Thesis Business Administration

Research on the professionalization of the strategic portfolio planning process by using a software tool

Development of a requirements list of functions
and methods and proof of concept

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1 Introduction

In my search for a final project for my Business Administration master I came across a very nice opportunity at Fortes Solutions which perfectly suits me. I worked here as web developer and so, was working as programmer. The CEO created this opportunity to do something totally different at Fortes Solutions than I did before. The company Fortes Solutions (henceforth Fortes) is specialized in developing project management software and their main product is the Principal Toolbox (henceforth Toolbox).

Their software package offers support for organizations to effectively run their project and project portfolio management. Worldwide enterprises work with their software product, mainly focusing on the Netherlands. A sample of their customer base is Vopak, Friesland Campina, Alliander, Delta Lloyd and a lot of government agencies. An often heard wish from their customers is the request to support investment appraisal and strategic portfolio planning in their Toolbox. When supporting these processes, organizations will get support in selecting the most value creating projects that fit their budgets, organizational strategy and available resources. This request has been there for some time and gave me a perfect opportunity to perform my master thesis research on this topic at Fortes.

This research has been conducted from December 2016 until June 2017 and is using the architecture from the Principal Toolbox version 9.5. The validation process was done in June 2017.

2 Problem Statement

In this section the origin of the problem will be explained and the research questions will be outlined in section 2.3. To construct these research questions from a situation in practice the 'General Business Problem Approach' by Heerkens et al. (2012) has been used. This approach will also be used in creating the possible solution.

2.1 Fortes Solutions

Fortes Solutions is specialized in project portfolio management and project management software. In the past their focus was the Toolbox which is a large software solution. A separate department of Fortes, Fortes Labs, has developed the platform Fortes Connect (henceforth Connect). It lends itself perfectly for smaller tools which can work together. Fortes has 3 programming teams with a total of around 30 programmers working on the Toolbox and Connect. Another 8 persons are working as Customer Support and Consultants to implement the software tools in enterprises and to support them in using the Toolbox. Both tools are accessible in a web browser and can connect to each other. The Toolbox Fortes is developing is supporting different levels in the organization. A large enterprise using this tool has hundreds of users for the Toolbox. Project portfolio managers use the Toolbox to have an overall overview of all projects in a portfolio while project managers use it to manage individual projects. The lower level employees use only the time tracking function in the Toolbox. The organizational context of portfolio and project management is shown in figure 1. Fortes wants to support the colored areas with the Toolbox. At the moment, the application is shortcoming on the highest levels of the organization. The information in the current Portfolio Planning process is minimal. Projects are selected and executed on information determined by the portfolio planner which is available in the individual projects. Data is merely aggregated. Therefore, a streamlined and formal process is required for project valuation, selection, prioritization and balancing to create an optimal portfolio.

2.2 Background information

The main goal of this research is to find the most important functions and methods the tool should have to support the Strategic Portfolio Planning process. The valuation and selection of projects in the portfolio planning process can be seen as the capital budgeting of a part of the firm. Most used appraisal techniques for capital investment are payback, IRR, NPV and less popular is ARR (Sangster, 1993). To calculate these discounted cash flows, a hurdle rate, also known as minimum acceptable rate of return, is often taken into account in irreversible investments like projects. This hurdle rate is the required rate by the portfolio planner that compensates for the level of risk present in the project. Besides the financial and risk aspects of the project, a portfolio planner should also take into account other limitations like human resources.

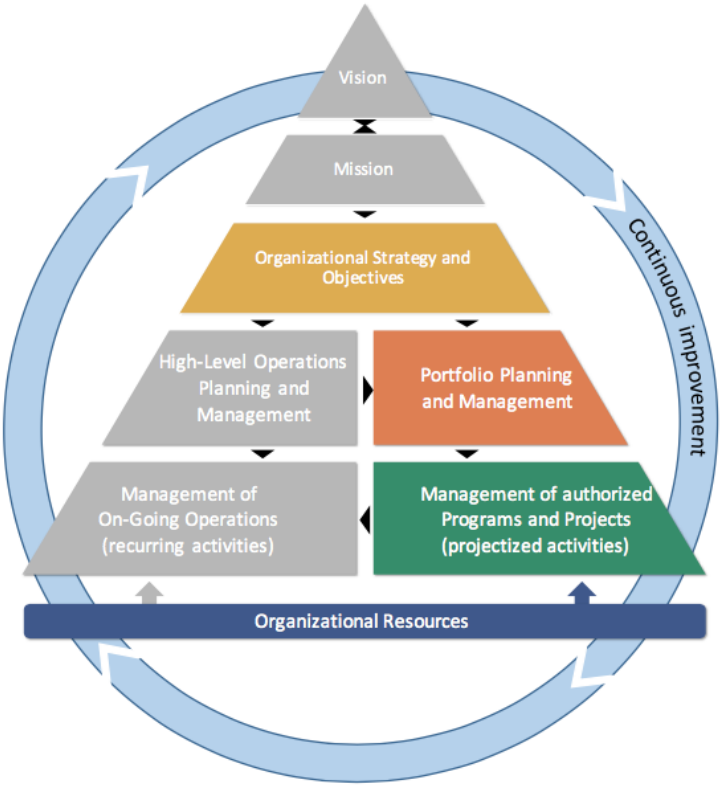


Figure 1: Organizational context of PPM, based on PMI (2012)

In section 4.1 a theoretical framework will be created around Project Portfolio Management (PPM). To gain a first understanding of what PPM is, figure 2 will be explained in this section already. Most enterprises have one or more Project Management Offices (PMOs) who manage their running projects and programs, which are a set of projects. On top of programs and projects there is the portfolio. How higher in the structure of figure 2, how more cross-project dependencies present. An Project Portfolio Management Office (PPMO) deals with the planning, coordination, control and support of the underlying items (Unger et al., 2012). They are combined in one portfolio because they have the same strategic goals and consume from the same resources; financial as well as human resources. Projects are selected and prioritized in order to achieve the financial and strategic benefits (Cooper et al., 1997).

A definition of a project is very broad; section 4.1 will elaborate on the definition of a project. For now the definition of the Project Management Institute (PMI) will be sufficient. They define a project as "a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of projects indicates a definite beginning and end" (PMI, 2001, p.5). Strategic

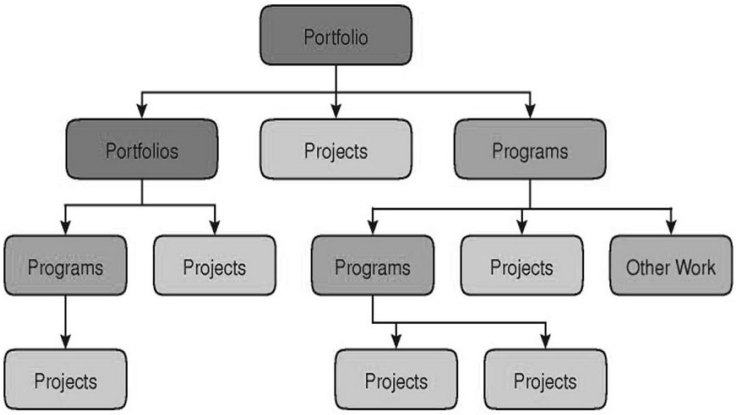


Figure 2: Portfolio, Program, Project structure (PMI, 2012)

Portfolio Planning focus is on planning these projects in such a way that budgets are used and not exceeded, strategic goals are achieved and resources are used in an optimal way.

2.3 Research questions

After two meetings held with the CEO of Fortes and the product owner (the one responsible for the Toolbox software) and reading notes from previous meetings held with customers, the main research question is established as follows;

How can a software tool facilitate the adoption and use of Strategic Portfolio Planning in large enterprises?

This elaborates on the practical problems Fortes' is experiencing and the preliminary literature research. In answering this research question, first the following sub questions will be answered;

1. **What exactly is (Project) Portfolio Management and Strategic Portfolio Planning?**
   To gain a full understanding of Strategic Portfolio Planning, first the methodology of Project Portfolio Management will be explained with a focus on the Portfolio Planning and Management role. Important is the capital budgeting task which means determining portfolio budgets and investment approval. Also the planning of human resources, which indirectly leverages costs, is important as well as risk aspects and the contribution of the project to the overall business strategy. These factors are useful in the project prioritization, balancing and planning process. Successful practices will be analyzed to determine the overall best practices. This all together will build an extensive theoretical framework based on literature.

2. **Which process should be supported by a Strategic Portfolio Planning tool?**
   Most-common frameworks and processes will be analyzed so a work flow can be created that models the process the strategic portfolio planning tool should support. This model will be used to create the requirement list for the tool.

3. **Which functionalities are currently supported by the software Fortes offers?**
   The Toolbox now offers a lot of flexibility and options at different levels; organizational units, portfolio level and project level. The new structure of the multi-app platform is shown in figure 1. The applications in relevant layers of the structure will be analyzed so shortcomings for Strategic Portfolio Planning can be determined.

4. **What are the requirements for a Strategic Portfolio Planning tool?**
   The total set of functional requirements will be given, including requirements that are already fulfilled by the Toolbox. A prototype will be built according to the requirements and is validated among professionals in Project Portfolio Management. The prototype will take into account the current software architecture. This might be of interest for professionals so they understand how the tool fits in the platform.

2.4 Research scope

The scope of this research is limited to the project valuation, selection, prioritization and balancing process. Also the planning of the projects is included, balancing will result in a portfolio planning distributed over a certain time horizon. Portfolio management is out of the scope of this research, so the control and execution of projects is not included.

3 Methodology

In this section the research design will be outlined. The research design is built upon the theories and frameworks from Heerkens et al. (2012) and Wieringa (2014) and is classified conform the theory of Saunders (2011).

3.1 Research classification

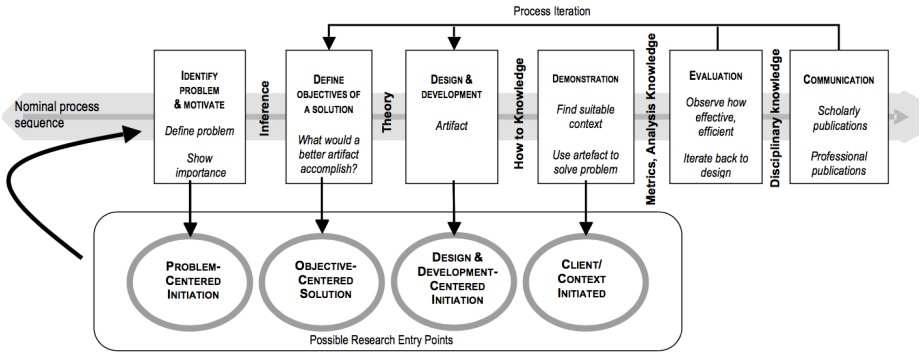


Figure 3: Design Science Research Methodology (Peffers et al., 2007)

As described by Saunders (2011), a research can be exploratory, descriptive or explanatory. This research can be classified as exploratory. Exploratory is described by Robson (2002) as 'what is happening; to seek new insights; to ask questions and to assess phenomena in a new light'. This type of research can be found in the first three research questions. Since it can be seen as a problem in an organization, Heerkens et al. (2012) will be used to best find and describe the problem.

The fourth research question and main one can be classified as Design Science, which is best explained by Peffers et al. (2007). Peffers et al. develop a methodology for design science research in information systems which is shown in figure 3. The framework is built upon design science literature and a well proved one. This research takes the problem-centered approach which means that the six steps in the methodology will be proceeded in nominal sequence starting with activity one. The research design as described in 3.2 reflects this methodology.

3.2 Research design

To answer the sub questions and the main research question the research is split in multiple parts. The research design is visualized in figure 4. The literature research will broaden and deepen the understanding of key aspects in this research. The formed theoretical framework will be used as knowledge base

during the interviews, comparison, best practice analysis and in defining the most important functions and methods.

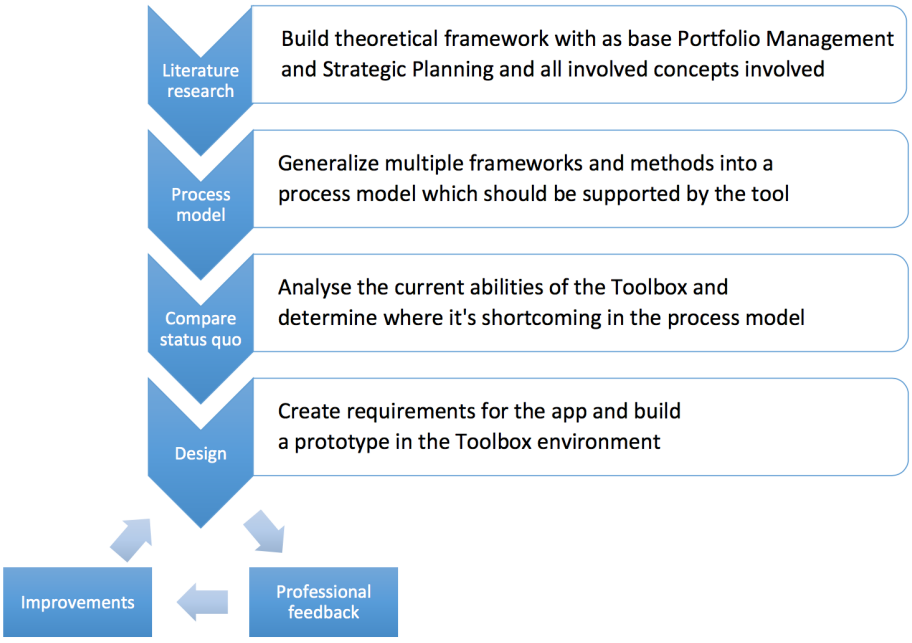


Figure 4: Research design

4 Theoretical framework

In this section the different concepts involved in this research will be explained and discussed. This starts of with Project Portfolio Management and Strategic Portfolio Planning and all steps involved in the planning phase. Furthermore, we will look into benefits management, success factors and dynamic capabilities. All articles were retrieved by using Google Scholar and Scopus by searching for the most relevant terminology involved in this research.

4.1 Project Portfolio Management

Worldwide companies are using Project Portfolio Management to achieve a centralized management process. Each company is doing this in their own way but almost all of them use a methodology to implement the related processes and to achieve a high level of PPM maturity. Worldwide well-known methodologies are PRINCE2, P3O, PMBoK and MoP. To gain an understanding of the most important practices the main concepts of PPM will be outlined in this research. Especially the P3O and PMI methodologies will be used to explain the theories since they focus on portfolios more than others. P3O stands for Portfolio, Program and Projects Offices and was published by a department of the UK Government. It supports in letting organizations build a structure that enables the successful delivery of portfolios, programs and its projects. PMBoK is a methodology developed by the Project Management Institute (PMI) to set a standard for Project Management in 1987. Their Body of Knowledge is kept up to date and the fifth version of these standards was published in 2013.

4.1.1 Projects and Programs

Projects are often the main source of achieving the organizational strategy which is visualized in figure 1. The definition of a project by PMI is "a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of projects indicates a definite beginning and end" (PMI, 2001, p.5), as already mentioned in section 2.2. The definition of a program according to PMI is "a group of related projects managed in a coordinated way to obtain benefits and control not available from managing them individually" (PMI, 2001, p.9). The relation of a project with a portfolio or program can be found in figure 2.

All PPM methodologies explain the concepts more or less the same. For example, P3O see a project as "a temporary organization, usually existing for a much shorter duration, which will deliver one or more outputs in accordance with a specific Business Case" (P3O, 2010). Also, here a program is a set of related projects which gives outcomes, whereas projects give outputs. According to PMI, a project has to be in a program when the project alone cannot achieve the benefit(s) itself or when it's difficult to manage it individually. The P3O approach is to generally put projects in program, except when not possible. These minor differences in methodologies do matter in the implementation of PPM in organizations but not in this research.

	Effectiveness	Coordination	Efficiency
Prior to project execution	• Project selection • Business planning	• Resource planning • Resource procurement	• Project / program plan review
Project execution	• Identification of bad projects	• Participation in steering groups • Prioritization of projects • Collection and aggregation of reports	• Initiate reviews • Handling of issues • Coaching of project managers • Improvement of process

Table 1: Roles of a Portfolio Manager (PMI, 2012)

A portfolio is a collection of projects and or programs that is grouped for effective management. No relationship between them is required but often they have the same strategic business goal.

4.1.2 The PPM process

One of the upper layers in the whole process is Project Portfolio Planning and Management. Some methodologies see the planning and management as one process while others strongly distinguish those processes. The management part is more about authorizing, managing and controlling the projects and programs while planning focuses on identifying, reviewing, prioritizing and planning the projects and programs in such a way that they achieve specific strategic business objectives, taking into account limitations in finance and human resources and minimizing risk (eventually through diversification). The total set of responsibilities of the Portfolio Manager role is shown in table 1.

The PPM is executed in so called Project Portfolio Management Offices (PPMO) in organizations. Recent research has mapped all different tasks in three distinct roles a PPMO has: supporting, controlling and coordinating (Unger et al., 2012). Unger et al. (2012) was with his research in 278 PPMOs the first one finding empirical evidence that PPMO contribute to project success. In this research we will focus on the processes of project valuation, selection, prioritization, balancing and planning. The reference to this set of processes is Strategic Portfolio Planning.

4.1.3 Strategic Portfolio Planning

Strategic planning of projects and programs have to take a lot of variables into account. Most enterprises have one or more portfolio planner (or scheduler) to perform the portfolio planning. Some organizations apply a simple form of portfolio planning but in this research we will look at the strategic portfolio planning. Strategic portfolio planning creates a formalized process making sure

the strategic goals in the organization are achieved in an optimized selection process. The steps performed in this process are explained in sections 4.2 - 4.5.

4.2 Project Valuation

4.2.1 Financial Appraisal

The main measures for financial appraisal are NPV, IRR, payback and ARR (Sangster (1993) and Drury (2012)). The first three methods take into account the time value of money, so a dollar today is more worth than a dollar next year. Therefore, these can be seen superior to payback and ARR. Also, payback doesn't take into account any cash flows after the payback period and ARR is not based on cash flows, only on net income. NPV discounts all cash flows and the sum of these, including the initial investment, presents the value of the project today. An important component of the NPV formula, which is shown in equation 1, is the discount rate. This rate discounts the cash flows to present value and should therefore reflect the firm's weighted average cost of capital (WACC). The discount rate might be adjusted for example for risk or opportunity cost. Projects with a positive NPV may be accepted since they add value to the firm while projects where the NPV is zero the decision should be based on other criteria like the contribution of the project to strategic goals. Projects with a negative NPV are generally rejected. IRR calculates the discount rate at which NPV is zero, so the rate at which an investment breaks even. IRR's difficulties when future cash flows are a mix of positive and negative and the inappropriate use when projects are not mutually exclusive makes it less popular in project portfolio management.

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_o \tag{1}$$

where C_t = net cash inflow during the period t, C_o = total initial investment costs, r = discount rate and t = number of time periods.

In R&D environments, one might chose to value projects according to the Least Squares Monte Carlo method (Villani, 2014) to make capital budgeting decisions since there is less certainty about returns. Monte Carlo Simulation can be used to calculate the average and volatility of the NPV for different cash flow assumptions and deviations. But the simulation can also be applied onto the whole portfolio to determine expected value and distribution. Besides financial parameters also risk and correlations can vary. In this way a risk and return profile of the portfolio and different scenarios can be calculated.

Discount rate

Measures for determining the discount rate for a project differs across organizations. As said before, a company might take the WACC as discount rate and in many organizations this is the starting point from where adjustments are made.

The WACC is calculated through calculating the cost of equity and the cost of debt. The cost of debt is simply the current market rate the company has to pay for debt, the cost of equity is more difficult to calculate since there is no explicit cost and it might fluctuate. The most accepted method to calculate cost of equity is the capital asset pricing model (CAPM). The CAPM takes into account the systematic risk involved in the stock market.

To adjust for risks involved in the project, one might choose for a higher discount rate than the WACC. This adjustment on the WACC is called the hurdle rate. The hurdle rate is described as the minimal required rate of return required for a project. Determinants of the adjustment of the hurdle rate has been widely researched. Research on the relation between length, risk and return on projects was performed by Boyle and Guthrie (2006). Since long-term investments have a greater systematic risk their cash flows should rationally be discounted at a higher rate in discounted cash flow methods. So how higher the payback time how higher the hurdle rate they should face (Boyle and Guthrie, 2006).

The use of hurdle rates in decision making was supported by Magni (2009), who did research on the hurdle-rate applied in NPV in practice. It seems that firms do not strictly implement the NPV criterion where CAPM is used for estimating the cost of capital. In most cases the use of hurdle-rates is predominant. They see the hurdle-rate as bounded rationality, and so biased heuristic, but plausible since it leads to close-to-optimal solutions. The hurdle rate is set at a base level but not rigidly applied: fluctuations are possible around the base level depending on specific project factors.

Scenario planning

When making the capital budgeting decision for projects with a high level of risk, difficulties might arise when calculating discounted cash flows and the results might be ineffective. Research on uncertainty in capital project budgeting has been performed by Alessandri et al. (2004). Alessandri et al. suggest the application of scenario planning if possible outcomes and probabilities are known since methods that calculate a direct NPV or IRR are ineffective. They see scenario planning as solution in uncertainty to identify leverage of long-term risks and uncertainty in projects. Scenario planning can be applied on the level of a single project but also on portfolio level.

4.2.2 Risk level

Individual projects will face a lot of project specific risks. At portfolio level not all project specific risks and counter actions have to be known yet. But to establish a well balanced portfolio in the next steps it is important the individual projects get a probability for success score. When the probability for commercial success is already taken into account in the calculating of the NPV by a hurdle rate, the probability for success depends solely on technical success (Cooper et al., 2002). Otherwise the success for probability is commercial success times technical success.

4.2.3 Strategic fit

Each project should be judged on how it contributes to the strategic goals and objectives of the organization. Creating strategic buckets is a successful way to create a well balanced portfolio (Cooper et al. (2002), Chao and Kavadias (2008) and Storey and Harborne (2012)) which contributes to the multiple organizational goals. These buckets are categories which can highly differ between organizations. One company might create buckets for different type of products while others differentiate between the type of market.

4.3 Project Selection and Prioritization

To ensure successful selection of the right project for execution, one should have a formalized systematic approach (Teller et al., 2012). The approach should support in the decision making process. Since not all projects can be executed because of financial and/or resource constraints there will be a continual search for best alternatives. The projects should be valued on the values explained in 4.2. Diverse methods and frameworks support in the selection and prioritization process and are analyzed by Le and Nguyen (2008). The frameworks are similar to each other (as shown in table 6) and one does not outperform the other. None of the frameworks outline specific methods or models, they only outline the processes of valuation, selection and adjustment for balancing. The most popular methods for valuing and comparing projects are financial methods (e.g. NPV and ECV), strategic buckets, bubble diagrams and weighted scoring models. To support the decision making process the Analytical Hierarchy Process (AHP) is found to be most popular (Le and Nguyen, 2008). This multi-criteria decision analysis tool is explained in 4.3.2.

When there is a capital constraint in place, the profitability index (PI) can be used as extra measure (Drury, 2012). By dividing the present value of all future cash flows by the initial investment, the profit margin is calculated. The PI can for example show that projects with large cash inflows might be less suitable to execute since they require a high share of available capital. When the PI is higher than 1 the project is profitable, which will also give a positive NPV. When projects have a high NPV but a low PI, one should considerate if the project should be executed since it probably requires a significant part of available capital.

Besides using financial methods or fit with business strategy, bubble diagrams are the third most popular method for project selection (Cooper et al., 2001). In a bubble chart projects are plotted on a scatter plot, where the difference with a scatter plot is that in a bubble chart the data points are shown as bubbles. These bubbles can have distinct sizes to show three dimensions of data. An extension to a fourth dimension can be achieved by giving the bubbles systematic colors. Also, one might chose to create quadrants in a bubble diagram as shown in figure 5. These quadrants allow categorizing projects according to the quadrant they are in. In this way a categorization close to the successful BCG matrix is achieved, except that axes are custom and in bubble

diagrams projects instead of business units are plotted. The configuration of the bubble diagram in figure 5 is one of the most well known (Padovani et al., 2012). Risks and benefits are shown on the axes and the bubble size represents the project size (in this case quantified in resources). Pearls, oysters, white elephants, and bread & butter are the categorization given to the projects by the different quadrants.

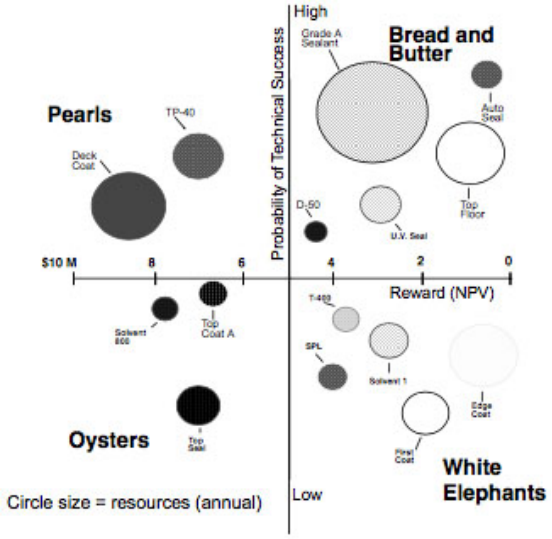


Figure 5: Example of a bubble chart using quadrants (Cooper et al., 2001)

Bubble charts allow for large customization since a lot of data dimensions are possible. The most popular types are shown in table 2. Very extensive research on determinants in the selection and prioritization of projects has been performed by Dutra et al. (2014). Their structured literature review found 21 selection methods for 37 selection criteria. The selection criteria found in literature are split into 4 categories; strategic benefits, business benefits, technical difficulty and financial costs. Concluded from this research can be that there are 11 quantitative criteria and 16 qualitative criteria split in project description-, investment quantification- and benefit quantification- criteria. The quantitative criteria are investments, revenues, environmental, social, intangible and extended benefits. In this research Dutra et al. performs Carlo simulation (Mooney, 1997) to calculate scenarios for the 11 quantitative criteria by giving them minimum, most probably and maximum monetary values. In this way the return distribution is calculated for different projects.

West (2015) supports the research by Dutra et al. (2014) in the increasing importance of environmental and social factors. West (2015) created a composite index which represent financial returns, environmental impacts and social effects with different weights. Examples driving the environmental performance index (EPI) are water efficiency, materials use efficiency and emissions. The

Rank	Type of Chart	Dimensions	
		Axis 1	Axis 2
1	Risk vs. Reward	Reward: NPV, IRR, benefits after years of launch; market value	Probability of Success (technical, commercial)
2	Newness	Newness	Market Newness
3	Ease Vs. Attractiveness	Technical Feasibility	Market Attractiveness (growth potential, consumer appeal, overall attractiveness, life cycle potential)
4	Our Strengths Vs. Project Attractiveness	Competitive Position (our relative strengths)	Project Attractiveness (market growth, technical maturity, years to implementation)
5	Cost Vs. Timing	Cost to Implement	Time to Impact
6	Strategic Vs. Benefit	Strategic Focus or Fit	Business intent, NPV, financial fit, attractiveness
7	Cost Vs. Benefit	Cumulative Reward ($)	Cumulative Development Costs ($)

Table 2: Popular axes used in bubble diagrams (Cooper et al., 2001)

social performance index (SPI) is, among other factors, driven by the use of local resources, safety and training and development. For each organization the important factors driving the EPI and SPI will differ but the research will contribute in the project prioritization process developed in this research.

4.3.1 Stochastic methods

Since outcomes of projects are not guaranteed it might be useful to use stochastic methods for simulation. The most used method in project selection is the Monte Carlo simulation technique. For quantitative criteria, this simulation generate all possible sets of input parameters and generates a distribution of possible outcomes. One can see the average value and the distribution of it which can be used in the project selection process. The Monte Carlo simulation method is especially useful in R&D environments since financial returns might highly differ. Investments in R&D projects often exist of sequential investments for each phase of the project. The commencement of the next phase depends on the successful completion of the preceding phase. This, together with the higher cost uncertainty compared to a non R&D project, allows Monte Carlo simulation to be applied to generate a set of possible returns Villani (2014).
The research by Dutra et al. (2014), mentioned in section 4.3, applied Monte Carlo simulation for 11 quantitative criteria in the project selection process.

Here the simulation was applied onto 3 projects in a portfolio. For each project the minimal, most probable and maximum outcome values for each criterion were estimated. Since these criterion where costs and financial measured benefits, the absolute and relative returns with a probability distribution where calculated so a decision makers gains insight in the distribution of the return. Especially in projects with a high level of risks, cost and financial quantified benefits might highly differentiate.

4.3.2 Multi-criteria decision making

Different methods exists for multi-criteria decision making which can be applied to every decision making process. In the project portfolio selection process, it's likely that not all projects that fulfill the criteria can be executed due to resource constraints. Therefore the most attractive projects should be executed. To select these, projects should gain a ranking based on multi-criteria. In this research we will look at two methods often used in project selection; the decision matrix and the AHP model.

The decision matrix is the most simple and can be seen as a weighted score model. All criteria get a score of how important the criteria is relative to others. Each project is scored on each criteria in a chosen range and the score is multiplied by the criteria weight. The total sum of all scores determines the final score of the project. When projects are ordered on final score, one has a prioritized list of projects.

The AHP model developed by Saaty (1977) supports in rationally selecting the best alternative based on quantitative as well as qualitative criteria in a structured way. When constructing and using the model, every time two items are compared to each other. While constructing, these items are the criteria where the projects are judged on. All criteria get a relative importance over the other criteria to calculate a weight for each criteria. All projects are compared to each other for each criteria and the outcome is a priority for each project. In this way projects can be judged on specific data or by human judgment when it is not possible to quantify the criteria. This unique advantage of AHP makes it perfect for to be applied in the selection and prioritizing process of Portfolio Planning.

The advantage of the decision matrix is the easiness but projects have to be given a classification relative to each other. For a portfolio planner this might be more difficult since no extensive information of all projects is known. In the AHP model, one only has to decide which projects scores higher compared to one other. The AHP model requires some more time to set-up and requires more difficult calculations so a software tool is favorable.

4.4 Portfolio Balancing

Like investing in financial assets, project portfolio also requires balancing by mixing the type of projects executed in a portfolio. This enables firm to achieve financial and strategic objectives without unreasonable risk. Financial data

Figure 6: Hierarchy of criteria in AHP (Vargas and IPMA-B, 2010)

can be aggregated to make sure the portfolio is meeting financial objectives. The research done so far on portfolio balancing does not show an agreement on parameters that should be balanced. The most common parameters are balancing risk and return. It is likely that projects with a high return face a high risk compared to projects with low return. When eliminating risks the return of the portfolio will be too low and when maximizing returns, the portfolio risk will be too high. Also a balance between short term and long term projects, strategic fit by using buckets, project type, project size, and resource demand is important (Cooper et al. (2002), Zeynalzadeh and Ghajari (2011) and Padovani et al. (2012)).

Also in balancing portfolio's, bubble diagrams are popular to support the decision-making process (Padovani et al., 2012). The most popular chart from the selection and prioritization process (risk vs. reward) can be used here as well. The strategic fit can be expressed by coloring the bubbles in the risk vs. reward diagram and the same applies to project type. Project size can be expressed by the size of the bubbles. To balance between short and long term projects it is likely the axes will be project length and NPV.

No research has been done on the balancing of project portfolios after using AHP. First of all, the result of the AHP is an list with all projects with a priority. It is unknown how many of the highest prioritized projects can be executed when under financial or resource constraints. Also, if the top X is selected and not exceeding financial and resource constraints, a balance between for instance strategic goals or project size is not taken into account. Therefore the result of AHP should also be used in combination with aggregated data or bubble diagrams to create a balanced selection.

4.5 Portfolio Planning

When a balanced portfolio is created it will be impossible to execute all projects immediately due to multiple type of constraints. Most likely is that the main strategic portfolio planning process happens annually with monthly or quar-

terly reviews and adjustments, but this depends on the organizational internal processes. When planning projects for a specific time horizon, one has to take into account four main constraints. These are specific timing constraints for an individual project, dependencies between projects and financial and human resource constraints. To plan projects over time, often a gantt chart is used. The gantt chart is a popular tool in project management and shows the start and end date of the selected projects and dependencies between them.
It also allows showing multiple planning data of the projects as shown in figure 7. For example different scenario's for the future can be created and be compared with each other. When the portfolio planning is done and projects are in execution phase, gantt charts also allow for comparing the present situation of projects with the planned one.

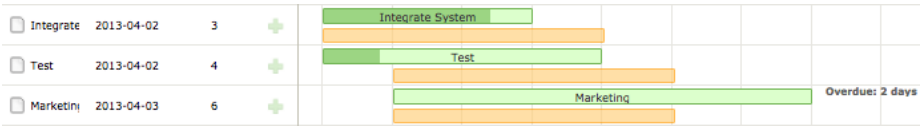


Figure 7: Gantt chart example (made using the DHTMLX JavaScript library)

To balance the use of resources and visualize the adequacy, it is recommended to use a stacked histogram as shown in figure 8. The stacked histogram shows the resource adequacy over time for different roles required by the selected projects. When exceeding the capacity for a role the overallocation colors red.

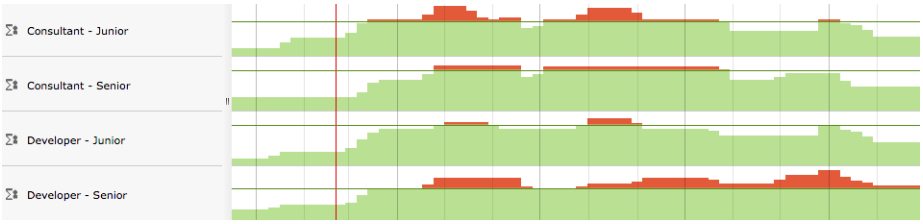


Figure 8: Resource adequacy over time (Meiserplan.com, version May 2017)

4.6 Benefits Management

Benefits realization management (BRM) can be generically described as the identification and the implementation of benefits to make sure projects and programs add real value to the organization. BRM is a process which is often applied in an organization with a framework. Project management methodologies (i.a. PMI (2016) and P3O (2009)) as well as scientific literature (i.a. Ward et al. (1996), Yates et al. (2009) and Badewi (2016)) have created multiple process models and frameworks and definitions of BRM which are close to each

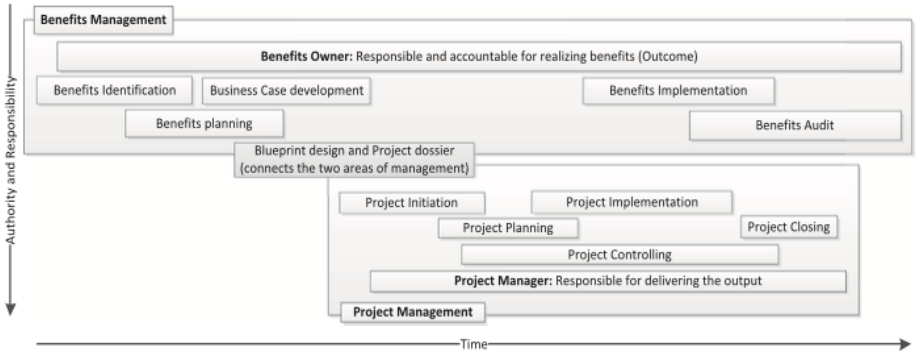


Figure 9: Relationship between PM and BM under project benefits framework (Badewi, 2016)

other. In this research, the definition of Badewi (2016) will be used since they focus on the combination of PM and BRM. Badewi's definition of BRM is 'the initiating, planning, organizing, executing, controlling, transitioning and supporting of change in the organization and its consequences as incurred by project management mechanisms to realize predefined project benefits' (Badewi, 2016, p.3). BRM is a process closely related to project management, both contribute to the success of projects. Recent research has shown the link and interaction between project- and benefits realization management. Badewi (2016) present a governance based framework, shown in figure 9, showing the processes of PM and BM over time. Important note here is that the benefits management process has a longer life cycle than an individual process.

Benefits identification is the initiation stage where a benefit is identified, documented and classified. Classification often finds place by value type or business impact (Bradley, 2016). When classified by value type the dimensions are tangible and intangible, where a tangible benefit can be definite (predicted with certainty), expected (predicted with high level of confidence) or anticipated (not reliably predictable). Another type of classification which can be used to create a well-balanced portfolio is shown in figure 10. In this way, a portfolio manager can be sure there is a balance between the different type of business goals in his or her portfolio.

A benefit owner is assigned to a benefit in a project and is accountable and responsible for capturing the benefits from the project. This seems critical for the project performance according to research by Zwikael and Smyrk (2015) since project managers only focus on the output of projects. Therefore this has to be a split accountability. The benefits audit, performed at the end of the project lifetime, makes sure the benefits are obtained after implementation.

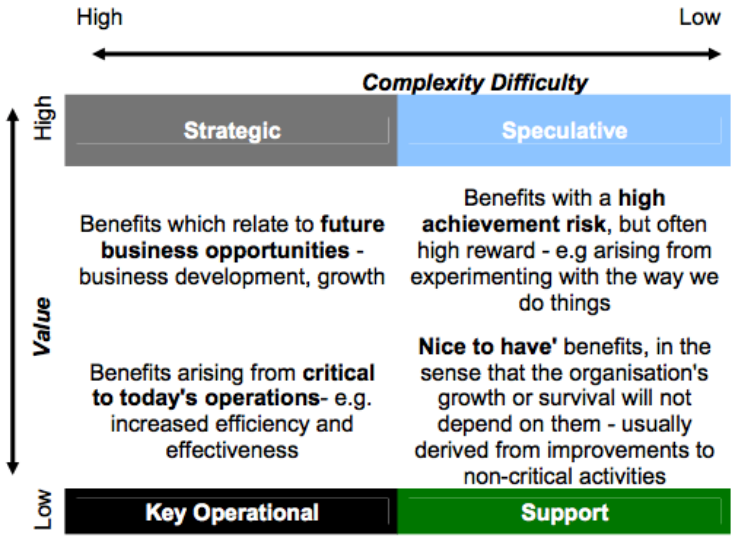


Figure 10: Sigma grid (Bradley, 2016)

4.7 Failure and Success

A lot of research has been done on successful Portfolio Management. According to research done by e.g. Beringer et al. (2012), Teller (2013) and Jonas et al. (2013), the main dimensions to determine portfolio success are as follows.

- **Average project success**
  The success of all single projects together mainly influences the portfolio success. The single project success is mainly measured among ROI, schedule and quality Gardiner and Stewart (2000).

- **Synergies**
  Portfolio success through synergies means making use of the interdependencies between the different projects. Additional value can be generated for example by executing projects synchronously for the same customer, projects using the same technologies, projects acting on the same market or redundant work is eliminated when the projects are performed at the same time. This additional value is not obtainable by executing all projects independently.

- **Strategic fit**
  The strategic fit of the whole portfolio should fit the firm's future view , should be implemented in an optimal way and resource allocation reflects strategic objectives (Teller et al., 2012).

- **Portfolio balance**
  The balance of a portfolio can be determined on three perspectives Jonas

et al. (2013): financial-, strategic, and learning perspective. This means respectively a balance between high and low risk projects, new and old areas of application and the use of new and existing technologies within projects. Also a steady utilization of resources give a balance to the portfolio (Teller et al., 2012).

Furthermore, formalization of PPM and a high PPM quality (measured by information quality, resource allocation quality and cooperation quality) improves portfolio success (Teller et al., 2012). Increased success by formal method is also supported by the research of Dutra et al. (2014) since it increases profits (Dutra et al., 2014, p.3). Unger et al. (2012) divides the role of the PPMO in a coordinating, controlling and supporting role and finds for each role improved PPM quality which predicts portfolio success.

Teller (2013) created a portfolio risk management framework. Based on a literature review, they define the organization, process, and culture as the three components of their framework. The organizations need role clarity and formalization, a risk management process should be defined and integrated into PPM and a risk management culture should be in place. Support is found that this should improve portfolio success.

Since these dimensions seems to determine portfolio success, it is important Portfolio Planners take these into account when planning the projects in the portfolio.

4.8 Dynamic Capabilities

Figure 11: Steps in a portfolio framework (PWC, 2012)

As shown in figure 11, portfolio management is a continuous process which brings as well as requires dynamic capabilities and agility (Killen et al., 2008).

Portfolio planners will try to formalize the PPM process to make sure they get the best information quality possible so they can create an accurate planning. But the uncertainty in projects and high interdependencies between those projects will almost always change the planning of multiple projects. Also changes in organizational strategies, project failures, budget changes, overrun project budgets or changes in risk might influence the portfolio planning during execution. Therefore, some level of dynamic capability in the organization is required (Daniel et al. (2014), El Hannach et al. (2016)).

The most extensive research on dynamic capabilities was performed by Killen and Hunt (2013) and Daniel et al. (2014). When PPM act as dynamic capability provides a responsive decision-environment to the organization which improves it's effectiveness Storey and Harborne (2012). Daniel et al. (2014) concluded from their case study research in five firms the four dynamic capabilities where present in the firms, shown in table 3

	Dynamic capabilities	**Cases in which capability observed***	**Fit with dynamic capability definition (see section 2.2)**
1	**Business objectives drive projects** *The ability to* use the organization's strategic objectives as explicit drivers of project investments, rather than select investments by post hoc alignment back to the objectives	ServicesCo ConsultCo	Projects use resources and ordinary capabilities to produce new assets, resources and capabilities required to achieve business objectives. As business conditions evolve the business and IS strategies will change and affect the criteria used in identifying and selecting new projects.
2	**Multiple and dynamic prioritisation criteria** *The ability to* use multiple criteria in the appraisal and prioritisation of investments and vary those criteria over time as business conditions change.	MediaCo ServicesCo PharmaCo ConsultCo	Project prioritisation and resource allocation must be based on criteria that accommodate projects that make different types of contributions (e.g., compliance, innovation). Prioritisation criteria must change to allow for changing business, IS and strategies, project performance and resource availability.
3	**Dynamic balancing of risk and reward** *The ability to* identify and balance reward and risk at both project and portfolio levels and adjust the project selection criteria to maintain a level of portfolio risk that reflects economic conditions.	MediaCo InsureCo PharmaCo ConsultCo	Balancing risk and reward requires that resources are allocated or reallocated to achieve the portfolio contribution. Both the potential rewards and risks will evolve as the business environment changes and as the projects progress.
4	**Cancel or reconfigure in-flight projects** *The ability to* stop, postpone, or reconfigure projects, including 'in-flight' projects, as their actual or relative value to the organization changes and to reallocate the resources to other projects.	All	Cancelling or postponing projects releases resources. It also reverses resource allocation decisions previously made. The criteria used to cancel and postpone projects will vary with business conditions, project performance and potential alternative investments that can use the released resources.

Table 3: PPM dynamic capabilities (Daniel et al., 2014)

This means portfolio planning process should allow flexibility for prioritization and balancing, strategic objectives are the main drivers of projects and the ability to reconfigure 'in-flight' projects. This was also found by (Killen and Hunt, 2013) who found that stopping projects and reallocating resources is a weak point in the case organizations. El Hannach et al. (2016) also described

the need to be able to revalue the portfolio if new projects are proposed or the strategy of the organization undergoes changes. So concluded can be that the constant evaluation of ongoing projects, by for example earned value management, is required and when projects are low performing, the organization should have the ability and agility to stop these projects. This enables the organization to reallocate human resources and investments to optimize the ROI of the whole portfolio.

The Earned Value Management process is applied (Shaik, 2014) during the projects and involves measurements as Planned Value, Earned Value, Actual Cost, Cost Variances, Schedule Variance and Schedule Performance Index (SPI). Also Estimate at Completion (EAC) is used as forecast to predict the cost at completion. SPI, EAC and milestones (determining financial benefits in time) can help during the project execution to determine project success and so, if a project should be canceled. The most used benchmarks are shown in table 4. After project termination, evaluation might analyze budget exceeding, ROI of the projects and portfolio and benefits achieved as explained in section 4.6.

PV	planned value
AC	actual cost
EV	earned value
CV	cost variance (CV = EV − AC)
SV	schedule variance (SV = EV − PV)
CPI	cost performance index (CPI = EV/AC)
SPI	schedule performance index (SPI = EV/PV)
BAC	budget at completion (the planned cost of the project)
PMB	performance measurement baseline (the cumulative PV over time)
IEAC	independent estimate at completion (the forecasted final cost)

Table 4: Earned value management formulas (Lipke et al., 2009)

4.9 Contribution to Strategy and Capability Based Planning

The results from this research can also be taken into account in the discipline of enterprise architecture and business strategy. Figure 12 shows how these fields are directly related to each other and should be taken into account in portfolio valuation. Figure 13 illustrates the relationship between capability based planning, enterprise architecture, and project portfolio management. A capability is split into capability increments and the architecture of the organizations changes through project across portfolios. This point of view also ensures strategy alignment of the project portfolios but is changing the organization as a whole.

In this research the Project Portfolio Management process is applied in ambidextrous organizations. Ambidextrous organizations (O'Reilly C and Tushman, 2004) refer to organizations that apply exploration and exploitation at the same time. So the executed projects are not meant to change the organization

Figure 12: Relationship Projects and Programs with other fields of interest (Iacob et al., 2012)

as a whole. They are executed to innovate or expand through new or existing products or services. In capability based planning one has already chosen which direction to go and projects have to be executed either way, there is no selection process. Only the planning aspect might be of interest in Capability Based Planning.

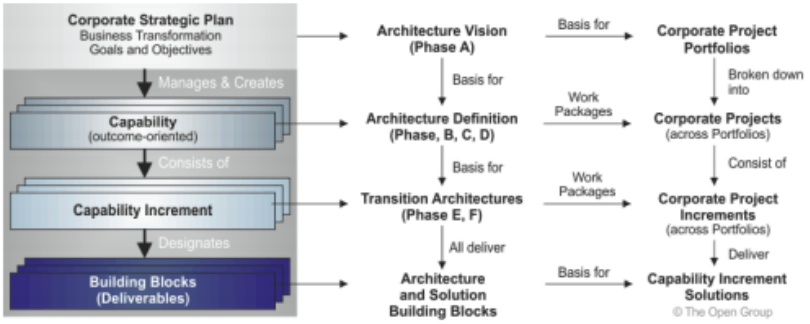


Figure 13: PPM in Capability Based Planning (Open Group, 2011)

5 Process model

When drawing conclusions from the theoretical framework as described in section 4, one can say that there is no clear specific selection framework with well established parameters for projects. This is not very remarkable since the process of project portfolio selection is very complex and differs highly across organizations. Research papers focus on a very specific process in the overall process and research settings are almost never in an existing enterprise but just hypothetical. In an enterprise, one has to deal with a hierarchical structure, different levels of knowledge and authority and information- asymmetry and incompletion. Furthermore, the solution design which is the result of this paper should be applicable in a wide range of organizations. These organizations will have different processes which all should be supported by the solution design. A process model was designed based on the theoretical framework and is shown in figure 14. The process model distinguishes four clear steps: valuate, prioritize, balance and plan. All steps are briefly explained in section 5.1. For each step data is required and through a method transformed to new data; the output. The data input and output and methods used are given in table 5. A mapping of the steps and on which literature these are based can be found in table 6.

5.1 Process steps

Since the tool focuses on the portfolio level, this section will only outline the steps at the portfolio level. In the designed process the executive level provides the portfolio level with the benefits mapping existing of benefits and goals. Furthermore, the project level delivers knowledge about the project so the portfolio level can make deliberate decisions.

1. Valuate project
   - 1.1 Determine strategic fit: map the project onto one or more benefits where the projects delivers value
   - 2.2 Financial appraisal: use financial appraisal methods to determine financial value of the project
   - 3.3 Determine risk level: set rates for economic and technical success
2. Refuse unprofitable projects: remove projects which are not delivering value in any way. For instance projects with a negative NPV and high risk level or projects not contributing to the strategy
3. Prioritize projects
   - 3.1 Set decision criteria: determine decision criteria for the projects
   - 3.2 Set decision criteria weights: give each criteria a relative importance over the others
   - 3.3 Score projects: for each project, give a score for each criteria

4. Set portfolio constraints: since not all projects can be executed, set the constraints for the portfolio. For instance financial constraints or resource constraints.

5. Select best subset: select the highest prioritized projects without exceeding the portfolio constraints

6. Balance portfolio: create a well-balanced portfolio by deselecting projects that create an unbalanced portfolio and select projects that create a more balanced portfolio.

7. Portfolio planning: since projects can not all be executed at the same time through financial and human resource constraints; use a resource constraint planning.

8. Authorize projects: finalize the selection process by authorizing the projects so project managers can start the project at the right time.

Step	Input	Output	Methods
Valuate	All possible projects that fit in the portfolio goal	List with valued projects	• Financial appraisal • Strategy mapping • Risk level
Prioritize	List with valued projects	Prioritized list	• Decision criteria • Multi-criteria decision making • Weighted criteria • Decision Matrix • Ranking projects (AHP) • Score projects
Balance	Prioritized list	Balanced project selection	• Project synergies / interdependence analysis • Portfolio constraints • Portfolio adjustment • Portfolio optimization • Bubble charts • Evaluate alternatives • Dynamic balancing
Plan	Balanced project selection	Balanced project selection fitting capacity in selected time horizon	• Planning horizon • Available resources (capacity) • Resource allocation • Project scheduling

Table 5: Schematic step explanation of the created process model

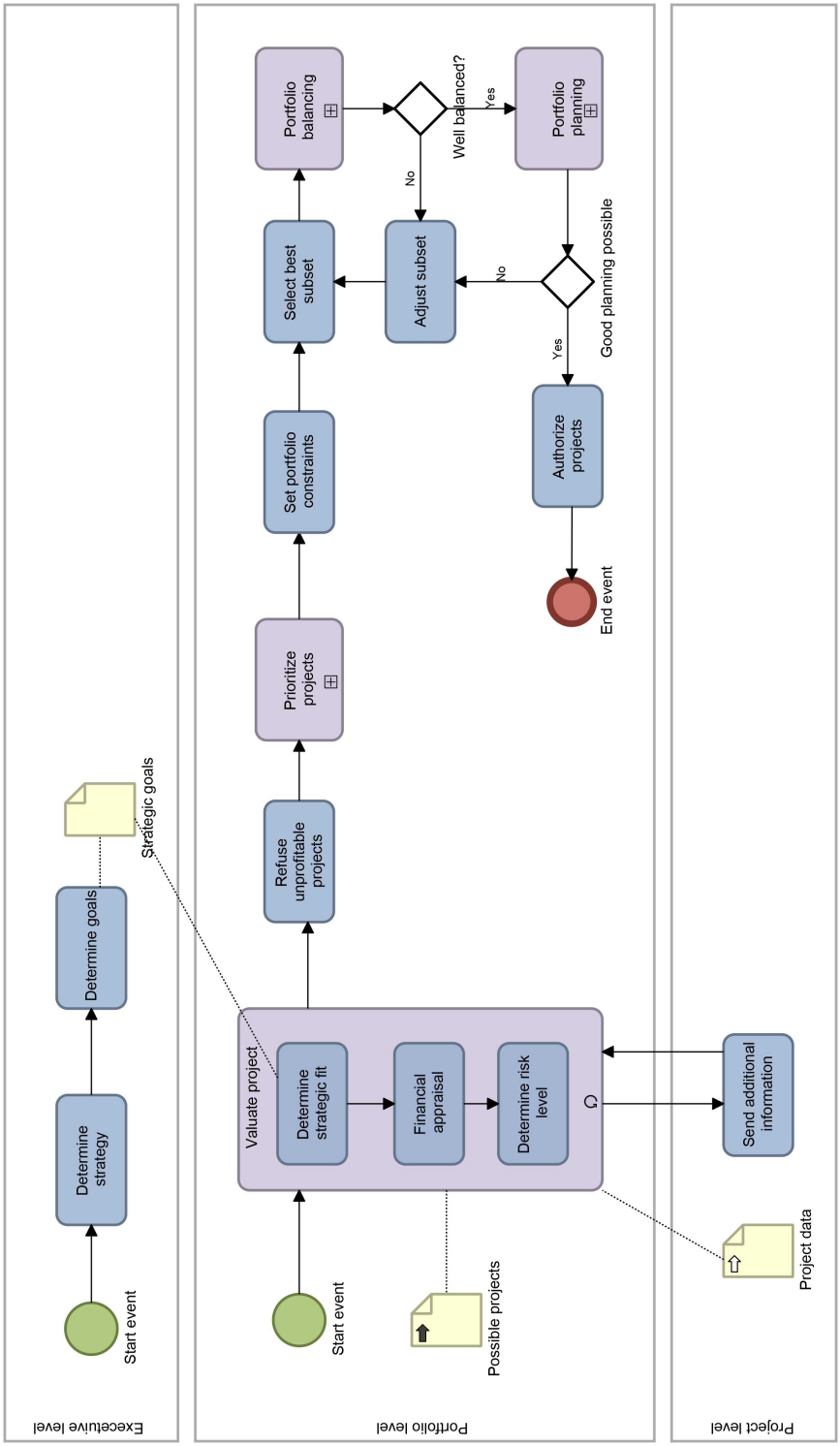


Figure 14: Process design

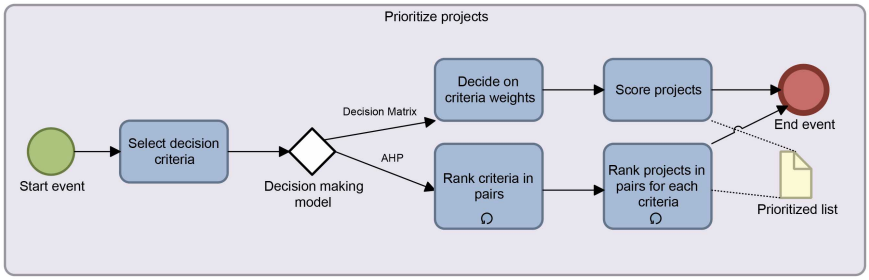


Figure 15: Prioritize projects

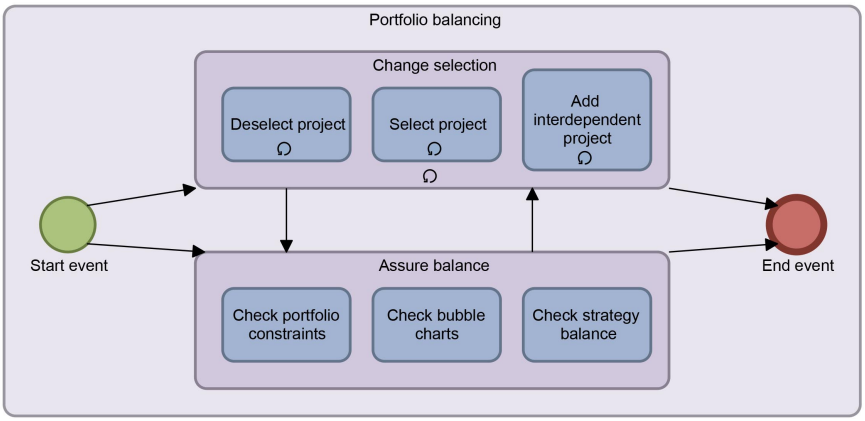


Figure 16: Balance projects

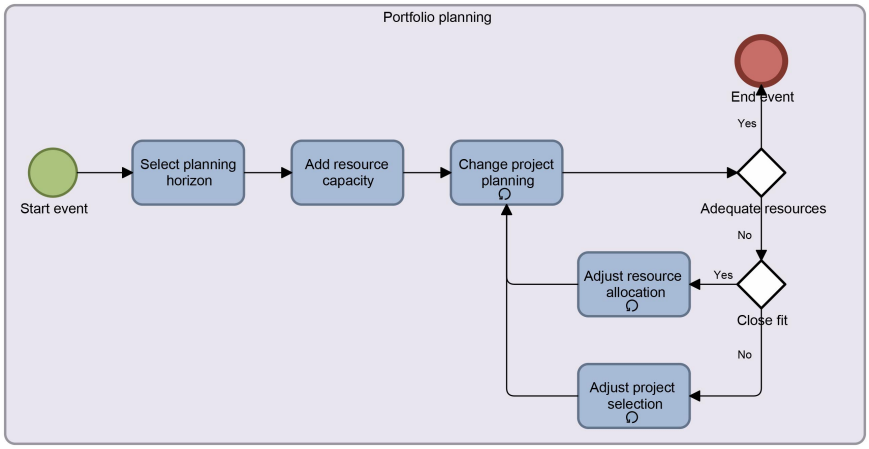


Figure 17: Plan projects

5.2 Literature mapping

As elaborated on in the theoretical framework, the literature described lot of different steps with most of them slightly different from others. The most extensive frameworks are the ones from Archer and Ghasemzadeh (1999), Tavana et al. (2015), Oktavera and Saraswati (2012), Zeynalzadeh and Ghajari (2011). None of these frameworks comprise all steps found in literature and the separate frameworks. Table 6 maps the steps described in the proposed process model and literature. All literature have been gathered by using Google Scholar and Scopus by using combinations of the words 'project portfolio', 'framework', 'prioritization', and 'selection'. The smaller steps from the process model are merged to the four main steps since in all literature the steps are slightly different which makes it impossible to map.

Step	Literature
Valuate	• Alpaugh (2008): Project proposals • Archer et al. (1998): individual project analysis • Archer and Ghasemzadeh (1999): strategic mapping • Cooper et al. (2001): Strategic fit • Cooper et al. (2002): Strategic buckets • Daniel et al. (2014): Business objectives drive projects • Englund and Graham (1999): Requirements • Oktavera and Saraswati (2012): Strategic-, cost- and risk analysis • Padovani et al. (2012): Characterization of projects • Pajares and López (2014): Valuation of new projects • PWC (2012): Review • Tavana et al. (2015): screen projects, strategy objectives per period • Urli and Terrien (2010): Screen projects • Zeynalzadeh and Ghajari (2011): Strategic fit analysis
Prioritize	• Alpaugh (2008): Project selection through AHP • Amiri (2010): Determine criteria and criteria weights • Archer et al. (1998): Weighted scoring (AHP) • Cooper et al. (2001): Scoring models and ranking • Daniel et al. (2014): Multiple and dynamic decision criteria • Dehouche (2012): Multicriteria methods • Englund and Graham (1999) Prioritized list through AHP • Gomede and de Barros (2014): Selection criteria, constraints, AHP • Oktavera and Saraswati (2012): Selection through creating criteria, AHP, Monte Carlo simulation • Pajares and López (2014): Ranking and project selection • PWC (2012): Prioritize • Tavana et al. (2015): Decision criteria and weights, score project, ranked list of projects • Vargas and IPMA-B (2010): Prioritized list through AHP
Balance	• Amiri (2010): Evaluate alternatives • Archer and Ghasemzadeh (1999): Optimal portfolio sel ection and portfolio adjustment with feedback loop • Cooper et al. (2001) Balance portfolio • Daniel et al. (2014): Dynamic balancing • Englund and Graham (1999): Decision mix, bubble chart • Keisler (2005): Synergies • Oktavera and Saraswati (2012): Optimal project portfolio selection analysis • Padovani et al. (2012): Balancing through bubbles • Pajares and López (2014): Portfolio balancing • Tavana et al. (2015): Portfolio constraints • Urli and Terrien (2010): Define good (efficient) portfolios, optimalisation of portfolio • Zeynalzadeh and Ghajari (2011): Balance analysis, interdependence analysis
Plan	• Archer et al. (1996): Project scheduling • Archer and Ghasemzadeh (1999): Resource allocation and competition • Cooper et al. (2002): Resource demand and capacity • Edgett and Kahn (2012): Resource adequacy • Englund and Graham (1999): People and capacity • Le and Nguyen (2008): Theory of constraints • Mira et al. (2013): Planning horizon, available resources • Pajares and López (2014): Scheduling, resource allocation

Table 6: Literature mapping process model

6 Status quo

As said before, Fortes is now offering an enterprise software solution which is conceived as too complicated by its customers. The new to be developed Multi-Application Platform (MAP) should therefore be based on the organizational context designed by PMI in figure 1. The four layers in this context Fortes wants to support are organizational strategy and objectives, portfolio planning and management, management of authorized programs and projects and the organizational resources. When all functional elements of the Principal Toolbox are mapped onto these 4 layers, the applications the multi-app platform will contain per layer are showed in table 7.

Organizational Strategy and Objectives
Benefits Management
Project Portfolio Planning and Management
Portfolio Management
Enterprise Portfolio Management
Change Organization
Idea Management
Management of authorized programs, projects and initiatives
PRINCE2
Stage-Gate
Kanban
Agile PM
Programme Management
Customized Project Management
Resource Allocation and Scheduling
Supplier management
Resources
Time Registration
Management of resource skills and pools

Table 7: Application landscape MAP

The MAP has to be extended with new apps to enable change in the organization by extending the functionalities of the two upper layers. As can be seen in figure 7, already some applications exist within these layers. Since the strategic portfolio planning app will partly fulfill the gaps of the two upper layers, the capabilities of the existing apps in these layers will be shortly analyzed in the next sections. For this research, the benefit management, enterprise portfolio management and portfolio management apps are of most interest, the other two apps will be omitted since they are not involved in the strategic portfolio planning process. This research is based on version 9.5 of the Toolbox.

6.1 (Enterprise) Portfolio Management

The portfolio management module in the Principal Toolbox contains a lot of reporting functions. The dashboard, scenario planning, financial and gantt functions are of biggest interest. Each functionality will be shortly discussed.

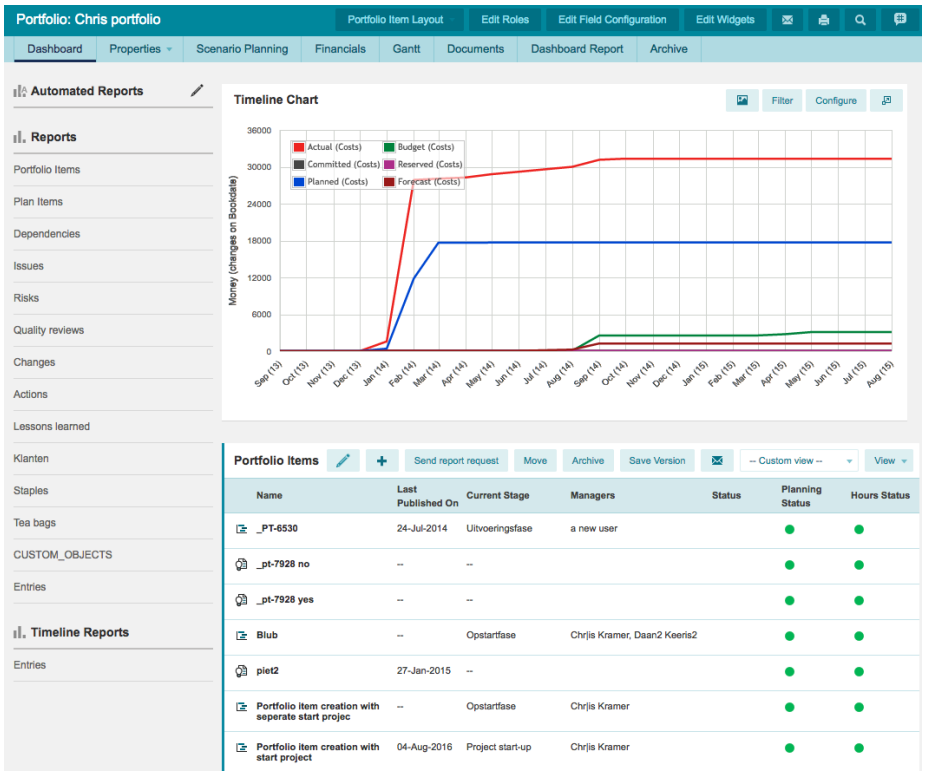


Figure 18: Screenshot of the portfolio dashboard in the Toolbox (v9.5)

Dashboard

The portfolio dashboard is, as most pages in the Toolbox, customizable. One can add widgets like bar-, bubble-, bullet-, funnel-, gauge- and pie-charts or more specialized charts like resource utilization. So the dashboard can show what the user finds to be of biggest interest. Each widget can be configured to show the desired information belonging to all underlying portfolio items. A portfolio item can be a program, project or initiative.

Scenario Planning

The scenario planning function allows selecting a subset of portfolio items. For the selected portfolio items three types of widgets are shown. The first one allows maximizing one value while being constrained to multiple other values. In this way for instance the sum of the NPV's can be maximized while being constrained by for instance costs and resource hours. The bubble chart allows for visualization of three values while the color shows if the project is selected in the portfolio or not. Clicking on a bubble moves the project to selected when unselected or the other way around. The timeline chart allows showing cost and resource costs in a selected time frame.

Financials

The financial component shows a grid where financials can be entered. For each project different financial categories are shown and for each month an amount can be budgeted.

Gantt

The Gantt chart shows the planning for the projects made at project level. It is not possible to change the planning of projects.

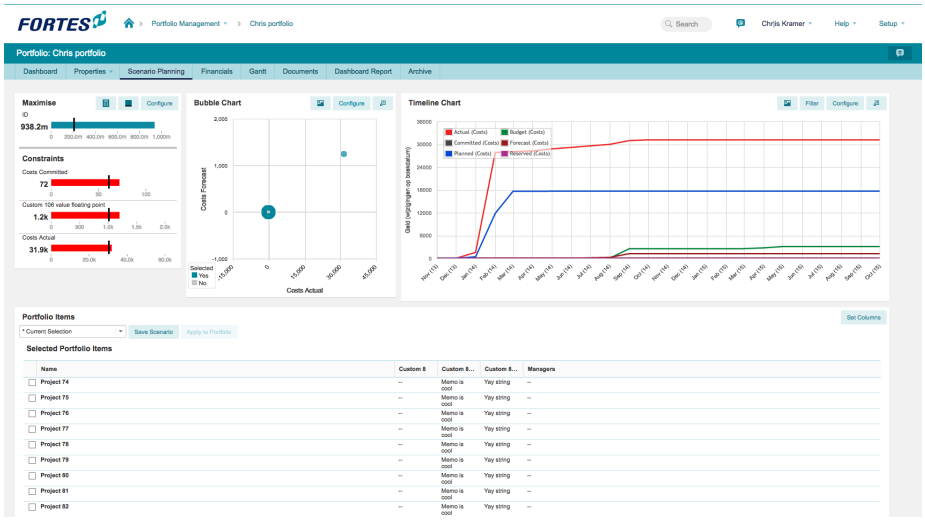


Figure 19: Screenshot of the scenario planning functionality at portfolio level in the Toolbox (v9.5)

6.2 Benefits Management

The current benefit management module in the Principal Toolbox is still in its first version. A minimalistic version as shown in figure 20 has been built and is included in the software. Benefits can be added to the list and optionally be mapped in the diagram. Each benefit has only a name, owner and description and is an item without any dependencies to a project.

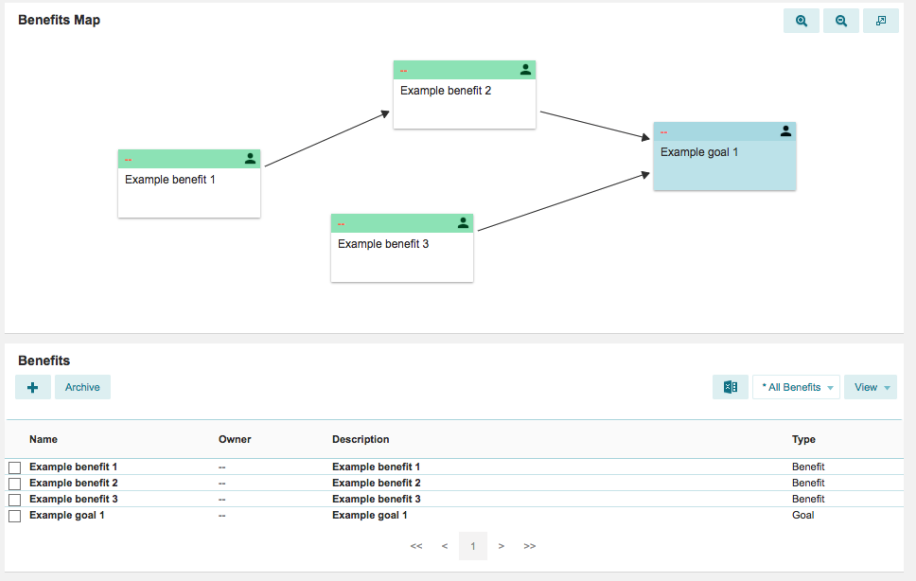


Figure 20: Screenshot of the benefits management functionality in the Toolbox (v9.5)

6.3 Limitations for Strategic Portfolio Planning

The main conclusion that can be drawn when comparing the required capabilities named in the theoretical framework and the current functionalities of the Toolbox is that there is no project planning component and no clear project selection process at the portfolio level. At the portfolio level one can select projects in the scenario planning to see if outcomes are better than selecting another project. There is no prioritization or general score of the projects. A visualization of shortcomings is given in figure 21. Red visualizes no support at all, orange means partially support and green steps are fully supported.

Valuation

There is no clear project valuation process supported by the toolbox. A Toolbox administrator can add custom fields to a project which can be used for such

specific purposes. A project manager can enter project specific values into these fields so they can be used for valuation at portfolio level. So there is no standardized valuation process and parameters but there are workarounds.

Prioritizing

There is no functionality to prioritize projects. The projects can be ordered at a column in a data grid so this is only for one value. There is no general prioritization of the most interesting project.

Balancing

The scenario planning in the portfolio management tab can be used for balancing. A subset of project can be created where one can try to maximize or minimize sums of parameters, use the bubble chart to visualize up to four parameters or the timeline to show resource or financial adequacy. The subset can be saved as scenario and another subset can be created. Comparison between scenario's is only possible by switching between them.

Planning

The Toolbox doesn't allow resource and project planning at portfolio level. Only the financials tab allows creating budgets and see actuals and forecasts. The only planning possible for resources is at the project level. The project is split into tasks (in the toolbox called plan items) which can be planned over time.

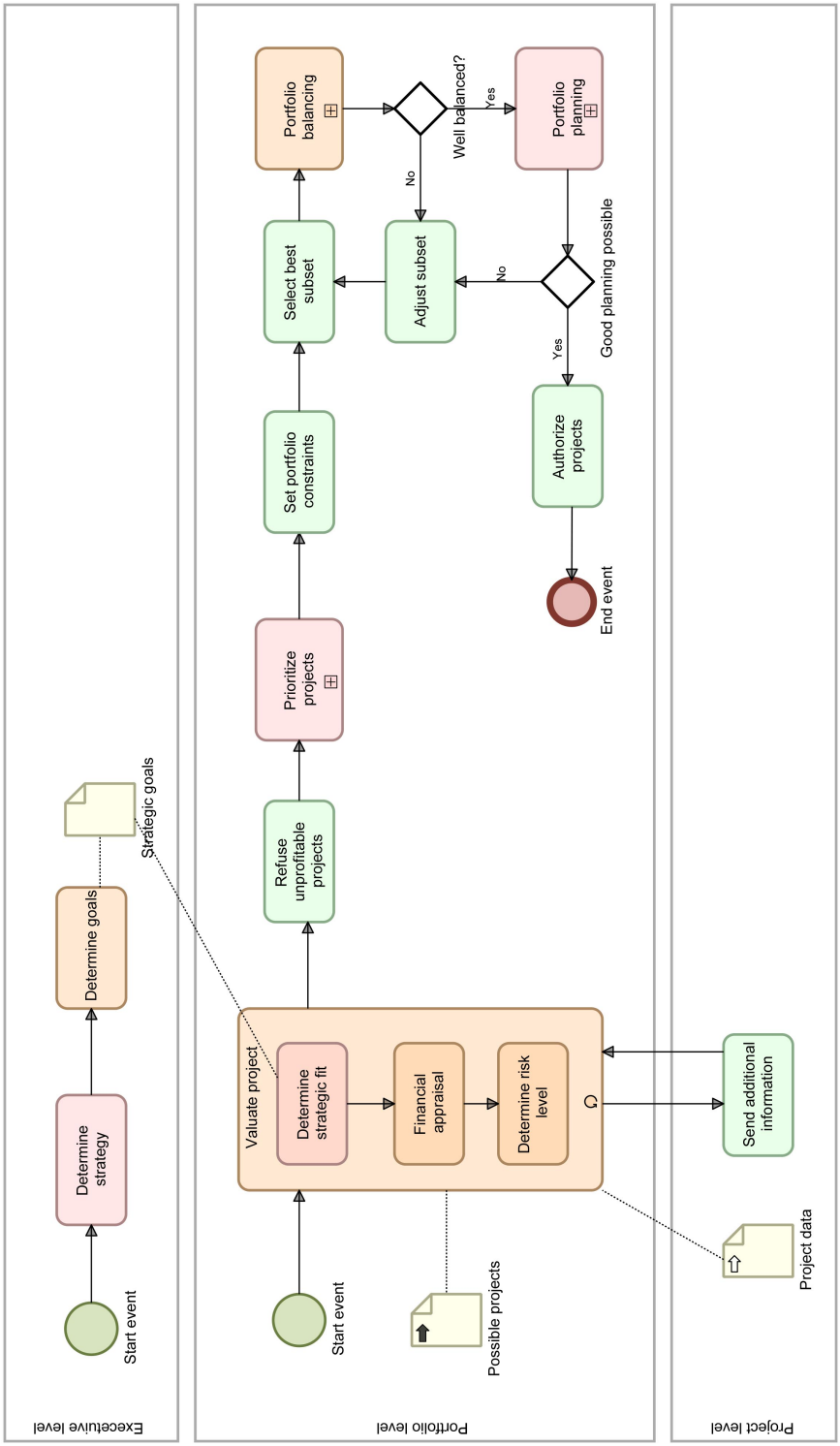


Figure 21: Process design compared with Toolbox functions

7 Solution design

This chapter describes the design of the artifact created in the design cycle which was based on the literature described in the theoretical framework and the created process model. A prototype was created from the requirement list for validation purposes and is evaluated in section 8. To let the artifact fit perfectly in the current Fortes software architecture this is outlined first in the prototype section.

The design of the artifact exists of a functional requirements list in the style of features the app should offer (Lauesen, 2002). In this case a features list is the easiest to read and understandable for almost all readers.

7.1 Capabilities

The designed process model as visualized in figure 14 compromises the steps valuation, selection & prioritization, balancing and planning. Since different levels in the organization are existing in practice, this model can not directly be used in large enterprises. Therefore, the design of the strategic portfolio planning process has been split into 5 steps as visualized in figure 22.

The valuation of projects is mainly done at project level, except for the strategic fit since a project manager doesn't have such extensive knowledge of this level in the organization. Therefore, the strategy mapping of the projects is the first step. In the next step the portfolio planner can select the criteria where the projects can be scored for. This can include criteria that are already included in the projects or new criteria. One should get proposed criteria based on often used criteria found in literature, enterprise specific important criteria and criteria where the value is already known (included in the project data).

In the prioritize step one gets support in prioritizing the projects. Through AHP or a decision matrix the weight of criteria are set and projects are scored through the selected multi-criteria decision method. This results in a prioritized list of projects which can be used in the next step to create a well-balanced portfolio. The balancing step extends the current scenario planning functionality of the Toolbox by offering a prioritized list of projects, a high strategic focus on the balancing part and by standardizing the bubble chart to guide the user. Furthermore, when the enterprise is resource-limited, or when some specific skills are limited, the planning component makes sure the selected projects can indeed be executed in the selected timeframe.

Figure 22: Strategy execution through strategic portfolio planning

7.2 Requirements engineering

This section describes the functional requirements of the designed artifact and so, are the functionalities that should be supported by the app. The functional requirements are split into the different steps as shown in figure 22.

Strategy

R1. The app should be able to add projects to the process. This can be a new project that doesn't exist in the Toolbox or reading projects from the Toolbox.
R2. The app should be able to read an existing benefits mapping from the organization unit level in the Toolbox.
R3. The app should visualize the original mapping made in the Toolbox with the benefit and goal titles and descriptions.
R4. The app should clearly show not mapped projects and distinguish them from the mapped ones.
R5. The app should allow projects to be mapped onto one or more benefits.
R6. The app should be able to save the benefit mapping and to read and change it later.

Criteria

R7. The app should allow the user to choose decision criteria
R8. The user should be able to add new decision criteria
R9. The app should advise the user in selecting decision criteria. Relevant, popular decision criteria found in literature should be available as proposed criteria. Also, an enterprise might have its own important decision criteria which should be available in the decision criteria selection.

- Total cost
- NPV
- IRR
- Payback time
- Total resource load
- Project length
- Probability of technical success
- Probability of commercial success
- Demanding limiting skills

Prioritization

R10. The app should support a multi-criteria decision making process.
R11. The app should take into account that not all criteria have the same weight.
R12. The app should allow the user to rank the project for each criteria for the AHP method.
R13. The app should give a score to each project which is the prioritization of the projects.

Balance

R14. The app should allow to easily select and deselect projects.
R15. The app should be able to visualize selected projects in a bubble diagram in three dimensions (X axis, Y axis, size).
R16. The app should propose the user dimensions to use in the bubble diagram. The proposed dimensions are as follows and are selected based on the research by (Cooper et al., 2001).

- Risk / Reward
- Newness
- Ease / Attractiveness
- Strengths / Project attractiveness
- Cost / Timing
- Strategic / Benefit
- Cost / Benefit

R17. The app should allow the user to create their own dimensions in the bubble diagram
R18. The app should have a clickable bubble diagram to (de)select projects
R19. The app should clearly show the goal the project is contributing to
R20. The app should show pie charts for the following parameters, where each segment in the pie chart is a strategy goal and the size is the sum of the projects values for this parameter

- Number of projects
- Total investment
- Total benefit
- Workload

R21. The app should be able to save the selection of projects and switch between them.
R22. The app should include the other current functionalities of the scenario planning tab in the Toolbox

- Timeline chart
- Sums / constraints
- Multiple scenario's
- Customizable data grid

R23. The app should offer an interdependency matrix as described by Keisler (2005) and Urli and Terrien (2010) to set project dependency factors
R24. The app should highlight unselected projects that have interdependencies with any of the selected projects

Plan

R25. The user should be able to add new resource to a project
R26. The user should be able to plan hours over time for each (resource, project)
R27. The user should be able to move the planned hours over time
R28. The app should allow to change the selected projects after they are planned
R29. The user should be able to create multiple scenarios where the planned hours over time differ
R30. The planned hours per resource should be shown visual summed up
R31. The user should be able to set a resource capacity

The definition of a resource is up to the organization; a resource can for instance be a skill, person, role or (agile) team.

7.3 Prototype design

Based on the requirements of the previous section a prototype has been build for validation. Since all Fortes apps are browser based and built in JavaScript, this was also done for the prototype. The newest technologies like React.JS have been used to built a modular view and Backbone to handle the data. Since the app should integrate with other functionalities, the relevant current software architecture was discussed with developers. Relevant components that were taken into account are shortly outlined below. A prototype was used to validate the design so not all requirements were implemented. Specific design decisions for the prototype are outlined as well. The prototype was build by the author of this article.

7.3.1 Current software architecture

Fortes uses a REST interface to access and manipulate data in their databases. The web service allows for CRUD operations; create, read, update and delete. Since no clear documentation was present, analysis of the current Toolbox and information from developers was used to set up the required REST calls. The prototype is connected to the Toolbox by a server layer as shown in figure 23. The first three functions are called upon initialization of the prototype while the last one is used when important new data is generated by the app. This is for instance the prioritization value and if the project is selected in the end or not.

For planning hours the Fortes entry system had to be taken into account. Hours and money are saved as immutable entries. This means, that when something changes the original entry has to be counter booked. An entry can be for one specific moment, count for every moment in the selected time interval or be divided over the selected time interval. Since the planned hours are saved in the Toolbox, the app should support this system.

An architectural view is drafted in figure 24. The given architecture only takes into account the business processes involved in the project planning part; a complete architecture would have been too complex.

7.3.2 Entity-relationship diagram

An entity-relationship diagram defines the information structure that has to be implemented in a database. The diagram shown in figure 25 is the data model used in the prototype. The PortfolioItems as well as the BenefitsGoals entities are automatically loaded by calling the API layer. ProposedCriteria are provided and not editable. The SelectedCriteria entity exist of the criteria selected in the criteria step, the sums entity is used for maximizing or constraining values in the balance step, the PriorityMatrix is used during the prioritize step and the scenarios and skills step during the plan step.

7.3.3 Design decisions

Since it is a prototype not all requirements were integrated in the prototype. The prototype only supports a decision matrix and no AHP, has limitations in the possible strategic mapping and doesn't have any support for project interdependencies. A extensive analysis of which requirements the prototype fulfills is given in section 8.1.

7.3.4 Screenshots

The screenshots of the prototype are shown in figures 26 - 30, for each step one screenshot is included.

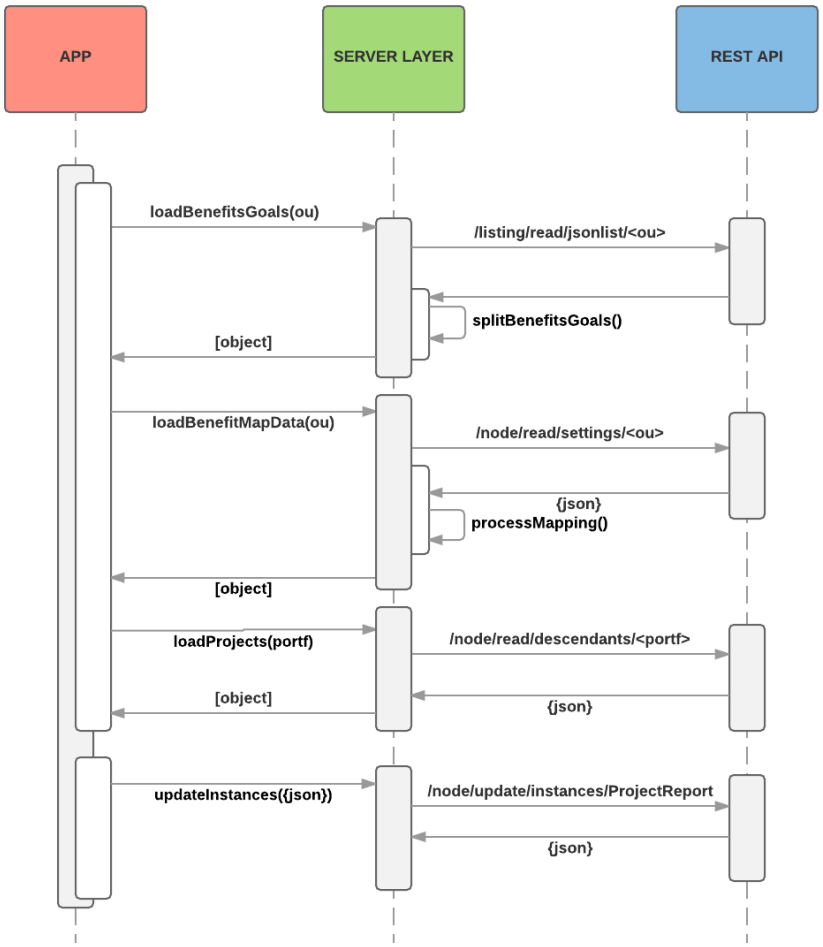


Figure 23: UML sequence diagram server layer

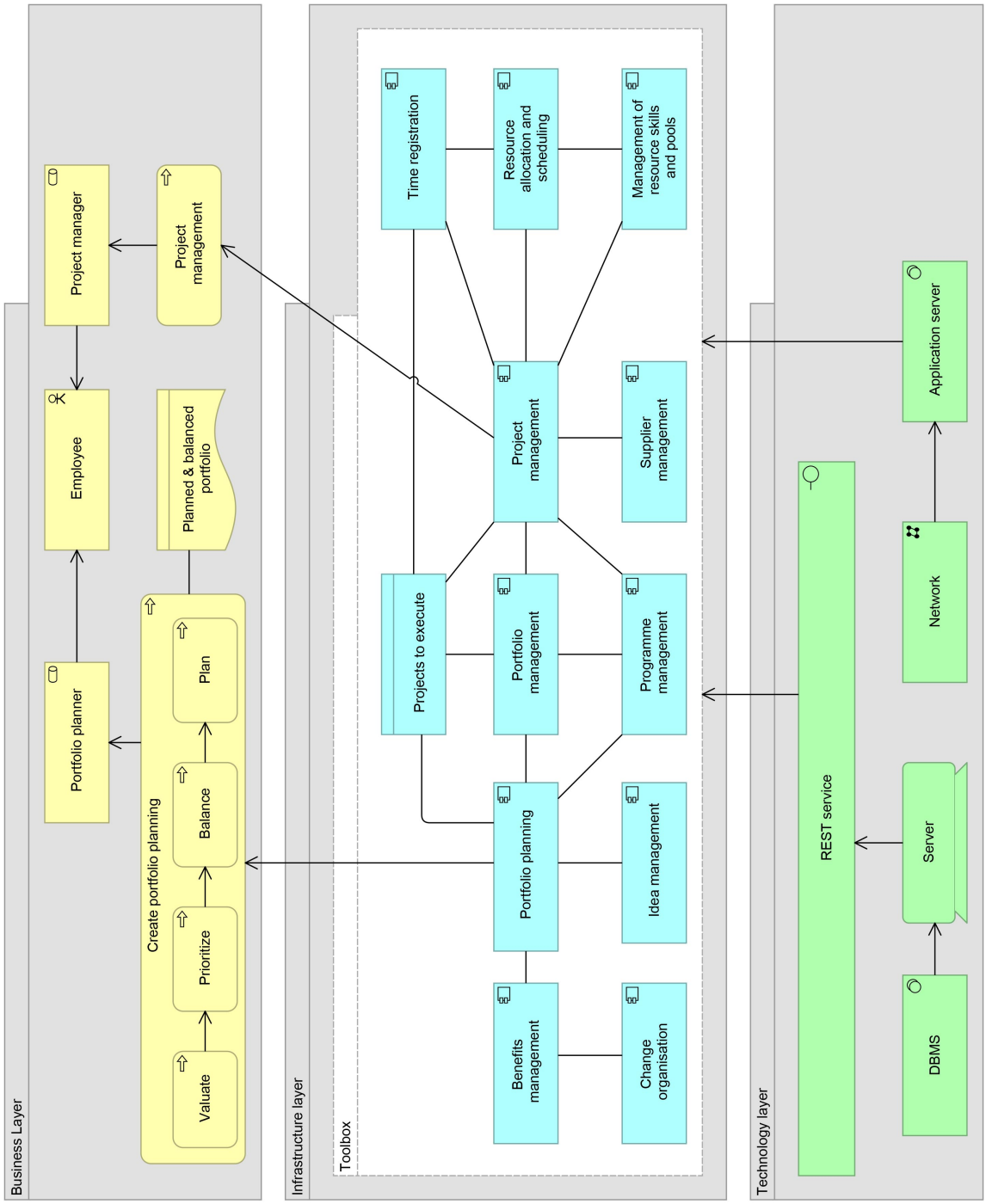


Figure 24: Architecture from project planning view

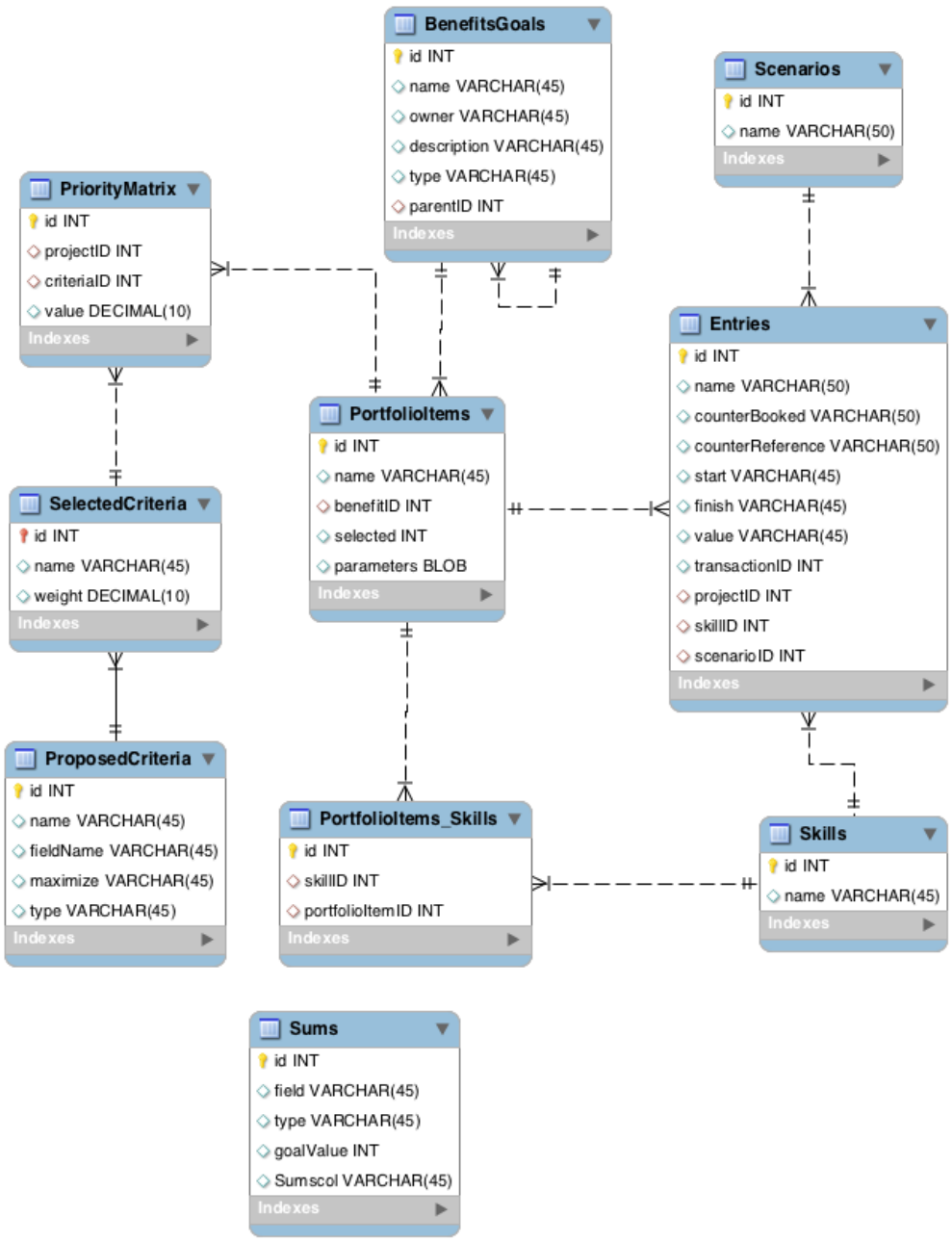


Figure 25: Entity-relationship diagram

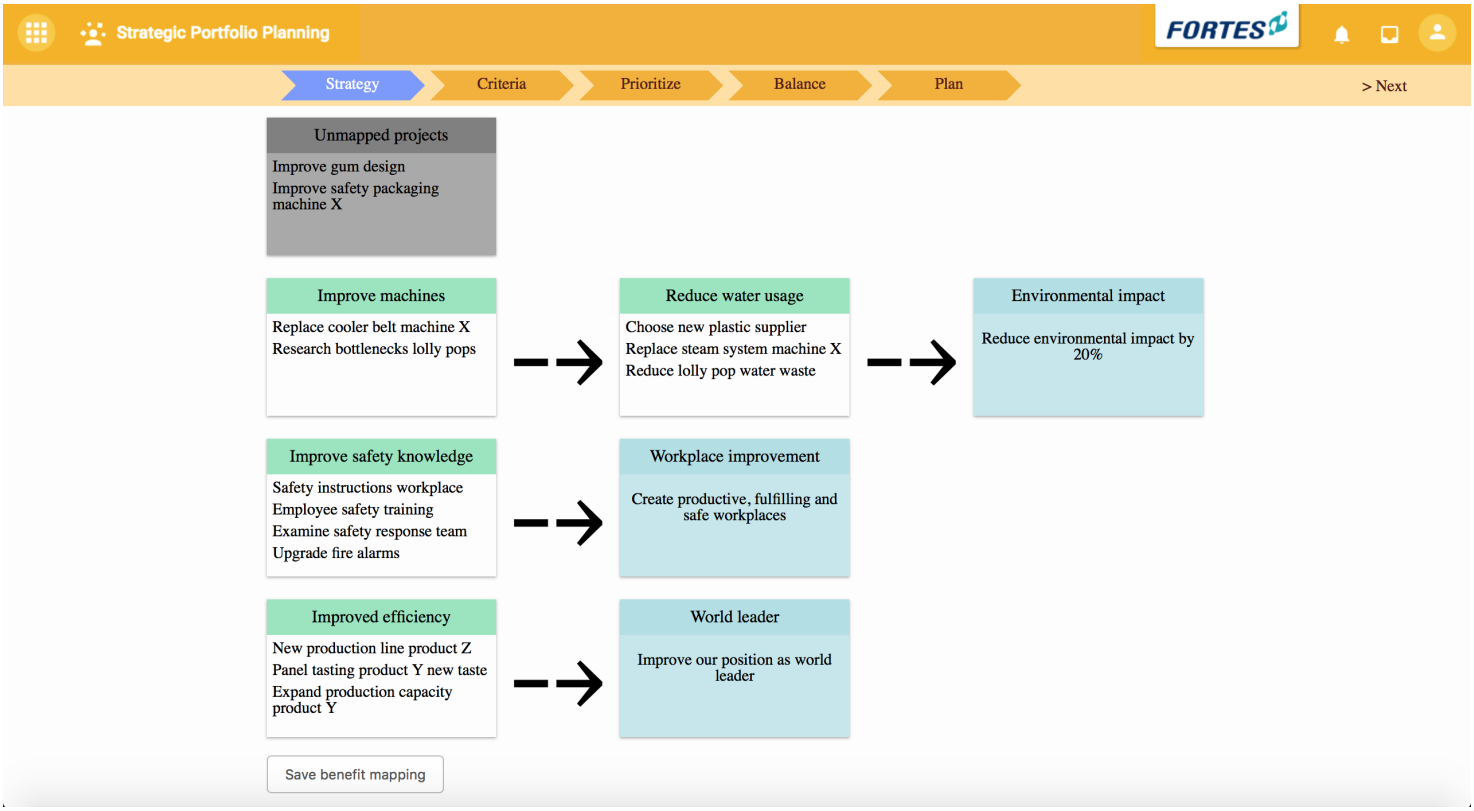


Figure 26: Step 1 - Strategy mapping

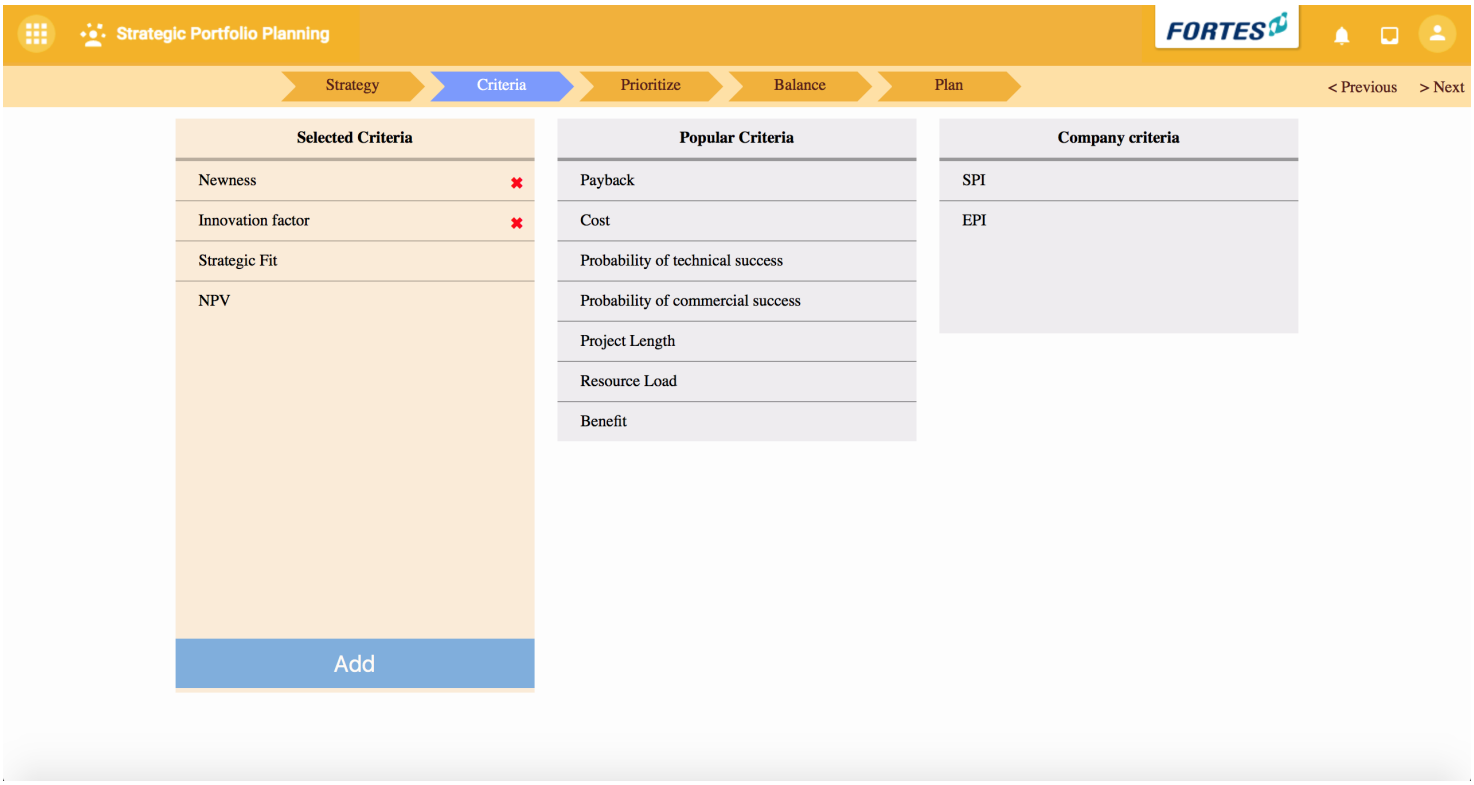
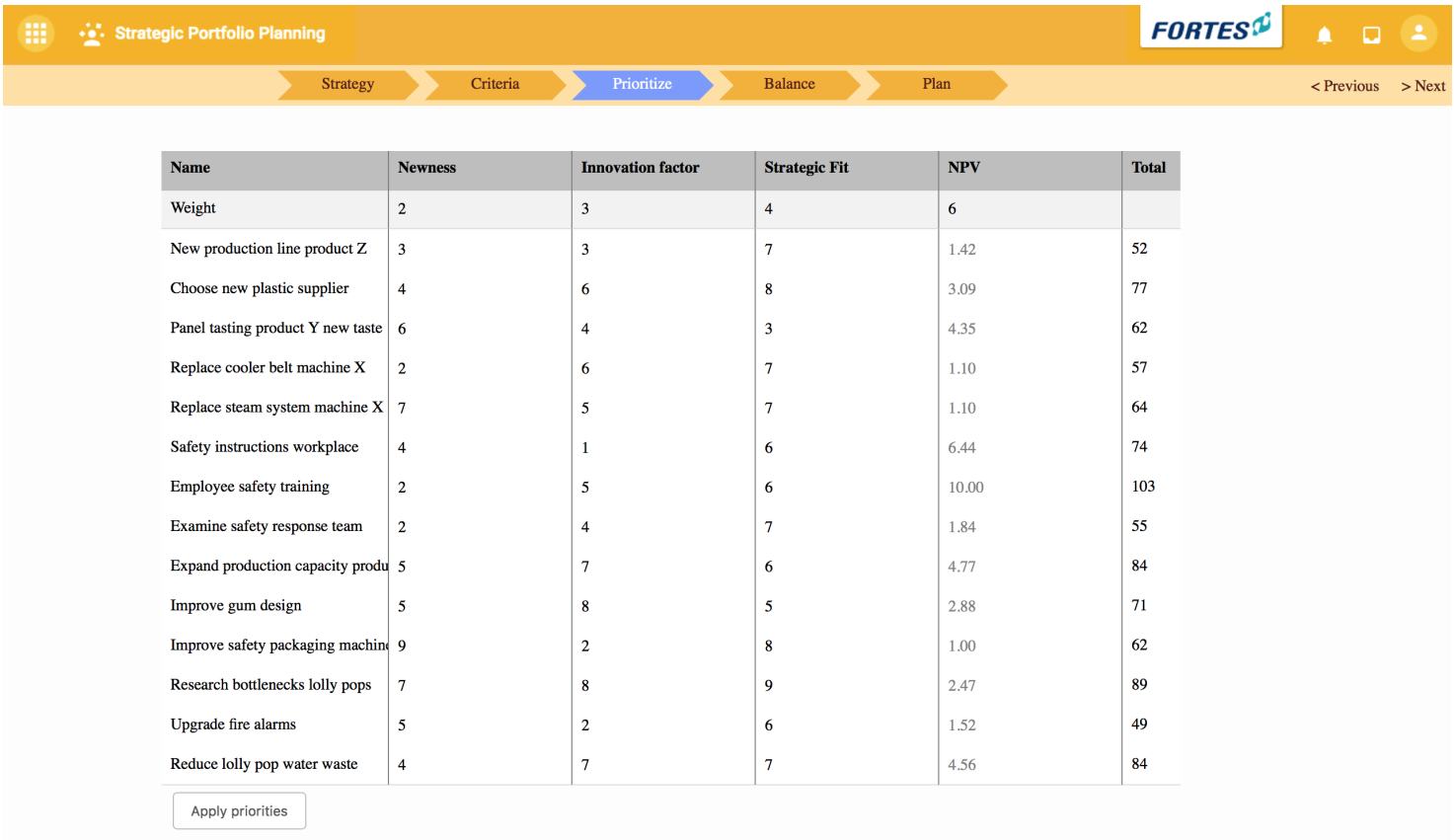


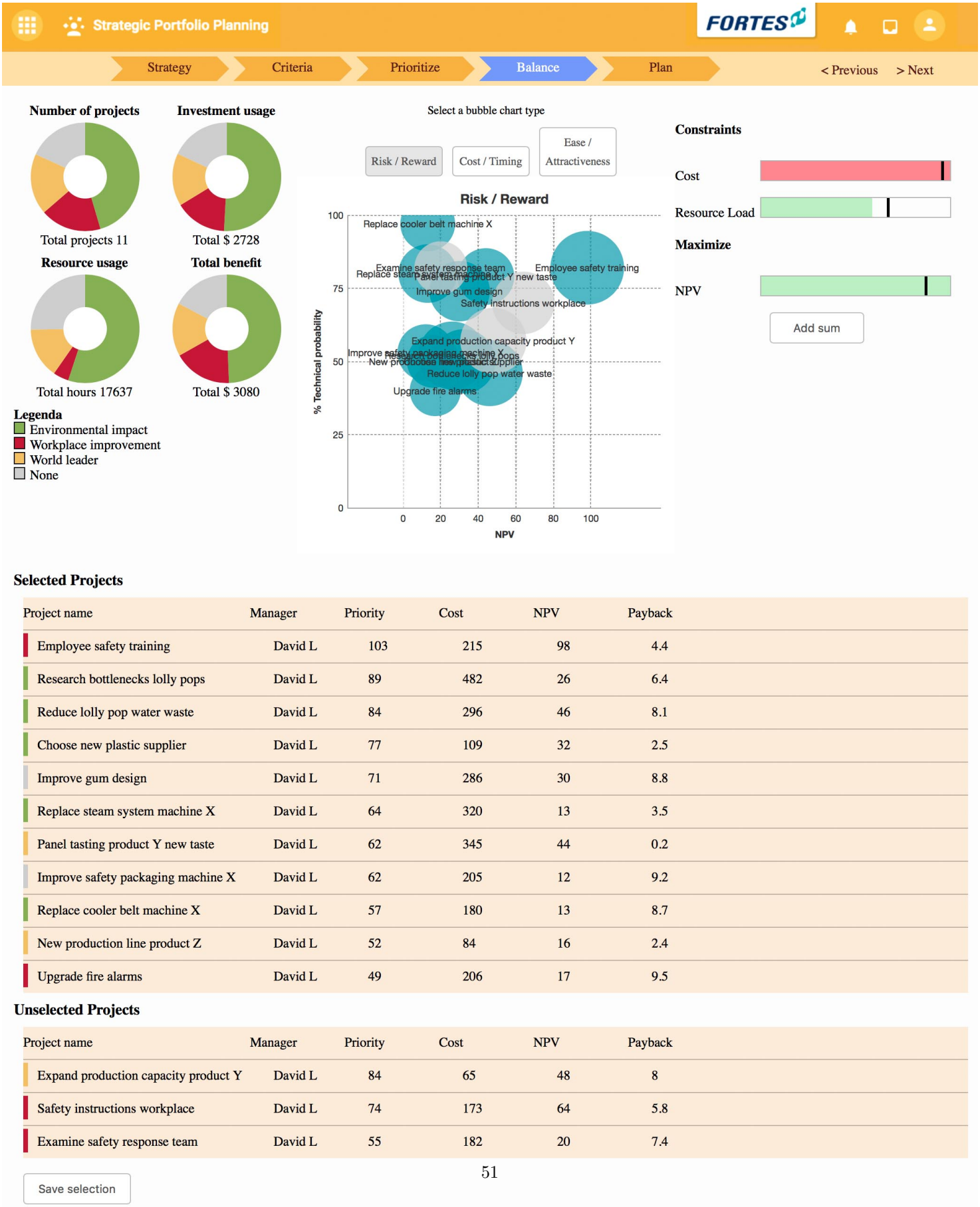
Figure 27: Step 2 - Criteria selection



Name	Newness	Innovation factor	Strategic Fit	NPV	Total
Weight	2	3	4	6	
New production line product Z	3	3	7	1.42	52
Choose new plastic supplier	4	6	8	3.09	77
Panel tasting product Y new taste	6	4	3	4.35	62
Replace cooler belt machine X	2	6	7	1.10	57
Replace steam system machine X	7	5	7	1.10	64
Safety instructions workplace	4	1	6	6.44	74
Employee safety training	2	5	6	10.00	103
Examine safety response team	2	4	7	1.84	55
Expand production capacity produ	5	7	6	4.77	84
Improve gum design	5	8	5	2.88	71
Improve safety packaging machine	9	2	8	1.00	62
Research bottlenecks lolly pops	7	8	9	2.47	89
Upgrade fire alarms	5	2	6	1.52	49
Reduce lolly pop water waste	4	7	7	4.56	84

Apply priorities

Figure 28: Step 3 - Scoring criteria and projects



Selected Projects

Project name	Manager	Priority	Cost	NPV	Payback
Employee safety training	David L	103	215	98	4.4
Research bottlenecks lolly pops	David L	89	482	26	6.4
Reduce lolly pop water waste	David L	84	296	46	8.1
Choose new plastic supplier	David L	77	109	32	2.5
Improve gum design	David L	71	286	30	8.8
Replace steam system machine X	David L	64	320	13	3.5
Panel tasting product Y new taste	David L	62	345	44	0.2
Improve safety packaging machine X	David L	62	205	12	9.2
Replace cooler belt machine X	David L	57	180	13	8.7
New production line product Z	David L	52	84	16	2.4
Upgrade fire alarms	David L	49	206	17	9.5

Unselected Projects

Project name	Manager	Priority	Cost	NPV	Payback
Expand production capacity product Y	David L	84	65	48	8
Safety instructions workplace	David L	74	173	64	5.8
Examine safety response team	David L	55	182	20	7.4

Save selection

Figure 29: Step 4 - Balancing of projects

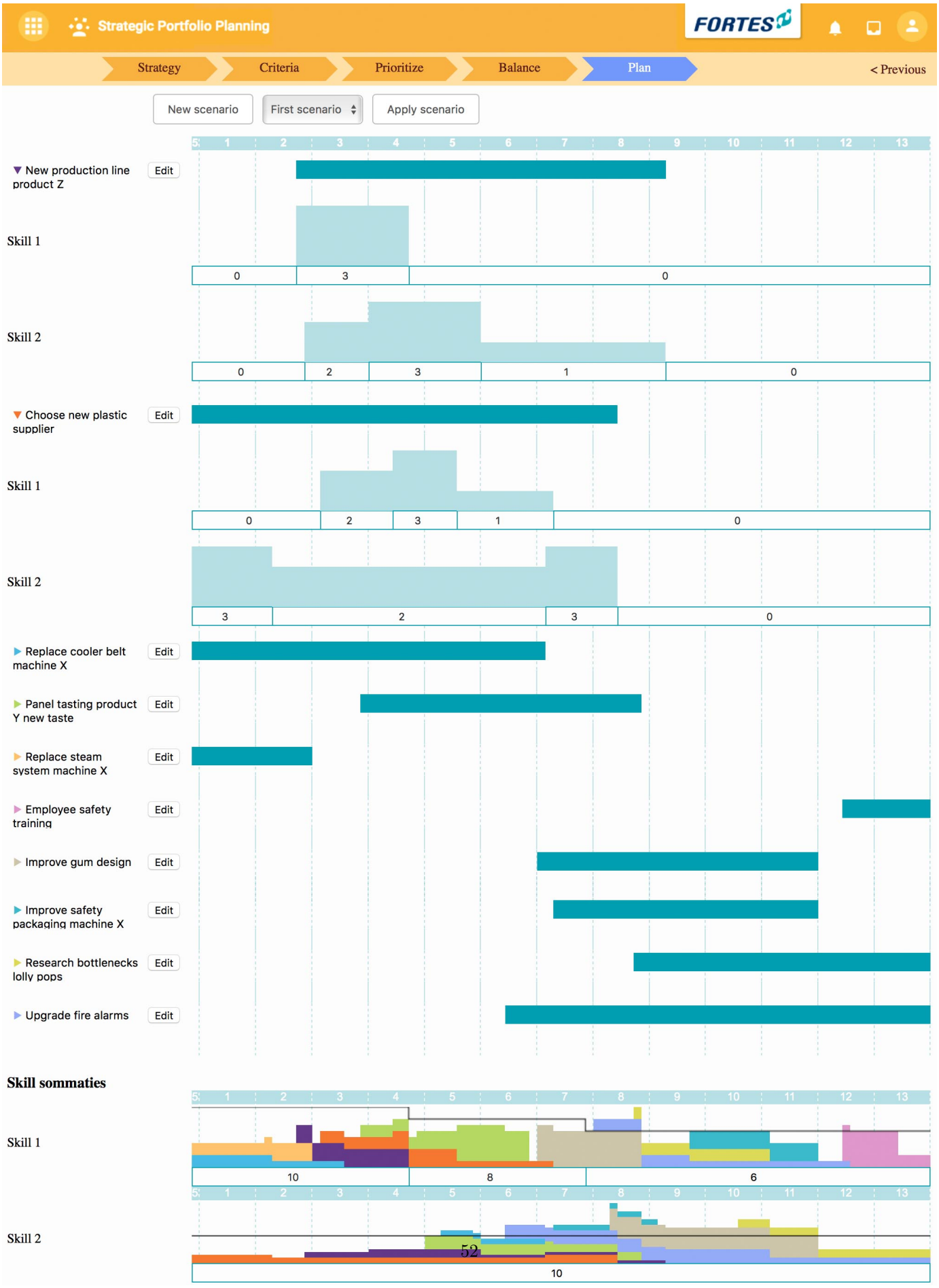


Figure 30: Step 5 - Resource Planning

8 Validation

8.1 Prototype

The prototype was built by the author of this thesis to validate the process model and the requirements. Existing interface components from the Toolbox could not be used and therefore the prototype itself is not fulfilling all the requirements. Another reason for not fulfilling them all is the time constraint. Some components are more advanced to build and are not required for validation; therefore they are left out of the prototype. Table 8 shows per requirement if it has been fully integrated (green), partly integrated (orange) or not integrated at all (red).

R1		Can only read from Toolbox	R17		
R2			R18		
R3		Limited visualization (no complex trees)	R19		In progress
R4			R20		
R5		One project can only be mapped onto one benefit	R21		
R6			R22		Only sum & constraints
R7			R23		
R8			R24		
R9			R25		
R10		Only decision matrix, no AHP	R26		
R11			R27		
R12			R28		
R13			R29		
R14			R30		
R15			R31		
R16					

Table 8: Supported requirements by the prototype

8.2 Professional feedback

8.2.1 Demo data

The dataset is hypothetical and is created to simulate a worldwide operating candy company with multiple products and production locations. They are world leader in the confectionery industry and their mission is to reduce environmental impact by 20%, create a healthy world, create fulfilling workplaces and create economic value through superior growth and profitability.

Fourteen projects where made with random values for the following fields: Cost, NPV, payback, resource load, project length, probability of technical success, probability of economic success, demand of limiting skills, benefit.

8.2.2 Feedback

The tool was validated with four professionals working every day in the project and portfolio management world as consultant. The decision was made to exclude people executing the role as project or portfolio manager since their vision is too low and only applicable for their company. This might not matter in a quantitative research but in this qualitative research with four professionals, it was more useful to use professionals with a wider range of knowledge. The professional was explained that the tool helps the user in selecting the best projects to execute in a project portfolio and that this will happen through the valuation, prioritization, balancing and planning of projects. Furthermore, there was explained that the use case comprises a world leader in the confectionery industry which has fifteen project ideas. Not all of them can be executed due to financial and human resource constraints. In this company, there are two skills which only two people hold so these are the most limiting. The candy company has defined their mission and has three clear goals: reduce environmental impact, improve employees workplace and strengthen their position as world leader.

In the toolbox a benefits map is made during the sessions and a portfolio with the fifteen possible projects is shown. Then the tool is shown with the five steps and a tutorial page where the steps are explained in more detail. Now the participants were prepared to walk through the whole tool. With guidance by explaining each page before usage they became familiar with the tool.

After the professionals had selected a project portfolio fitting the limited resources they were asked about their opinion about the tool. First, their general perception and feedback was asked followed by a discussion concerning the following points. The sessions took about one hour per person.

- Does the process design fit in the general steps your customers take when selecting projects for a project portfolio?
- Do you think that the app in general supports in executing the companies strategy and is the mapping of projects onto benefits sufficient?
- Is the selection of the criteria clear and do the suggested criteria fit in the overall selection of projects in practice?
- Is the scoring of the project for each project a clear process and is it useful to work with in practice?
- Does the strategy aspect help in the balancing process? Do the standardized bubble charts improve the decision making process? Would existing functionalities from the Toolbox like timeline and human resource balancing methods still be useful?
- Does the resource planning aspect give sufficient functionalities and is it clear what is does? Does it add value to the project portfolio selection process?

8.3 Improvements

The app was well received by the professionals and their feedback was positive. All of them found the app to be contributing towards a more professional project portfolio selection process with useful features. Since the proof of concept did not compromise all requirements (which is shown in figure 8) there were some constraints in the prototype which were sometimes recalled by the professionals. From the meetings held with the professionals the following additions and improvements in the requirements can be made.

Since the app exists of multiple steps where the input from preliminary steps is used in successive ones this was sometimes experienced as unclear. The steps are also split in different screens there was no oversight in what was coming up. Therefore, a first time user should get a more extensive tutorial on the first page or even a click through demo where the user is guided through the app in an interactive way.
The tutorial page should contain a short explanation of all steps and how decisions in certain steps influence other steps

The benefit mapping of projects to a benefit is useful but should be extended. Besides the ability of mapping projects onto multiple benefits which was in the requirements but not in the proof of concept, one should be able to add indicators. For instance, a specific project should lead to a decrease of 10% in water usage. In this way the contribution to company goals can also be measured while the project is running and afterwards, so it can be compared to the initial value.
The contribution of the project to a benefit should be measurable if possible. For each mapping of a project to a benefit, a performance indicator should be set and a measuring unit

The criteria selection screen was perceived illogical. It's common to drag your selection from left to right while the situation was from right to left. It should also be more clear if any information about proposed criteria is already available in the projects or that one still has to give a score to each project for the criteria.
Create a more logical user interface for the selection of criteria
It should be clear to the user for which criteria information is available and for which he should score the projects himself.

A company might have must have project which should be executed anyway, even if it is low on the priority list generated by the app. To prevent unnecessary steps and information retrieval this should be clear from the beginning. Therefore it desirable that in the prioritize step, one can select projects that have to be executed anyway. Proposed is to do this by creating checkboxes or by dragging them to the top of the list above a must have line.

The user should be able to selected projects in one of the initial steps that have to be executed no matter what and it should be impossible to deselect them in the balance step.

In the prioritize step, it was unclear why the projects where already scored for some of the criteria. This was data retrieved from the projects itself and this was scored on a linear scale. Although automation was appreciated, an automated linear scale scoring from 1 to 10 was not useful. Therefore, users should always score all criteria themselves without any prefilled fields but if the projects contain useful data about the criteria this should be displayed in some way.
The prefilled scoring functionality for known criteria should be removed from the prioritize step. Available project information for certain criteria should be shown to the user to simplify scoring.

Projects should be clickable to retrieve more information during the prioritize, balance and plan step. By opening a pop-up the user can easily reach the project for details.
In the prioritize, balance and plan step the user should be able to easily lookup project details by making the projects clickable.

For a lot of projects there are also already plan items are available. These are major steps in the project or phases the projects goes through. Since resources highly depend on the project phase it will help the planner to plan per project phase.
The planning step should also load the plan items that belong to the projects, if available. It should be possible to plan these as well and the first and latest date of the plan items are the project length.

The whole app should also support ideas and initiatives. The app was now only retrieving projects in a portfolio through the API. Even though less information might be available in ideas and initiatives, it happens that users of the software create a portfolio solo with items in this stage.
The app should also load ideas and initiatives and treat them the same way as projects. A visual element should make it clear to the user it's not a project yet.

Financial aspects should be taken into account in the planning step. Organizational departments might get budgets so there are financial constraints per quarter, half-year or yearly. Also, for quoted companies who have to provide quarterly results this is an important feature. It is already possible to create a financial planning per month at project and plan item level in the Toolbox so the data is available. This data should be aggregated per quarter, yearly or month depending on the user settings so expenses and revenues can be visualized in the selected time frame. Dragging projects over time will create different

quarterly, half-year or yearly expenses and revenues.
The planning step should support financial planning as well. Aggregated expenses and revenues should be visualized per quarter, half-year or year.

Another large modification desired by Fortes was to support also an agile way of working (Cockburn, 2002). This requirement came from Fortes after the presentation. This case was discussed with the managing director and development manager. Even though no long term planning exists in agile working, most CEO's and top level management want to have some kind of planning to create a road map and to know if the human resources, or agile teams, are sufficient. Since the Toolbox also supports agile working it is desired the planning step also works standalone and support teams instead of skills.
The app should be modular so the plan step can be used in Agile portfolio planning as well where one can plan teams instead of skills.

9 Conclusion

The goal of this research was to design how a software tool can facilitate the adoption and use of strategic portfolio planning tool. This goal has been reached in the environment of the Fortes Toolbox and has been achieved in a successful way. In the first steps literature research helped to adopt terms like (project) portfolio management, strategic portfolio planning and the steps in such a planning process. After generalizing multiple frameworks to some basic steps these were mapped on the functionalities of the Toolbox. Complying functions and missing functions were found. To reach the goal of implementing a strategic portfolio planning tool requirements were made and implemented in a prototype. The prototype was validated with multiple project management professionals and found to be very useful. In this section we will answer the research questions independently shortly, look at the prospective for the Fortes Toolbox with this tool and future work for research.

9.1 Answering the research questions

The research questions have been answered throughout the thesis. In this sections we will shortly recap the answers.

1. **What exactly is (Project) Portfolio Management and Strategic Portfolio Planning?**

   Worldwide multiple methods exists for Project Portfolio Management and most of them follow the hierarchy as shown in figure 2. A clear distinction can be made between the management process which is the management of ongoing projects and the planning process. The planning process happens before the execution of projects, in most cases at portfolio level. In the planning process projects are valuated at inter alia financial return, risk and strategic fit. All information of the projects is taken into account during the prioritization step where the most attractive projects are prioritized highest. To create a diversified, well balanced portfolio a balance step is included. The last step is the planning step where projects are planned over time to ensure no financial or human resource limitations are faced when projects are executed.

2. **Which process should be supported by a Strategic Portfolio Planning tool?**

   A generalized process model has been created after an extensive literature research, as shown in table 6. This has led to 5 steps with each step having multiple methods as shown in table 5. These steps exist of valuate, prioritize, balance and plan. The process models are shown in figure 14 - 17.

3. **Which functionalities are currently supported by the software Fortes offers?**

   The abilities of the Toolbox were mapped on the organizational context of PPM by PMI (2012): organizational strategy and objectives, portfolio planning and management, management of programs and projects and organizational resources as shown in table 7. The parts of the Toolbox having any overlap with the designed process model were analyzed. Section 6.3 outlines where the Toolbox is coming short and this is visualized in figure 21. Projects can only be valuated through custom fields so there is no standardized process offered to customers. There is a balancing process present in the Toolbox consisting of maximizing or minimizing sums of fields and bubble diagrams. However there is no link with strategy. Prioritizing and planning steps at portfolio level are missing.

4. **What are the requirements for a Strategic Portfolio Planning tool?**

Section 7 describes the solution design which is validated in section 8. The solution design is an app which offers five steps to the user: strategy, criteria, prioritize, balance and plan. In the strategy step the user maps the projects onto the organizational strategy, the criteria steps let the user set scoring criteria for the project, the prioritization step lets the user score and so prioritize the projects. In the balancing step the user creates a balanced portfolio with multiple methods and the selected projects are planned over time in the last step. Requirements per step are outlined in section 7.2 and a prototype is created. The prototype is build as Toolbox app and was validated with multiple professionals.

These sub questions have contributed in answering the main research question:

How can a software tool facilitate the adoption and use of Strategic Portfolio Planning in large enterprises?

The solution design which, requirements can be found in section 7.2 and the prototype in section 7.3.4, was found to be increasing the ability for strategic portfolio planning. Even though the prototype did not fulfill all requirements yet (table 8), it was already usable and was found to be very useful by project management professionals. The validation process delivered also some useful improvements which can be easily applied to the prototype.

9.2 Prospect Toolbox

The prototype was perceived really useful by the project management professionals. Also at high level, the managing director of Fortes saw a match with his future vision for the Toolbox. A few years ago a employee created a more extensive benefits management app that could perfectly fit with the designed prototype. Furthermore, the current flows of data in the Toolbox between the different levels in the organisation are shown in figure 31. As can be seen, the focus of the toolbox was mainly on money and hours. Planitems were only available at the portfolio item level (project) and created value by the projects was not managed in the toolbox.

(image hidden)

Figure 31: Current data flow between the organizational levels in the Toolbox (internal management information Fortes, June 2017)

In cooperation with the managing director and consultant team lead some meetings were held to determine the future vision of the Toolbox and the multi-app platform and the results of this research was taken into account. The proposed flow of data is shown in figure 32. The three most important steps influences of this research can be found in the creation of a benefit/value management flow through all levels of the organization, strategy mapping and strategic portfolio planning through the portfolio management, capacity and scenario planning app.

(image hidden)

Figure 32: Future data flow between the organizational levels in the Toolbox (internal management information Fortes, June 2017)

9.3 Limitations

The main limitation in this research is in the validation process. It was difficult to reach out to end users in different types of companies who are a professional in portfolio planning. Their feedback would have been valuable to this research and could have given useful input for more improvement. Due to time limitations only the proof of concept is validated with professionals while it could also have been useful to validate requirements. This would have created more input from the professionals in the first proof of concept. Also not all requirements were implemented in the proof of concept but the most important ones have already created a successful proof of concept.

9.4 Future work

For future work within the direct context of this work, and so within the context of the Toolbox, one could take the next step in the design cycle. So applying

the feedback from the validation step executed in this research to the prototype and then validating it again. It could also be validated against another type of professionals. For instance the end users, so portfolio managers and/or planners at different type of organizations using the Toolbox. It could also be beneficial to research how the tool can be used when the execution of projects has started, so during the management phase. In this stage, benefits management is very important to make sure the contribution to organizational strategy and objectives is achieved. Furthermore, it might be projects are aborted so changes in the planning are required. The planning aspect can be used with slight changes to create differences between started projects and future projects. To extend the concept of project portfolio planning process model it would be useful to implement for instance optimization algorithms for project selection, automated balancing of the portfolio or cooperative functions to let project- and portfolio managers and the (P)PMO work together in one tool to create efficient processes throughout the organization.

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