HELSINKI UNIVERSITY OF TECHNOLOGY
Systems Analysis Laboratory

FINAL PROJECT REPORT

MAT-2.177 SEMINAR ON CASE STUDIES IN OPERATIONS RESEARCH
VTT: PROJECT PORTFOLIO AND DECISION MAKING

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ABSTRACT

The Problem

VTT Technical Research Centre of Finland is an impartial expert organization. VTT has hundreds of ongoing research and development (R&D) projects. Currently VTT has the need for process description for the research projects lifespan and tools for analyzing project portfolios of ongoing research projects.

Methodology and material

The project team interviewed the key decision makers to gain knowledge of the current decision making process. Building the framework for improving project portfolio management was based on the interviews as well as a literature study of relevant articles.

Results

In the results several kinds of improvement methods were identified. For example to increase transparency of the decision making, the project evaluation criteria should be made public. Also by publishing project ideas in-house, the researchers could be selected to a project rather than vice versa to start a culture change from resource-based to task-based organization. In addition the communication between the beginning of the innovation chain and the Business Solutions department should be improved by increasing the amount of co-operation. To improve all the other suggestions, proactive project monitoring practices should be established.

Project manager

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CONTENT

1 INTRODUCTION

This report presents the case study "VTT: Project portfolio and decision making". The report deals with our team's progress during the project, the means which we used to find a solution to the given problem and the actual outcome with suggestions and risk assessment. Project portfolio management is a widely studied field and many articles and studies concerning it can be found. We noticed that many of these were not applicable to our problem because as we later discovered our project was not going to be solved with mathematical modeling or problem solving, but a clear view of the organizational structure and the decision making process from a new idea to a finished project. The VTT project portfolio and decision making process is studied with a systematic approach.

1.1 VTT

VTT Technical Research Centre of Finland is the largest impartial contract research organization in Northern Europe with over 2700 employees. VTT has hundreds of ongoing research and development (R&D) projects. These projects are divided in different technology areas (biotechnology, materials and building, industrial systems, etc.). New projects are founded in regular basis during the whole calendar year.

1.2 Background

Selecting R&D projects has attracted considerable academic interest in the last few decades. Multiple inexactly defined goals and subjective evaluation criteria are typical for competing R&D project submissions. Thus selecting an optimal group (portfolio) of R&D projects is a multi-criteria decision analysis (MCDA) problem for the decision makers. Although mathematical methods are found to back up the decision making process there is no use for these if the process in itself is not suitable for using them. In other words there has to be a certain type of decision making process in order to achieve significant gain from these models.

1.3 Need behind the study

For every profit making organization, one of the main purposes is to create positive revenue for the owners and other interest groups as well as keep the operations profitable in the long run. In VTT's case profit is not the only interest, but of course an important factor for long term performance. One of the main reasons limiting VTT's financial performance is the lack of sufficient communication between the two ends of the innovation chain.

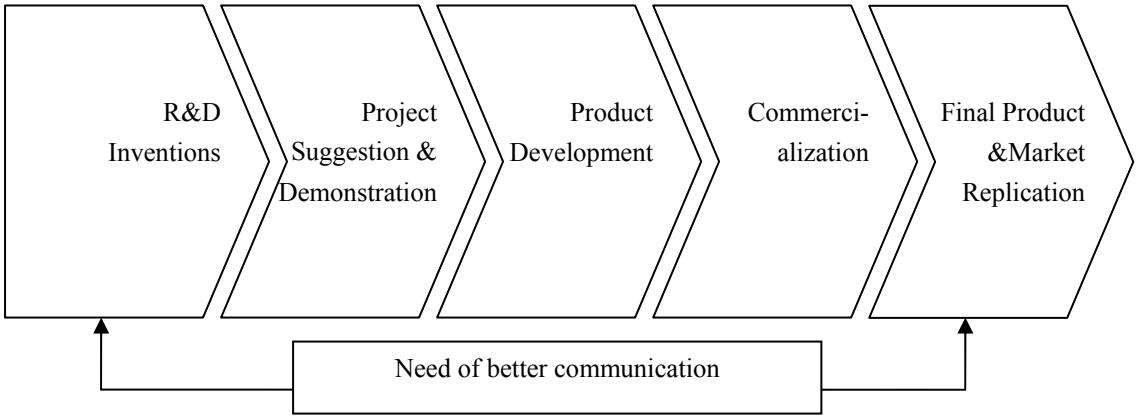


Figure 1 – Need of communication through the innovation chain

Lack of communication can be seen in the large amount of projects which end up without sufficient market demand and therefore do not create any incoming cash-flow. To solve this problem, better tools for assessing the potential of new projects, as well as the current state of VTT's project portfolio is needed.

1.4 Objectives

Currently VTT is in need of process description for the research projects lifespan and also tools for analyzing project portfolios of ongoing research projects. In VTT, the decision for funding a new research project seems at the moment to be based on the general feeling the decision makers (DM's) get from the project application forms. It also seems that all the DM's do not take part in the decision making even though they are all responsible for the made decision.

The monitoring of ongoing projects and systematic collection and iteration of new project ideas has been somewhat neglected. This can be due to the fact that gathering the up-to-date information of the projects is difficult. As the result of this negligence research projects are not suspended for re-evaluation even though the risks of the project have been realized. Also new project ideas seem to come up only just before the decision meeting, sometimes without comments from all relevant stakeholders within the organization. In addition the ongoing research projects are not studied in bigger context to discover if they fulfill VTT's strategy.

This translates to four separate objectives for our project. They are presented in the issue tree of Figure 2.

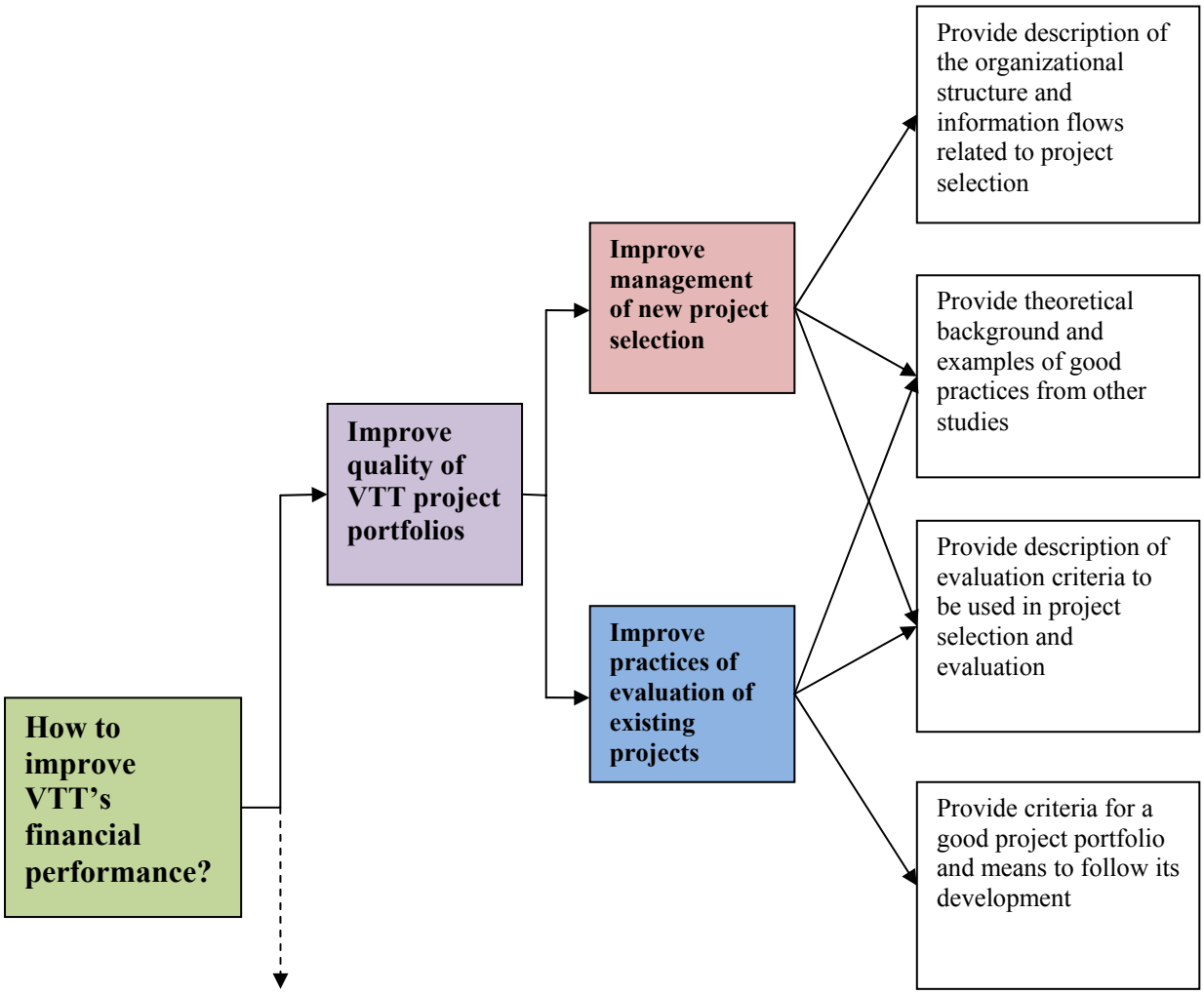


Figure 2 – Project issue tree

1.5 Structure of the report

This report is structured as follows, in Section 2 we describe briefly what was done and Section 3 concentrates on theoretical models of project portfolio management. Section 4 describes the VTT's organizational structure and Section 5 models project's lifespan from idea to the end of the project. Section 6 gathers the projects up to form a project portfolio and describes the needs for portfolio management. Suggestions are presented in Section 7 and Section 8 concludes the study.

1.6 Definitions

AR

(VTT) Customer solutions / Business solutions. Acronym from Finnish name: Asiakasratkaisut.

STOR

(VTT) Steering Group of the Strategic Research. Acronym from Finnish name: Strategisen tutkimuksen ohjausryhmä.

Mentor's portfolio

Mentor's portfolio is a collection of projects the mentor is managing (Figure 4)**Error! Reference source not found.**.

STOR portfolio

STOR project portfolio is a collection of mentors' portfolios. All the mentors belong to the same STOR (Figure 4).

2 PROJECT DESCRIPTION

The project was first introduced in the kickoff seminar at 19.1.2007 in the facilities of Helsinki University of Technology. The project team was formed and project manager, Kalle Korpiaho was chosen unanimously at the first meeting. In the beginning the problem was analyzed, and a detailed project plan was made. However, the specific demands were not clear until the interviews were concluded in March. Five high-level managers and decision makers were chosen from the VTT and the interviews were done using an evolving approach to the current questions.

At the beginning, the project focused on finding a mathematical method for solving the given problem. We found a suitable model in cooperation with Professor Ahti Salo. In our literature studies we found similar cases, and some of them were quite close to ours in theoretical approach.

Project meetings were held roughly once a week. In these meetings our progress and tasks were discussed and developed further. A lot of ideas came up during our brainstorming sessions and many proved to be helpful as the scope was altered. After the first interviews we found out that the initial problem was not going to be solved merely with mathematics but we needed to clarify the whole process. We introduced the new approach in our interim report.

Our new approach included building a new model of the whole project life span, describing the evaluation criteria of a single project, modeling the information flows between different shareholders, finding examples of good visualizations of the project portfolio data, and writing down good practices the interviewees told us. This caused abandoning of the mathematical model, and focused our attention to the organizational structure and decision making process.

A part of our literature study concentrated on the mathematical side of the decision making process and the methods in these studies were thus not applicable anymore. The new field is widely studied and we refer to these articles in this project report. This expanded our literature study from the original project plan.

3 THEORETICAL FRAMEWORK

In this project we have decided to concentrate on VTT project selection decision process rather than modelling the decision making situation and optimizing its outcomes.

In the management science literature R&D project-selection has traditionally been presented as a constrained optimization problem. According to several recent studies this approach has its pitfalls. Thus new approaches have been developed. The philosophy this report is following has its groundings in these new approaches and it is somewhat different from the traditional optimization models. The new approach studied e.g. by Schmidt and Freeland (1992) seeks insight rather than outcomes and focuses on the decision process. (Schmidt and Freeland. 1992)

3.1 From decision making to decision process

The literature on R&D project selection can be divided into two approaches: the traditional "decision-event" and the more recent "decision-process" or systems approach. The traditional decision event approach studied models of streamlined decision making situations, while optimizing the event that was, and usually still is, held behind closed doors. This approach did not take into consideration the various aspects related to the R&D project selection process as a whole. (Schmidt and Freeland. 1992)

These classical models have to an extent a narrow view of the process, while focusing on the outcomes. The new decision process approach has evolved through a new branch of literature studying R&D project selection from a systemic point of view. According to Schmidt and Freeland (1992):

> "The classical model focuses on outcomes: Given a set of projects, the model determinates the subset that maximizes an objective. This model focuses on decisions on a given organizational level and at a certain point in time. They assume a top-down fixed criteria and bottom-up alternatives but have no possibility to alter the problem within the planning cycle. They cannot create new criteria, objectives or alternatives unless in a specific re-evaluation or programme shift period." (Schmidt and Freeland. 1992)

It is important to note that the R&D project selection is different from traditional investment or capital-budgeting systems. Several studies have shown that R&D project selection problems usually consist of multiple, interrelated selection criteria and resources which complicates the

decision making. The problem has also critical dependencies form e.g. external funding decisions and the risk is multiplied by uncertainty arising from the future benefits of a new technology. There are also difficulties of measurement when it comes to qualitative factors such as strategic directions influence on decision making itself. (Schmidt and Freeland 1992.)

The R&D project selection process is challenging to optimize According to Schmidt and Freeland. (1992):

> "Formulating the problems is difficult and modelling challenging because decisions evolve over time as a result of coordination of organisational sub-units and related projects. The new systems-oriented philosophy recognizes the value of organizations decision process. Systems models seek insights on decision process." (Schmidt and Freeland. 1992)

The decision makers can gain more objectivity and reduce external pressure by developing the decision process. By a coherent and transparent process the decision makers can make better justifications to the stakeholders. (Chien. 2002)

The objective of the systems approach is to gain insight regarding general managerial policies rather than to provide answers to specific selection problems. Systems models can be used as laboratories to study questions about organizational design and management policies. For example by simply choosing the best projects the decision makers do not necessarily end up with the optimal portfolio as a whole. The decision makers should be able to form a holistic approach to the variety of R&D activities including projects relationships to each other. (Roussel, Saad and Erickson. 1991) (Chien. 2002)

The key problems in project portfolio selection are the following:

- Funded projects do not reflect on the strategic choices of the organisation
- Quality of the portfolio is poor
- Go/Kill decision are weak and once funded, projects have a life of their own.
- R&D focus is lost. Too many project for too little resources
- Trivial projects with learning or update results, nothing with a breakthrough or competitive edge.

(Chien. 2002)

As a result of these problems R&D performers are faced with:

- Poor performance
- Low impact projects
- Too long to get to market
- Higher than acceptable failure rates

(Chien. 2002)

3.2 A systemic approach

The VTT's organizational R&D environment can be viewed as a matrix of interrelated clusters or units that are organized towards a goal. The organizational units are interrelated because they share inputs and outputs. The relations between different units constitute the systemic structure of the organisation. We are actually looking at a complex system-within-a-system because each unit has goals which are determining the function of the unit. These goals are be directed by the organizations strategic direction. (Schmidt and Freeland. 1992)

Not only the research performing units but also the R&D projects in a portfolio are often connected to each other. The continuation or success of a given project can depend on the results and success of other projects in the portfolio. (Chien. 2002) From this point of view the current research shows that a holistic approach in selecting the best possible portfolio instead of selecting the best possible projects should be practiced.

Performing and thus also selecting R&D project is not a closed system. The impacts of a single successful project can be diluted if other projects on related fields fail. In an ideal situation the results of a successful R&D portfolio "pile up" in a predictable and measurable way. One of the simplest examples of interrelationship between projects is time, which can cause linear problems to project execution.

According to the systemic approach the R&D project selection process and decision making should be viewed as a part of a general management system or strategic-planning system rather than as an isolated decision event. Thus a fully integrated model of an R&D project-selection process should include all these subsystems: a planning model that oversees a coordination process and a system for project implementation. (Schmidt and Freeland. 1992)

From a functional perspective project selection systems are considered with three general tasks:

1. Adaptation (learning, strategy formulation, goal setting)
2. Coordination/ Control (Policy setting)
3. Transformation (project implementation)

(Schmidt and Freeland. 1992)

3.3 Project selection approaches

When selecting portfolios of projects the criteria of evaluating a single project is nevertheless crucial. Vonortas and Hertzfeld (1998) argue for

> "[A] method to appraise ex ante longer term, strategic R&D programs that would reflect the inherent value of such R&D in terms of opening up opportunities (but not obligations) for future investment in new technological areas with potentially substantial returns." (Vonortas and Hertzfeld. 1998)

Investing in R&D projects should be done according to Vonortas and Hertzfeld (1998) in groups of projects or programs. Along with the systemic approach to project selection researchers have been able to formulate foundations to a methodology that enables measuring what previously had been described only intuitively and qualitatively. (Vonortas and Hertzfeld. 1998)

The early days of this methodology can be traced back to a branch of finance theory which developed measures of the intrinsic value of stock options. The basic idea of R&D portfolio decision making can be transferred to "real investments" which are also characterized by irreversibility and considerable uncertainty. However, it is, of course, a simplistic approach to the evaluation of risk. (Vonortas and Hertzfeld. 1998)

Although strategic directions might be hard to measure it is essential for a firm to keep in mind these directions while making decisions that might have an influence on the firm's future. Archer and Ghasemzadeh (1999) discuss this problem in their study and they came to a conclusion that the firm has to use either a top-down or bottom-up method logically and not to change its perspective in the middle of decision making process (Figure 3). (Archer and Ghasemzadeh, 1999)

Many relatively divergent techniques have been created for the project portfolio selection but the problem with many of these is that they often are too complex and they require too much input data that they might be too difficult to use. Archer and Ghasemzadeh (1999) therefore suggest that only the techniques and procedures that use the most critical project measures must be used.

Proposition 4 from their study simplifies they key element of this problem: "*Users should not be overloaded with unneeded data, but should be able to access relevant data when it is needed*". Thus they also suggest that none of the methods are used if they are not understood readily by managerial decision makers. They emphasize the phrase tools for decision support, not decision making tools. (Archer and Ghasemzadeh, 1999)

Archer and Ghasemzadeh (1999) say that the amount of time required making the project portfolio selections increases geometrically with the number of projects to be considered and there fore they emphasize the fact that proper screening is essential in making good business choices. If the amount of time used to evaluate project that really would not need any consideration increases it will compromise the evaluation process of projects that might jeopardise the making of sound business choices. (Archer and Ghasemzadeh, 1999.)

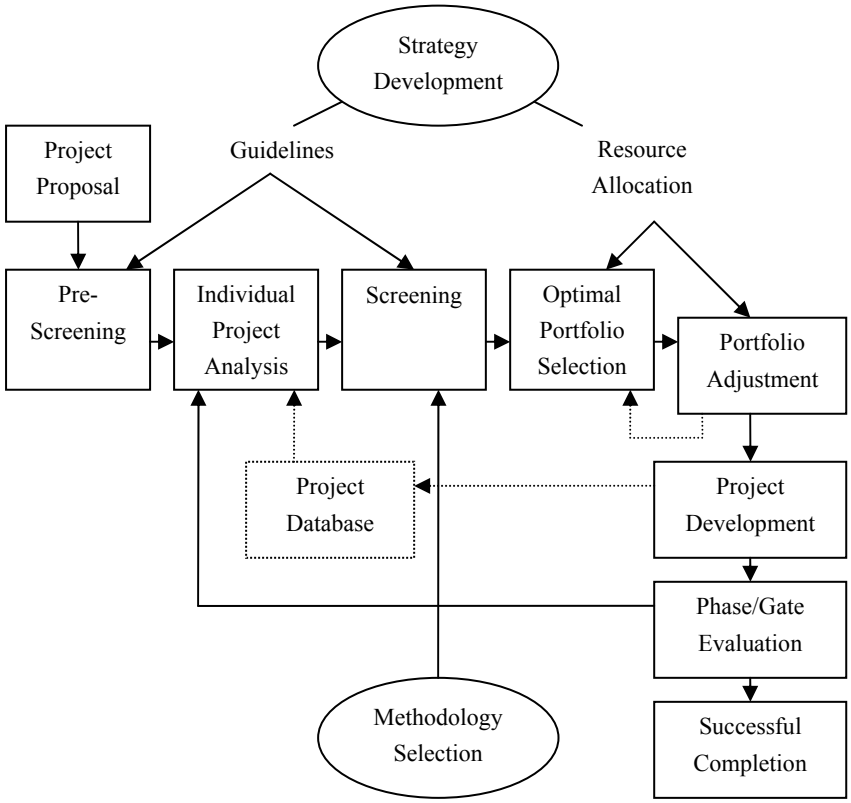


Figure 3 - Framework for Project Portfolio Selection (Archer and Ghasemzadeh, 1999)

3.4 Evaluation in stages

In selecting high risk strategic research project the administrators should concentrate on providing options on future technologies rather than focusing on the best NPV (net present value) calculations for the best economic choice (Vonortas and Hertzfeld. 1998). If a project is rejected it means saving resources, but in the meantime someone else is most probably developing the intellectual property (IP) and thus has the options that may shape the future technology markets.

According to Vonortas and Hertzfeld (1998) these options should be renewed from time to time. Projects or portfolios should be reviewed annually in a way of buying time while the risk decreases. This way the portfolio develops in a coherent strategic direction while investments stay on a moderate risk level even for high risk projects. (Vonortas and Hertzfeld. 1998)

Another kind of approach should be applied when evaluating closer to market development projects. Those projects should be subjected to a more detailed cost-benefit analysis. The identification of commercial uses must be done at an early stage for a go-decision to be reached. A positive NPV calculation is a clear signal for a company to implement the project. If no commercial use can be identified the project could be implemented with a non-profit, or options approach.

When considering public sector research activities and government funded R&D also social aspects can make a difference. A cost-benefit analysis can be calculated from a public sector perspective by calculating a social NPV to the project. According to Vonortas and Hertzfeld (1998) this calculation must include both the social and private benefits, even though the latter were not enough to induce private firms to go forward with the project. (Vonortas and Hertzfeld. 1998)

In any case a periodic monitoring and re-evaluation of the project should be applied. This way new information can be taken into consideration as it becomes available. This in turn will determine along with the options approach how much closer to market the research is directed by the stakeholders. At some point the private sector, unless the project risks have been realized, will recalculate and perhaps take over or licence the project results. According to Vonortas and Hertzfeld (1998) the public sector usually remains involved until either private NPV turns positive or both private and social NPV turn negative.

The model presented by Vonortas and Hertzfeld (1998) goes by the name of Langford-GRA model. Its merits have been in the clear articulation of the four successive steps the government

should follow in selecting R&D programs, and in the analytical simplicity of the underlying model that rests on the well-understood method of NPV analysis. In a traditional fashion, the incentives of a firm to undertake an R&D project are represented by the expected NPV of the after-tax cash flow generated by the project. (Vonortas and Hertzfeld. 1998)

The Langford-GRA model

Step 1. Identification of commercial uses.

Step 2. Cost-benefit analysis (CBA) from private sector perspective.

Step 3. Cost-benefit analysis (CBA) from public sector perspective.

Step 4. Periodic monitoring.

(Vonortas and Hertzfeld. 1998)

3.5 Strategic R&D funding as options

In general terms, the biggest financial risk of an R&D project is that investments to the project will be lost if the results are not commercialized. In financial terms the necessary follow-up investments to capitalize on the results are crucial. This means in concrete terms seed funding to start-ups, licensing of patents, etc. According to Vonortas and Hertzfeld (1998) an investment in R&D project should increase its value if the project is considered as buying an option to a potentially very valuable technology.

The task of any organization interested in investing in R&D is to evaluate if, by undertaking a proposed R&D project portfolio, it creates an option to a technology that can exercise in the future.

4 ORGANIZATION STRUCTURE

Management of the VTT projects is organized as presented in the Figure 4.

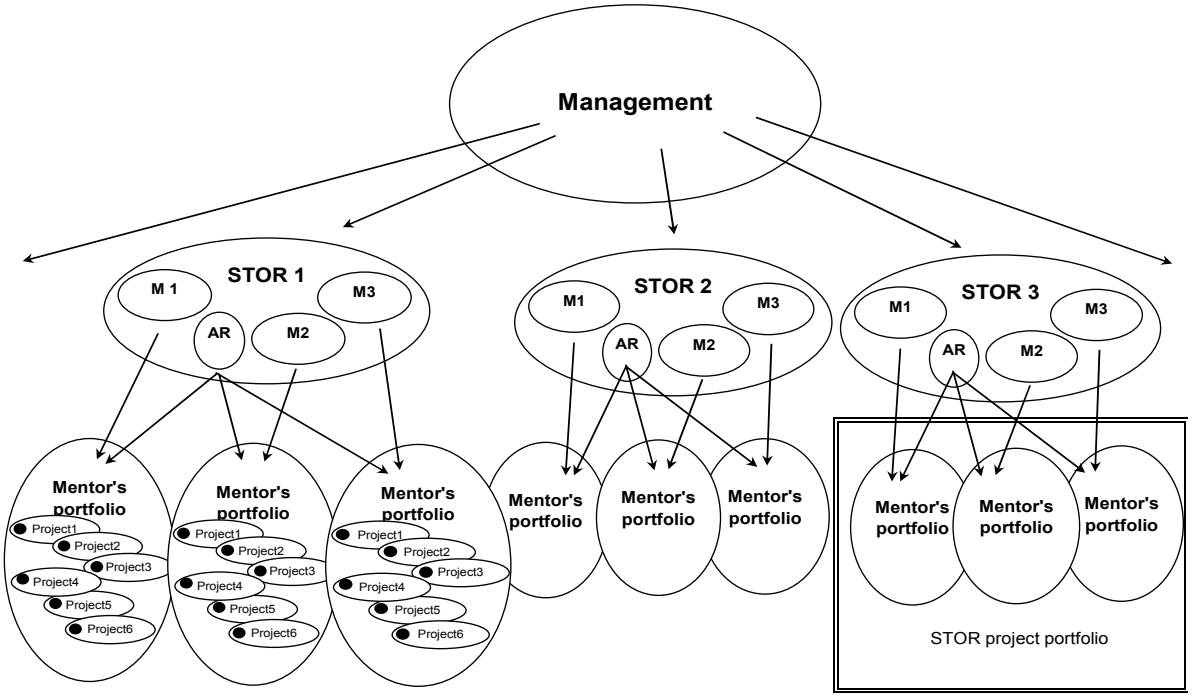


Figure 4 - Project organization in VTT

The top level in the Figure 4 is the management of VTT, which in charge of all the STOR-meetings and therefore for the whole VTT project portfolio. Every STOR-meeting includes one person from the Business solution function – an AR person, who is in charge of the customer solutions, so that in projects beneath that STOR, there is a sufficient amount of projects that actually have business solutions. Every STOR member, except the AR-person, has their own project portfolio that contains projects they are mentoring. Hence, every mentor is quite aware of the content of their own project portfolio. The projects in a mentor's portfolio are related usually to same technology or share some other classification information. Each project has a project manager, who is responsible for the project, and communicates with the STOR member in charge. Project managers are represented as black dots inside each project in the figure. Beneath every STOR, there are STOR project portfolios structured similarly as presented beneath the STOR number three in the figure. The VTT portfolio management system has thus different layers of portfolio, depending on the level or task belonging to the owner of the portfolio.

The general tasks of the project selection systems as Schmidt and Freeland (1992) described, can be applied to the VTT project organization so that *adaptation* is for the management and STOR meetings, *coordination / control* is for a single STOR member mentoring a project and the *transformation* is a task of the project manager.

5 DECISION MAKING PROCESS AND PROJECT SELECTION

In VTT's organization the project selection process is operated by actors described in the previous chapter.

In general project selection process is an essential part of a technology-management system for organizational units such as VTT clusters or strategic-planning systems such as STOR. Project selection should not be seen as an isolated decision event. According to Schmidt and Freeland (1992) a well functioning model of an R&D project-selection process should include a project planning selection model that includes a coordination process during the lifetime of the project as described in Chapter 4 of this report as well as a fully operational system for project implementation. (Schmidt and Freeland. 1992)

5.1 Project lifespan from idea to final reporting

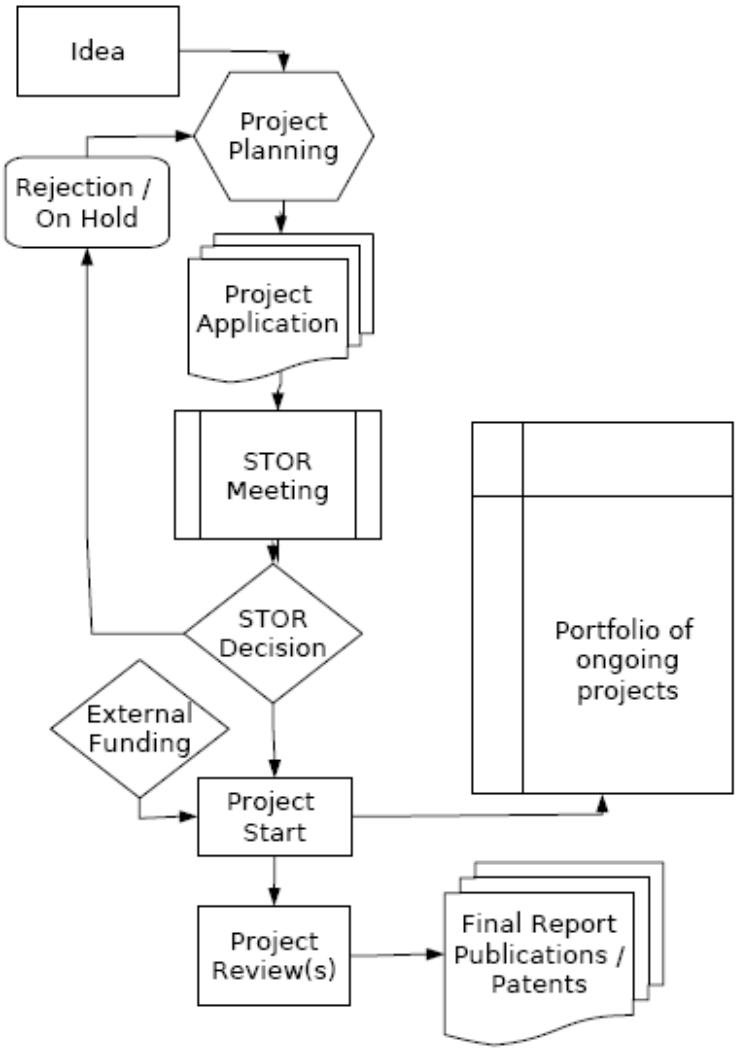


Figure 5 – STOR decision making process at VTT

According to our interviews the project selection process could be described as in Figure 5. At the idea stage, researchers and teams work substantially on their own. Developing new project ideas is an essential part of researcher's work in today's R&D performing organizations. The actual project preparation and planning is usually done by a small group of people mostly consisting of researchers. The involvement of decision makers at an early stage of project planning was identified as a challenge for the process development. For example a project proposal might arrive to a STOR member as late as the previous day before the decision making event.

When a given STOR meeting concludes and decides on projects, they move on to implementation are put on hold or rejected. When a project moves to implementation this doesn't necessarily mean project start, but it in some cases must wait for an external funding decision. When projects are put on hold, this means return to the drawing board at the project planning level.

According to our interviews it was seen as ideal if all STOR evaluated projects would be accepted. Thus later in this chapter we introduce ways to direct the STOR discussion and document project evaluation for portfolio management. As a project moves on to implementation it becomes a part of the STOR portfolio of ongoing projects.

It should perhaps be mentioned here that the STOR members are mainly involved with the projects in their own portfolio distinguishing it from STOR project portfolio and portfolios consisting of other STOR's in different technology areas (see Figure 4).

While in implementation projects go through a review from time to time, but at the moment this cannot be regarded as a re-evaluation of the project. When the project comes to an end the project managers conclude a final reporting, including e.g. publications, patents and other IPR as a result of the project.

One of the main problems in the current project selection process is the amount of tacit knowledge. In this report we provide some suggestions of how to produce more open and objective, if possible, information of the project evaluation and STOR decisions to inform project applicants and ease portfolio management.

Another problem that was identified is involvement of AR to the project preparation and planning at an early stage. The AR is in charge of product development for clients of VTT and their main concern is that strategic research is doing things they cannot use in the future. From AR point of view the strategic research may be too much on the basic research end of the innovation cycle.

Thus their involvement at idea-level project iteration is important. When it comes to the decision process their notes must be included in the STOR meeting memos to provide a possibility to later review projects from the portfolio with AR specific needs and purposes.

According to our interviews the researchers are usually recruited to the projects at preparation level. In real life researchers start writing themselves a new project when previous projects are closing to an end. It could be argued that a more suitable recruitment time would be right before the project start or final funding decisions from external funding agencies.

If at the idea level there would be a system, researchers could express their interest to a project in preparation at an early stage, and not consuming their efforts to the subject until the actual project starts. This could also help in visualisations of project portfolio and work as a voting material for potentially interesting ideas. Such an open-minded idea generation system requires a critical mass to function, but might work as a part of an integrated project portfolio management system.

As part of VTT portfolio management ongoing projects should be subjected to a more systematic internal project review. Currently the tacit information stays at STOR level. However, the information is crucial at the organisation level. Corporate technology management should be able to produce visualisations of the project portfolio in a way that themes could be identified at project deliverable level. Questions like what projects are ending next year are somewhat trivial when compared to: What results are these projects coming up with? How many patents or publications are foreseen? What kinds of products can AR start marketing for next year? What is our IPR portfolio as a whole?

5.2 Evaluation criteria of a single project

The basic idea of the evaluation criteria of a single project is to provide a framework to ease up all the formal and informal discussions between decision makers and project managers. There has also been identified a need to make the decision process more transparent. With a common understanding of the criteria, the project managers and other members of the project group know the matters to be evaluated and can properly plan their projects.

The evaluation criteria can be divided to three major categories: 1) utility, 2) risk-minimizing factors and 3) costs. These categories can be further divided to sub criteria as presented in Table 1.

Table 1 – The Evaluation Criteria

Main criteria	Sub criteria
Utility	Compliance with strategy
	Novelty value
	Market potential
	Partners in cooperation
Risk-minimizing factors	Research group's references
Costs	Distribution of funding

By evaluating each criterion on the right column, the values of the main criteria can be calculated – if desired and for example diagrams of utility over costs or risk-minimizing factors can be done.

5.2.1 Utility

The evaluation criterion of utility has four sub-criteria: 1) compliance with strategy, 2) novelty value, 3) market potential and 4) partners in cooperation.

Compliance with the VTT strategy is evidently one of the most important criteria. It includes matters such as positioning of the project and the project size. The project size is relevant since at VTT there is a need to have bigger projects with a lot of cooperation and less small, independent projects.

The novelty value is the next important issue. If a project is a research project, its scientific novelty value is probably greater than usually is for applied development projects. Project's novelty increases when there is scientifically important new research or the state-of-the-art is over-achieved. In this case the probability of a scientific success can be assessed before initiating the project. The challenges and risks need to be calculated in this section. It is good to check who else has previously studied the area, where this has been done, and what were the results. Possible subsequent patent applications, or intellectual property rights (IPR) issues and the development of the know-how of the project members should also be considered here.

Market potential increases when there are possible patentable inventions at sight, or the project aims at developing new products. Interest from the private sector is also an indicator of potential market value of the given project. Development projects have frequently higher market potential and the probability of a technical success should be considered. The achievable effects of the project should be listed here as well as the possible companies involved.

VTT benefits from the partners in cooperation, so the collaboration with different Finnish and foreign organizations should be listed here, as well as the possibilities to obtain new partners. In addition to external networking benefits, different cooperation's can also produce beneficial internal interconnections. The project should be evaluated in advance, in case of lacking some essential know-how that needs to be acquired before initiating. Here can also be listed the subcontractors needed to be involved with the project. Generally the current level of cooperation and networking is not as intense as it should be. Suitable partners should not be merely researchers or R&D performing organizations of the area but the whole production chain should be considered as well, looking all the way to business developers and consumers.

5.2.2 Risk minimizing factors

For the projects to succeed, the risk factors need to be minimized. This can be done by considering following matters. Even though there is currently little desire in VTT to evaluate the suitability of the project members, the information of their know-how, and especially the know-how of the project manager is quite essential and should be considered. Due to different personal factors, an individual can prefer and perform better in an innovative project than in well-defined, more monotonous tasks – and vice versa. It is good to be aware of the different competence centers and teams the project members are part of; the publications they have done and the intellectual property rights they have from the last, say five years. Here should be considered, whether the project is properly planned in order to be executed efficiently considering the work to be done and the resources available. The challenge in this part of the evaluation is also that even though the project groups do wish more feedback from their projects, the decision makers do not want to report the personal characteristics of the research groups, say suitability for the task. The information is very important in the evaluation process, but these evaluations cannot be published.

5.2.3 Costs

The costs and especially the distribution of funding need to be assessed, for example where the funding comes from and what is the percentage of each financier. The distribution of external funding gives information of the phase of the project's innovation process. For instance, if all the funding comes from VTT, the innovation process is at its beginning phase. If half of the funding is public and the other half is funded by ten companies, it can be concluded that the companies are clearly watching where the project is going to, and want to be involved. When there is public money and few companies funding the project, obviously something is being done especially to the needs of these few companies. Although the phase of the innovation process can be estimated

with the help of this distribution, it is not straightforward whether the external funding involved is merely a good or a bad thing. Even though external funding is desirable, if all the projects are carried out with mere external funding, there will be no profit for VTT from the projects. Challenge for the evaluation of this part is that in the phase of the project evaluation, it is not necessary clear, what the funding distribution of each project will be. There are only probabilities.

In addition to these criteria, there should be considerations of overlaps or synergic benefits with other ongoing somewhat related project. If the project is ideal for the project portfolio, it will supplement the whole project portfolio. In general, certain amount of openness is desired for the evaluation process, but due to the delicacy of the personal information of the project members, there cannot be too much of it. However, some augmentation of feedback is wanted.

5.3 Project preparation and decision making

The project manager makes the necessary preparations for project proposal. At this stage the project manager fills in the project application form and discusses with technology manager about the project. The present practice does not obligate the project manager to discuss about the idea with STOR member or with Business solutions (AR). In order to get better projects from the project portfolio view point this practice should change.

The project manager should remember the project evaluation criteria and use them as a planning tool. This would help him to make better project applications and to answer the questions the STOR is interested in. When the project evaluation criteria are common knowledge the decision making process is more transparent and STOR can more easily give feedback of the project applications.

STOR makes the project founding decision at the STOR meeting. There are two possibilities for STOR meeting to proceed:

First possibility is the evaluation of each upper criterion (compliance with strategy, research group's references, novelty value, market potential, partners in cooperation, distribution of external funding) with an evaluation value ranging from 1 – 10. To provide a qualitative note, the scale of the scoring could be expressed in verbal scale also. For example the criteria "compliance with strategy" could be expressed in the way presented in Table 2:

Table 2 – Example of qualitative evaluation at verbal scale

9-10	Project is essential for the fulfilment of strategy
7-8	Project definitely complies with strategy
5-6	Project loosely complies with strategy
3-4	Project does not comply with the strategy
1-2	Project is adverse to strategy

The second possibility is that the criteria are only listed to help the orientation of the conversations. In practice the evaluation is done beforehand and at the STOR meeting a STOR member will give a short presentation of the project proposal. If the numerical evaluation is in use it would be possible that the project manager also evaluates the project proposal regarding the criteria. The risk is that these evaluations are highly biased. The advantage of this evaluation is that these project manager's evaluations can be compared to STOR member's evaluations. If the evaluations differ there should be discussion regarding these criteria.

The most important thing is that key points of the project proposal presentation and of the following discussion are written down. This recorded information is essential for the project monitoring purposes. Without this recorded information the monitoring of a founded project is very difficult. Another important thing is that at the same time as the project is founded there should be a decision at which day the project will be re-evaluated.

5.4 Project review and follow-up

The project review or follow up is dependent on data collected from the initial STOR decision making event. If the projects are evaluated at the STOR meeting and the criteria are given values, the project review will be a lot easier. There is a possibility to execute advanced project portfolio search to locate projects that need special attention, as well as quantitative measures of the whole project portfolio and its development. Otherwise the project review is based on a systematic review of all projects or a general feeling and tacit knowledge of the project portfolio. However, to increase the transparency of the decision making process, as much as possible of the means of evaluation should be formalized and documented.

The project review or re-evaluation should be a part of the process whether it is made to a selected group or all projects. Sometimes changes are needed as something unexpected occurs, e.g. there can be a need to re-evaluate the project / update the project evaluation by some new criteria. This can be due to internal organizational changes, changes in innovation ecosystem, or project management teams.

Two first and most important parts of the implementation of a follow-up system are the criteria on which the analyses are based and that there is an individual or team who is responsible for the maintenance of the system. It is also crucial that the system is easy to use and provides usable information. In many cases 80% of the performance can be achieved by 20% effort, and this also applies here.

A further thought about the follow-up process is to combine the original evaluation of the project, the follow-up process and the actual success of the outcome of the project. This can be used to calibrate the original evaluation, by seeing how the grades given correlate with the real-life performance. The real-life performance can be measured by subjective quantitative or qualitative measures, or e.g. the actual financial performance of the projects outcome.

6 PROJECT PORTFOLIO

In this report there are multiple layers of portfolios. In order to avoid confusion we have named each portfolio by its owner. A "Mentor's portfolio" consists of the projects the mentor is responsible. The "STOR portfolio" consists of all the mentors' portfolios and theirs projects of one STOR. So each mentor's portfolio is a subset of STOR portfolio. The Figure 4 illustrates this structure.

6.1 Choosing projects to the project portfolio

It seems that there is no active steering toward a predefined target STOR portfolio, whose outlines and budget structure has been designed beforehand. This does not mean that there is not a vision what a good project portfolio would be, but the current process of selecting projects does not make it easy to get the right kinds of projects to portfolio. The following were identified to influence most of the problems:

- VTT is too resource-oriented organization
- Project applications are evaluated only based on the project at hand
- Projects are not prematurely ended or merged to other projects

6.1.1 VTT is too resource-oriented an organization

Most of the new project ideas come from the researchers. The result of this is that the projects are technology based but not necessary based on any true exterior needs. Usually the researchers invent new project ideas at the point where their current project is at the final stage and the researchers realize that they need to get new project to employ themselves. A better approach would be a mid-term project review when the researchers should think, together with the business solutions people, how the results of this project could be put to use.

In the future more of the new project ideas should come from a true exterior need. For example the business solutions unit could propose, sell and implement more new projects which have emerged directly from customers needs. This would shift the resource-oriented organization to more customer-oriented organization and the research results would be commercialized more often. This would lead to an optimal situation where people would be selected to a project instead of people selecting projects for themselves.

6.1.2 Project applications are evaluated only based on the project at hand

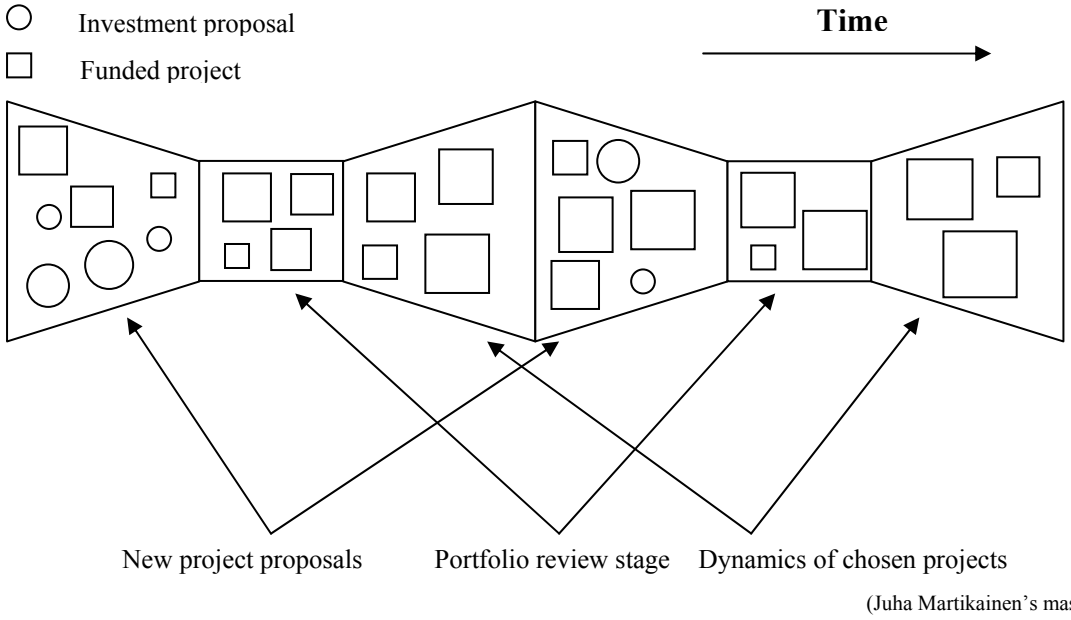
The portfolio is defined by the projects in the portfolio instead that the projects would be selected to fulfill a predefined portfolio. Even though the best project proposals are approved and the projects are added to portfolio this does not necessarily constitute efficient portfolio (Chien. 2002). The project is evaluated without considering the status of the portfolio and how suitable the project is to the current portfolio or would the evaluated project shift the current STOR project portfolio towards the target portfolio.

One of the problem is that the ideas are too complete at the stage where there are presented to STOR members. At this point it is very difficult to modify the research idea towards a project plan that would better fit in a predefined target portfolio. The researchers should be encouraged to present the raw ideas to some STOR member and the idea should be improved and steered towards the predefined target portfolio. An idea management system could also be introduced.

6.1.3 Projects are not prematurely ended or merged to other projects

After the launched projects are added to project portfolio they start to live their own life regardless what happens to the target portfolio. For example if the strategy of the predefined target portfolio changes the on-going projects are not re-evaluated based on the new strategy. At most of the times the projects are not terminated prematurely even if it seems clear that they cannot reach their predefined goals. Juha Martikainen (2002) illustrates a stage-gate model in his master's thesis where the evolution of project portfolio is presented in Figure 6. The projects which will not achieve their predefined goals and are to be terminated prematurely should be removed from the project portfolio at these stages.

It is possible that there are many small projects in the project portfolio which scope is very close to each other. These projects should be identified at the portfolio review stage. After the identification has been done there should be a discussion how similar the projects are and could there be some synergy benefits if the project were merged to one bigger project. The managers should also remember that it is easier to manage and monitor smaller number of bigger projects than huge number of small projects.



(Juha Martikainen's master's thesis)

Figure 6 – Sketch of project portfolio management process

6.2 Data mining the project portfolio

The STOR project portfolio consists of tens or even hundreds of projects so it is essential to get a holistic view of the portfolio and different kinds of summary information of the projects in it. It should be possible to get the up-to-date information at any moment and the information should be presented either in numerical or graphical format depending on the reviewer's choice.

Each project has its own classification information and this classification information defines this project's position in the multidimensional classification space. Its axes are the classification attributes and the possible coordinate values depend on each attributes. The project may have multiple values related to some attributes. The classification attributes are presented in

Table **3**. The first column in the table presents the attribute and the second its possible values. The last column defines if the project can have multiple values related to this attribute.

Table 3 – Classification attributes

Attribute	Category possibilities	Multiple values
Mentor's portfolio	Mentor's 1 portfolio … Mentor's N portfolio	Only one value allowed
The phase of the project	On-going phase Bidding phase In preparation phase	Only one value allowed

	Closed Lost project	
Research Instrument	VTT Frontier VTT Theme …	Only one value allowed
VTT's Strategic program	Center for printed intelligence Systems biology …	Multiple values allowed
Phase of the innovation process	Derivative action Basic research and development Development project …	Only one value allowed
Industries	Electronics ICT …	Only on value allowed
International program	CIP COST FP7 …	Only one value allowed
Countries		Multiple values allowed
Important foreign partners		Multiple values allowed

The most needed up-to-date information is the summary of the whole STOR project portfolio as presented in example Table 4. From this table the vice president of STOR can get a holistic view of the funding structure of the whole project portfolio. Also the other STOR members can look at their own portfolios and compare these to other mentors' portfolios.

The information in the table is divided to different categories based on the phase of the project. At first there is a summary (TOTAL) part over all the project phases. Each row contains information of one mentor's portfolio. This information is presented per year and at each year the amount of funding is divided to external funding and VTT funding. After that information there is a summary where the total funding of project portfolio is presented and its percentage distribution. After the TOTAL funding the funding structure is presented for each different project phase separately in the same format.

Another equally important information is the table of budget information and its realization as in example Table 5. The table follows basically the same structure as the Table 4. At first there is the budget information and then the realization of the funding structure. The differences between the planned and the realization are very easy to detect from the percentage numbers. At this table everything seems to be exactly in balance except the mentor's 3 portfolio in preparation phase. Small external funding percentage number at project preparation phase should be perceived and

appropriate operations initiated. At Table 5 there are also lines "Comparison to ST budget". These lines give information what was the originally planned budget for the STOR project portfolio.

Table 4 and Table 5 represent the up-to-date information of the project portfolio finance structures. This information is needed to monitor that the project portfolio is financially balanced. This information should also be considered when deciding of new projects. Does the financial information support the funding of the project? If the project is founded would the project portfolio be financially in better balance?

Table 4 – Example of project portfolio finance summary

Mentors' Portfolios	Income and finance 2007			Income and finance 2008			Income and finance 2009		
	External funding	VTT funding	Combined funding	External funding	VTT funding	Combined funding	External funding	VTT funding	Combined funding
TOTAL									
Mentor's 1 Portfolio	27,9	16,7	**44,6**	40,6	9,6	**50,2**	51,9	19,0	**70,8**
Mentor's 2 Portfolio	91,5	31,5	**123,0**	127,7	61,9	**189,6**	185,3	134,4	**319,7**
Mentor's 3 Portfolio	61,5	12,8	**74,3**	68,8	38,3	**107,1**	96,9	40,4	**137,3**
	180,9	61,0	**241,9**	237,0	109,8	**346,9**	334,0	193,7	**527,8**
	74,8 %	*25,2 %*		*68,3 %*	*31,7 %*		*63,3 %*	*36,7 %*	

Mentors' Portfolios	Income and finance 2007			Income and finance 2008			Income and finance 2009		
	External funding	VTT funding	Combined funding	External funding	VTT funding	Combined funding	External funding	VTT funding	Combined funding
Closed + on going									
Mentor's 1 Portfolio	10,0	5,0	**15,0**	13,0	5,0	**18,0**	16,0	8,0	**24,0**
Mentor's 2 Portfolio	30,0	10,0	**40,0**	43,0	21,0	**64,0**	63,0	44,0	**107,0**
Mentor's 3 Portfolio	20,0	6,0	**26,0**	21,0	12,0	**33,0**	32,0	14,0	**46,0**
	60,0	21,0	**81,0**	77,0	38,0	**115,0**	111,0	66,0	**177,0**
	74,1 %	*25,9 %*		*67,0 %*	*33,0 %*		*62,7 %*	*37,3 %*	

Mentors' Portfolios	Income and finance 2007			Income and finance 2008			Income and finance 2009		
	External funding	VTT funding	Combined funding	External funding	VTT funding	Combined funding	External funding	VTT funding	Combined funding
Bidding phase									
Mentor's 1 Portfolio	8,5	5,4	**13,9**	13,4	2,8	**16,2**	18,4	5,7	**24,1**
Mentor's 2 Portfolio	31,8	10,0	**41,8**	43,5	20,4	**63,9**	60,7	44,3	**105,0**
Mentor's 3 Portfolio	21,7	4,2	**26,0**	23,4	12,0	**35,4**	31,2	12,7	**43,9**
	62,0	19,6	**81,6**	80,3	35,2	**115,4**	110,2	62,8	**173,0**
	76,0 %	*24,0 %*		*69,5 %*	*30,5 %*		*63,7 %*	*36,3 %*	

Mentors' Portfolios	Income and finance 2007			Income and finance 2008			Income and finance 2009		
	External funding	VTT funding	Combined funding	External funding	VTT funding	Combined funding	External funding	VTT funding	Combined funding
In preparation phase									
Mentor's 1 Portfolio	9,4	6,3	**15,7**	14,2	1,8	**16,0**	17,5	5,2	**22,7**
Mentor's 2 Portfolio	29,7	11,4	**41,2**	41,2	20,5	**61,7**	61,6	46,1	**107,7**
Mentor's 3 Portfolio	19,7	2,6	**22,3**	24,4	14,3	**38,7**	33,7	13,7	**47,4**
	58,9	20,3	**79,2**	79,7	36,7	**116,4**	112,8	65,0	**177,8**
	74,3 %	*25,7 %*		*68,5 %*	*31,5 %*		*63,4 %*	*36,6 %*	

Table 5 – Example of project portfolio finance and budget comparison

	Budget 2007 (1000 €)			TOTAL (1000€ & %)					
Mentors' Portfolios	External funding	VTT Funding	Combined funding	External funding	External funding %	VTT Funding	VTT Funding %	Combined funding	Combined funding %
Mentor's 1 Portfolio	301	98	**399**	267	89 %	107	109 %	374	94 %
Mentor's 2 Portfolio	1062	96	**1158**	1076	101 %	97	102 %	1173	101 %
Mentor's 3 Portfolio	163	63	**226**	146	89 %	32	51 %	178	79 %
	1525	256	**1782**	1488	**98 %**	236	**92 %**	1725	**97 %**
Comparison to ST budget	***1500***	***240***	***1740***		***99 %***		***99 %***		***99 %***

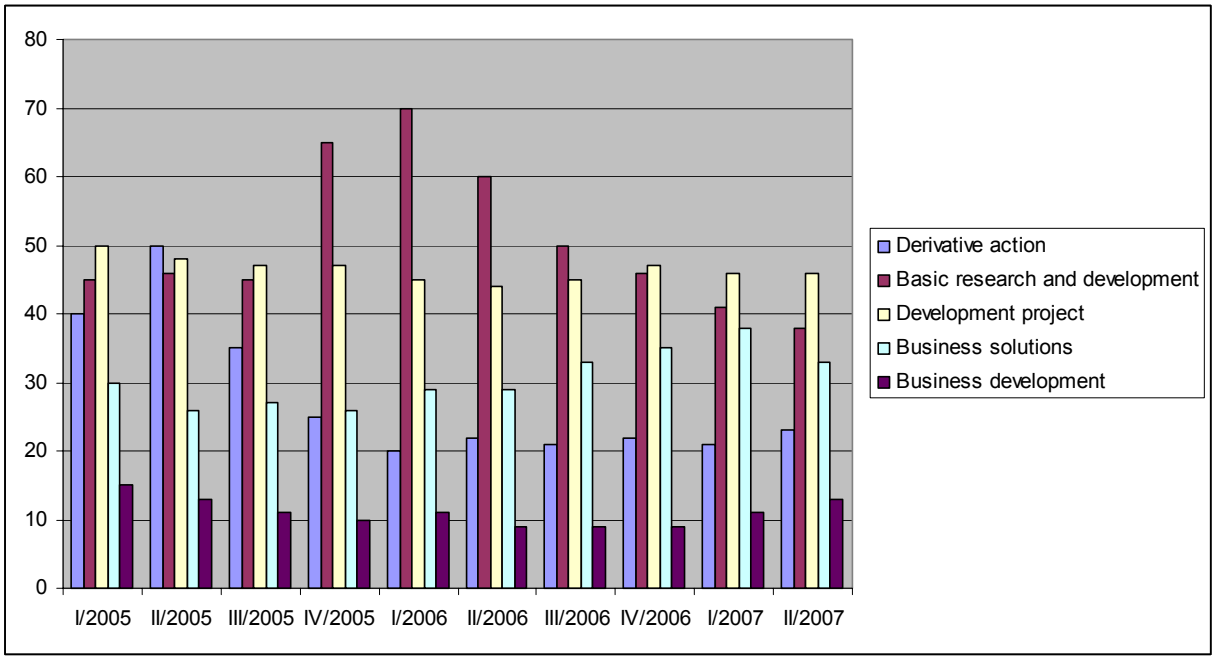
	Budget 2007 (1000 €)			Closed + On going (1000€ & %)					
Mentors' Portfolios	External funding	VTT Funding	Combined funding	External funding	External funding %	VTT Funding	VTT Funding %	Combined funding	Combined funding %
Mentor's 1 Portfolio	100	32	**132**	90	90 %	35	109 %	125	95 %
Mentor's 2 Portfolio	353	32	**385**	360	102 %	35	109 %	395	103 %
Mentor's 3 Portfolio	53	21	**74**	50	94 %	16	76 %	66	89 %
	506	85	**591**	500	**99 %**	86	**101 %**	586	**99 %**
Comparison to ST budget	***500***	***80***	***580***		***100 %***		***108 %***		***101 %***

	Budget 2007 (1000 €)			Bidding phase (1000€ & %)					
Mentors' Portfolios	External funding	VTT Funding	Combined funding	External funding	External funding %	VTT Funding	VTT Funding %	Combined funding	Combined funding %
Mentor's 1 Portfolio	99	34	**134**	86	87 %	37	108 %	123	92 %
Mentor's 2 Portfolio	354	31	**386**	357	101 %	30	97 %	388	101 %
Mentor's 3 Portfolio	54	20	**74**	49	90 %	14	71 %	63	85 %
	508	85	**593**	493	**97 %**	81	**95 %**	574	**97 %**
Comparison to ST budget	***500***	***80***	***580***		***99 %***		***102 %***		***99 %***

	Budget 2007 (1000 €)			In preparation phase (1000€ & %)					
Mentors' Portfolios	External funding	VTT Funding	Combined funding	External funding	External funding %	VTT Funding	VTT Funding %	Combined funding	Combined funding %
Mentor's 1 Portfolio	101	32	**133**	91	90 %	35	110 %	126	95 %
Mentor's 2 Portfolio	355	32	**387**	358	101 %	32	99 %	390	101 %
Mentor's 3 Portfolio	56	22	**78**	47	84 %	2	9 %	49	63 %
	512	86	**598**	496	**97 %**	69	**80 %**	565	**95 %**
Comparison to ST budget	***500***	***80***	***580***		***99 %***		***87 %***		***97 %***

Up-to-date information is not the only needed information the project portfolio should provide. There is also a need to monitor if the financial investments to the early phase of innovation process have generated new projects to the later phases (each project is positioned to some phase of the innovation process). Figure illustrates an example of total volumes of different innovation process phases. At the first and second quarters of year 2005 there has been financial investments to projects which are positioned to "Derivative action" –phase of innovation process. These investments have clearly generated projects to the "Basic research and development" –phase at last quarter of year 2005 and to the first quarter of year 2006. For some reason the volume of "Development projects" has been quite steady over the whole period which means that the financial investments to projects at "Derivative action" –phase have generated only boost to "Basic research and development" -projects. This kind of monitoring should help the STOR to monitor if the financial investments have positive effects to the whole innovation process. If the positive effect does not arise naturally the STOR should force it to happen.

Figure 7 – Example of innovation process phases total volumes



These presented examples do not represent all the information which is needed from the STOR portfolio. These are only the few important examples. One equally important example would have been a table of mentor's portfolio. At this inspection level the projects and their financial information among the other classification attributes would have been presented in deeper details. The most needed tables and figures would only be found out at normal everyday use of the system.

7 SUGGESTIONS

While enthusiastically exploring the VTT organisational aspects, project portfolio management and decision making our team has come to realise some aspects which could need improvement. In this chapter we recapitulate the challenges what might also have been said earlier in this report and give suggestions for improvement. We also analyse the improvement ideas with the same idea as presented in Figure 8.

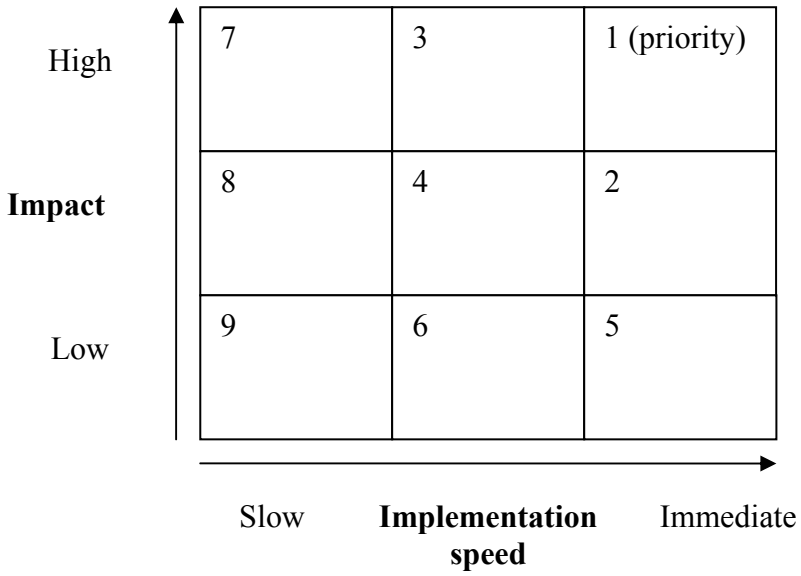


Figure 8 – suggestions table with priorities

STOR and STOR members need more means to coordinate their project portfolios to assist in general policy setting. Project teams, who actually implement the R&D work and do most of the planning at idea level, should involve the STOR members and AR in their iteration process of new project proposal. Especially the co-operation between the project manager and STOR members should be more active in an earlier stage of the project preparation. This way the needs of the project portfolio would be taken in account in the project proposal. The impact of this better communication between the shareholders would be quite high. Unfortunately there is no easy way to implement this increase of co-operation in practise but it will grow slowly if the new decision process demands it.

The project evaluation criteria should be made public. This would make the decision process more transparent and help the project manager to consider these aspects in the project application. This is probably the easiest idea to implement fast and still it would have considerable impact.

There has been some discussion if the new project ideas could be published in-house. If at the idea level there would be a system, researchers could express their interest to a project in preparation at an early stage. This way the researches could be selected to a project and not vice versa. These researchers would not consume their efforts to prepare the project proposal but they would begin to give their contribution when the actual project starts. The same system could also be used to discuss about the potentially interesting ideas and this way expand the project idea and get new projects or bigger projects. This idea shares the same implementation problems as the increase of collaboration.

VTT should start to use proactive project monitoring. When new project is decided to be founded it should also be given a date when project would be re-evaluated. This way the projects would be subjected to a more systematic internal project reviews. The date of the re-evaluation should depend on the project at hand. If it seems that there are only few small risks the re-evaluation date could be further in future than in the case where there are several or big risks. Opposed to proactive project monitoring there is also a reactive way. This means that the monitoring and re-evaluation of projects happens only when something goes wrong. The problem with this kind of approach is to get the information of problem situations to be able to react to them. In the most optimal situation the monitoring is focused only to projects in need of it, but in practise this is impossible because in order to find those projects all the projects should be monitored. Setting the re-evaluation date for founded project is an easy task but the re-evaluation itself takes time.

STOR members should be able to get up-to-date information of the project portfolio. Today's practice is that the data is collected manually and is usually a bit out-of-date. The collection of the data and making the summaries out of it is also a substantial work. This data mining of project portfolios should be automated. This automatization takes a lot of work but the system would enable to monitor the STOR project portfolio more efficiently.

In addition the communication between the beginning of the innovation chain and the AR department should be improved by increasing the amount of co-operation. This kind of procedure would be crucial especially for the projects which target some level of commercialization in the future. If the AR personnel are involved in the project as early as possible, the amount of failed projects (e.g. no market demand) would be considerably decreased.

8 CONCLUSION

In this final project report VTT project portfolio and decision making the project group formed a holistic view of the project founding process and the project portfolio management. The project group interviewed some on the STOR members to get familiar with the problem at hand and the main results of the interviews are the following.

Firstly, while interviewing decision makers we found out that VTT has recently changed their organization structure and are currently refining their processes. Internal project selection process has also gone through some major changes and new functions are in an operational phase at the moment.

Secondly the need to find a general understanding of the project selection process led our team to develop a bigger picture of the situation and then worked our way to find ways to improve the current status.

Thirdly, while developing the criteria for evaluating a single project we introduced a set of criteria which can be of use when STOR discusses and decides on selecting new project. It is recommended to proceed by using criteria by giving values, both qualitative and quantitative to projects, which helps in communicating the decisions to stakeholders and later review projects in a systematic way.

With regard to the portfolio management and visualizations we found out that the STOR members need a tool to get holistic view of the STOR project portfolio. We presented few example tables of the most needed features. These would help to find ways to manage portfolio analysis and to improve management view on what is going on at a given point in time.

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In addition all the material describing VTT's organizational structure, financials or any other VTT specific knowledge has been provided by our contact person in VTT, Toni Jarimo, through the project manager, Kalle Korpiaho or by Kalle Korpiaho himself.