Päivi Tuhkanen

Human Resource Management in Customer-constrained Multi-project Environment

Helsinki Metropolia University of Applied Sciences

Master of Business Administration

Business Informatics

Thesis

11th October, 2015

Helsinki Metropolia University of Applied Sciences

Author(s) Title Number of Pages Date	Päivi Tuhkanen Human Resource Management in Customer-constrained Multi-project Environment 39 pages 11 October 2015
Degree	Master of Business Administration
Degree Programme	Business Informatics
Specialisation option	
Instructor(s)	Pia Hellman, Senior Lecturer James Collins, Lecturer

This Master's Thesis examined the issue of allocating human resources to projects in a multi-project environment where the projects are done for customers and have a large number of external dependencies. The case company was a Finnish ICT company struggling with project resourcing, and this thesis focused on the project management office, consisting of project managers and subject matter experts (SMEs) working mainly on projects. The goal was to improve the resource management process across the project portfolio, which suffered from delays and unpredictability, constant interruptions for the SMEs and general chaos and stress for everyone involved.

The development project was carried out as action research from within the organization. After a current state analysis, a new process was established and reviewed in several workshops with stakeholders, and rolled out along with a new resource management tool that supported the process. The theoretical framework consisted of project portfolio management principles with a special focus on dynamic project portfolios and projects with a customer influence.

The improved process takes into account long-term resourcing and places requirements at the project planning phase, which will pay off during the project. It also aims at reducing the fragmentation of work and improving on-time deliveries. The process and tools were rolled out and preliminary results were promising, but to strengthen the planning phase, a Technical Project Office function was established.

The final results are still pending but the new tool has been well received and process changes are slowly taking effect. Recommendations for future development are also given.

Keywords	Project management, human resource allocation across projects, multi-project environment, customer-constrained project environment, resource management tool implementation

Contents

1 Introduction 1

1.1 Background 1
1.2 Case company 1
1.2.1 Organization 2
1.3 Research questions and scope of the study 4
1.4 Stakeholders in the process 4
1.5 Research methods 5

2 Literature review 8

2.1 Project portfolio management 9
2.2 Dynamic project portfolios 13
2.3 Resource allocation algorithms 16

3 Development plan 18

3.1 Current state analysis 18
3.1.1 Background 18
3.1.2 Process description 18
3.1.3 Issues with the current process 21
3.2 Requirements and goals for the new process 24
3.3 Metrics 25
3.4 New process and tool 26
3.5 Results 32
3.6 Further changes made to the process 33

4 Discussion and further development needs 34

4.1 Reliability and validity 36

References 37

1 Introduction

1.1 Background

Resource allocation is never an easy task and it seems to be something all organizations, especially service organizations, struggle with. This Master's thesis looks at the issue of human resource allocation across projects from a theoretical point of view and through a case company that operates in the ICT sector and has a large number of consecutive customer projects constantly in progress, in addition to internal development projects, and these need to be completed within a set timeframe and are dependent on a number of external factors.

I don't expect to find an easy answer to end all issues, but I believe there must be something that can be done to make this process more efficient and effective. Being able to efficiently use the right people in the right projects is crucial to a company's success from a customer and financial point of view, and therefore looking into this should definitely be worth the effort.

This thesis looks first and the case company and research methods used. A literature review on the topic is then presented, followed by a description of the current state and issues at the case company. The new process is described and recommendations for the future are presented.

1.2 Case company

The case being examined is a company of about 400 employees that provides various ICT services to businesses, with a focus on medium-sized customers. It is owned by a larger, local parent company.

The company's business areas include:

- IT infrastructure services: server hosting facilities, workstation management, IT support services, network services, equipment life cycle management, service management

- Application services: application development, integration, and maintenance services
- Consulting: helping the customer determine their IT needs through mapping and evaluation, roadmaps and planning, implementation and production, support, and monitoring
- Productivity services: Intranet and communication services as well as related consultation, training and support
- Cloud services: virtual server hosting, cloud-based office applications, integration, cloud storage and partnership solutions

The case company is based in Finland and has operations in several cities, but no offshoring activities. Outsourcing is used in some cases, but most of the work is done by the company's own employees.

1.2.1 Organization

The organization of the case company is divided into departments: Delivery, Customer and Product Solutions, and Business IT, plus support functions. The majority of employees are part of the Delivery department, which consists of production staff, service management, and the project management office (PMO), which is the focus of this study.

The project management office consists of 9 project managers and a team of about 20 subject matter experts (SMEs) who mainly do project work. The subject matter experts have their own team manager under the PMO manager. In addition to this group of SMEs, experts from the production teams (Operating Services and Support Services) also occasionally participate in project work. The project SMEs do operational work in addition to projects, and they are an integral part of project teams for internal technical and process development projects too.

The number of customer projects open at any time is between 90 and 120, so this is a large portfolio of projects, varying in sizes from 10 to 1,000 man-days, for different customers and with different service content. Projects include onboarding new customers as well as development projects for new customers. In addition, the same SMEs do consulting work directly to customers with no project management involved.

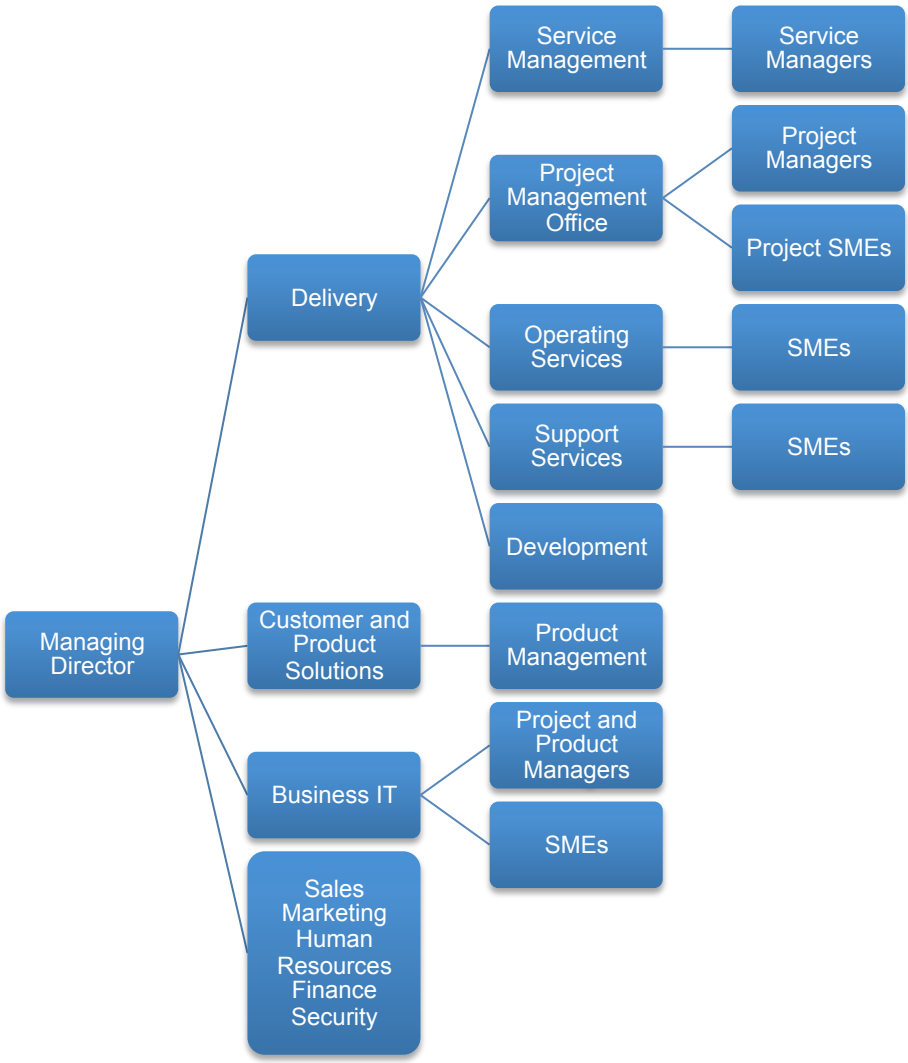

Figure 1. Organization chart of the case company

All work related to the maintenance of server platforms and data centres is carried out by a separate division of the parent company. The project managers and SMEs work closely with them in projects and on production activities and their employees are an integral part of the project team in many projects.

While projects are not the core business of the company and continuous operations bring in the bulk of revenue, project work has a significant impact in the big picture. Projects are needed to implement services for new customers, and therefore it is important that the end result of an implementation project is a high-quality IT environment that can be transferred to production smoothly and with minimal disruption to the customer. Also, projects are carried out to add new services for existing customers and to develop customer environments so they are kept up to date with the most recent technology and serve customers' needs as well as possible. The financial side is, of course,

also important: a service implementation project needs to be completed on time so that the customer invoicing for continuous service can start, and these projects often also have financial penalties for late completion. Projects do also bring revenue of their own and this needs to be a predictable and continuous flow of work.

1.3 Research questions and scope of the study

The scope of this study is internal personnel resourcing in delivery projects in the IT infrastructure services of the case company. This includes the following aspects:

- The process of selecting subject matter experts (SMEs) for projects.
- Managing the workloads of SMEs working on projects.
- Tracking who is working on each project.
- Prioritizing projects.

This means that the following are out of scope:

- Selecting project managers for projects and managing their workloads.
- Projects in the Business IT services of the company – this is a separate group that handles software development and has slightly different processes, although there are similarities and cooperation as well.
- Managing resources of any other kind than persons.
- Resource allocation of external parties, including the platform and server division of the parent company as described above.
- Selecting projects that need to be completed – this is done at the pre-sales stage as part of the business case evaluation, and once a customer project is won, it needs to be completed with no exceptions.

1.4 Stakeholders in the process

The resource management process touches a large number of people and functions within the organization:

- Project managers in the PMO, who provide input for the resource allocation and run the customer projects with the resources they get
- SMEs, who carry out the work based on resource allocations

- Manager of the project SME team, who helps with the resource allocation and is the escalation point for issues
- Manager of the PMO, who supports the PMs and is the next escalation point for issues
- Director and managers of the production SME teams, whose team members also participate in projects and who use the project SME team in their production activities
- Production SMEs, who participate in project work
- Managers of internal development projects, who compete for resources with the PMO's project managers
- Project owners, who act as an escalation point and want to see their projects finished
- Customers, who want their projects to be finished on time
- Upper management, service managers and salespeople, who want to see projects run smoothly, customers happy with the end result and revenue pouring in.

1.5 Research methods

The research method used here is action research. Action research consists of working from within the organization, and the research process follows a cycle that is repeated for as long as is needed. (Coghlan & Brannick 2014)

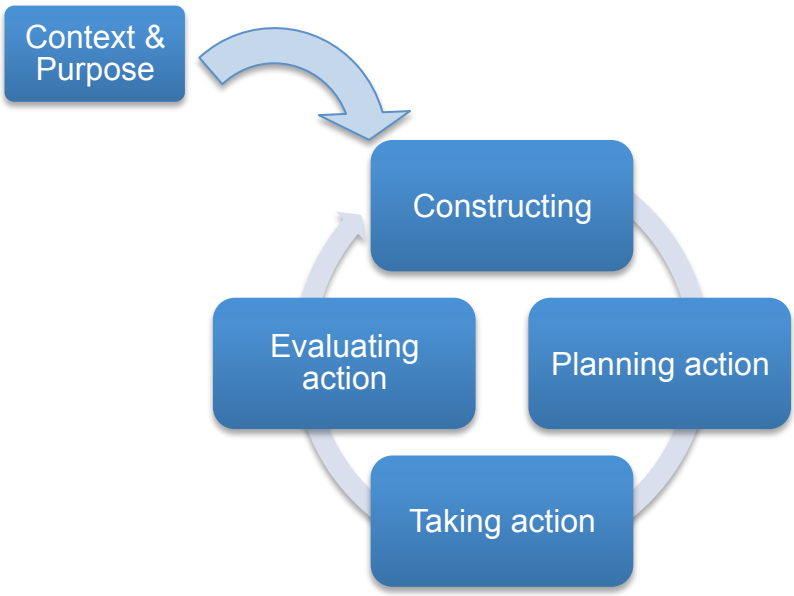

Figure 2. Action research cycle (Coghlan & Brannick 2014, p. 9)

When I started working for the case company in the summer of 2014, I had discussions with each of the project managers in the PMO and asked them what the number one process issue was in their opinion. SME resourcing quickly rose as the most frequent pain point, and in subsequent months, I observed this firsthand as well and saw that something needed to be done. This provided the **context** for the topic and a real need for developing the process.

In **constructing** the project, I had discussions with management representatives, observed the existing process in real life and saw how the process worked and what the issues were.

The **planning** of the project started already in late 2014, as the project was about to start as a very extensive exercise with a large roomful of people in the kickoff meeting. The focus was on implementing a new tool for the whole company to use for resourcing, and the tool had been pre-selected as the resourcing module of the ERP system that was already being used for production activities and that had a project and timesheet module in implementation. However, due to high workloads from customers and other development projects, this project was put on hold indefinitely. In January-February 2015, the software development department of the company wanted to pilot and implement another resource management tool, as the resourcing module for the ERP system was not considered very good. The PMO joined in on the pilot, but we wanted to postpone implementation until we had looked at the process issues first and ensured that the new tool would work with the changed process. So we quickly picked up the process development initiative with a more limited scope and accelerated schedule, as the issues were only getting worse and changes were really needed quickly. A review of the related literature was conducted at this point.

I then joined forces with the development team director and together we looked at the current process, identified the issues and drafted a new process in two workshops. This was reviewed first with a small team of team managers, then project managers and SMEs, and we got some good feedback on points that still needed attention and revised the process accordingly.

Workshop	Participants	Results	Output
Workshop 1: current state and issues	Myself Development Director	Issues caused by process not working and not being followed	List of issues that need to be addressed
Workshop 2: new process	Myself Development Director	Ideas for new process	Draft of new process
Workshop 3: review with team managers	Myself Development Director Manager of project SME team Director of operational SME teams Project coordinator	Issues that needed further addressing or details	Updated process
Workshop 4: review with project managers	Myself Three project managers from the PMO	Issues that needed further addressing or details	Updated process
Workshop 5: review with SMEs	Myself Manager of project SME team Three SMEs from the project SME team	Issues that needed further addressing or details	Updated process

Table 1. Workshops held during the development project

The tool that had been piloted previously fit our needs for enforcing and managing the process and making it easier for everyone involved, so we decided to roll out the tool and new process in May 2015 and take them into use from the start of June.

Taking action consisted of training the project managers working on customer projects, as well as anyone using the same pool of SMEs for their internal or customer projects. The SME team was also trained. Preparations for the tool rollout were made. The tool and process were taken into use on schedule.

The outcome was constantly **monitored and evaluated** after implementation during the summer and in the autumn. Some additions and changes were made and the pro-

cess then moved to maintenance mode, with constant tweaking and enforcement as needed.

The output of the project was the new resource management process as well as recommendations for future actions. The results were monitored based on qualitative and quantitative metrics as described in section 3.3.

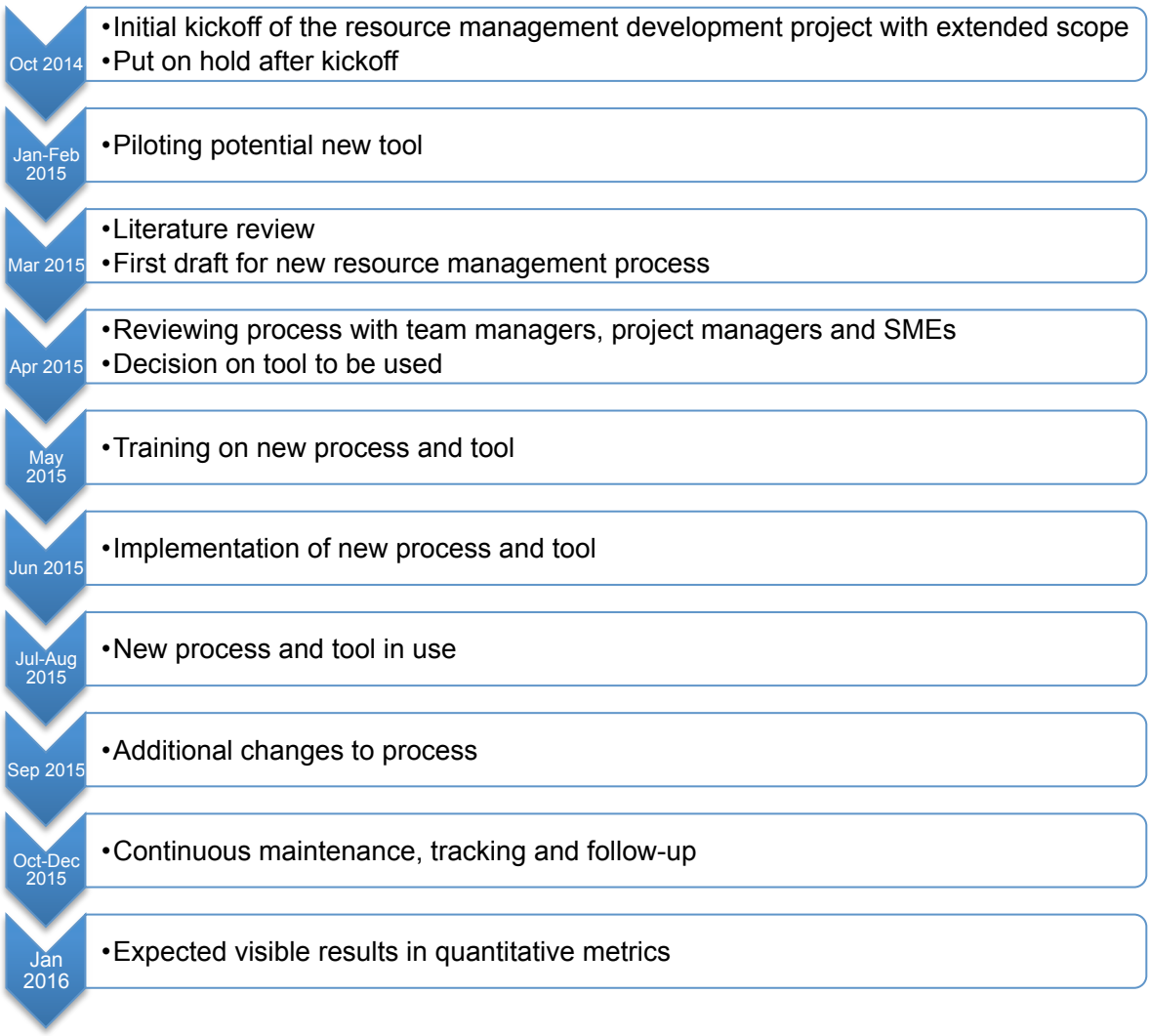

Figure 3. Timeline of the development project

2 Literature review

The issue of human resource management is linked to both portfolio level management and the management of individual projects.

The PMBOK guide on project management (PMI 2013) discusses human resources management at project level and provides guidance on creating a human resource management plan for a project. This is an important step and is required for consolidating a cross-project resource management plan, but the PMBOK does not discuss the management of the project portfolio.

The PMBOK guide also lists different types of project management offices (PMOs): supportive, where the PMO provides consultation, templates and processes for projects; controlling, where the PMO provides support and require compliance; and directive, where the PMO directly manages the projects (PMI 2013, p.11). In the case company, the PMO is directive as it hosts the project managers and subject matter experts and is responsible for carrying out the projects, but it also provides project management support, processes and templates for other parts of the organisation.

2.1 Project portfolio management

Project portfolio management deals with managing the entire set of projects that is ongoing in the organization at any point in time. Resource management is part of the portfolio management process, and an integral feed for resource management is the prioritization of projects.

Yoshimura et al (2006) suggest that in research and development (R&D) projects, the optimal project set needs to be selected based on the best total estimated profit. Their algorithm for project selection is based on the expected profit obtained after project completion and the strategic importance of the project.

Yang and Sum (1997) look at the impact of different rules used in a multi-project environment. Their portfolio structure consists of two levels, a common structure used in companies: the project managers on one level and one higher-level manager responsible for all projects. The types of rules they examine in their study are:

- Project release rule: the rule for when a project gets started. The purpose of this type of rule is to limit the number of concurrent projects and spreading the available resources too thinly over too many projects.
- Due date rule: methods for setting the due date of a project. Five different rules are examined.

- Resource allocation rule: four different rules for transferring resources between projects are compared, based on an environment where there are significant transfer times for resources between projects.
- Activity scheduling rules: the methods for scheduling activities within one project.

Yang and Sum (1997) conclude that based on a simulation analysis, the first three rules have a higher impact on project success than activity scheduling, but that the results vary depending on the project environment and customer influence.

Wang (2001) has studied the dynamic allocation of resources in heterogenous resources in new product development projects. He notes that resource sharing between multiple projects is a requirement in reality, and that activities can also be shared by multiple resources. The flexibility of resources to work on different projects is limited by their expertise. These factors as well as resource availability constraints and activity precedence constraints, plus general resource processing rates, contribute to how resource planning between projects is carried out. He proposes a continuous-flow model and algorithm for resource allocation.

Hendriks et al (1999) identified five elements that are vital for human resource allocation in multi-project situations: long-term, medium-term and short-term resource allocation as well as links and feedback between the long, medium and short term allocation processes. They introduce the concept of project scatter factor, which measures how many people are actually needed to do one man-year's worth of work on the project (linked to efficiency). Another concept they bring in is the resource dedication profile: to minimise the project team size and make it more efficient, you need all-round project members at the heart of the project, complemented by experts brought in for special situations or issues, and service employees, who take care of routine activities. Implementing a process that takes into account all five elements and the two concepts resulted in a simple process that did not even need sophisticated planning software in the large R&D organisation they studied. Due to the nature of the organisation, their focus was on very long-term planning, up to five years.

Zika-Viktorsson et al (2006) focus especially on the effects of working in a multi-project setting on the project members and project managers. An environment of tight schedules, multi-tasking, high coordination costs and time spent alternating between tasks

results in fragmentation, disruption and inefficiency – all in all, a negative effect on performance and the development of professional skills as well as psychological stress. Mitigating this requires balance between human resources and project demands, but also adequate routines and support processes in high-pressure situations.

Lari et al (2010) look at resource allocation in multi-project programs and also raise the question of true capacity: project level estimates may not be accurate, but a significant factor is work that needs to be done apart from actual project work. For example, a software developer may be needed for a certain amount of actual development work, but they also need to attend meetings, provide information, dig up documentation or create it, travel and do other tasks related to the project. This is often work that has not been taken into account in the initial planning but needs to be done in order to complete the 'real' project work in a satisfactory manner.

Similarly, Blichfeldt and Eskerod (2008) investigate project portfolio management based on in-depth interviews in 30 companies and conclude that a key reason for project portfolio management failure is often that it only covers a part of the projects in progress within the organisation. Projects from outside the portfolio also tie up resources that were allocated to official projects and are thought to contribute only to them. Including all small projects in the portfolio would be time-consuming and overly bureaucratic, so it is important to also leave time for projects that are not covered by the portfolio management process.

Browning and Yassine (2010) look at the resource-constrained multi-project scheduling problem from two lateness aspects: project lateness and portfolio lateness. They tested 20 different priority rules and found that popular priority rules perform poorly in some situations. The success of a priority rule also depends on perspective, as some rules will have better results for the individual project manager, whereas others are more beneficial for the entire project portfolio.

Nearly all studies look at research and development projects or a company's internal IT projects. It seems a little odd that customer projects – cases where the project is a business service that the customer actually pays for, or that are mandatory in order to start the service – are so visibly absent in project portfolio research. There are many industries where project work is an integral part of the business, either in taking the company's product or service into use or as a business in themselves. For example, my own work history consists entirely of companies where customer projects have

played an important part in revenue generation. In the ICT industry, taking a service into use for a customer requires an implementation project, although new cloud services are changing this to some extent, but they only cover a small part of the playing field. While these projects may be sold to the customer at lower rates than usual hour rates would suggest – to attract the customer to change service providers – they are always done in close cooperation with the customer, with schedules often dictated by the customer and with dependencies with a number of third parties. In addition, I have worked in the field of localization and translation, a fully project-based business, again with customers setting the deadlines and taking their business elsewhere if a service provider is unable to meet their requests. There are many other such industries, and it is therefore surprising that this has not been studied more. The same companies will of course also have various R&D projects in their portfolio, often utilizing the same resources as the customer projects, and balancing the different types of projects brings an added dimension of difficulty into the resourcing mix. It also usually eliminates the decision-making for project selection, as all projects that have been sold will have to be completed.

One exception is the research of Yang and Sum (1997), who have also studied environments where customers have some control over project due dates. They discovered that the flow time, tardiness, and lateness standard deviation of the due date and resource allocation rules deteriorates as customers' control over the due dates increases.

Engwall and Jerbrant (2003) also have one case example with customer projects, and another with R&D projects. They state that the resource allocation syndrome is the number one issue in multi-project environments due to failed project scheduling, overcommitment of resources, financial issues and opportunistic project management. They identify a number of differences between the customer and R&D projects:

- R&D projects required innovation by default, whereas customer projects aimed at delivering proven solutions cost-efficiently
- Customer projects were much larger, more complex and technologically advanced than the R&D projects
- Customer projects aimed at figuring out how to deliver the contracted project, whereas uncertainty in R&D projects stemmed primarily from the problem of what to produce

- In these cases, the R&D division was a more recent addition to the organization with less mature processes, and the customer project division had a long history and mature system for project management
- On portfolio level, the customer projects were divergent, with tailored systems based on a small number of generic technological platforms, and the R&D projects were more scattered, with many different types and origins.

In the research by Engwall and Jerbrant (2003), customer and R&D projects also had a number of common characteristics:

- Extensive project interdependencies, dependency on the same personnel for multiple projects, resulting in significant lead time and delays
- The primary everyday portfolio management issue was priority setting and resource re-allocation
- Tough competition between projects to get the resources they need
- Management focus on short-term problem solving due to fire fighting needs, resulting in a lack of long-term planning.

Voss (2012) also focuses on customer impact on project portfolios. He looks at R&D projects for specific customers and other projects with direct deliverables to external customers, with a stronger focus on the former type. He combines marketing with project portfolio management and proposes integrating customers into the project portfolio management process. In R&D projects especially, integrating customers in the process improves company performance and should be done through the customer relationship management (CRM) process.

2.2 Dynamic project portfolios

Eskerod (1996) compares projects to a dragon that constantly moves and changes, as opposed to an older perception as a static Great Wall of China. She states that as companies adopt a strategy of managing by projects, project managers end up competing for resources and not waiting for top-down orders on priorities.

Abrantes and Figueiredo (2015) look at how changes in the new product development (NPD) portfolio impact the reconfiguration of human resources and propose a resource

management process framework for this type of project portfolios. They also examine agile methods used in projects and raise a number of causes for resource conflicts in the NPD portfolio:

- Dynamic scope changes – as the market changes, the projects may need to change accordingly to ensure optimal results
- Innovation risk – with new product development, the team does not always know at the start of the project how to achieve the goals
- Complex technical dependencies between projects and within a project
- Resource management inefficiencies – while people are allocated to a certain set of official NPD projects, there is always also a number of smaller unofficial projects or other distractions that cause inefficiencies in resource allocation
- Lack of reliable resource information – a sufficient level of detail on resource needs and usage is difficult to model in advance and to carry to the portfolio level.

The solution proposed by Abrantes and Figueiredo (2015) is based on a real-life implementation of an enterprise project management system and related processes. They defined the responsibilities of the team, project and portfolio management level as well as those of the individual team member. Key aspects of their proposed solution include initial decision-making at team rather than resource level, usage of external teams to balance workload peaks, constant updates of project plans and weekly review of resource needs, communication of the resource plan, monitoring any conflicts and also reviewing the portfolio performance. This requires an information system capable of collecting and presenting the needed data.

Turnquist and Nozick (2004) examine the impact of uncertainty in the duration, resource requirements and outcomes of project tasks on single project level. They especially raise the issue of tasks not completing successfully the first time, a common phenomenon in systems development, but also in other projects where you may run into unforeseeable problems mid-task. One solution to ensuring project success despite this sort of uncertainty is to simultaneously pursue alternative paths, and this needs to be taken into account in resourcing as well. They provide an algorithm that maximises the project's chances of success, taking into account this non-linear approach to scheduling and the need to define relationships between tasks.

Martinsuo et al (2014) also study uncertainties in project portfolios and introduce a framework on managing them. Uncertainties may originate from organizational complexity, the external environment or single projects due to changes, deviations and unexpected events. The portfolio manager needs to be able to process information on these uncertainties, and most often they were perceived as threats rather than opportunities in the interviews conducted by the authors. The interviewees did not have much to say about managing uncertainties and considered to have little control over it, even though the impact on projects may be significant.

Laslo and Goldberg (2008) investigate the use of the matrix structure in multi-project environments and especially the conflicts occurring between functional managers and different project managers. The resourcing policies they identified in the companies they had studied were:

- Profit and cost centres policy: Project managers have the power to make resource decisions and have full control over their budgets. Resource shortages are resolved through increasing the resource pool or outsourcing.
- Comprehensive allocation planning policy: In a functional matrix structure, the functional managers make the resource decisions and all projects are treated as equal.
- Directed priorities policy: Project priorities are set, and the project managers with the highest priority projects have greater power in resourcing decisions.

Conflict, in the companies studied by Laslo and Goldberg (2008), occurs when the organizational participants wish to strengthen their power. The authors simulate a complex high-tech environment and suggest that some conflicts are unnecessary or unrealistic: managers should note that they actually have no real conflicts of interest and can agree upon a resource allocation policy. The efficient utilisation of resources should be a shared objective.

Yaghootkar and Gil (2012) examine a common phenomenon in organizations: a project starts late, and resources are transferred to it from another project. An overemphasized focus on schedules can lead to a vicious cycle that prevents the organisation from meeting project milestones long-term. Switching back and forth between projects also hurts the productivity of the project resources. The authors studied the projects of a truck manufacturing company and used computer simulations to confirm findings.

Petit (2012) looks at project portfolios in dynamic environments and how uncertainty is managed at the portfolio level in R&D projects. He compares risk management and uncertainty management: risks are usually events rather than more general sources of uncertainty. In project portfolio management, managing uncertainty requires an understanding of variation and changes in the environment. Uncertainty may come from technical sources (technology changes and third party products), the market situation (customer needs, competition, new customers, markets and applications), the organization (resource availability), financial aspects (funding structure) and norms and regulations (new regulations and agreements).

2.3 Resource allocation algorithms

A number of authors have proposed different algorithms for allocating resources to projects. The classic resource-constrained multi-project scheduling problem refers to the situation that is being examined here: there are multiple projects with different schedules and needs for resources with different skills and workloads, and these need to be reconciled in an optimal way, taking into account project priorities.

Yoshimura et al (2006) suggest an optimisation system for the allocation of human resources for the projects that have been selected based on project prioritization. The human resources planning takes into account the skills needed for each project and the related workloads: the skill levels of each person are evaluated for every skill needed in the organization on a scale of 0 to 2, the skill requirements for all projects are added up and compared to the available staff for that skill. The calculation assumes that several people with a little skill provide the same amount of work as one person with expert skills, but in real-life projects, this isn't always the case. While some tasks can be done by less skilled people, some tasks will require deeper knowledge that cannot be complemented by throwing more people into the project.

Yoshimura et al (2006) also raise the question of motivation and career paths, and these are taken into account in their algorithm. These are considered both from the individual's point of view – what they like to do and where they want to go with their career – and the company's view – what is needed in order to stay competitive. Taking project selection, financial data, skills, and personal development into account, the algorithm

results in the most efficient way to divide resources between projects, tested through calculated models and a set of 12 projects.

Lova, Maroto and Tormos (2000) have also developed an algorithm for resource allocation in a multi-project environment where projects share common and constrained resources. Their multicriteria heuristic method is based on two steps. In the first step, the algorithm aims to minimize mean project delay or multiproject duration, as selected by the user. In the second step, the aim is to minimize project splitting (continuity makes the work more efficient), in-process inventory (the amount of work that cannot be processed immediately due to lack of resources) and idle resources as well as maximize resource levelling (a constant resource need for a particular resource). This results in a final multiproject feasible schedule. This algorithm was proven to be efficient through calculated models. The method does not take into account the different skills needed in projects but assumes all tasks and resources are the same in this respect.

Beşikci et al (2015) also propose an algorithm for allocating resources to projects in an environment where sharing between projects is not possible, with an additional view to the budgeting aspect of resourcing.

Cohen et al (2007) present an algorithm for resource allocation in a finite-capacity, stochastic and dynamic multi-project system where the network is controlled by limiting the number of concurrent projects. They find that a pull model, where projects are allowed to enter the system when there is capacity for them, decreases project throughout time compared to a push model, where work is started immediately when a project arrives, with no queue. They test their algorithm on a number of theoretical test scenarios.

Singh (2014) has developed an algorithm for the prioritization of projects, which in calculated tests proves to be better than existing priority rules. The algorithm integrates project priority with activity priority, and is based on the urgency of the project, net present value, risk, and growth potential. The result is a multi-project resource plan that minimizes delays.

3 Development plan

3.1 Current state analysis

3.1.1 Background

The case company has started out as a small company, and flexibility and agility have been key differentiators in providing services. The challenge is that the company has grown and is no longer small, and on top of that, it is now owned by a larger player that reduces some of the much-valued flexibility. Processes have traditionally not been very rigid especially in project activities, but as the number of people in the company grows, you really need documented processes to ensure consistency and high quality of the customer experience and the company also needs to ensure these are being followed – you cannot continue to rely on the individual skills of the employees to lead to the best results. At the moment, the company is at the point where these need to be properly established and enforced, although there have been previous attempts and quite a few processes do exist already (some are being followed, some are not).

In a small company, resource allocation is fairly simple, as everyone will know everyone else and workloads are easy to track. You can simply go talk to someone and ask them to work on your project, and that's it. This company has moved a bit further and established a system for tracking who is working on what, and there have been several attempts to improve resourcing. The current process has been established in the latter half of 2013.

3.1.2 Process description

Below is a graph of the current resourcing process followed by details of the steps involved. This has not really been documented anywhere in much detail, and the description is based on my discussions with the project managers and coordinators and observing how the resourcing process happens in reality.

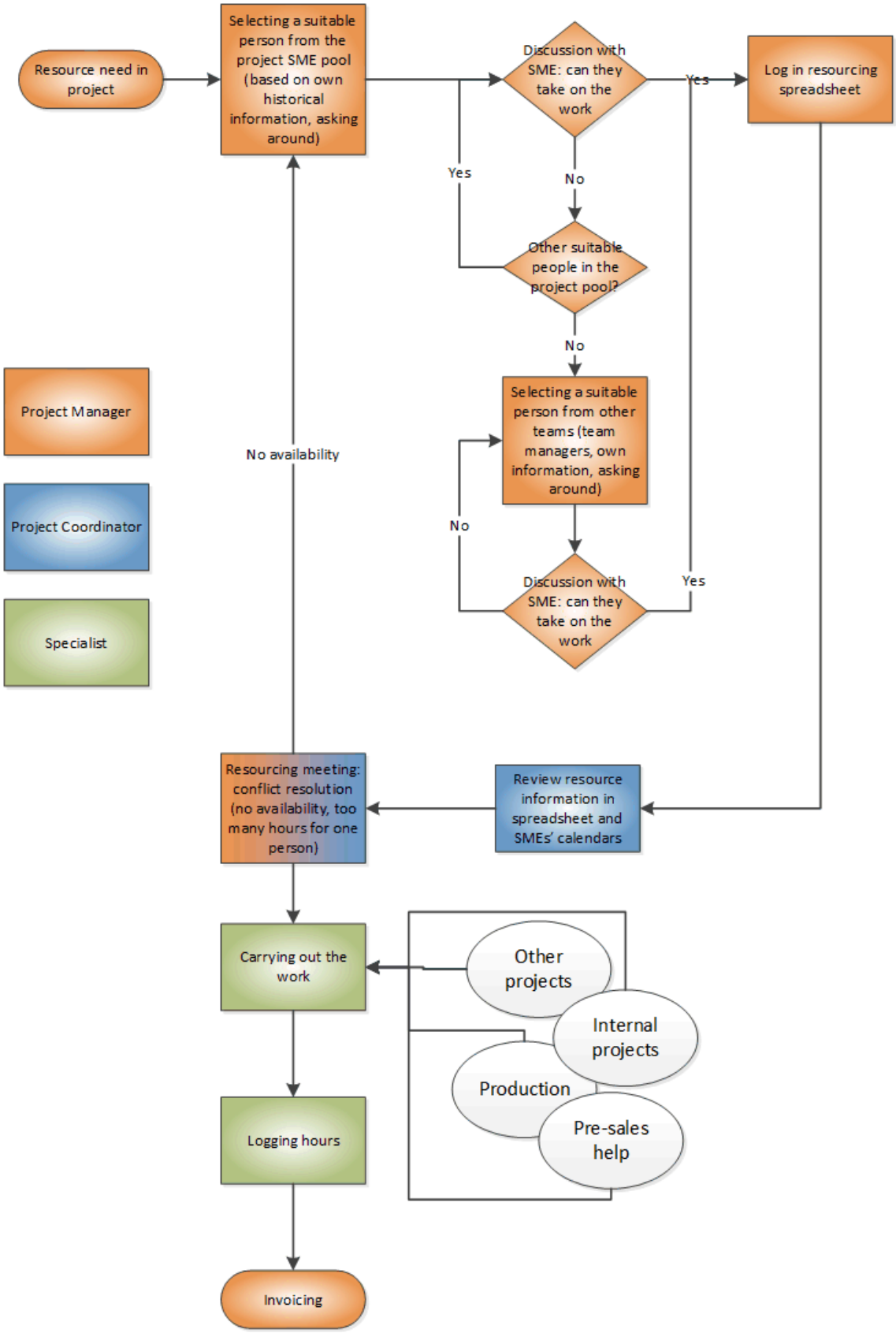

Figure 4. Current resource allocation process

1. When a project manager (PM) needs a subject matter expert (SME) for their project, they select one they know can do that particular task. If they don't know who has the right skills, they often ask the other project managers, and may also go to the manager of the SME team if needed.
2. The PM then goes and talks to the SME they want for the job. If the SME is able and willing to take on the work, a resource has been found. Otherwise, the PM will select another one in the project SME team or, failing that, in the production teams.
3. Once an SME who is able and willing to take on the job has been found, the PM logs the estimated number of hours in a common spreadsheet under that day, project and person. The spreadsheet retrieves data from the project management system so that projects and actual hours are linked. The PMs add their resource needs to the spreadsheet weekly on Thursdays with their expectations for the next week. They may also log needs for further ahead, but that is not done in reality.
4. On Fridays, the project coordinator checks and adds up all the entries in the spreadsheet to identify conflicts such as allocating too much work to one person or allocating work to someone who is on vacation. She also reviews the calendars of the SMEs to complete the information, as they are required to mark agreed work in their electronic calendars.
5. On Friday afternoons, all the project managers, the PMO manager and the manager of the project SME team have a resource allocation meeting where the project coordinator goes through the plan for the coming week. If there are any issues, they are discussed and resolved. Occasionally (but not regularly) the meeting also looks at planned versus actual resource allocation.
6. The next week, the SMEs do their work and log their hours on the corresponding projects in the project management system. These hours are used as the basis for billing at the end of each month.

The process relies on a spreadsheet that is connected to the project management system via a reporting cube and where the project managers fill in their resource needs.

Kuukausi 1
Project Status käyn
Internal Cost Cer All
Internal Cost Cer All
Team Member U All

Tallenna muutokset

Hour Quantity

	ke 27.5	to 28.5	pe 29.5
	0	0	0
	0	0	3
	2	3	3
	0	0	0
	1	1	1
	2	2	0
	4	0	1
	9	6	8
Grand Total	9	6	8

Figure 5. Resource management spreadsheet.

3.1.3 Issues with the current process

Simply put, the process does not work in the most efficient way possible. There is overlapping work: the project manager logs their needs in the spreadsheet, the SME logs what they plan to do in their personal calendar, the project coordinator transfers the calendar data to the spreadsheet and tries to compare it to the project bookings through communication with the SMEs, who often are the best people to say what really needs to happen in projects and the project manager is not up to date on resource needs. Nobody is centrally managing the resource allocations, it is a group effort that doesn't result in an even workload for the SMEs.

Although it may look like a fairly well functioning process on paper, even this process is not followed very strictly. The project managers' workload estimates are sometimes guesstimates at best, as the project plans are not detailed enough to provide the input that is needed for overall resourcing. The Friday meetings are unable to resolve issues as we don't know the real workloads and who else could do the same task, resulting in chaos and wasted time for the participants. Some project managers simply book too much time on purpose to ensure they have the resources they need, which hurts other projects.

The skill sets of the SMEs are heterogeneous, as the field of expertise required is wide and it is in reality impossible for everyone to be as skilled at everything, as also stated by Wang (2001). When selection of the right person for the job is based on the knowledge of the SMEs skills that each project manager has in their head, this leads to the PM often simply going to the person they like to work with, or who worked with

them the last time, or who they happen to know has the skills needed. They may not know that someone else with the same skills has more time on their hands, or that someone should get to work on certain types of tasks in order to develop their skills. As a result, the number of people used for some tasks is small, resulting in high workloads for the most 'popular' SMEs. Especially in the case of the SMEs in teams other than the project SME team, the project managers don't know who would be available and skilled.

In many cases, the plans for resource allocation do not get followed. We may simply notice that although an SME has been allocated to work e.g. 20 hours on a certain project in a given week, they in fact only worked 5 hours on that task, and we were not aware of this and don't know why. While we do need to allow for changes in plans due to the nature of our projects – delays in one task may impact others, something more urgent may come up, schedules may change due to external issues, etc. – changes should still be handled in a controlled manner to ensure we don't just chaotically run to whatever happens to fall on our desk. In reality, prioritization happens on the SMEs' desks and they are constantly interrupted by other work, from customer projects, development projects or production, which makes their days less productive and they have no peace to do their work. As also stated by Zika-Viktorsson et al (2006), this makes the work ineffective and causes stress and negative effects on performance and job satisfaction. Workload estimates are also not always realistic. This is partially due to unrealistic productivity expectations as administrative activities also take time (Lari et al, 2010) and partially due to lack of expertise from the project managers' part.

Long-term resourcing is seldom done: we tend to focus on the next week, and the elements of medium and long term allocations as raised by Hendricks et al (1999) are completely absent. This makes it difficult to plan further ahead and ensure that projects have the resources they need, and to use the data for predicting recruitment needs. There is no time to really resolve issues ahead of time, and all resource conflicts are urgent.

The resource management process is not in sync with that of the platform division, although we are often heavily dependent on their input in our projects.

In terms of tools, the Excel/database solution is technically unreliable and does not provide a view of more than one SME at a time. We are therefore unable to look at the overall situation, and work cannot be scheduled for weekends, although rollout work for

customers often does happen outside office hours. All work needs to be allocated directly to a specific person, and there is no way to indicate the skill that is needed or the task that the resource booking is linked to.

As with many companies, based on the research of Blichfeldt and Eskerod (2008), the resourcing process only covers customer projects. The same SMEs also work on internal development projects, but the resource needs for these do not get taken into account, nor does the time needed for sales support tasks or production activities, where the same people are also often needed. No prioritization with business owners is done, and internal development usually takes last place.

Actual hours versus planned resourcing can be seen from the spreadsheet, but we seldom have time to look at these, and have no view to the reasons for the differences.

As a result, we get a lot of negative customer feedback about resourcing issues, as well as failures with schedules, which are often related to resource allocation. We are unable to use our SMEs to their full potential, with work piling up on some SMEs' desks. Cooperation with the SMEs from production teams is not efficient and there are disagreements over how much we are able to use them in projects. Resolving issues at the last minute results in a chaotic environment, a lot of unnecessary work and stress for everyone involved – the SMEs, project managers, managers and business owners.

Poor resourcing has a business impact in terms of both customer satisfaction and the ability to start invoicing customers for new services after projects have been completed. Also, existing customers want to wait until we are able to give them a definitive project schedule before they order a job – if we cannot plan ahead, the work goes somewhere else or does not get done. Having a well-functioning resource management process would definitely be a competitive advantage in the ICT field, as this is something all service providers struggle with.

We also have other initiatives in place to improve project planning, which should help with the resourcing process as this is where the feed for it comes from. These include a common format and location for project task lists and other project materials, better enforcement of project management requirements, predefined task list templates, and improved post project reviews among the whole team to enable cross-team learning. Another linked project in progress is the change of project management system.

Project management will move to the same ERP system that has been in use for production activities, and this project is estimated to complete by the end of 2015.

3.2 Requirements and goals for the new process

The goals set for this development project were the following:

- Better planning and predictability in project work, resulting in improved customer satisfaction and the ability to sell new projects more easily.
- Reduced stress for everyone involved.
- Long-term visibility into the resource situation.
- Allowing the SMEs to focus on their work instead of interruptions.
- Reducing the fragmentation of work for the SMEs due to involvement in too many projects.

Based on the literature review, there are several points that should be taken into account in designing the new process.

While resource allocation algorithms are popular among researchers (Wang, 2001; Yoshimura et al, 2006; Lova, Maroto and Tormos, 2000; Beşikci et al, 2015; Cohel et al, 2007; Singh, 2014), none of them report actually using them in a real multi-project environment – the results are always calculated computer models. Implementing such a system would require a very high level of maturity from the project management and planning processes of the organization, predictability and stability in projects as well as a system that manages all of this, and while this sounds like a beautiful idea on paper, the project set covered by my research is not a good candidate for such a process. The company has a large number of projects, customers place strict requirements on schedules, the projects keep changing and have a lot of dependencies from third parties, and projects often need to get started quickly. This would require the pre-existence of very detailed plans, all within the same system, which is not currently the case.

Many of the models presented start with the prioritization and selection of projects that will be taken on at a specific point in time (Yang and Sum, 1997; Yoshimura et al, 2006). In an R&D environment, project selection criteria is an important factor, but in the project management office of the case company, we deal almost solely with customer projects and not completing a project is not an option.

Having project team members that are more or less fully dedicated to a single project seems to make the work more efficient, as there are no interruptions from other work and no fighting over the time of one person between different projects (Hendriks et al, 1999; Zika-Viktorsson et al, 2006). This is something that has also been observed in real projects at the case company: having a stable and dedicated team makes the projects run more smoothly and on time.

Realistic workload estimates are also important in ensuring the correct resourcing (Lari et al, 2010) and as we are dealing with customer projects with a high degree of uncertainty and dependencies on other parties, the process needs to be flexible (Engwall and Jerbrant, 2003; Eskerod, 1996; Abrantes and Figueiredo, 2015; Martinsuo et al, 2014; Petit, 2012).

The project portfolio and resourcing process also need to include all significant projects that place demands on the group of resources, but leave time for small things that will inevitably come up (Blickfelt and Eskerod, 2008). The efficient use of resources needs to be a shared goal to avoid conflicts between projects and their managers (Laslo and Goldberg, 2008).

3.3 Metrics

The following will be used as quantitative metrics for the success of this project:

- The percentage of the project SMEs' time that gets spent on project work based on timesheet data
- Resource planning hit rate
- On-time project deliveries: the percentage of projects that have not been delayed due to issues caused by the company (this excludes delays due to customers and project scope changes)
- Accuracy of financial forecasts for projects, as these are based on the number of hours spent on each project in a given month.

Data will be collected from the timesheet and project schedule data from the project management system, the resource management system, and project forecasts and financial data.

The following will be used as qualitative metrics:

- Feedback from an online survey that was done in the autumn of 2014 to determine the maturity level of project processes and repeated in September 2015
- General feedback from the project managers, SMEs, project owners and other stakeholders in the process.

Data will be collected through the online survey and in discussions with the teams.

3.4 New process and tool

The new process and tool were taken into use from the start of June 2015, following trainings to all users. This included managers of customer projects and the SMEs working on them, but also the managers of development projects who need the same SMEs. Resource bookings for production activities are also managed through the same tool.

The selected tool is called Silverbucket, a cloud-based resource management solution with an easy to use, graphical user interface and a view to the overall resource situation of the company or a specific team or project, and visibility of the SME's overall workload on a daily level. The tool is linked to the project management system for importing actual timesheet data, so that we can easily compare planned and actual resourcing on project level. It also enables logging resource requirements based on skills rather than persons. The old spreadsheet was retired from use, so there is no possibility of using the old tool by mistake or due to resistance to change.

The support services department was excluded from the process at this point, as they have more complicated needs in terms of shifts and already have a process in place for this.

The new resource management process is the following:

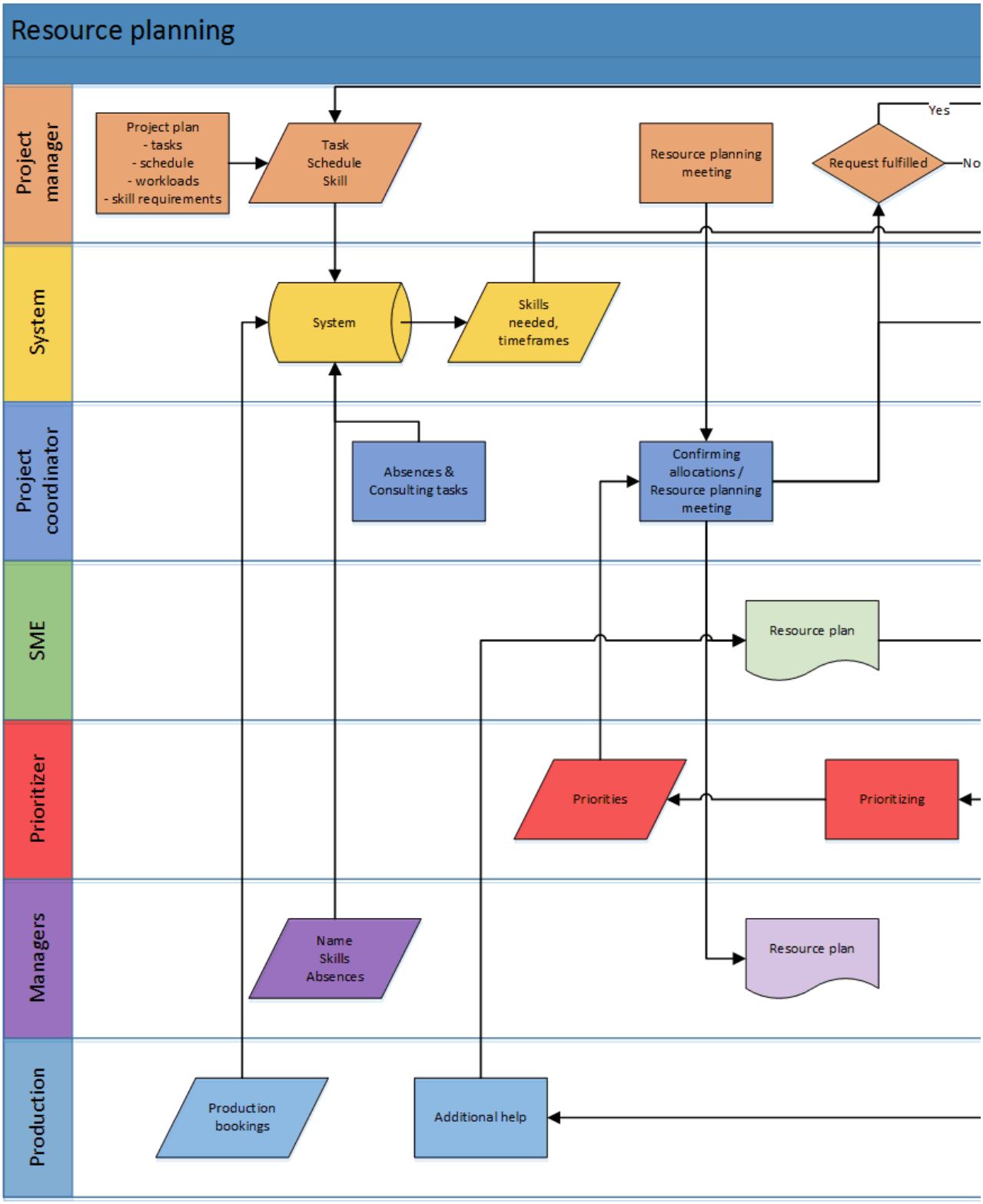

Figure 6. New resource management process, part 1

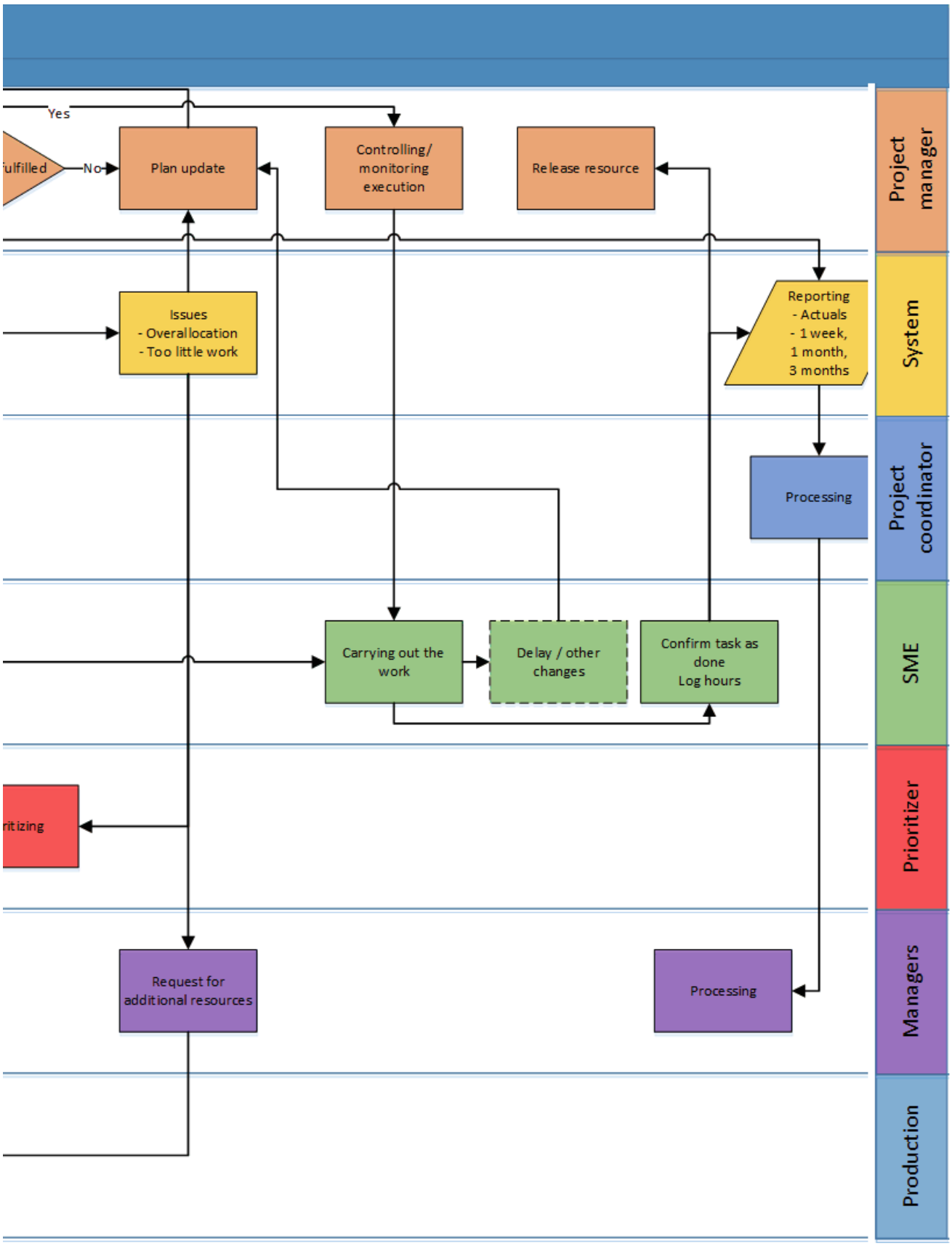

Figure 7. New resource management process, part 2

The flow of the process is:

1. Together with the SMEs, the project manager creates a project plan, with tasks, workload estimates per task, schedules and task linkages, as well as the skills needed for each task.
2. The project manager logs these requirements in the Silverbucket tool weekly, by Thursday afternoon. Requirements are logged for the duration of the entire project on high level and detailed for the next two weeks.
    a. For pre-sales tasks, we have a pre-sales project where the PM logs the SME requirements.
    b. Managers of internal projects log their needs.
    c. Managers of the production SME teams log the production SME needs, both on the production SMEs and project SME team.
    d. The project coordinator logs bookings for consulting jobs, where no project manager is involved. These are based on the information logged by the SMEs in their own calendars.
    e. The project coordinator adds agreed holidays and other known absences to the tool, based on calendar and holiday planning data.
    f. If a SME for a specific skill has already been appointed to the project, the PM logs the requirement directly on them. If no SME for the skill in question has been appointed or additional resources are needed, the PM logs a generic, skills-based booking.
    g. A comment is added to the booking in the case of a task being conditional on another event, or in the case of work that needs to be done outside normal office hours.
    h. Workload estimates need to be realistic, not more ‘just in case’.
    i. At this point, it is OK for the workload of a single SME to exceed maximum capacity.
3. The resource planning meeting on Friday mornings is attended by the PMs, the project coordinators, and the team managers. The meeting looks at issues (too much or too little work for a specific SME, skill-based bookings that have not been allocated to a person).
    a. If there was no availability for the desired time, the allocation is moved to the next free time slot and the PM updates their project plan accordingly.
    b. Prioritization is based on customer-level prioritization that has been created within the customer relationship management process.
    c. Bookings for the next two weeks are reviewed.

   d. A preliminary view to the next month is also used.
   e. If the PM is unable to detail the tasks covered by a booking, they are last in line of priorities.
4. Each PM communicates the end result to the SMEs: the amount booked for the next week and the tasks needed (if not specified elsewhere in project documentation).
5. The SME carries out the work as planned.
   a. If the work proceeds as planned and workload estimates are correct, the SME marks the job as done in the project task list and logs their hours in the timesheet system.
   b. If the SME is unable to do the work due to delays by other parties, he notifies the PM and the PM removes or moves the booking in the Silverbucket tool. If there is other work for the SME available in his other projects, he takes on that work; otherwise, he goes to his manager to discuss what he should do.
   c. In case of unplanned absences by SMEs, such as sick leaves, the SME notifies his manager and project managers. The PM moves the booking forward. If the task is critical, the PM discusses with the team manager whether someone else could take on the job and the PMs of other projects on priorities if the alternative SMEs could be spared. In case of conflict, the manager of the project management office is responsible for priorities.
   d. If the work takes more time than expected, the SME notifies the PM of this. The PM discusses with the PMs of other projects the SME is working on to decide on priorities. In case of conflict, the manager of the project management office is responsible for priorities.
   e. In case of urgent production emergencies where the project SMEs are needed, these take first priority. The priority decision is made by the manager of the production department.
   f. In case of other jobs not included in the resource bookings for the week, the SME refers the person asking for the job to the resource planning process.

In addition, the following rules are in place:

- The use of production SMEs needs to be agreed in advance with the production SME team manager.

- Long-term resource requirements are reviewed by the management team of the delivery department monthly.
- Attending the resource planning meetings is mandatory.
- SMEs from the software development team can be booked directly through the tool and vice versa, as the tool was implemented in the software team at the same time.
- SMEs' maximum capacity for project resourcing is 80% (6 hours per day) to allow for unplanned small tasks and administrative tasks such as team meetings. Only absences are marked at 7.5 hours per day.
- Overtime needs to be agreed with the SME and their manager.

Key points that the new process addresses include:

- Detailed plans for all projects as a basis for resource planning, so that we have reliable information as also stated by Abrantes and Figueiredo (2015).
- The inclusion of all projects in the resource management process, not just customer projects, as raised by Blichfeldt and Eskerod (2008). The process also covers pre-sales cases where SMEs' input is often needed in preparing the preliminary project plan and quotation for the customer.
- Medium and long-term resource allocation, as the process requires logging the resource needs for the entire duration of a project at project start and prospective projects are also included in the planning, an issue addressed by Hendriks et al (1999).
- In addition to medium and long-term allocation, allowing for constant changes in the projects through a weekly review cycle – a typical feature in customer-constrained projects based on the research of Engwall and Jerbrandt (2003), Eskerod (1996), Abrantes and Figueireido (2015), Turnquist and Nozick (2004), Petit (2012) and Martinsuo et al (2014).
- Acknowledging the fact that SMEs cannot spend their full working day on technical project activities, as they also need to complete other work in and outside projects, as also observed by Lari et al (2010).
- Reducing conflict between the managers, visible also in the research in a matrix environment by Laslo and Goldberg (2008) of the project SME and production SME teams through a detailed definition of responsibilities and resource allocation across teams.

- The possibility to add a resource requirement based on skills rather than to book a specific person directly, to ensure work is allocated more evenly to different SMEs with similar skills.

3.5 Results

At the time of writing, the final results of the project are still pending, as the changes were rolled out at the start of summer and the summer months tend to be more quiet. Any new process requires enforcing and constant reminders, and it takes a while until everyone is really on board. Also, the effects are properly seen as projects that have started with the new process go on and finish, and the duration of a typical project is several months, up to a year. This means that the changes will only start to have a real impact in the autumn, and results in metrics will not be visible until the beginning of 2016 at the earliest.

The new tool, Silverbucket, has proven to be much easier to use and to process in the weekly meetings than the old spreadsheet. It provides an overall view of resource requirements for the whole team at a glance, not just an individual person, and highlights any overallocations, which can then be addresses. Making high-level, long-term bookings in projects is much easier than it was with the previous spreadsheet, encouraging the project managers to actually do this sort of planning.

Figure 8. New resource management tool, Silverbucket.

A survey on project operations was carried out at the end of August 2015, and while resource management was mentioned most frequently in the results as the area that has improved the most during the last year, it was also the issue raised most commonly as the number one issue that still requires work and would have a significant impact on the respondents' daily work. This shows that some progress has been made, but as resource management is an extensive field linked to other project processes, such as planning and scheduling, changes do not happen overnight.

The other qualitative metrics – on-time deliveries, percentage of SME time spent on project activities, resource planning hit rate and financial forecasting accuracy – are being followed, but the results of the new process will be visible later on.

3.6 Further changes made to the process

The new process places more stringent requirements on project planning, as project managers need to be able to generate more detailed task lists than before, with accurate resource requirements and links between tasks. As the projects are highly technical in nature, the project manager usually lacks the competence to create such a plan

on their own, and requires the help of the SMEs. While help has been available in the past from the SME team, we saw a need to enforce this further and make it easier for the project managers, as the weekly resourcing meetings still proved to be ineffective due to lack of information.

Work also still seemed to flow the same people as before despite the possibility of using generic skills-based allocations. Resolving these conflicts and finding alternative resources requires detailed knowledge of the SME team members' skills that is not always possible to accurately document in the system.

To help with these issues of planning and skills knowledge, a new function called the Technical Project Office (TPO) was established in September 2015. The TPO consists of two experienced SMEs from the project SME team, who will continue to do project work but also coordination work under the TPO. One of their key tasks is to help project managers to create more accurate project task lists and workload estimates, so the other SMEs can concentrate on project work uninterrupted. They are also available for other small questions from project managers, service managers and sales. In addition, they know the team very well and can suggest other alternative SMEs in case of overbookings. They participate in the weekly resource meetings and bring their input and technical expertise to the table.

Based on initial experience, the technical project office seems like a very good addition. They have been able to help resolve resource conflicts and find people for new jobs, and have taken an active role in the development of standardised tasks lists for different project types, which will help with project planning and project consistency.

4 Discussion and further development needs

Due to commitments made prior to the implementation of the new resource management process, old projects are still partially running with the model of an extensive number of SMEs, which is ineffective as also pointed out by Hendriks et al (1999) through the concepts of project scatter factor and resource dedication profile. This is something that will be taken into account as new major projects get started: based on the project plan, an estimate of the resource needs will be established and appropriate resources appointed full-time. In addition to the full-time resources, there will be a need for additional hands at busy points or due to special skill requirements at specific points

of the project, and these will be added to the project for a fixed term and then released after their part is done. In the past, everyone who has been involved in the project has, for example, participated in project status meetings all through the project, even though their part of the project may already be finished and they have no further input to the meetings. This will free up time for other work. Also, the dedicated people will be able to establish an overall view of the project and identify dependencies and possible issues more easily than if they were jumping from one project to another.

As discussed above, resource management is heavily linked to project planning and requires more effort at the start of the project, which should then pay off during the project through less chaos and stress, improved on-time deliveries and increased customer satisfaction. This part still requires some work and the Technical Project Office is an integral part of the equation that has already quickly started to pay off and will be utilized further as a support function for the project managers.

As with any process, the resource management process needs to be constantly monitored and enforced. Customers often want to get projects started quickly, and the project manager is under pressure to skip some of the more detailed planning. We need to ensure we take the time for planning, and this has also been discussed with the company's own sales department to obtain support for the project manager in assuring the customer to wait with starting actual project work while planning activities are carried out.

As the new process is used, we also need to start systematically analysing the deviances between the planned and actual resource bookings and find out the reasons for differences. This is very necessary in order to learn why we may sometimes miss the mark and to improve the process further.

Based on the amount of research in the field, multi-project resource allocation is clearly an area that provides a challenge in most environments. As most existing research deals with internal research and development projects, I think there is a need for more customer-focused research as well, as customer projects are carried out and form an important part of business in many companies. In some cases, the company may be able to put customer projects in a queue and only pick them up as resources allow, but often this is not the case and projects need to be completed within a given timeframe.

Many researchers also presented resource allocation algorithms to resolve the issue (Wang, 2001; Yoshimura et al, 2006; Lova, Maroto and Tormos, 2000; Beşikci et al, 2015; Cohel et al, 2007; Singh, 2014). It would be interesting to see a case study where such an algorithm has actually been used in a real multi-project environment, what it would require from the company, and what the long-term results would be. The project management processes of the case company are not yet at a maturity level high enough to conduct such an experiment.

4.1 Reliability and validity

Since every organization is different in structure and every field of industry has their individual challenges, the results and model presented in this study may not work in every environment. However, for the case company and other similar companies, especially those where a large percentage of project work is attributable to customer delivery projects, I believe the ideas and solutions will be useful.

Although we still need to wait to see full results at the case company, we already have promising first results from the changes and hope to see more improvements as the process gets into full swing. Since the metrics are based on several different factors and aspects, the results are reliable and not only dependent on one variable. This development project has definitely been beneficial in pointing out the issues and getting the changes off to a good start.

References

Abrantes, R. & Figueiredo, J. (2015) Resource management process framework for dynamic NPD portfolios. *International Journal of Project Management.* 33. p. 1274-1288.

Beşikci, U. et al (2015) Multi-mode resource constrained multi-project scheduling and resource portfolio problem. *European Journal of Operational Research.* 240. p. 22-31.

Blichfeldt, B. & Eskerod, P. (2008) Project portfolio management – There's more to it than what management enacts. *International Journal of Project Management.* 26. p. 357-365.

Browning, T. & Yassine, A. (2010) Resource-constrained multi-project scheduling: Priority rule performance revisited. *International Journal of Production Economics*. 126. p. 212-228.

Coghlan, D. & Brannick, T. (2014). *Doing action research in your own organization.* London: Sage.

Cohen, I. et al. (2007) Resource allocation in stochastic, finite-capacity, multi-project systems through the cross entropy methodology. *Journal of Scheduling*. 10. p. 181-193.

Engwall, M. & Jerbrant, A. (2003) The resource allocation syndrome: the prime challenge of multi-project management? *International Journal of Project Management.* 21. p. 403-409.

Eskerod, P. (1996). Meaning and action in a multi-project environment. *International Journal of Project Management.* 14 (2). p. 61-65.

Hendriks. M. et al (1999) Human resource allocation in a multi-project R&D environment. Resource capacity allocation and project portfolio planning in practice. *International Journal of Project Management.* 17 (3). p. 181-188.

Lari, E. et al. (2010) Allocating Resources in Multi-Project Programs: Lessons Learned from the Trenches. *The Journal of Defernse Software Engineering*. May/June 2010. p. 18-21.

Laslo, Z. & Goldberg, A. (2008) Resource allocation under uncertainty in a multi-project matrix environment: Is organizational conflict inevitable? *International Journal of Project Management*. 26. p. 773-788.

Lova, A., Maroto, C. & Tormos, P. (2000) A multicriteria heuristic method to improve resource allocation in multiproject scheduling. *European Journal of Operational Research.* 127. p. 408-424.

Martinsuo, M. et al (2014) Identifying, framing and managing uncertainties in project portfolios. *International Journal of Project Management*. 32. p. 732-746.

Petit, Y. (2012) Project portfolios in dynamic environments: Organizing for uncertainty. *International Journal of Project Management.* 30. p. 539-553.

PMI (2013) *A Guide to the Project Management Body of Knowledge (PMBOK Guide) – Fifth Edition*. Newtown Square, Pennsylvania: ANSI/PMI.

Singh, A. (2014) Resource Constrained Multi-Project Scheduling with Priority Rules & Analytic Hierarchy Process. *Procedia Engineering*. 69. p. 725-734.

Turnquist, M. & Nozick, L. (2004) A Nonlinear Optimization Model of Time and Resource Allocation Decisions in Projects With Uncertainty. *Engineering Management Journal*. 16 (1). p. 40-49.

Voss. M. (2012) Impact of customer integration on project portfolio management and its success—Developing a conceptual framework. *International Journal of Project Management.* 30. p. 567-581.

Wang, Y. (2001) *Dynamic management and resource allocation in new product development projects*. Ann Arbor: Bell & Howell Information and Learning Company.

Yaghootkar, K. & Gil, N. (2012) The effects of schedule-driven project management in multi-project environments. *International Journal of Project Management*. 30. p. 127-140.

Yang, K. & Sum, C. (1997) An evaluation of due date, resource allocation, project release, and activity scheduling rules in a multiproject environment. *European Journal of Operational Research*. 103. p. 139-154.

Yoshimura, M. et al (2006). Decision-making support system for human resource allocation in product development projects. *International Journal of Production Research.* 44 (5). p. 831-848.

Zika-Viktorsson, A. et al (2006) Project overload: An exploratory study of work and management in multi-project settings. *International Journal of Project Management*. 24. p. 385-394.