TRANSFORMATION OF A RESEARCH CENTRE TOWARD AN INNOVATION PARTNER IN THE CONSTRUCTION SECTOR

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Innovation processes of the construction sector have been studied from the viewpoints of research-based consultation at VTT Technical Research Centre of Finland. The starting point of an internal analysis and benchmarking concerning the role of a research centre came from a Finnish product manufacturer that challenged its capacity to a short introduction lead-time. Understood as an opportunity, a core team was set up representing different expertises, and a co-operation project was proposed to the manufacturer. In addition, an in-house follow-up project was created. After completing successfully the product development project, and based upon findings of the follow-up project, a feasibility study was conducted concerning consultation packages for development of construction products and concepts. However, during this study phase, the objective of packages was replaced by an ideal of a collaborative process that integrates competencies, tools, and management of a research & development organisation, and links them to those of the customer.

The process model of a multidisciplinary commercialized research-based consultation is a new way to organise work of a research centre, and its core is collaboration with the customer. During the follow-up process, feasibility study and development of a research-based process, approaches of the Action research were applied. A market study and two external evaluations were made that gave partly consistent partly inconsistent results with the learning outcome concerning appeal of the new type of partnership. New sector-wide strategies at the national and European level show however that key findings were justified. Next challenges in the development of the multidisciplinary innovation services concern internationalisation, external networking and globalisation.

Keywords: Expert service, Commercialized research, Integrated methods, Action research, Innovation, Construction sector.

INTRODUCTION

In Finland, the construction sector became academic when the technical university was founded in the beginning of the 20th century. The governmental technical research centre VTT under the Ministry of Trade and Industry extended research in the year 1942. At VTT, activities have been closely related to the actual needs of various phases of construction sector and society: during the rebuilding of the country in the 1950ies and late urbanisation 1970ies, the demands concerned mainly quality of construction and design codes. Typically, the employees worked in several rather independent units, until major organisational changes in the 1990ies. The current

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activities cover main fields of research and development in the sector, from markets and processes to materials, structures and technical systems.

At the end of 1990ies, VTT started to allocate resources to new types of projects that aimed at integration of diversified activities in the construction sector. There were both research-based findings and quests from clients that pointed to multi-technology and multi-disciplinary approaches. A growing number of studies showed that performance of buildings needs to be predicted and managed in a holistic way; further, ageing of society emphasized user-orientation. Development of computational methods facilitated new interests.

The operational environment of VTT changed also due to increased competition for funding opportunities. Traditionally, a great deal of projects was purely research-driven, both in internal and joint-funded projects. Re-thinking of position of research took place in many OECD countries; initiatives to address the “third task” to universities as catalysts of innovations were common especially in the United States. In the European Union, a transition from a technology policy to innovation policy took place at the end of nineties, and in the Lisbon Strategy was launched in 2000. Nowadays, it is commonly expected that research organisations co-operate closely with companies.

At the end of 1990ies, several factors in internal and external circumstances challenged to search for integrated research methods and collaborative customer-oriented working methods. In order to realize this transition, and to serve the changing construction sector, an internal Action Research process was set up at VTT.

**2 TRANSFORMATION PROCESS**

2.1 Series of internal projects

VTT organised four succeeding internal development projects to study and propose new internal processes and working methods in product development, aiming at fast and relevant co-operation with companies of the Finnish construction sector – and thus better services. The projects are introduced Table 1.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Short description</th>
<th>Schedule</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Follow-up (Case-study)</td>
<td>1998-1999</td>
<td>Customer-oriented methods of one special group involved in a case-study.</td>
</tr>
<tr>
<td>II</td>
<td>Feasibility study</td>
<td>2000</td>
<td>Propose research-based activities for product development in the sector.</td>
</tr>
<tr>
<td>III</td>
<td>Service packages</td>
<td>2001</td>
<td>Planning of four commercial packages for product development.</td>
</tr>
<tr>
<td>IV</td>
<td>Service process</td>
<td>2002 - 2003</td>
<td>One service process for customized projects.</td>
</tr>
</tbody>
</table>

The working and learning methods and communication during the different stages of internal development process are shortly described in the Table 2.
Table 2. Work, learning and communication in the internal development projects.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Work content</th>
<th>Learning methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Follow-up of a real development project. Lists of research-based services and</td>
<td>Problem solving, pair and group working, participation in training courses concerning</td>
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<td></td>
<td>evaluation of their meaning to companies in product development.</td>
<td>product development and service business.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Self-reflexion on own working methods.</td>
</tr>
<tr>
<td>II</td>
<td>Data gathering of product development in which VTT had been involved. Interviews</td>
<td>Group working and self-reflexion.</td>
</tr>
<tr>
<td></td>
<td>and data mining in archives. Internal network.</td>
<td>Two workshops with invited speakers from a client company and other research groups.</td>
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<td></td>
<td>of the national R&amp;D.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Market survey about prospects of SME’s.</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Selection of four focused service packages and associated duties to realize</td>
<td>Literature surveys. Interviews. Internal and external evaluations.</td>
</tr>
<tr>
<td></td>
<td>of tools available and needed. Planning marketing material. External evaluation</td>
<td>Benchmarking with various generic tools.</td>
</tr>
<tr>
<td></td>
<td>of drafted services and packages by two consultants. Interviews of company managers.</td>
<td>Self-reflexion. Identification of own strengths and weaknesses (SWOT)</td>
</tr>
<tr>
<td>IV</td>
<td>Building up internal resources and research infra for a service process. Generic</td>
<td>Learning by studying and problem-solving. Reading and writing. Self-reflexion.</td>
</tr>
<tr>
<td></td>
<td>process model for development of construction products. Production of internal</td>
<td>Workshops. Organisational learning.</td>
</tr>
<tr>
<td></td>
<td>learning material and web-based help-desk.</td>
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</tr>
</tbody>
</table>

2.2 Stages of the spiral learning process

In the beginning of the transition process, VTT was mainly regarded as the organisation for pre-competitive research, and provider of focused expert statements. However, VTT had a portfolio of testing, inspection, quality assurance and certification services to the construction sector that were run mainly by an service centre independent from research work. The situation matched with the needs of clients, too.

In the beginning of the transition process, the bottom-line question was, whether any research organisation should become a product developer. A lively debate arose when the client of the case-study project presented a wish of “light approach”. The opponents argued that it simply is not possible; research on any subject needs time and thinking, and opinions based on engineering knowledge belong to the companies.

A change of attitude resulted from the positive experiences during the true product development project. It was proven that a product development project can be done in close co-operation with a company, and the role of a research organisation can be
based on and framed to its core competences. The fast implication of research findings in a real construction product was also found very motivating.

The requirements of a new construction product are presented in figure 1. VTT’s expertise was focused to issues of technical performance and building processes. The company’s share of tasks included same requirements but it focused to tasks that were important for launching a new product on the market.

![Figure 1. Grouping of product requirements to be taken care of in a product development project.](image)

Based on experiences in the true product development project, conclusions were made that VTT should proceed and develop its internal processes and methods for flexible, integrated, efficient and step-wise product development. The case study and other signs showed that the construction sector was changing and implementing new methods from other sectors. Re-organisation of R&D in companies followed thoughts of concurrent engineering approach (figure 2).

![Figure 2. Recognized changes in product development: Concurrent engineering and cross-functional interaction.](image)

The feasibility study about supporting services for product development was established at the time when several expert services were under development around VTT. Its aim was to produce an overview of the sector’s expectations, and VTT’s various options to respond them. Some of the options were evaluated in detail, like for example a fast-track technical due-diligence service funded by the technology agency.

Based on learning, brainstorming, forecasting, benchmarking and self-reflexion, researchers concluded that VTT should develop “ready-to-buy” service packages. A commercialized package should be developed in co-operation with the customer segment. The benefits of the packages were seen to be faster responses on requests.
and cost-effective preparation of a technical programme and an offer. In the action plan for development of service packages, the targets were presented with the figure 3.

Figure 3. Proposal for composing service packages from own core competences. The triangle represented the limits of the research organisation.

The next stage of the spiral learning process concerned reasoning and content of service packages. The project plans themselves document the learning process during which the goal and steps of the work were evaluated and vision of the outcome became clearer. A major part of ideas was based on understanding that VTT's strength would rely on combination of individual competencies. The concurrent engineering was regarded as a skill needed in a company. The conclusions made followed these thoughts, and four service packages were proposed to cope with the areas that were expected to have potential. The role of the own research organisation was regarded as technical assistant in special tasks for which the companies do not have resources.

Division of a product development project in clear phases was regarded as a means to foresee better the tasks of a technical programme and thus assist cost-evaluation – instead of seeing the division as a means to manage a project. However, modelling various approaches for divide, it could be seen at first that the phases are crucial for decision-making and then the importance of the initial phase – front end - was realized. For decision-making purposes, the product development project became divided in five phases with defined targets (figure 4).

Figure 4. Main phases of a product development process.

Segmentation of customers was the next problem in the learning process. The sector presents a fragmented industry, in which consolidation amongst the biggest European competitors is high but at the same time the share of small-size companies is great. The actors involved in a single building project are numerous and their dependence on
each others is great. The same holds the number of products: whenever a new product is entering the market, the launching affects to the learning process and systems of the others. Coping with the great variety of customers and their needs with packaged services was seen problematic. The benefits and harms of four ready packages were analysed and slowly the idea was abandoned due to its poor flexibility and relatively high costs to build up any price-tag service.

Based on studies on customer management and marketing, the expert service became understood in a totally new perspective. The interest transferred to develop such a process that customized projects could be combined based on one process model (figure 5).

![Figure 5. Services as processes inside a research organisation (Grönroos).](image)

The combination of generic expert service model and model of the construction product development process was chosen the approach of VTT to develop its services. It was found very essential that the approach should support preparation and conduct of a customized project but also supports faster implementation of research inventions.

3 RESULTS: FROM CO-OPERATION TO COLLABORATION

3.1 Identification of needs for R&D services

During the recession years in the beginning of 1990ies, companies - that survived- tended to cut expenses of product and process development. The cuts never recovered completely. An opportunity was seen at VTT as a reliable and knowledgeable provider of outsourced services. The needs of research-based services vary in large ranges: the SME’s have reduced the number of R&D personnel at minimum and some big companies have hired doctors in their r&d departments.

The competitiveness of a new product depends on the usability, technical properties, quality, price and supporting and additional services – on the overall concept. Success presupposes combining of the segmented knowledge concerning markets, technologies, product development and product approvals. Several of the European research centres are involved in all these activities.

The product development became more networked also in the construction sector at the time when the internal development process started. In a network, the knowledge management is in a key role. Due to VTT's expertises in this area, there were good reasons to believe in the competitive edge.
The short product introduction lead-time was the catalyst for the internal learning and development process. Shortening of the time used for a product development presupposes a simultaneous development of marketing, engineering and manufacture. This kind of multi-discipline organisation of development processes was introduced in several studies and papers about product development in globally competitive companies. In a research-based product development, the role of a research organisation could grow to a partnership. In such a case, the collaborative process should facilitate a constant flow of relevant information.

During the internal process, an assessment was made in the form of SWOT concerning an introduction of new process approach. Shortly, the findings concerning the alternatives were:

1. Continuation of traditional ways in which the client was in charge of all actions and schedules was evaluated to have strong points in targeted results exactly to the identified problems and direct communication with the expert representative of the company; at the same time the overall schedule most likely was long and overlapping and interrelated problems remain hidden causing risks at later stages of the project.

2. Transfer to a process model that incorporates methods of concurrent engineering was evaluated to beat the traditional model in aspects concerning time, creativeness, expertise and collaboration; at the same time the requirements on capabilities to interactive work become higher.

3.2 Outcome from the learning process

Concerning the outcome of the learning process, the following conclusions can be made:

- Innovations in construction sector require in common research-based data
- A multi-technology research organisation has core competences necessary for cross-functional technology development
- Tacit knowledge of experimental work and engineering knowledge offer chances for remarkably value added project provided there is a good collaboration
- In order to shorten the introduction lead-time information flows inside a company, inside the research organisation and between two parties involved in the common development project should be arranged efficiently both between humans and using networked tools; further, concurrent engineering should be adopted by each participant in such a way that the main phases proceed simultaneously.
- Definition of main phases of a product development is necessary in order to manage the process with respect to objectives, resources and costs and in order to perform the tasks at a right level that produce relevant and reliable data for decision-making at the end of each phase
- Preparation and initial phase of a project is crucial in stating the objectives and requirements, which should later be evaluated continuously but especially at the end of each main phase.

Planning and realization of a multidisciplinary, networked project is a new type of challenge for experts in the construction sector that requires training and tools.
3.3 Three parallel processes in a collaborative product development

The very essence of the research-based consultation service is the close collaboration between service provider and the client in such a way that the core competences of each partner are used efficiently and systematically. The share of tasks to the internal projects of the client and VTT and presented in the figure 6.

At a very early stage of the development process, it was concluded that VTT should not be in charge of success on the markets because its main competences are on research and development of technologies. The overall responsibility of a product development should be in the company although the collaborative project may be managed by a representative of the research organisation. This conclusion does not exclude the necessity of awareness about markets and customer needs. VTT should also develop its services in technology foresights and tools for customer-oriented processes.
3.4 Web-based support

A web-based support was developed in order to guide and advice researchers in establishing a technical programme for a product development project. It was also aimed to function as a toolbox. It was possible to find checklists, templates, links to libraries and databases there. The principle of the internal website is presented in figure 7.

Contract work. The product development service is a collaborative process together with the customer. The process shall be planned and performed according to principles of concurrent engineering and multi-technology management.

Contract work

<table>
<thead>
<tr>
<th>PREPARATION</th>
<th>IDEAS</th>
<th>ALTERNATIVES</th>
<th>CONCEPT MANUFACTURE</th>
</tr>
</thead>
</table>

**Figure 7. The principle of opening view in the process model and toolbox of the product development service.**

4 DISCUSSION

The succeeding projects of an internal development process of VTT were conducted according to principles and methods of the Action Research. During the process, collaborative learning changed the mindset of the participants to understand an expert service as a process that may incorporate some commercial packages but essentially it means new working procedures. This approach was chosen after trials to commercialize fixed service packages; this way was found both risky and costly.

As a starting point, the need to learn about the product development methods was understood. The rapid changes in technologies had generated new thinking in many technology fields but generic methods were not usually applied in the construction sector. The learning material was brought to the project from other sectors; the product development methods and innovation management are not taught in civil and environmental engineering departments of universities.

The content of a possible service started to get a shape when the differences of science-based research work and research-based development were understood better. The main point is the objective of the work: science-based research aims at new methods and new knowledge, the product development strives for successful innovations. The picture of research-based product development was created as a combination of experiences of the own organisation, learning process and surveys on companies.
The process model and tools were not well validated or tested in practice. There were many reasons and explanations; one of the most influential reasons was that the researches involved in the internal process were distributed to new positions in the fundamental organisational change of the entire research centre in the year 2005. The strategy of VTT was oriented to an innovation organisation. New internal activities were established to expand the research-based services, and new tools and approaches were taken into use. The next stage was also necessary as the research market was changing global, and the companies were competing on global markets. The changes in business models have networked the various companies thoroughly. This phenomenon is graphically represented in the Figure 8.

![Figure 8. Networking of companies.](image)

### 5 CONCLUSIONS

A research-based service for product development in the construction sector was developed in an internal learning and action process. The start of the process was one research group and a true development case. Through a spiral learning process and various trials, and expanding the number of participants, the service became defined as a collaborative process with clear decision-making steps. The service consists of description of the process and its phases and subdivision to various tasks. The project management and quality assurance are an essential part of the process.

An expert service means internally that the organisation recognizes and legalises a matrix organisation that enables collection of various expertises and capabilities from the whole organisation and in special cases from its allied companies.

As a multi-functional research organisation, VTT has competences and research infra to develop its activities as a service provider for networked and outsourced product development of companies. However, there are challenges for organisational learning and new working methods. Innovations – understood as invention plus exploration – ask for systematic work that combines different competencies in creative ways.

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REFERENCES


