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Case Study: Researching a Smart Cable

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Abstract: **Research and development play a crucial role in innovation processes. R+D is an investment in the future, resulting in new products, processes and services through the transformation of newly developed technologies and thus far unexploited potential. This document provides an overview of the stages and outcomes of the research and development process in question. INFONIA Foundation was entrusted with complex research tasks in the project entitled Piac_13-1-2013-0242 automated cable standardization technology research. The main task of the research institute was to prepare and support the Client's decisions, in the Piac_13-1-2013-0242 Automated cable customization technology research for VLG Ltd.**

Keywords: **smart cable, research report, R+D development, case study.**

I. INTRODUCTION

Research and development play a crucial role in innovation processes. R+D is an investment in the future, resulting in new products, processes and services through the transformation of newly developed technologies and thus far unexploited potential.

R+D crucially impacts the competitiveness of businesses in the industrial and technological sectors, while its consistent and strategic application may result in a sustained market leader position in the given industry.

Among the basic factors of successful innovation, the ownership of knowledge and technology are assigned an important role. R+D activity supports the development of both. When a company invests time and resources in R+D activity, it will witness a hitherto unprecedented influx of knowledge, which will be the value that – if managed well – may serve as the basis of the given company's successful operation and facilitate its continued success. It must also be noted, however, that R+D is not to be conducted for its own gain: it should not be used to establish and operate a new division within a company but instead its primary objective should be to acquire and accumulate knowledge and integrate it into new products.

This document provides an overview of the stages and outcomes of the research and development process in question.

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II. RESEARCH REPORT

A. Stage one:

1 January – 30 September 2014

The first stage of the project lasted nine months, and its objectives were to select, acquire and set into operation the venue and equipment required by the pilot/experimental research and development. The research tasks were designed to support the implementation of these objectives: out of the four studies conducted, two discuss the setting up of the research venues, one is devoted to the organization of the innovation process and the acquisition of its priority equipment (3D printer), and the fourth study supported the big picture approach and the openness to trends. Although the entire project spanned three years, its concepts defined a dimension extending far beyond three years; therefore, it would not have

sufficed to provide a recent snapshot but instead we needed to survey trends and try to outline their possible future development to enable us to draw up a strategy for 8 to 10 years (which could of course be updated later on if necessary).

Our research institute basically carried out three activities to support the Client's decisions, help its preparation process and enhance its competitiveness:

- We supported the research activity conducted by the Client's researchers by finding and selecting the literature and specialist materials required.
- We held biweekly professional workshops in order to ensure and develop the continuous professional background for the research process. We collected specialist documents (mainly specialist monographies in English but also numerous academic articles and in some cases product brochures) to be studied during a two-week period, after which the researchers delegated by the two parties participated in meetings for an entire day and jointly selected and processed the knowledge relevant to the project. Besides ensuring a professional dialogue, these workshops also helped to maintain continuous communication and thus guaranteed the theoretical continuity of the research and adherence to the deadlines.
- We wrote four studies.

The studies play a role in each stage of the project: we always defined the crucial decisions and/or questions that needed to be made and answered by processing the knowledge available in the given stage. We planned to write four studies in stage one. Below is a summary of their content and conceptual framework.

VLG-001 Market analysis, research, technical requirements (STEEP expert study)

This study surveys the future trends, outcomes and potentials of cable technology, and highlights the positive impact of the IoE (Internet of Everything) concept. What is the possible path of development in cable production? What will the important markets and trends be?

I. Executive summary

II. Cable technology trends and potentials in the next few decades

III. Internet of Everything

IV. Wireless vs cable

V. Market analysis

VI. Recommendations

VLG-002 Expert study on acquisition preparation, planning and innovation organization

In order for the most efficient and successful acquisition of the 3D printers to be used in the laboratories being set up, it was necessary to decide which 3D printers are the best (technology, direction), what direction the trends are following, what type of printers should be used (for the entire duration of the project). Supporting the outcome (plastic) of the project is of priority importance.

I. Executive summary

II. The history and development of 3D printing

III. The potentials and limitations of using 3D printing

IV. 3D printing in cable technology

V. Types of 3D printers, hard selection variables

VI. Recommendations

VLG-003 Expert study on designing the research laboratory

The basic research reviews the equipment in innovation labs all over the world, looking at the hardware and software support systems they have, and collects the list of equipment recommended for acquisition. Close cooperation is required with the Applicant's acquisition team and the professionals involved in setting up the laboratory.

I. Executive summary

II. Concept and recent definition of the research laboratory

III. Requirements in regard to the research laboratory

IV. The research laboratory as a workplace: safety, technology, environment

V. Equipment in the research laboratory

VI. Recommendations

VLG-004 Setting up the test laboratory, preparing the acquisition of the printers (SWOT)

Continuation of study VLG-003 and integrating the findings of study VLG-002. Close cooperation required with the Applicant's expert team and acquisition professionals.

I. Executive summary

II. Concept and recent definition of the research laboratory

III. Requirements in regard to the research laboratory

IV. The research laboratory as a workplace: safety, technology, environment

V. Equipment to be acquired for the test laboratory

VI. Cooperation between the test lab and the research lab

VI. Recommendations

The handing over of the studies was accompanied by presentations given by the top management (two presentations).

B. Stage two:

1 October 2014 – 31 March 2015

Our research institute used the same methodology in stage two as it had in stage one:

- We supported the research activity conducted by the Client's researchers by finding and selecting the literature and specialist materials required.
- We held biweekly professional workshops in order to ensure and develop the continuous professional background for the research process. We collected specialist documents (mainly specialist monographies in English but also numerous academic articles and in some cases product brochures) to be studied during a two-week period, after which the researchers delegated by the two parties participated in meetings for an entire day and jointly selected and processed the knowledge relevant to the project. Besides ensuring a professional dialogue, these workshops also helped to maintain continuous communication and thus guaranteed the theoretical continuity of the research and adherence to the deadlines.
- We wrote two studies.

VLG-005 Preparing the production line design:

The study's findings resulted from the targeted basic research based on specialist literature and the biweekly workshops scheduled in the research and development process set up for the project. During these discussions, the two research teams worked together to draw up a picture of international experiences as well as experiences gained during the company's own production, and synergies were established. The setting up of the production line is not only a vast financial investment but might introduce a fundamental change in regard to the company's entire future development activity. Therefore, every single decision was verified and validated many times. For the purpose of quality assurance, the INFONIA Foundation worked with external experts at this stage of the process; their expertise is manifest in the selection and sequencing process. The targeted basic research produced two fundamental results for the study in question: the structural draft design of the production line, and the specified description of the production line modules.

I. Introduction

II. Executive summary

III. Cable production

IV. Processes to be completed

V. Production line design process

VI. Production line modules

VLG-006 Smart cable development:

The study was aimed at surveying the specialist literature of smart cable development. Surveying the specialist literature produced virtually no valuable findings in regard to smart cables, which is a very strong positive indication as to the novelty of innovation in this area and shows immense potential to be exploited. In specialist literature, smart cable was mostly used to refer to the various accessories of computers (predominantly to USB cables) that connect various ICT equipment. In these cases, it is mainly the solution or the outcome that can be called 'smart', or rather 'clever', but in no way, do these cables have any additional features. Smart cable network development is a rapidly expanding market, in which the cable to be developed by the Client might well play a key role, since it can be installed faster and is a solution that can be standardized in the future. The study delivers a detailed presentation of an experiment conducted by a Munich research team to produce smart cables with the aim of utilizing its conclusions in this research and development project. The two most important areas of the problems related to cables are cable tears and cable theft. The smart cable to be developed is expected to provide solutions for these problems, as it would significantly reduce the loss of money and time suffered by industries and consumers using cables.

I. Executive summary

II. Smart cable vs smart systems

III. Survey and grouping of cable types

C. Stage three:

1 April – 30 July 2015

Stage three was the busiest phase of research for our institute. In this phase, we prepared background materials within the shortest period of time in order to avoid any 'down-time' in the research and development process. We completed five studies, and as in the previous phases close cooperation and frequent meetings were required between the two research teams.

VLG-007 Connector market and trend analysis:

This study reviews the production process and provides a summary of the plan jointly set up by the research teams of INFONIA and VLG. This study is aimed at identifying markets that can form the basis of sales, hence we recommend that the demands of such markets are considered during the research and development process. During our analysis, we highlighted two main areas: the automotive and the robotic industries, both of which have great potential, a vast array of opportunities and a market niche; moreover, there is a huge demand in both these areas for smart cables.

I. Executive summary

II. Market trends

III. Robotic industry

IV. Automotive industry

VLG-008 Preparing the 3D printing methodology:

An especially important role was assigned in the research to the use of 3D printing technology, as it makes the production of product prototypes faster and easier during the connector development and the test cable production processes alike. This study surveys the 3D printer types, their operational solutions and the role they play in product design in order to help the Client make a decision regarding the procurement of the most appropriate 3D printer types based on authentic information.

I. Introduction

II. The objective of 3D printing in the project

III. Survey of 3D printers

IV. 3D printing and product design

V. Case studies about rapid prototyping with 3D printers

VI. Bibliography of the most important reference literature

VLG-009 Twenty connector types recommended for testing:

One of the three pillars in the given research and development project was the selection of the right connector type. In order to select this connector, we first reviewed the literature and made our recommendations based on it; the selected connectors then need to be acquired and tested with the help of 3D printers. The testing process is followed by a further narrowing down of the suitable connectors. This study is the first ever written to support the development of connectors. The twenty connectors selected virtually cover the whole connector segment, so we will have primary and control data too during the testing. In addition, we will be able to gain governing data in regard to future marketization. It is important that conventional and customized connectors are equally tested during the research and development process.

I. Executive summary

II. Selected connector types

VLG-010 Preparing the production line design:

This study reviews the production process based on publically accessible sources, and provides a summary of the plan jointly made by the research teams of INFONIA and VLG. This study forms an integral part of expert study 005.

I. Executive summary

II. Production line modules

VLG-011 Preparing the testing:

This document is aimed at providing help in documenting the testing to be conducted in VLG's laboratory. It takes a look at the machine used for the testing, the requirements of form and content pertaining to the documentation to be made, and the management of the documentation of the test cases.

I. Setting up the testing environment

II. Rules of testing – recommendations

III. Management of test cases

D. Stage four:

1 August 2015 – 28 February 2016

The main planned event in stage four was the launching of the pilot production and the hypothesis testing. Both these processes were started off with an introductory study in which the conceptual system and methodologies of the given area were reviewed, while we made our recommendations for VLG. Since the process of narrowing down and selecting the most suitable connectors ended with the result that the desired outcomes cannot be attained by using the connectors currently available on the markets, it was necessary for VLG to develop its own connector. The research team soon got down to work on developing their own connector for which they already had the technological background thanks to the research laboratory already being set up; the specification requirements had also been laid down during the narrowing down research and discussions. Hence, we deviated from the original plan and in stages four and five our objective was neither to survey the connectors available on the markets, nor to reduce the number of the most suitable ones to ten, but instead to make the specifications for the connector to be developed by VLG (first study) and finalize it (relevant study in stage five).

VLG-012 Developing VLG's own connector I:

It became increasingly clear during the selection of the suitable connectors that knowing the industrial standards and their usage was not going to be sufficient for the successful marketization of the smart cable. In order to have a smart cable that works systemically, that can be connected to a network and has a functional alarm feature, VLG had no option but to

develop its own connector. The development of a connector also opens up the opportunity to develop a smart grid. The new connector is expected to ensure the seamless patching, extension and network connection of the smart cable. After presenting a review of ten connectors, this study documents the draft concepts.

I. Reducing the number of connectors to ten

II. R+D decision: develop VLG's own connector – draft concepts

III. VLG's own connector – first technical drawings

VLG-013 control of primary outcomes, hypothesis testing:

We opted for the methodology known as rapid prototyping (RP) already during the planning stage of the research and development project, which is why 3D printers were included in the acquisition stage. RP is a technical solution whereby products can be manufactured automatically, i.e. by 3D printing using CAD data, so temporary prototypes can be made in a matter of a few hours or days. This study presents recommendations for VLG's research team in the area of hypothesis testing.

I. Forms of testing

II. Hypothesis testing

III. Methods of design of experiment in industry

IV. Summary

V. Bibliography

VLG-014 control and analysis of the pilot production:

During the smart cable development, a VLG Ltd set up a pilot plant, i.e. an R+D laboratory where all the development and testing phases can be implemented. In this study, we collected expert knowledge about pilot production methodology as well as the circumstances and limitations to be considered in order to achieve efficiency and precision of implementation. The findings of the study were agreed with the engineering team in workshops, and the recommendations and rules governing the pilot production were also formulated during these occasions. This study presents recommendations for VLG's research team in the area of pilot production.

I. Introduction

II. The concept of pilot production

III. Production processes

IV. Process development and process qualification

V. Summary

VI. Bibliography

E. Stage five:

1 March – 30 June 2016

Three studies were made in the final stage of the research and development project. They were aimed at supporting the conclusion of the project, finalizing the documentation and providing help with the patenting process.

VLG-015 Final specification of the connector viable for development:

INFONIA research team followed and supported the entire process of VLG developing its own connector, started in stage four. After the initial draft concepts, the study in stage five documents the final versions of the technical drawings, which contain the technical solutions and specification of the connector developed by VLG.

I. Introduction

II. Technical documentation of the specification of the connector developed by VLG

VLG-016 Control of primary outcomes, preparing the patenting process:

The expert documentation is aimed at providing support for VLG in regard to the patenting process. It focuses on the discussion of the concept and process of patenting and highlights the risks the Client should be aware of during the patenting of the prototype it developed.

I. Introduction

II. Survey of patenting processes

III. Recommendations

VLG-017 Control and analysis of pilot production 2:

Preparations for the pilot production had been made in stage four. Pilot production was launched based on the recommendations made in that stage. This study comprises the technical drawings that provide the summary of the outcomes of the pilot production.

I. Introduction

II. Technical documentation of the finalized connector developed during pilot production

III. CONCLUSIONS

Research has two main experiences:

- It is worthwhile to include representatives of social sciences in engineering projects. With extensive research, we saved a lot of time, we fend off dead-end paths, and last but not least the result product became truly niche item.
- Not only big and spectacular innovations can have a multiplier effect. The intelligent cable solution developed during the project has brought back development costs for the first two years and provides the company with several years of competitive advantage. In addition, R & D has contributed to the organization's organization development and the growth of its knowledge.