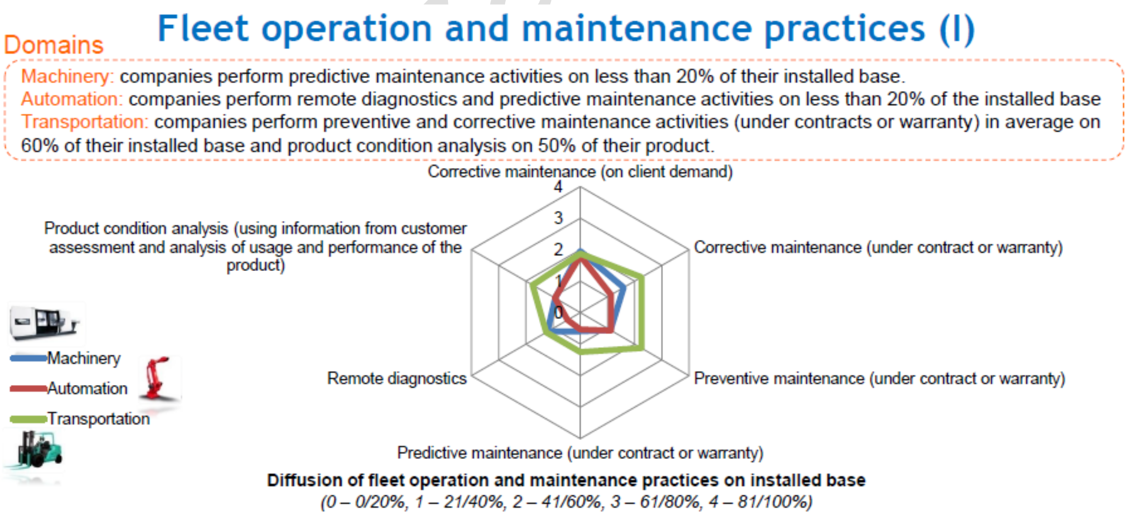

Figure 3 – Fleet operation and maintenance practices (Saccani et al., 2014)

Having this in mind, the improvement of maintenance practices is based on two key pillars (Jardine et al, 2013): the existence of new technologies that helps in the inclusion of these practices, and the appearance of new simulation tools capable of providing a complete understanding on different maintenance strategies requirements and impacts.

Concerning the identification of best alternatives, Arnaiz et al. (2013) shows the development of a continuous improvement cycle concerning maintenance activities, including a simulation tool to evaluate condition-based technologies. Common techniques, standards and tools for different strategies evaluation are applied to take cost-effective decisions, mainly relaying in the incorporation of new technological embedded monitoring devices and faults prediction/prevention technologies as support for remote maintenance (e-maintenance). A graphic that shows an example of how, for a particular component, manual activities related to monthly inspections or preventive yearly replacements are not the right approaches while corrective and monitoring strategies have lower costs over its lifecycle.

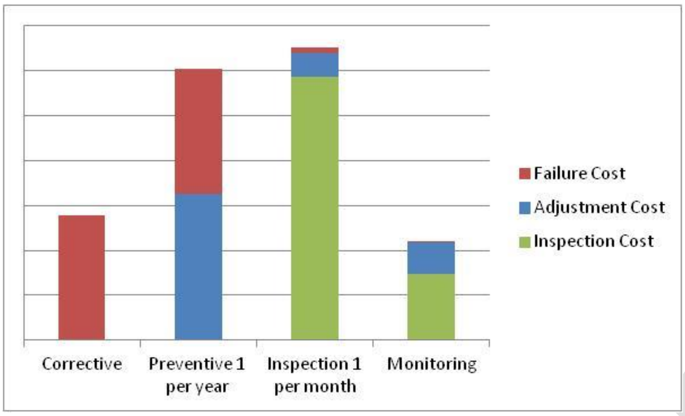

Figure 4 - Results of a cost-effectiveness analysis where maintenance strategies are compared (Arnaiz et al., 2013)

This is coherent with the latest results on the perceived importance of certain tools, such as use of smart sensors or condition monitoring tools is perceived for an adequate maintenance service provision (Holgado, 2014). At the same time, the EC is promoting the use of smart devices and systems based on ICT when renovating or upgrading existing products for new assets management methods along its entire lifecycle. Maintenance importance is remarked in twofold: on one hand to make new business profitable, and in the other hand to expand maintenance service portfolio in industrial sectors.

Conclusions

Even though T-REX project has started recently, preliminary findings of the project are coming from:

- Developing a Research Framework consisting in an extension of the Business Model Canvas to guide the data collection and the analysis of the empirical research.
- Conducting an extensive Survey among European industrial companies on actual marketing strategies and on the current adoption of usage-oriented Business Models in the domains of transportation, machinery, and automation.
- Analysing Survey answers, together with other best-in-class case studies and industry reports as well as in-depth study of T-REX industrial partners target sectors (forklift trucks, machine-tools, and robot systems).
- Analysing persisting Gaps and Obstacles to find out how firms should reconfigure their Business Model in order to make it more usage-oriented.

- Defining a General Framework for new service-oriented Business Models deployment and identifying five deferent business model typologies in order to give insights on how companies can shift from ownership-oriented to service-oriented Business Models.
- Designing of techniques, tools and guidelines for the development of new Business Models and for the new services portfolio definition.
- Defining Condition Monitoring specifications for the three domains (machine tools, forklift trucks and robot systems), designing of embedded monitoring devices and defining of architecture for the fleet-wide remote Asset Health Management.
- Identifying suitable new service-oriented Business Models for each of T-REX target sectors and selecting accordingly use cases to demonstrate expected outcomes.

This process should provide any managerial team the necessary insights to identify, develop and implement new service-oriented business in a successful way, by considering in advance all the required models and technologies to support such transition.

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