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Thesis report

Improving Integral Project Management by applying Systems Engineering

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Preface

This Thesis report is the final result of my study at the University Of Applied Sciences. My study was a Master Of Engineering (MOE) for Integral Building Processes (IBP). This study was a good choice for fulfilling my needs.

It was a pleasure to execute this assignment. Finding the right assignment for this Thesis was not difficult. The fact that there are a lot of difficulties and discussions in the organization to work on a more integral and structured way was my stimulus to improve my knowledge at this field. I wanted to improve my working methods and help colleges to become better.

The improvement of the working methods in projects is a subject which is considered on a daily basis. By performing this research it was possible to use my applied knowledge for finding handles in order to help people in finding their way. The combination of exploring the field and being able to help team members to improve made this assignment extra fulfilling. The coordination and involvement of the companions was very helpful and inspiring. To validate the results the good help of colleges was a positive experience. They invested their time for advising me and reviewing the results. Also the interviews were a great method for determining the situation.

I would like to thank my tutors for their guidance. Their comments and suggestions helped me to delve into the subject. This made it easier to overlook the big picture and find structures. I wish you pleasure at reading this report.

Maarten Oliedam
24 September 2010

Summary

The measurement and benefits of the SE method for all projects is still controversial. Usable guidelines and frameworks for a better performance in projects are not available for project members. Also, the link between the IPM model and SE and the performance of the methods is not clear. The main question is how can IPM-project teams of RWS improve their results by making the best use of the method of Systems Engineering?

A multi-layer development approach is required for project successes and a proper appliance of SE. The knowledge based productivity must improve by increasing the learning ability, knowledge re-use and information architecture. Projects need clear guidance to direct and control them on a structural and profitable way. Before a project starts the starting points must be defined. Project members need to understand the organizational requirements and must know their contribution for the organization. By introducing KPI's the directing, monitoring and controls will improve the stimulation and the use of methods. Solid project management processes are required in addition to the current SE oriented process descriptions.

It was not feasible to make a clear description for applying SE for project teams. The development of best practices, models and frameworks is still a great challenge. The expertise in RWS and in the field must be used for the further development of useful tools. Anyway this thesis resulted in process, activity and control models and descriptions which are a very helpful for IPM-teams. They are a first step towards a better performance in project teams by applying SE. By giving more insight in the role-fillings the missing knowledge and skill will become visible, so that it can be adequately resolved. The role of people is decisive for a proper completion of the processes.

To improve the learning capability of the organization and individuals the development of information systems and feedback control loops is needed. Knowledge must be modeled and combined to be developed. The design of flexible and modular building blocks can improve the basis quality of the organization. This is a good start for further improvements. Project- and building information system should be centrally managed and available for project and maintain organization. Information about performances and figures are not monitored and centrally processed. So it was not possible to give quantity analyses with charts. In the future it will be important to demonstrate and prove the effects of changes by applying the suggested management dashboard and methods. The results have a wide scale of impact in the organization and offer a solid support for project members and the management. Most changes are already put in motion on small scales in the organization. The ingredients are already available but the consistency and connections are missing. Overall coordination and focus is required on short-term. To improve the role of end-user and building information asset management must play a central role in the organization. This field is underdeveloped and a concern. To be able to change the whole organization in a short period is impossible. A phased improvement path to increase the maturity of the organization seems to be a realistic and acceptable route. Also the associated change of culture need extra

time and suits the ambition of the organization and the projects. For the summary in Dutch see Appendix 8.

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List of Abbreviations

BIM	Building information model
BIS	Building information system
CMMI	Capability Maturity Model Integration
DBFM	Design Build Finance Maintain
DSDM	Dynamic Systems Development Method
FMECA	Failure Mode and Effects Critically Analysis
IDEFØ	Integration Definition for Function Modelling
IEC	International Electro technical Commission
IO SCAN	Integral Design scan
INCOSE	International Council on Systems Engineering
IPMA	International Project Management Association
IPM	Integral Project Management
ISO	International Organization for Standardization
KING	Knowledge on a larger scale
KPI	Key performance indicators
LWT	Learning on the job program
MIRT	Map Infrastructure Area and Transport
NIMO	Project Management Institute
OPM3	Organizational Project Management Maturity Model
P3M3	Project Management Maturity Model
PAM	Process Assessment Model
PMI	Project Management Institute
PRINCE2	PRojects IN Controlled Environments
PWW	Professionalization Working Method
RUP	Rational Unified Process
RWS	Directorate-General for Public Works and Water Management
SE	Systems Engineering
SNIP	Ground Rules Wet Infrastructure
SPICE	Simulation Program with Integrated Circuit Emphasis
QCF	Quality Contract File
UPP	Uniformity Primary Processes
WCP	World class performance

Definitions

Systems Engineering "An interdisciplinary approach to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem: Operations, performance, test, manufacturing, cost & schedule, training & support, and disposal. Systems engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs." Ref: <http://www.incose.org/>

Stakeholders "Any group or individual who can affect or is affected by the achievement of the organization's objectives" Ref: Edward Freeman

Project management "the application of modern management techniques and systems to the execution of a project from start to finish, to achieve predetermined objectives of scope, quality, time and cost, to the equal satisfaction of those involved" Ref: cio.osu.edu/projects/framework/glossary.html

Verification "Confirmation by investigations and provision of objective evidence for meeting documented requirements or specifications." Ref: Guidance SE 2.0, int. 9

Validation "Confirmation that the comprehensive product meets customer requirements and needs by objective evidence and effective experiences in addition to the verification" Ref: Guidance SE 2.0, int. 9

Integral Project Management "Project Model that describes the controls of processes within a project, the relationship between them and the relationships with the project environment" Ref: Guidance SE 2.0, int. 9

1 Introduction

The Directorate-General for Public Works and Water Management "Rijkswaterstaat" is an executive department of the Ministry of Transport, Public Works and Water Management. The mission is to protect the country against floods, to ensure clean water and to provide the traffic flow on roads and waterways. Since 2004 Rijkswaterstaat (RWS) is trying to become more productive and cost efficient. The politics had depreciated the entire infrastructural building sector, due to the construction fraud allegations. Also the organization was too expensive, ineffective and unpredictable. The license to operate was at stake. By introducing radical changes the organization became 20% smaller and far more productive. On the other hand the realization of proper solutions with an increasing mobility and a changing society is a major task. To maintain and build infrastructure RWS are one of the largest contracting authorities in the Dutch building industry. In 2012, the goal is to become the leading, public friendly, sustainable executive organization of the government (business plan and diary 2012 RWS)! The changed approach, size and increasing complexity lead to the implementation of "new" methods in the projects. To become this 'Leading director' everything is focused on improving the deployment of contractors and changing the role fillings and responsibilities. Also the nature of projects changed at the following subjects:

- They became larger because of bundling and scaling;
- Social developments increased the impacts on desired functionalities;
- Durability and safety became more important.

The roadmap to the desired leading position is based on the professionalism of the organization, the stimulation of the market involvement and addressing and maintaining of new practices and knowledge. The following major changes were achieved in the past few years:

- The establishment of the project department (Directie projecten);
- A new integral project management model (IPM) was introduced in the organization;
- An additional learning on the job program was released to improve the quality of project members (Leer Werk Traject; LWT);
- To become a more efficient purchasing organization the method of Systems Engineering (SE) was embraced and preceded by the introduction of functional specifying;
- The purchasing strategy shifted towards more innovative integrated contract forms with more responsibilities and development opportunities for contractors.

To enforce another way of working in the sector RWS and its rail equivalent Prorail collaborated with other partners to produce the publication of a new guideline for the use of SE (Guideline 1.0 and 2.0). To guarantee and unify the approaches in the organization they were described in the description "Werkwijzer Aanleg". Also the processes were described as Uniformity Primary Processes (UPP). These radical changes and the reorganization mend the end of the "traditional" way of working in building projects. This started the struggle for project teams to coop with the changed circumstances. They tried to adapt to their changed environment and role filling.

1.1 Purpose

This research is conducted as a thesis project for a professional Master. The investigation focuses on an audience that is involved in building projects. This report must be fully in line and connected with business management objectives in the organization of RWS. The analysis is limited to the preliminary phases of the project. The outcomes need to be generic and uniform for water- and road projects.

RWS wants to generate more project successes with a much smaller organization. Therefore solutions are needed for a more effectively way of working towards primary goals. By focussing on customer needs and core businesses necessary efforts and results were put in motion. The release of IPM and SE already results in an increased production with less use of recourses. In the next few years this trend has to be continued.

Therefore several groups of experts are commissioned to develop plans for knowledge development and improving processes for building projects. The decision to introduce IPM and SE led to radical changes and a lot of ambiguities. The IPM method focuses on filling in and improvement of project IPM-roles. The introduction of SE was intended to improve and fasten market approaches and to reduce activities. The management expects that both methods should lead to the improvement of the project results and knowledge-based productivity. The goal of this research is to find possibilities for applying SE in project teams. Project teams and individuals need support and the tools to apply SE.

This research will try to find possible improvements for project teams of RWS by making use of the method of Systems Engineering given the current circumstances. The recommendations will give guidance for what to do in the organization and the teams. The purpose is to give realistic and executable advices to improve project results and approaches. To assist project teams this Thesis will generate a usable new model for the project organization with additional conclusions and advises. The recommendations are intended for project team members and the staff.

1.2 Problem description

The measurement and benefits of the SE method for all projects is still controversial. Usable guidelines and frameworks for a better performance in projects are not available for the members. Also, the link between the IPM model and SE and the performance of the methods is not clear. This results in project teams who repeatedly and separately are finding out their needed work processes and task divisions. Basics are constantly re-invented. Teams are struggling with the techniques and at the same time are trying to adapt to their changed environment. For project teams the IPM and the SE method seem to have a lot of overlap and are complementary. The different members of an IPM-team should know what is expected of them and how they should act. Also the controlling of the SE process and the measurement of the effects are still not clear. It is unlikely to expect this situation to be optimal, so significant improvements and benefits are expected.

1.3 Research questions

1. How can IPM-project teams of RWS improve their results by making the best use of the method of Systems Engineering?
 - 1.1. What are the requirements and criteria for the improved IPM approach with SE?
 - 1.2. To what extent can the method of SE help improve Integral Project Management and in what way?
 - 1.3. How to measure the effect and performances of systems engineering with respect to the improvement of IPM in projects?
 - 1.4. How to manage the project management and SE processes from the project initiation during the phases towards the IPM-team?
 - 1.5. How to connect the processes to IPM-roles within the project phases?
 - 1.6. What are the changes for the different IPM-roles and the teams?
 - 1.7. What are the expected benefits of the proposed measures?

1.4 Reading guide

This reading guide supports the reader in the main structure of this report. The following topics are addressed:

- After the introduction of what this thesis is about the second part will treat the used materials and the theoretical framework. This section gives an overview of the different applied methods and theories for finding the results;
- The third part contains the results of the analysis of the data from the field. The problem is analyzed by using the indicated methods and the results of the literature. This will lead to the findings of the research;
- The fourth part will estimate the effects of the findings in the organization and discuss the results. This part will interpret the results and determine the quality;
- The fifth part will give a quantitative describe of achievements, differences and how the theory relates to practice. This part will give answers on what was intended and what is possible to achieve;
- In the final sixth part the recommendations, ifs and buts are described. Also the interpretation of what is not achieved is indicated. Any possibilities to improve the results even further are indicated.

2 Materials and methods

The introduction of SE in the organization is the matter for this research. To be able to analyze the situation to find the desired result a solid approach is needed. In the past section the situation, problem and the goals were described. This section will determine the path towards the desired results. The applied methods will be determined and explained. After certifying the approach relevant theoretical information is described. This information is input for the research. At the end of this section the approach, applied methods and relevant theoretical information must be clear. They will be described as basics and essences. The following parts have to be considered to find solutions for the problem description:

- Finding out what the organization wants to achieve (focus, criteria and requirements);
- The possible improvements in the organization;
- The goals of current improvement initiatives in the organization;
- Project management in general and IPM at RWS;
- Project management and SE in general and at RWS;
- The current market situation and possibilities in the sector.

2.1 Research model

The research question and the sub-questions will structure this research. To find the required answers the following approaches are determined:

1. To determine the way to improve IPM-project team results by making the best use of the method of SE is illustrated by a model design. The best solution is determined for the required situation. The results of the gap analysis are input for the conclusions and advices. The outcome will be validated on the criteria's, requirements and parameters. Also a few project members will be asked to check the outcomes as a part of the validation. In the conclusions the answers are rated. The final step is to look at additional recommendations.
 - 1.1. To find the requirements and criteria for an improved IPM approach with SE the relevant literature of project management and IPM must be studied (literature study). By selecting the basics requirements and criteria can be determined. Results of this research must fit this framework. The analysis is also based on the interviews with different RWS project members. To map the current situation at RWS and to determine the needs for improvement the method of interviews is used. The interviews are held with members of different projects to find out the generic situation and findings. The outcomes are set in a censored summary. The interviews are based on an anonymous approach for getting the factual needed information and insides;
 - 1.2. To determine the expected extent of improvements and to find possible ways for applying SE in projects an analysis is performed for finding organizational goals (document study at RWS), generic project management mechanisms and SE benefits (literature study). The methodology developed by Geary A. Rummler and Alan P. Branche (lit. 2) is a practical tool to understand the variables that influence the organization and the individual performance. The methodology is based on three levels of performance and nine performance variables that

determine the effectiveness and affectivity of an organization. The status of knowledge base productivity must be determined by using the IO scan. This IO-scan is designed by TLO and is handed during the Master classes for measuring the knowledge based productivity. It is an adequate way for finding out the organizational position;

- 1.3. To measure the organizational aspects a comparison between generic accepted business values (literature study) and project successes is needed. To be able to measure the effect and performances of systems engineering with respect to the improvement of IPM performance indicators will be set;
- 1.4. To determine how to manage the project management- and SE processes from the project initiation during the phases towards the IPM-team the current processes are analysed by usage of the IDEFØ method. IDEFØ (Integration Definition for Function Modelling) is a method designed for analyzing complex processes to model the decisions, actions, and activities of an organization or system. The method is derived from the technique Structured Analysis Design Technique (SADT) and developed by Douglas T. Ross in the period from 1969 to 1973. The IDEFØ result will define the needed changes and give a clear direction for the required situation. The World Class Performance (WCP) method is used to define the capability level of the organization. WCP has its origins in the CMMI guidelines;
- 1.5. By transferring the processes towards an activity diagram the connections between the processes and people (tasks and roles) will be indicated. So it will be possible to connect the processes to IPM-roles within the project phases (analysis current situation);
- 1.6. The changes for the different IPM-roles and the teams are determined by a gap analysis. For the current situation the RWS guidebooks are studied along with the results of the interviews.

The research model (Figure 1) shows the necessary steps for the research approach. The following research model is developed for this assignment. The results of the various examinations are described in this report on the order of the questions.

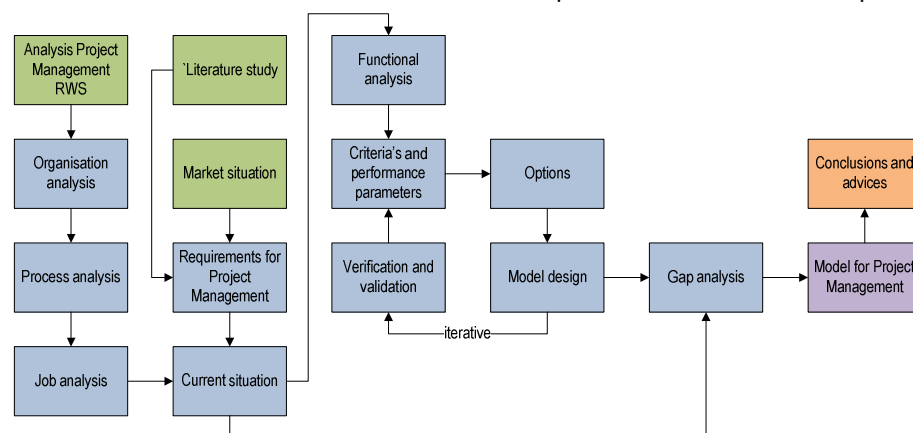


Figure 1: Research model

Legend:

Chapter 2
Chapter 3

Chapter 4
Chapter 5

2.2 The theoretical framework

The theoretical study is focused on elements which are related to the problem definition and are needed for the research. The theory is summarized and brought to useful essences to clarify available information. Because the research field is wide and complex the different methods and systems are put on row to get more insight in the matters and to be able to understand choices. The different models and methods are selected because they are accepted in the field and they are useful for the situation at RWS. To consider new ways of improving the effects of SE in project it's important to set a starting point based on useful existing information (input for analysis).

The outcomes of the study are presented in the next paragraphs for the following subjects:

- Business value creation;
- The organizational capability and maturity;
- Program- and project management;
- Systems Engineering;
- Methods and procedures at RWS;
- Risk management;
- Market Situation.

2.2.1 *Business value creation*

A healthy business must be profitable and reach goals of sustainability. This incentive is absent in the public sector, but instead they have to uptake important obligations for society demands. Their performance is dependent on ensuring access to resources and securing and maintaining operations. The problem with trying to improve business value is that these goals are long term. But to control the improvements an short term (monitoring) system is required. The solution is to link the overall corporate goals of value to strategic and operational targets. The most widely used method is the balanced scorecard methodology by Robert Kaplan and David Norton. The balance scorecard provides an integrated framework for balancing financial and strategic goals. A strategic scorecard system is built around organization strategic objectives critical for creating value for citizens and other stakeholders, around programs and services that make the objectives actionable, and around the value creation chain (called a strategy map) that defines what must be done to be successful.

In a strategy-based scorecard system, strategy is analyzed through four performance dimensions, called perspectives:

- Financial/stewardship;
- Customer/stakeholder;
- Business process;
- Organization capacity.

The figure below illustrates an example for a governmental balanced scorecard (int. 12).

Municipal Government Balanced Scorecard

Mission: Provide effective and fiscally responsible services in a manner that promotes high standards for community life

Vision: Be a world-class model for a successful urban community

Strategic Themes: *Government Reform* *Nurturing Families* *Public Safety* *Economic Abundance*

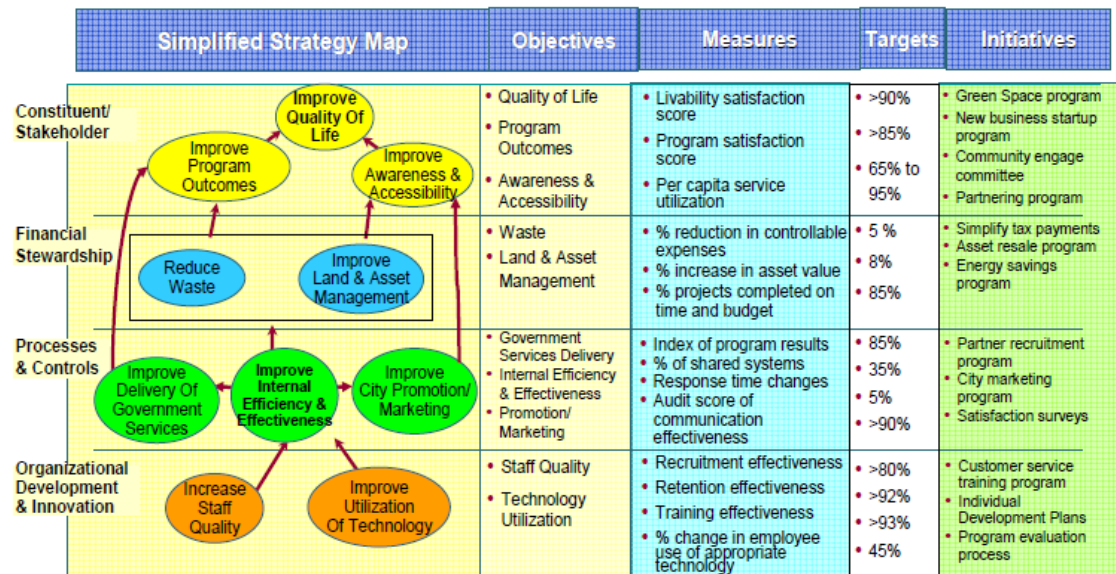


Figure 2: Municipal Government Balanced Scorecard

Normally it takes 2 - 3 months to build a scorecard system, depending on the size of the organization. The example is used to check the strength of the measurement, monitoring, and communication of the organization's vision and goals to make the business strategies actionable.

2.2.2

The organizational capability and maturity

How processes are designed can really make a decisive difference for organizations. To create more value it is important to look at the design of the multiple levels of processes. Business objectives, culture and processes need to be effectively aligned and integrated. To measure the capability and maturity of organizations several capability models are developed. Capability models direct and control the development or improvement of processes to meet organizational goals. The models consists capability levels and support an incrementally maturity grow of an organization. Examples of accepted models are:

- CMMI (Capability Maturity Model Integration);
- ISO/IEC 15504 (Software Process Improvement and Capability determination);
- Organizational Project Management (OPM)3-Model;
- Portfolio, Programme and Project Management Maturity Model P3M3.

CMMI is the successor of the capability maturity model (CMM). In 2002, the CMMI version 1.1 was released by the Carnegie Mellon University. The CMMI is intended software development projects with SE (integration). CMMI addresses three areas of interest, which are:

- Product and service development;
- Service establishment, management, and delivery;
- Product and service acquisition.

The CMMI for Acquisition (CMMI-ACQ) provides guidance's to acquisition organizations like RWS. With an official "SCAMPI A Appraisal" the organization's maturity or capability level can be certified by the Software Engineering Institute. The approach focuses on an optimally combining of existing organizational strengths by using the model's best practices. The CMM(I) is combinable with agile methodologies such as RUP and DSDM and improvement methods such as Lean and Six Sigma. The figure below illustrates CMMI model.

Capability Maturity Model – Integrated

Level	Focus	Process Areas	Result
5 Optimizing	<i>Continuous process improvement</i>	Organizational Innovation & Deployment Causal Analysis and Resolution	Productivity & Quality
4 Quantitatively Managed	<i>Quantitative management</i>	Organizational Process Performance Quantitative Project Management	
3 Defined	<i>Process standardization</i>	Requirements Development Technical Solution Product Integration Verification Validation Organizational Process Focus Organizational Process Definition Organizational Training Integrated Project Management Risk Management Decision Analysis and Resolution	
2 Managed	<i>Basic project management</i>	Requirements Management Project Planning Project Monitoring & Control Supplier Agreement Management Measurement and Analysis Process & Product Quality Assurance Configuration Management	
1 Initial	<i>Competent people and heroics</i>		

Figure 3: CMMI (Capability Maturity Model Integration)

The ISO/IEC 15504 or SPICE (Software Process Improvement and Capability Determination) model was developed and published as a technical report in 1998, by the Joint Technical Subcommittee. The integrated Process Assessment Model (PAM) supports assessments and helps the interpretation of processes and results. The model is based on definitions of the ISO / IEC 15288 for systems engineering and system life cycle processes (section 2.2.4). The figure below illustrates the ISO/IEC 15504 or SPICE model.

Level	Attributes
5 "Optimising"	<ul style="list-style-type: none"> Process innovation Continuous optimization
4 "Predictable"	<ul style="list-style-type: none"> Process measurement Process control
3 "Established"	<ul style="list-style-type: none"> Process definition Process deployment
2 "Managed"	<ul style="list-style-type: none"> Performance management Work product management
1 "Performed"	<ul style="list-style-type: none"> Process performance

Figure 4: ISO/IEC 15504 (Software Process Improvement and Capability determination)

Since 1998 the Project Management Institute (PMI) developed an organization-wide project management maturity. OPM3 is based on three elements, which are knowledge, assessment and improvement and the five maturity levels. The biggest difference with the other models is the introduction of three separate levels of control. The urgency to use multi layer managements is also needed for excellent project management (section 2.2.3).

Finally the P3M3 defines thirty-two Key Process Areas (KPA's). P3M3 is owned and developed in 2006 by the British Office of Government Commerce (OGC) to help the public sector in a more focused and effective functioning. All models have the same characters and appliances. They are also a framework for assessing the process maturity of the organization. The models can be considered as representative standardized assessment models.

2.2.3 *Program- and project management*

Program Management is used in organizations to manage large projects or multiple projects. There is a big difference between a program and projects. A Program is focused on achieving organizational goals in the longer term and a project is focused on delivering a specific project result in the short term. A Program is generally larger and more strategic in nature than a project. A program consist more projects which must be managed in conjunction. The force in a program is targeting and the some objectives may be contradictory. The efforts often carry the character of improvisation, routine or project. The program approach involves five processes (lit. 5) which are: programming, control, authorization, coordination and cooperation. Each of these processes contributes to approaching goals and good cooperation. Available different applied methods for managing projects are:

- Twynstra Gudde called Project Management Works (PMW);
- Project (Management Body of Knowledge PMBoK);
- PRINCE2 (PProjects IN Controlled Environments);
- Project Creation (PMC);
- IPM (Integral Project Management method).

In ICT, there are many system development methods like DSDM, RUP, SDM and Scrum. These methods are sometimes confused with project management methods! Basically every method uses the same basics and essences. First, the involvement of both the principal and the supervisor is very important. A clear definition of the end result, a list of all acceptance- and quality criteria and the validation strategy are crucial. Finally, a project needs the involvement end users. Even before a project starts, it is important to define its starting points. This is known as the preliminary work. The preliminary work includes (lit. 6):

- The business case, reasoning from information;
- Involvement of the client and supervisor;
- Definition of the final result;
- Acceptance Criteria;
- Quality;
- Involvement of users.

Within the framework of the preliminary work should also address the choice between an engineering approach and development approach. Research shows that 80% of the projects organizations almost automatically choose the design approach. The same study shows that three quarters of these projects 80% failed.

Organizations that choose the development approach had a success rate of 75%. The figure below illustrates the study results.



Figure 5: Outcome of research Prof. Jaap Boonstra

To direct a project successfully it is divided into phases (lit. 6). During the project's life cycle practices proved to divide a project in six stages: initiation, definition, design preparation, production and the aftercare. There are only five parameters on which the project manager directs the project: time, money, quality, organization and information (TMQOI). The TMQOI elements return in the project planning, progress control and project accountability. The results from the Chaos report (int. 7) of the Standish Group indicate the ten project success factors:

1. User Involvement
2. Executive Management Support;
3. Clear Statement of Requirements;
4. Proper Planning;
5. Realistic Expectations;
6. Smaller Project Milestones;
7. Competent Staff;
8. Ownership;
9. Clear Vision & Objectives;
10. Hard-Working, Focused Staff.

A project team needs to be equipped with the right systems and techniques. Also the role fillings in and from outside the project are important. To optimise results for project management in an organisation an open, generic and adaptable structure is required. A solid and accepted structure is offered by the IPMA Project Excellence Model. The elements in the model are based on the fundamental insights, concepts and experiences of Total Quality Management (TQM). The model was introduced in 1993 and is the follow-up for the American Capability Maturity Model CMM. The CMM model was for European organizations not in accordance with their understanding of management and quality. The Project Excellence Model is intended for individual projects. The figure below illustrates the Project excellence model.

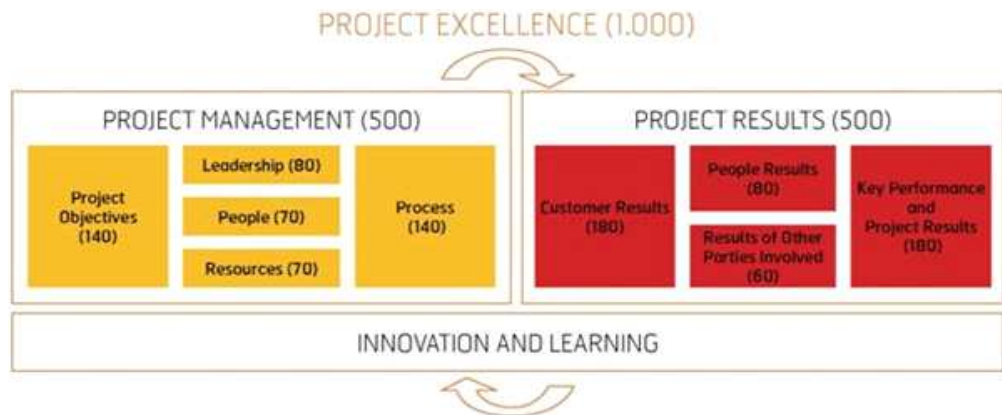


Figure 6: Project excellence model (IPMA)

The IPMA Project Excellence Model covers the important aspects (int. 13):

- Customer satisfaction
In well-managed projects, the customer decides on quality perception. A project team must completely understand customer needs and wishes;
- Development and participation of employees
The complete potential of employees can only be released in an atmosphere of confidence and openness;
- Partnership with suppliers
A customer-supplier relationship based on confidence and cooperation is a great asset for both sides;
- Leadership
True leaders influence the culture of the organization and control resources and efforts for an outstanding performance. Leadership is an essential quality. It is not possible to make optional decisions if there is isolation with the environment;
- Social responsibility
To obtain lasting and outstanding results expectations and demands of all parties involved have to be well-balanced;
- Processes and facts and results
Activities must be conducted as processes which are permanently improved. Clear measurements serve as a basis for control.

2.2.4

Systems Engineering

The Council on Systems Engineering (INCOSE) indicates that activities such as setting requirements, conceiving and design features have a consistent spot in the working methodology known as Systems Engineering (SE). SE has emerged from the defense industry and has developed from the need for the development of complex products to better control. The essence of SE is to create products and systems that meet customer needs. Therefore it's important to let users and clients decide in the process. Often the focus lies on technical aspects but within a government or business environment is easy to extend to other aspects. Requirements of customers can be supplemented with many rules and conditions, but become really complex when multiple clients are involved and if several solutions are possible. Through policy analysis and process support tools pros and cons can be and necessary process space achieved for reaching a unanimous verdict.

In the method of SE the technical, administrative, operational and administrative requirements of suppliers, users and customers are bundled on a way that a mutually acceptable solution is achieved. Communication about products takes place by means of 'sharing' information with a real time information system and a constantly aware of each other virtual activities. The figure below illustrates the Systems and Software Development Process (int. 14).

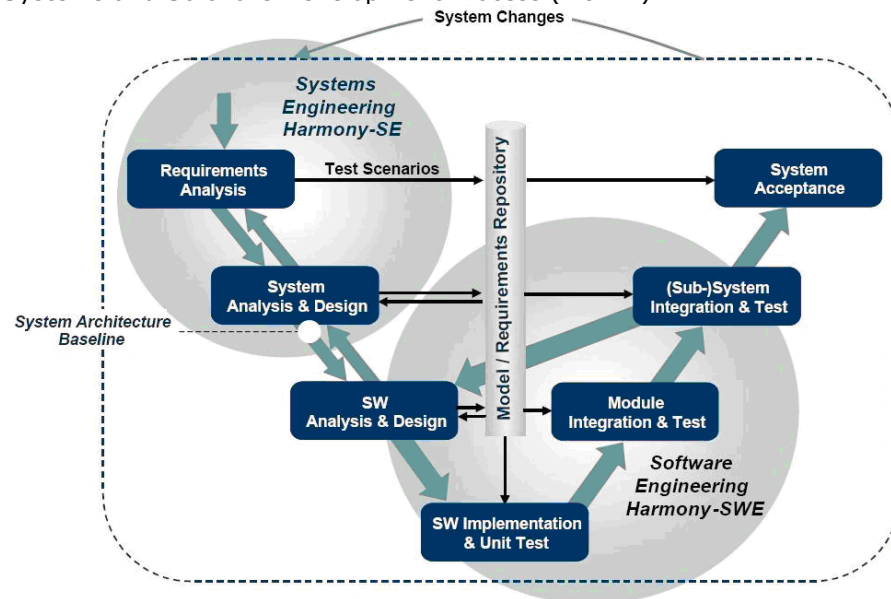


Figure 7: Harmony® Integrated Systems and Software Development Process.

Systems engineering adds value to projects of all sorts but is particularly important in big (complex) projects for efficient multiple team working. Systems Engineering should be early and correctly applied to offer benefits.

Benefits for applying SE are (INCOSE, int. 14):

- Better products for the customer on requirements;
- Better traceability of decision making;
- Clear understanding of the scope and context and working environment;
- Reduce problems with suppliers and sub-contractors;
- Flexibility to respond to changing context, requirements and environment;
- Management of risks;
- Improve knowledge productivity;
- Reduce cost and time overruns;
- Reduce through-life costs;
- Reduce changes and problems;
- Improve reliability;
- Minimize integration difficulties;
- Improve adequate testing;
- Eliminate malfunction in use.

The SE processes are related to the phases in the product lifecycle. The start is typically at the very beginning of a project. A variety of SE process standards have been proposed by different international standards bodies. Most SE process standards have evolved from the early standard DoD-MIL-STD 499. The heritage of standards is illustrated in the figure below.

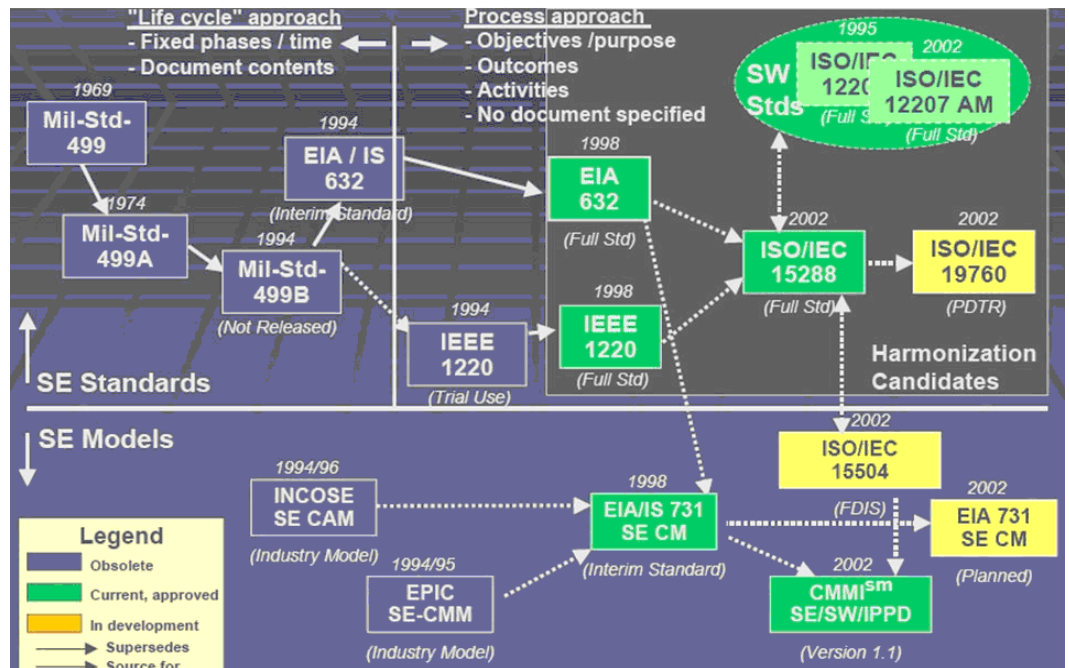


Figure 8: Heritage of Systems Engineering Process Standards and capability models

The system standards ANSI/EIA 632 "Processes for Engineering" and the IEEE 1220-1998 "Application and Management of the Systems Engineering Processes" were sources for the development of the ISO/IEC 15288:2002 "Systems engineering and system life cycle processes". The ISO/IEC 19760 is a guidance document for the 15288. The Institute for Electrical and Electronic Engineers (IEEE) and the INCOSE are connected to the 15288. The 15288 contains a common framework for describing the life cycle of systems and life cycle processes. The figure below illustrates the ISO/IEC 15288 processes.

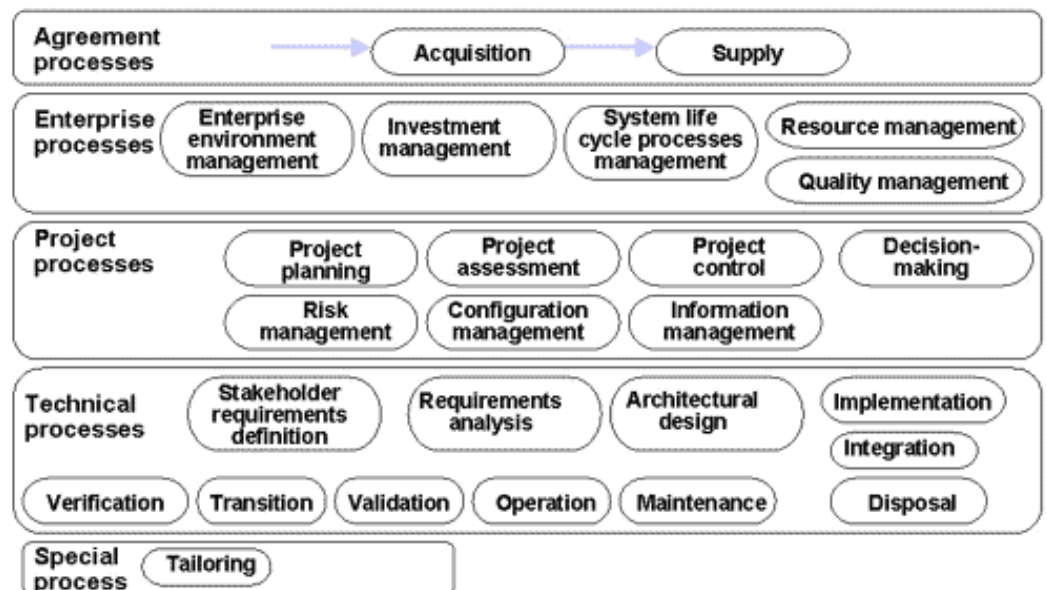


Figure 9: ISO/IEC 15288 processes

For the civil engineering sector the guideline Systems engineering 2.0 was released in 2009. The main features of SE were adopted. According the standards of SE the guideline focuses on customer demands, life cycle optimization, an iterative central specification process, top-down development, bottom-up realization and verification & validation. The starting point for a project is an analysis of problems and opportunities related to consumer demands. These customer demands are linked at the considered system "System of Interest", and the intended use of the system "initial requirements". Systems Engineering creates optimal solutions for a problem within the given solution space. To meet the customer needs, the system must perform the functions. Within the solution space several design choices are possible to meet the requirements. The procedure is based on the iteration between features, requirements and solutions. Specifying requirements must be realized at the right level in the organization and with the right people. It is important to take account of the project management aspects of time, cost and quality. The defined values of SE in the Dutch civil engineering are:

- Requirements Management with verification;
- Detection and traceability of the Contractor;
- Legality for the Client (validation);
- Solution Space for contractors;
- Life-cycle thinking, the ability to take into account the following phases of a system at any stage;
- Multidisciplinary approach based on the principle of "thinking out the whole system" instead of thinking from parts. This results in the full view of system components;
- Structured information management, structured and explicitly defined adequate information management;
- Attention for stakeholders, necessary for a good SE process is the understanding of who is actually a stake in the project. Subsequently, customers and stakeholders think about requirements, needs and solutions and how choices are made. The result is borne by all stakeholders solutions;
- Top-down work and the iteration of requirements and design from system level to deeper component and element level;
- Interfaces between engineering and other disciplines such as risk management, configuration management and document management.

2.2.5 *Methods and procedures at RWS*

Besides the (inter)national standards and methods for project management and systems engineering RWS has its own derived forms. To understand the business situation this section will give an overview of RWS.

RWS wants to become the leading, public friendliest, and most sustainable implementing organization of the government! (Business plan & diary RWS 2012). RWS wants to be:

- Fulfilling its task with innovative processes;
- Public friendly partner;
- Leading at relationships with market participants and Co-managers. RWS wants to become a leading building contractor;
- Leading agency at the politics. RWS wants to become a reliable and efficient partner;
- Leading at the employers. People of RWS are decisive.

The increasing complexity and accelerating changes within organizations strengthen the demand for more highly qualified project managers to perform multi-project management. The project results are expected to make a clear contribution to the organization's goals. To respond to developments a great deal of improvisation is needed. Conform the description in the "Werkwijzer aanleg" the control lines for projects are defined D1 till D4. The figure below illustrates the control lines.

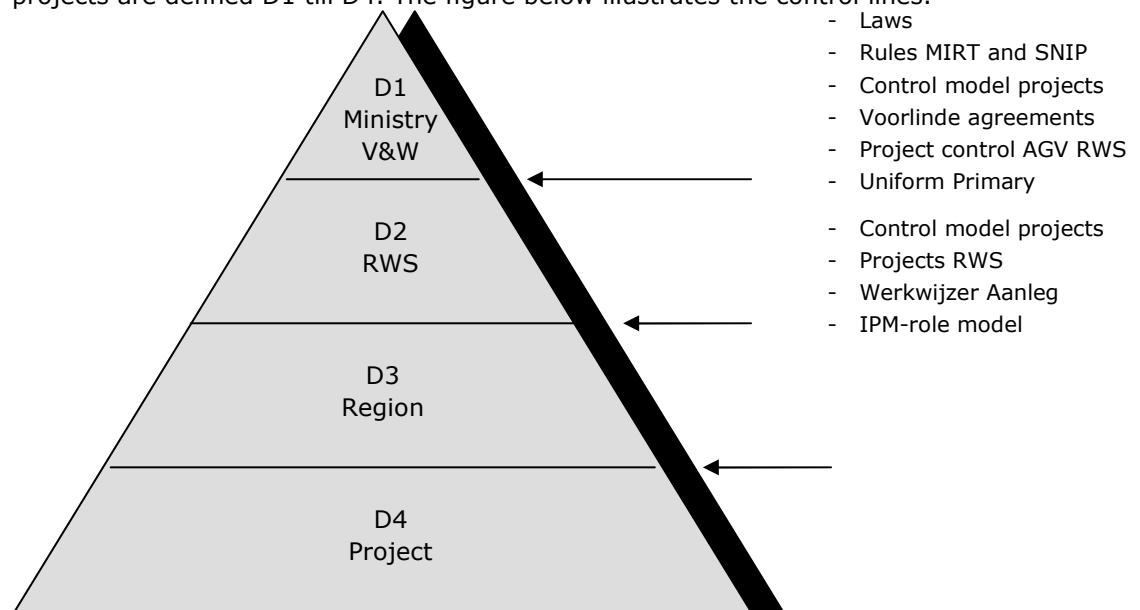


Figure 10: Control lines RWS

The procedure (MIRT/SNIP) divides the (internal) decision-making process in three phases, the exploration phase, the study phase and construction phase. The procedures are similar in outline. The decision starts with an intake decision. The exploration phase is used to analyze the problem, to determine the need and to identify possible solutions. The exploration phase is completed with the decision whether the project moves to the study phase. In the study phase alternatives are developed. For each alternative, including a zero alternative, the effects mapped. An alternative choice is made for deciding which variant is being developed into a design. If the chosen alternative is sufficiently developed, a project decision is made. The planning of the study phase is completed when the legal objection periods have expired. Once the funding for the project is provided, the realization phase starts. The construction phase is completed when the project is completed and the final payment has occurred. The project will be deleted from the budget for the handover decision. Results of performances are shown in the management dashboards of the department.

RWSPD-011 D2/D3
Lang Overzicht



Door u geselecteerde parameter(s): LD DI
Stoplichten

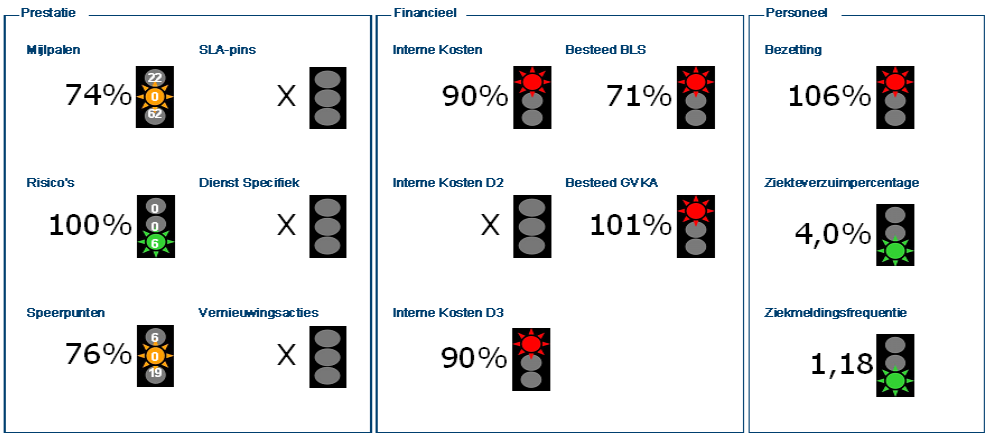


Figure 11: Departmental management dashboard of RWS

The business, calendar 2012 describes the ambition of RWS become "the leading, public friendly, sustainable executive organization of the government ". The Project department "Dienst Infrastructure" wants to be the knowledge based department. By executing a continue dialogue with the market, the processes, contracts and purchasing services have to be improved.

The goal is to achieve efficiency and uniformity in projects through the renewal of existing knowledge and practical experience. The projects at RWS are performed by using the method of Integral Project Management (IPM). The guidance "Werkwijzer aanleg" describes the Integral Project Management Method (IPM) for projects. IPM means a standardized integrated project approach to accomplishing tasks with lifecycle thinking. An IPM project team consists of five key role players. These key roles are: project manager, manager controls, contract manager, surrounding manager and the technical Manager. Every key role player led a team with project leaders and advisors. An IPM project organization is externally oriented. The figure below illustrates the IPM model.

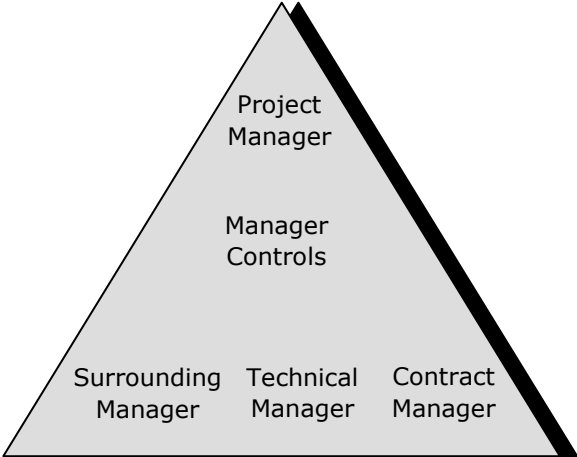


Figure 12: Integral Project Management Model (IPM)

- The project manager is primarily responsible for achieving the project results within the predetermined conditions with respect to time and money and quality. The project manager assures that results are approved by the client. The project manager leads, strengthen the team spirit, binds team members and monitors the mutual interfaces within the team;
- The project manager is associated by the manager controls that is responsible for correct TMQOI elements and is responsible for project-wide progress reports and configuration management;
- The surrounding manager is responsible enabling the environment aspects to realize the project within public and private conditions. In this context the surrounding manager overcomes various planning procedures, obtains permissions, (re)construct cables and pipelines, represents real estate matters and directs surrounding, archaeological and explosives investigations;
- The technical manager is responsible for the technical results during the project phases. Under his responsibility, the (functional) specifications are prepared for contracting and realized within frameworks by the contractor. Technical management directs the usage of systems engineering in the project team;
- The contract manager is responsible for managing the entire contract process from preparation and implementation towards the market. The contract manager represents the principal towards the contractor.

Characteristic differences between IPM and other project management methods are:

- Specific for RWS and Prorail;
- Wide flat structure;
- External focus;
- Emphasis on results and goals;
- Extra care for stakeholders;
- No attention for behavior;
- Suitable for public contracting and a politic environment.

The trends within project management in RWS are:

- Bundling projects;
- More complex environment;
- More ICT elements in projects;
- Interpenetration between study- and realization phase;
- Integration of area development;
- More DBFM contracts;
- More corporations with partners.

Mechanisms for controlling (source "Werkwijzer aanleg") project management are: second opinions, gate reviews, QCF reviews, tender boards and PAR meetings. RWS invest a lot of effort in knowledge structures. Therefore the introduction of knowledge groups is set. To develop knowledge for the field the group KING (Kenniss IN het Groot) is founded. This cooperation is a joint venture between RWS and Prorail. To improve the pool of project teams specific development programs are designed. A wide range of project tools is in view:

- A process framework containing the processes and their interrelationships;
- Process descriptions of the processes;
- Guidelines for use of custom tools based on the characteristics of a project;

- Life cycle models;
- Product descriptions, formats of documents, such as a project, the contract buffet etc.;
- Methods such as RISMAN, Work Package Management, Systems Engineering;
- Techniques such as IDEFØ , force analysis, stakeholders, FMECA;
- Tooling, such as PRI, PPI, MS Project, WBS tool, network diagrams, SE tool;
- Manuals of parts of instruments;
- A conceptual and definition list;
- Best practices for components of the tools and lessons learned.

2.2.6 *Risk management*

In projects, programs or organizations the control elements time, money, quality, information and organization are always threatened by risks. Risk management supports a structured way of achieving objectives by making risks explicit, linking controls to risks and implementing them in the (project) management. Risk management begins with the analysis then the identification of control measures for key risks and determining management measures. Risk management will ensure the effective implementation and evaluation and helps to be as effectively and efficiently as possible. Risk management is basis for all used methods.

2.2.7 *Market Situation*

In today's increasingly difficult market building companies are looking for ways to distinguish themselves against other players. Currently in the specialist and journals (ZIBB, PSIBouw, Cobouw etc.) a lot of articles are about integrated approaches and "another way of thinking" in building projects. The building sector is currently an ambitious and innovative



market segment. The building companies deliver the same products but want to distinguish. This is only possible with an innovative approach. The current market often focuses on product improvement instead of a total change in the developing focus. Just like in other sectors the building sector is exploring and creating new markets. Another way of thinking allows building companies to create new markets and great advantages which they can use to mutually distinct themselves (Building innovation, Rob van Bodegom). Many changes are focused on the use of an ICT Building Information Model (BIM). Besides the applying of new ICT possibilities the soft side "the way of thinking" is even great challenge to overcome (improve cooperation between the parties, culture, contract formation etc.). (Cobouw, Frans van der Velden, BNA, website). Customers expect more service and want to get what they expect. The customers are more and more aware of what they miss and want to see changes in the building sector. (Zibb, DMNews.com) At the same time customers must have sufficient knowledge and ability to control the projects. Another partner structure is needed instead of the traditional methods. (AEDES, Zibb, etc) Change begins with the first step, yourself!

2.2.8 *Conclusion of the theoretical framework*

During the study of the theoretical aspects it became clear that the problem field was very comprehensive. A lot of methods and models are available and to some extent comparable. The parts often have different backgrounds and origins but are deployed for the same purposes. By bundling and finding the basics the field becomes more transparent and understandable. The study resulted in the following insights:

- To add business value the overall goals of value have to be linked to strategic and operational targets (balanced scorecard);
- Capability and maturity models are useful to support an incrementally maturity grow of the organization. The models also support the system oriented processes of SE;
- In project management the starting phase and the management approach (development) are important for success. Research has yielded project success factors;
- The benefits of SE are determined and appropriate for project management. For the method a top-down development and a bottom-up realization is required. The method must be applied by people with the right knowledge and skills (thinking in abstracts);
- The decision making process at RWS is financially driven;
- The IPM method is mainly based on role-fillings;
- In the organization are a lot of tool which are separately developed and not very useful for applying SE in project teams;
- Risk management is essential for all methods;
- The markets are trying to find new ways and tools to mutually distinct themselves;

These insights are the basis for the thesis research. Next section will present the results of the analysis.

3 The results

In the previous section the theoretical input was collected and bundled for finding out the needed answers to the research questions. This section will systematically deal with the questions. At the end of this chapter the main question will be answered to complete the results. The theory in the previous section is used for creating new knowledge by the re-use of existing knowledge. This section will create (new) solutions by analysis and combining knowledge. This section provides a factual statement of what is observed during this investigation. Analyses are described in detail.

3.1 The requirements and criteria for the improved IPM approach with SE.

To find the requirements and criteria for an improved IPM approach with SE the relevant literature of project management and IPM was studied. The basics, requirements and criteria were determined by combining and filtering the theory in section 2. This analysis was also based on the outcome of the interviews with different RWS project members. The different parts in the theory represented the range of relevant influences. By projecting the theory at the IPM situation a filtered list of requirements and criteria was composed. The following requirements and criteria were set according the aspects for creating organization value by projects (Balanced scorecard):

1. Stakeholders expectations must be met and additional value must be delivered for achieving customer satisfaction;
2. Reduction of expenses, waste. Increase of assets value. Projects are completed within time and money;
3. Improvement of delivery services, response time and communication;
4. Improve internal efficiency and effectiveness of the organization;
5. An effectively assignment and access of resources must be arranged to get the best performance in the organization. Increase staff quality;

The following requirements and criteria were set according the important aspects of organizational capability and maturity systems for projects:

6. Systems business objectives, culture and processes must be effectively aligned and integrated. Processes must be well designed and contains at least three separate levels of control. Sets of processes must be applied for managing and performing the stages in the system's life cycle. So, an effective aligning and connecting of objectives, processes and people is important and must be managed by at least three levels of control;

The following requirements and criteria were set according the basics of project management:

7. The research of Prof. Jaap Boonstra proves that organizations must use the development (system) approach in projects;
8. Different studies on projects and project management show the importance of the involvement of the principal, the supervisor and the end-users. So these parties must be involved;
9. At the beginning of a project the starting points must be defined. The customer must determine the problem, the solution space and the requirements;

10. Aspects of time, cost and quality must always be taken in account;
11. The role fillings in and from outside the project must be clear;
12. True leadership must be deployed to influence the culture of the organization and control resources and efforts for an outstanding performance;
13. To obtain lasting and outstanding results expectations and demands of all parties involved must be looked at and well-balanced;

The following requirements and criteria were set according the basics of Systems engineering:

14. Communication about products must take place by means of 'sharing' information with a real time information system and a constantly aware of each other virtual activities;
15. The focus must lie on policy analysis of technical, administrative, operational and administrative requirements of suppliers, users and customers (thinking in abstractions);
16. The iterative specification process for top-down development and the bottom-up realization with the verification and validation must be supported and executed. Specifying must be realized at the right level in the organization and with the right people.

These requirements were defined for project management. However the question was to find the criteria for an improved IPM by applying SE. Therefore the SE requirements were confronted with the bases of the SE theory in section 2.2.3. All requirements for project management were also important for applying SE.

3.2 The extension of improvement of Integral Project Management by SE.

In order to define the benefits and successes of methods for an organization it was important find out the connection between the different organizational layers. All methods or approaches needed to add value for the organization. To determine the expected extent of improvements and to find possible ways for applying SE in projects the outcomes of the theoretical analysis of project management mechanisms and SE benefits in section 2 were combined and filtered towards the RWS situation. The organizational goals were also collected from the business plan and diary 2012 of RWS (section 2.2.5). By comparing and combining the different layers in the organization contradictions, mismatches and matches were determined. The contradictions and mismatches needed to be investigated and matches had to reinforce each other. To find the improvement potential of the organization the different levels of performance were also analyzed (organization, process and job analysis) by using the nine performance variables. The possibilities for improving the knowledge base productivity were determined by using the IO scan. The results of the different analysis were grouped into goals, performance and knowledge themes.

3.2.1 *Connection between business goals and project results*

The theory in section 2.2.1 demanded that results of the organization had to increase business benefits. By analyzing the connections between the different layers the improvement aspects for projects which are reinforcing the business position became clear. To define the situation of RWS an aggregation was made based on the balance scorecard aspects, RWS objectives, project management success factors and the SE benefits. The findings were illustrated in Appendix 3

which pictures these combined value aspects. The figure below illustrates the detail of the RWS organization (level) values.

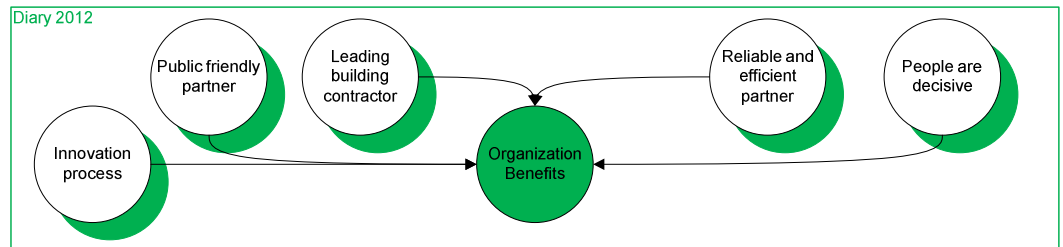


Figure 13: RWS organization (level)

By analyzing the different aspects it appeared that the vertical connections between the balanced scorecard, the RWS diary 2012, the project management success factors and SE benefits did not fit and that interfaces were not connected. The goals which were determined in the business plan and diary 2012 of RWS did not meet the objectives of the balanced scorecard. This explained why goals are being perceived as multi interpretable and subjective. Therefore the contribution of daily activities towards the organizational goals is not properly secured. To improve the effectiveness of the organization clear success factors and business objectives (municipal government balanced scorecard) are needed. So by introducing specific impulses the project organization will be able to control and deliver desired results. For example the development of knowledge in the organization was set as a priority in the departments and was directly executed by the staff. This showed the effect of setting directions from the board.

For analyzing the project management control aspects was looked at the theory in section 2.2.3. The intended project successes had to meet the organizational value aspects. The figure below illustrates values of a project organization (level).

When we look at the question to what extent the method of SE can help to IPM a conclusion is that without proper impulses, indicators and associated controls the implementation of new methods and processes is not effective. However the development of organizational goals was no part of the scope of this research.

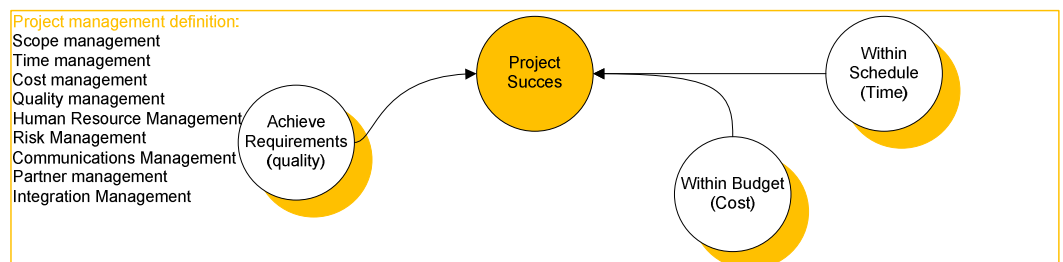


Figure 14: Project organization (level)

The results from the Chaos report of the Standish Group and the aspects of the project excellence model were based on research of several projects. An important success factor for projects proved to be the execution of a system approach. So, a layered management structure is essential for success. There must be no hierarchies in these layers! People have to think in processes. The organizational layer sets the project direction. The strategically layer plans the project. The tactical and operational layer manages the possibilities and results. This management

approach is based on the development (system) approach conform the research of Prof. Jaap Boonstra (section 2.2.3).

When we look at the question to what extent the method of SE can help to improve Integral Project Management a second conclusion is that the commitment and use of the development approach is essential. The execution of organizational, strategically and operational and tactical management by a multi-layered management structure is already in progress. The IPM-model is based on collaboration and in itself is not hierarchic. Managers must be assisted to be aware that a development (system) approach must be applied. Thinking in processes will remain difficult for former technical employees who were accustoming to the engineering approach. To change the direction of team's real leadership is needed in the projects. To execute the development approach and the SE method the quality and competences of people must be increased. Also the learning cycle must pass a few times to gain experiences. To accelerate these cycles the help of experts will be needed for coaching programs. In the organization a small group of experts is available. Available resources including the quality and competences of the people and teams are not monitored yet. The current tool for recourses should be upgraded and completed. The measuring of needed recourses can be done on clear criteria.

The theory of the method of SE was analyzed (section 2.2.4) and appeared to have a lot of key elements and benefits which matched the business success values and the current organizational goals. It appeared that the development (system) approach must also be applied to practice SE successfully. By improving the management of projects the indicated SE benefits can be applied for the organization. This offers the following possible SE benefits for project management:

- Better user involvement and satisfaction;
- Information for decision making;
- Approval and authorization of requirements;
- Time control by work package management;
- Realistic expectations by validation agreements;
- Shortening turnarounds by concurrent working;
- Ability to learn and reuse knowledge;
- Better development and participation of employees;
- Smoother partnerships with suppliers;
- Controllable processes and results by explicit working and verifications;
- Reducing costs by applying the life cycle approach and by preventing failures.

3.2.2 *Results of the nine variables performance method*

To have a good insight and knowledge of the business situation and its performance was essential. Changes and activities in an organization had to result in increasing business benefits otherwise they were unnecessary. The results of the nine variables performance method are shown in Appendix 1 Table of Nine Performance Variables (Performance Needs). The theory of this method is shown in section 2.1.

This analysis was based on the current situation with respect to a more optimal situation (Integral Development Domain). The result indicates the potential for improvement. The findings of this analysis were:

- Goals and the direction of RWS are not clearly translated towards controllable success factors and performance indicators for projects.

Measurement of performance must be done on criteria, dashboards and standards;

- Links between the IPM organization and the building processes must be determined and described;
- Processes must be optimized for the building projects and linked to the organization goals, requirements and key processes. Interfaces and work packages in the processes must fit and be controllable;
- Building processes need to be monitored and controlled on a structural and standardized way which is based on clear goals and criteria. Without the ability to monitor and control (plan -> do -> check -> act) the improvement circle is not closed and no progress is achieved. Effectiveness and quality is not assured. Performers determine their goals on individual experiences and estimations no expectations, produces and standards are available. Adjustments are only possible afterwards or indirect. A proper verification and validation procedure is indispensable;
- The start of the optimization conform the theory of CMMI (section 2.4.2) is an important first step for change;
- Process requirements and organization goals must be related to the jobs in the building projects;
- Job outputs and standards have to be developed and linked to processes and organizational requirements;
- Resources must be clearly linked to activities. Job activities steps must be unified, determined and sequenced for the people. Now the sequencing is done by knowledge of employees and project managers. Required knowledge/skill to achieve the job goals is difficult to determine;
- Available resources including the quality and competences of the people and teams must be accessible. Measurement of quality and amount of resources must be done on clear criteria. For people it is difficult to decide if the meeting job goals are reached. People need to know the expectations to be able to improve or adjust their skills and competences;
- Performers need to know the priorities.

3.2.3

Results of the IO scan for improving knowledge based productivity

In order to diagnose the potential of improvements regarding the knowledge based productivity the situation was analyzed. To determine the possible improvement aspects for knowledge based management different employees of the department Realization Infrastructure filled in the IO-scan. The results are shown in Appendix 2 Results IO scan. The analysis showed the need for the improvement of the learning capability of the organization. To improve the learning capability the information architecture and the knowledge re-use also had to be improved. The figure below illustrates the average results of the group.

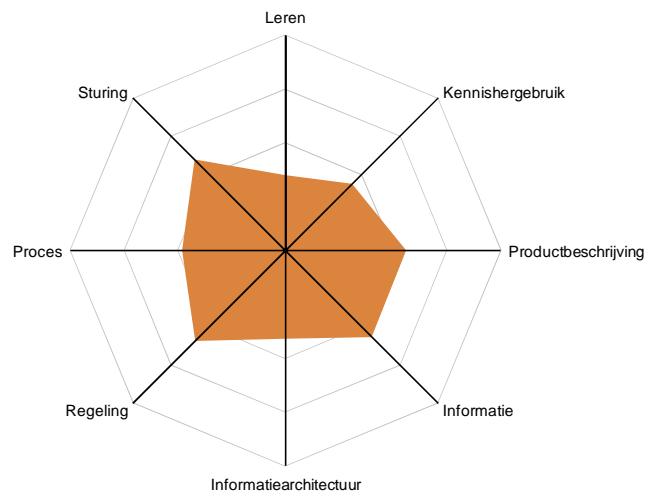


Figure 15: Results of the IO scan

This analysis showed the current situation with respect to a more optimal situation. The result indicates the potential for improvement. The findings of this analysis were:

Learning (Leren):

- Possibilities for development as a team and organization are not clear;
- The organization design must be more dynamic to be able to work with the processes;
- Single loop learning is not developed or managed for the main process. People discuss their needs with the staff without proper measurements. Human problem-solving is a daily practice;
- New knowledge is needed for the proper execution of tasks and the improvement of learning processes. Knowledge has to be externalized from the heads of employees, modeled and combined into new collective knowledge;
- An appeal must be done on the ability to think in abstractions.

Information architecture (Informatiearchitectuur):

- There is no equipment for integral electronic data transfer. Data is constantly being introduced, copied and paste over. Everyone manages its own working files;
- Data transfer is not done by standard formats that are provided by suppliers of ICT systems. Work files cannot be easily exchanged by ICT enabled information sharing;
- Semantic tools are missing to help establish relationships between data elements which are needed for the projects;
- In the current situation much time is lost by searching for required information and standards. RWS cooperates with Coins (Building Information System /Building Information Model) but no results are available yet.

Knowledge re-uses (Kennishergebruik):

- Knowledge is mainly available in personal files and copying and the recycling information from old projects is done mainly individual;

- Knowledge must be extended with knowledge of functions, processes throughout the lifecycle and targets to become more flexible and modular;
- Semantic software should unlock the knowledge of the different life stages and monitor the meet of customer goals.

When we look at the question to what extent the method of SE can help to improve Integral Project Management a third conclusion is that single loop learning is not developed or managed on clear criteria and with solid feedback loops. Explicit knowledge should be modelled and combined into new collective knowledge. There is no equipment for integral electronic data transfer. Semantic tools should help to establish relationships between data elements for a basis of a project management ICT tool. The developments of new Building Information Systems/Models (BIS/BIM) are required.

3.3 The measure of effects and performances of SE in projects.

To find out the possible measurement of results, the SE benefits for project management had to be developed towards associating key performance indicators (KPI). This ensures a controlled creation of value for the organization. This KPI's must be implanted by the staff of the organization to manage and control the project portfolio. Results of current performances were shown in the management dashboards (section 2.2.5). Extra project performance indicators can be added in the future to direct this workflow or a special project dashboard has to be developed to direct the projects and the appliance of SE. The table below is an example of KPI's for controlling and monitoring the effects of SE. Targets can be adjusted to improve performances. The SE benefits were described as KPI's. The associating measure, target and frequency are examples and have to be set by the staff in collaboration with project management.

Key performance indicator	Measure	Value (target)	Frequency
Satisfied users	Percentage satisfied users by a report	≥85%	Annually
Information quality	Check by external expert	Average score green	Annually
Approved requirements	Check on acceptance requirement spec by stakeholders	≥85%	3 monthly
Exceeded time limits of workflows	Check on amount of exceeds	≤15%	3 monthly
Expectations met	Check on acceptance validation report	≥85%	Annually
Shortening turnarounds	Average project duration	≤28 months	Annually
Improving knowledge reuse	Average score IO scan	≥80%	Annually

Key performance indicator	Measure	Value (target)	Frequency
Development and participation of employees	Percentage of employees gone through training	$\geq 45\%$	Annually
smoother partnership with suppliers	Average amount of unwanted contract amendments	≤ 20	3 monthly
Controllable processes and results	Check on acceptance verification report	$\geq 85\%$	3 monthly
Reduce project cost	Amount of average cost exceed	$\leq 15\%$	3 monthly

Table 1: KPI's for SE benefits

3.4 The management of project- and SE processes towards the IPM-team

To analyze the management of the project- and SE processes the current processes were analysed by usage of the IDEFØ method. The IDEFØ result defined the needed changes and gave a clear picture of the situation (analysis current situation). To find out how to guarantee the best results for the customer the covering of the project management requirements which are set in section 3.2 were required. So it becomes possible to achieve the SE benefits which were set in section 3.1.1. To inform the project director during the phases the three layer approach proved to be the solution (section 3.1.1). And to control the results the use of KPI's (section 3.3) proved to be essential.

3.4.1 Results of the IDEFØ analysis

In Appendix 5 the IDEFØ for the current situation was created based on the "Stappenplan SE", the guideline and "Werkwijzer aanleg". These guidelines were the available tools for project teams. Also the results of the interview were input for the design of the IDEFØ. After indicating the current situation improvements were processed (in colour) for the design of the new situation. To be able to achieve desired project results it's important to direct projects as a building director. Ratios, KPI's and criteria should be used for guarantee project results. A project starting document should be the mechanism for project viability. Quality standards, requirements and templates should be available as an input for the building processes. An overall quality system should guarantee the results of the building processes. Integral project management software should be used for projects. Project- and building information must be available through (semantic) databases. The current building processes are based on experiences of the former engineering approach. Project management processes are not elaborated and should be added and described.

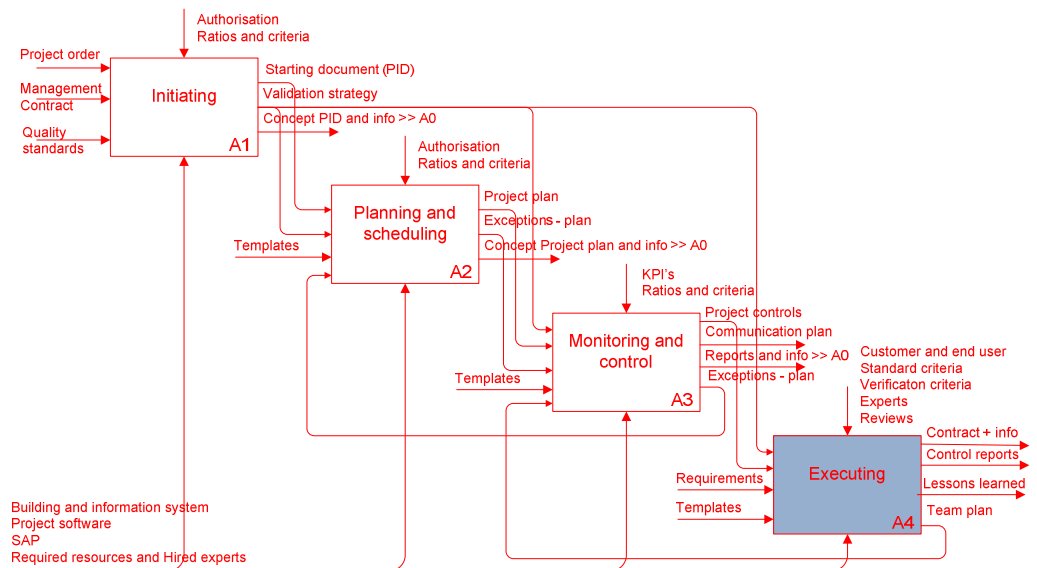


Figure 16: Project management process

To improve the quality and effectiveness of the sub-processes standard input information should be developed. These changes will make a fundamental change in the execution of projects. The controls must be based on criteria and acceptations of the customer and the end-user. The design process should be upgraded with a functional analysis. For the functional analysis and design a loop towards structuring is needed. Because RWS is already adjusting the processes according the CMMI standard it is not useful to look at underlying processes. The sub-process of designing the system is an iterative decomposition process.

3.4.2

Results of World class performance analysis

In Appendix 7 the results of the world class performance (WCP) analysis were illustrated for the current situation and the improved situation. The WCP figure illustrated the process controls and improvement loops. The main process was changed for the improved situation by IDEF0. To illustrate this radical change a fragment is shown in see figure below. The controls in projects are based on expert's opinions. Experts are used to determine the project quality by the project directors at the project stages. There different quality checks in projects are being used to cover the responsibility of RWS in contract towards contractor and internal management. Reports are sent towards the program director. Since 2010 there are also additional quality checks (QCF) introduced. These checks are also executed by a team of specialists.

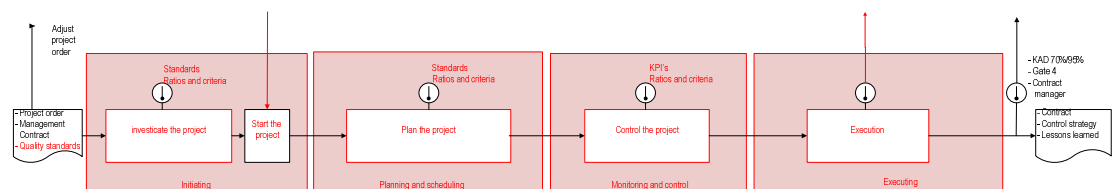


Figure 17: Main process control

To improve the quality of processes and results it's necessary to verify during the process and at the transition moment between processes by using standard quality checklists. To be able to redirect projects intermediate and continuous controls are

required. This is possible by working with a central project- and information system. To improve the quality of the checks the reviews must be based on standards, criteria and ratios. Special loops are needed to improve the quality of the standards and templates which are used in the process. An active link between the main processes, the as managed- and the as learned layers are vital. These feedback loops must be applied by nationally operating experts groups. By apply this changes IPM-teams are better equipped and controlled to perform the project management processes.

3.5 The connection of processes to IPM-roles within the project phases

The ISO/IEC 15288 in section 2.2.4 provided processes on different layers that support the definition, control and improvement of the life cycle processes within an organization or a project. The technical processes were linked to the IPM-role technical management except the process for stakeholder requirement definition and surrounding aspects. These processes were linked to the IPM-role surrounding manager. The project processes were linked to the IPM-role manager control except the process of decision making. This process was linked to the IPM-role project manager. The project manager is also the linking pin towards the project director.

The guidance SE and the associated roadmap SE were used to determine the current and desired processes in the projects. The translation of the processes (IDEFØ) towards the activity diagram indicated the connections between the processes, activities and people (tasks and roles). In Appendix 6 the results of the activity analysis are illustrated for the current situation and the improved situation. The activity diagram illustrated the activities on which the different IPM-roles are responsible. This model can be used as a tool for linking activities to IPM-roles. In this diagram the link between process and jobs was visualized. In the improved situation the team must perform according the requirements of section 3.2. This results in another project start. The leadership of the IPM/team must result in the development focus in the team. Also the multilayer management must be performed. The recruiting of team members must be done on requirements and qualities. Project information and controls must be integral and based on the product life cycle. The usage of standards and modules must be applied and improved. The awareness of the needed activities and responsibilities should have consequences for the daily activities and behavior. The development approach has consequences for the required quality and competences of team members and IPM-roles. For the current situation the following tasks are connect to IPM-roles within the project phases (analysis current situation):

The project director must set targets and goals for the project team which includes the support and appliance of the development approach by the project team. Required resources and tools must be approved by the project director. Information must be provided to make better integral decisions. Also the chance for success increases substantially. The activities of the project director are:

- Initiating the project;
- Deliver project information documents;
- Negotiate about project managers mandate;
- Describe project brief;
- Review project plan and scope;
- Authorize plan;
- Estimate the results of the Quality Contract File (QCF) scan 1;
- Authorize Customer Requirement Specification (SRS);

- Estimate the results of the Quality Contract File (QCF) scan 2 and 3;
- Estimate the results of the Gate review;
- Estimate the results of the tender board.

The project manager must arrange the circumstances for applying the development approach. He also ensures the required focus in the team. When the plan is authorized a careful composition of the team is important. A functional interaction with the project director is required. Without quality leadership and a solid relation with the project director project success is difficult to achieve. Decisions must be submitted on the basis of comprehensive considerations. The activities of the project manager are:

- Make agreements with project director;
- Compose team;
- Describe project plan and scope;
- Install and direct the team;
- Determine the starting point of the system design phase;
- Determine the starting point of the market approach.

The control manager is the key-role for the project control aspects TMQCI. The changes in this area are the life cycle approach. Because this approach is needed for all roles there are a lot of added necessary interfaces and interactions. This role is central in the IPM-cooperation model. The activities of the control manager are:

- Set for the project;
- Structure the project;
- Combine information to overall project information;
- Risk management;
- Life cycle costing;
- Planning management;
- Configuration management;
- Storage and access to project information and knowledge;
- Make reports.

The surrounding manager had a lot of interfaces with the project manager and the technical manager. The dialogs are important activities in the iterative development process with the technicians. The required and needed project results must be determined by stakeholders. The validation strategy is input for the development process. The project manager and director must decide which requirements are rewarded. This requires negotiations. The activities of the surrounding manager are:

- Analysis of stakeholders;
- Analysis of customer needs, functions and performances;
- Dialogs with stakeholders;
- Determine validation strategy and criteria;
- Describe Customer Requirement Specifications (CRS);
- Dialogs about adverse effects;
- Validate the products.

The technical manager must find out the solution space for the stakeholder needs by a top-down development approach. The solutions have to meet stakeholder expectations. Validation and verification strategies have to match. The technical team delivers information and consequences towards the surrounding team. The team also assists the surrounding team in the dialogs. The use of generic building blocks is a matter for the technical manager. This improves the re-use of knowledge

and guarantees a certain quality and uniformity of solutions. The activities of the technical manager are:

- Analyze problem and expectations;
- Analyze technical systems;
- Structure and allocate requirements;
- Define standard modules and project sets;
- Determine V&V strategy;
- Analyze technical systems;
- Structure and allocate technical requirements;
- System designing;
- Describe System Requirement Specification (SRS);
- Validate products.

The contract manager has to determine an appropriate purchase strategy to launch the project towards contractors. This strategy must support the development approach. Based on the risks the detailing of the decompositions will be determined. He also assists the tendering process. The risks, verification- and validation strategy are input for setting up the contract controls. The activities of the contract manager are:

- Determine purchase strategy;
- Determine tender strategy;
- Determine decomposition detailing;
- Describe contract scope;
- Complete contract formats;
- Describe contract;
- Validate products.

3.6 The changes for the different IPM-roles and the teams

To find out how the needed changes and expected effects in the prior sections the theoretic findings and results of the analyzes were described. To find out the changes for the different IPM-roles and the team these findings were projected towards the current situation and summarized for different IPM roles and teams. The method of IPM was developed in the past few years. The model was designed task oriented. The strength of the method was the external focus. The method suited the desire to operate public friendly. However the method was only developed as a framework. Other methods like PRINCE2 are worked out in descriptions for project teams. Also the certification of project managers is possible. Some project teams use the ISO/IEC 15504 and 15288 for their approach (theory, section 2). These norms are applied to guarantee the process quality of the contractors. It seems logical to upgrade the IPM method to a uniform international standard for project- and portfolio management. The activities per IPM-role were treated at the previous section. The major changes for the IPM-roles are expected at the following areas:

- Working with performance indicators;
- Ensuring and supporting integral decision making by directors and customers;
- Explicit attention for the project start-up phase;
- Applying a development approach;
- Compose teams on requirements and skills;
- Improvement of role-filling by increasing knowledge and skills;

- Dialoging with stakeholders, the customer and end-users;
- Apply and determine a validation and verification strategy;
- Applying a top-down development approach (thinking in abstractions);
- Show strong leadership;
- Improving learning and knowledge re-use;
- Applying proper project information systems;
- Study and explore new process descriptions and guidelines;
- Improve the internal quality controls (loops);
- Develop generic building blocks, standards and ratios (with the help of experts);
- Besides plan and do also check and act to become a self-controlling (project) organization;
- Being able to apply life-cycle approach in projects.

3.7 The expected benefits of the proposed measures

In the prior sections the theoretic approach and the results of the analyzes illustrated the needed changes. To determine the expected benefits of these measures a summarize is made of the expected effects. These effects were also mentioned in the theory of at the results. After the summarizing the benefits the overall will be determined. The following benefits are expected by applying the proposed measures:

- Better monitoring and control of project. Projects will meet expectations and are delivered within time and budget;
- The effectiveness of the organization will increase;
- Partners and stakeholders will be satisfied with the project results;
- Knowledge productivity will increase;
- The appreciation by the public and the politics will increase;
- Project successes will increases substantial;
- The increasing complexity and size of projects is manageable;
- Uniformity in project approaches for improvement of re-use and flexibility;
- The quality and attraction of workforce will increase;
- The amount of product failures will reduce;
- Decision making in the organization will be based on clear information and opportunities and consequences;
- The quality and accessibility of information is assured;
- Improvement of the management of risks and opportunities;
- A better transfer of projects towards contractors without losses is possible.

The expected benefits of the proposed measures match the goals of the different organization layers and the factors of the balanced scorecard. A lot of problems were also mentioned during the interviews. The proposed measures will contribute at the improvement of the capability and maturity level of the organization. It will be a start for solving the struggle of project teams with the techniques and the adaption at the changed environment.

3.8 How to improve the results by making the best use of the method of SE

To make the best use of the method SE the current business management objectives has to adjusted or transferred to connect with the project department. The project management processes and management layers have to be linked to the (technical) SE processes. A multi-layer development approach is required for project successes and a proper appliance of SE. The knowledge based productivity

must improve by increasing the learning ability, knowledge re-use and information architecture. By introducing KPI's the directing, monitoring and controls will improve the stimulation of use of methods. Solid project management processes are required in addition to the current SE oriented process descriptions. The employment of capability and maturity methods is a good start in the organization to improve the maturity level. The activities in the project phases are modeled and described in the previous section. This model and description helps to give more substance to the SE method. The results are help full for a more effectively way of working towards primary goals. By giving more insight in the role-fillings the missing knowledge and skill will become visible, so that it can be adequately resolved.

Next section will look at the practical effects of these results. It is important to look critical to the intended goals and the measurements for a good result.

4 The discussion

The results of the analysis in section 3 are now considered on the effectiveness in the organization. To determine the effects of the result the summary of the interviews and the requirements for the new situation (section 3.2) are used as a review guideline. This section systematically discusses results of section 3. The questions are treated in the same order.

4.1 **The requirements and criteria for the improved IPM approach with SE.**

The requirements in section 3.1 are found by combining fundamental criteria for success. In section 3.2 the different layers were compared to each other. No doubts occurred at combining and linking these layers. Also the comparison between the method of IPM and SE indicates that both methods fit together. The requirements seem to be clear but are not exhaustive because it is based on accepted general success indicators. Every item is recognized in the field of project management. Also no doubts were found in the literature and acceptance is expected in the organization. So, this appears to be a solid framework for the verification of the results. By checking the propositions before execution with the requirements their effectiveness will be assured. The only weakness is the lack of concreteness. Not determined specifically yet! The value factors of RWS are this complicates the factual value of the verification.

4.2 **The extension of improvement of Integral Project Management by SE**

The development of departmental business objectives for projects to create a controllable situation has only indirect effects towards the appliance of SE. It is a measure which is based on business principles. Substantial effects are expected but depend on the degree of commitment of the staff and the way of implementation and execution. To connect and combine the different organizational layers in reality is difficult. The organization is not focused on creating business objectives. The main organizational focus will remain multi-interpretable and subjective. Therefore project departments should develop their own (local) associated business objectives to create a controllable situation. The opinion of staff members is expected to be restrained because this measure changes the current management approach.

The other suggested explicit change towards a development approach is the key for projects successes at RWS and the proper use of the method SE. Research proves the positive effects on project successes. This measure is clear and logical. The success rate of projects will increase significantly to ca. 75% (+50% experiences in the building field). The staff should make the explicit decision, and this will have extra consequences as mentioned in section 3.2. This approach is already supported by the ratification of the guidance SE 2.0. The indicated improvement benefits of SE appear to be very useful for IPM. Most benefits are still left untapped. Especially the aspect of decision making can mean a great improvement with SE. The benefits of SE versus IPM are comprehensive but difficult to measure. By monitoring parameters and results in projects the benefits can be reported and quantified.

The analysis provides a few different but coherent adjustments. Some adjustments are already in progress. The outcomes clarify that the organization is started a complex and long range changing route. A proper monitoring and controlling system

is required to direct the organization and the staff. These results are general guides for the organization. Therefore a phased implementation plan is required. The results of the 9-var analysis and the IO-scan are useful as a framework and guidance for the improvements. The outcomes give a complete picture of the improvement aspects which are needed. For the discussion of the main question they will be used as input.

4.3 The measure of effects and performances of SE in projects.

The KPI's in section 3.3 will monitor and control the performance of projects. The effects of KPI's in organizations are well accepted and applied. They are already in use at top of RWS. The targets must be set on experiences towards realistic figures. The proposed KPI's are examples which are based on the project success factors. Not every staff member will be able to implement and control KPI's without extra attention. By using the instrument of KPI's a change of culture shall progress in the organization. It is virtually impossible to achieve the implementation of KPI's in a short time. Also a matching connection is needed between the project organization and the formal organization (section 4.2). To work with KPI's a more businesslike culture is needed. The management must support and embrace this approach. The KPI's were based on proven success factors for projects so the result should automatically lead to another culture and way of working. By implementing specific project KPI's the organization will deliver more project successes and is able to measure and control the effects and performances of SE in projects.

4.4 The management of project- and SE processes towards the IPM-team

The results of the IDEF-0 and WCP analyzes are clear. RWS needs to complete the descriptions and implementation of project processes. The SE processes are described by the guidelines but are not connected and embedded in the IPM method. The answers in section 3.4 are clear measures for the project organization. The effects of these measures are expected to be substantial but it is not possible to quantify. No doubts occurred concerning the effects of adjusting the processes and the quality loops. Also the use of standards and ratios for pro-active controls and quality improvement is required. Most solutions are already put in motion and need to be further directed by the measures of section 3.4. The improvement groups at RWS need to use these results for input. This requires an overall coordinated by the program management. The research question is adequately answered.

4.5 The connection of processes to IPM-roles within the project phases

The models in section 3.5 in combination with the descriptions are a clear start for illustrating the desired approach towards IPM-roles. The models are based on the current guidelines so project members should recognize the processes and activities. The desired situation is also modelled and described. The activity diagram illustrates the activities on which the different IPM-roles are responsible. This helps the IPM-roles to find their playing field. The awareness of the activities and responsibilities should have consequences for their daily activities and behaviour. To assist team members an associating description clarifies the models per role. The models were made for the internal project organization. By addressing project processes to roles awareness and required assistance will be clear. This is the starting point for the system oriented approach which is required at projects in RWS. To improve the performance of team's proper descriptions must be developed. First the improvement of the processes and controls should be completed. Until then this models will be sufficient to start the awareness and insights in the needs. The

introduction of KPI's and the adjustment of the vertical alignment of organizational goals are essential to stimulate and control these changes. The effect of these measures is a better role filling and a further improvement of execution of the method SE.

4.6 The changes for the different IPM-roles and the teams

The question was intended to reveal the changes for project members. The results are summarized and are logically established from the previous results. The question is answered on a general qualitative basis, so concrete changes for members should be individually assessed. The results are endorsed by the theory, the requirements and the outcome of the interviews. No discussion is expected about the changes. Only the interpretation could lead to misunderstandings or avoiding behaviour.

4.7 The expected benefits of the proposed measures

The question was intended to convince people to apply the proposed measures. The results are summarized and are transferred from the previous results. It remains difficult to prove that the benefits are fully attributable to the use of SE. Research of several projects shows that substantial benefits are possible. Only the circumstances and situation are not equal to the situation at RWS. The benefits are likely to achieve but are estimated. They are not concrete or expressed in figures. Some discussion or disagreement is expected, but most items were also mentioned during the interviews. Finally, all benefits are mentioned in the theory.

4.8 How to improve the results by making the best use of the method of SE

It was not feasible to make a clear description for applying SE for project teams. The development of best practices, models and frameworks is still a great challenge. The expertise in RWS and in the field must be used for the further development of useful tools. Anyway the models in appendix 5, 6 and 7 are a helpful starting point for a first step towards a better performance in project teams by applying SE. These model and descriptions are reasonable way of expressing the required method on basis of accepted models. Information about performances and figures are not monitored and centrally processed. So it was not possible to give quantity analyses with charts. In the future it will be important to demonstrate and prove the effects of changes. The results have a wide scale of impact in the organization and offer a solid support for project members and the management. The results fit within the current framework of changes in RWS. Most changes are already put in motion on small scales. The ingredients are already available but the consistency and connections are missing. Overall coordination and focus is required on short-term. The execution of the measures has to be made based of an implementation plan.

5 Conclusions

The objective of this research was to ensure and the improvement the integral approach and to improve project results by the execution of SE. The question was whether SE can help you and how to apply the method in IPM. To create an overall picture of the situation and methods the selected topics were considered at the analysis. To meet my master aspirations the opinion is based on an overall consideration.

During this research it became clear that the problem and the different methods are comprehensive and complex. The overview in the theory is helpful to become aware of the field and the global initiatives. The situation of RWS is recognizable in the field but the questions are not simply the answer. It is almost impossible to pick the right models, because the pros and cons are difficult to translate to the situation in the building sector. Approaches are originally from software development (product development). A lot of measures were found during the investigation. The potential of achieving results by a better usage of SE appears to be great. Only the difference between the building organizations and software houses are enormous. To be able to change the whole organization in a short period is impossible. A phased improvement path to increase the maturity of the organization seems to be a realistic and acceptable route.

The results of the analyses and the models are a solid basis to convince project teams to change. Also the associated change of culture suits the ambition of the organization and the projects. The results will help set focus towards the desired direction. When project teams read this report it will be indispensable to some imagination and knowledge to know what to do. Support and explanations is still needed. There appear to be a lot of dependencies. This explains why my supposition at the beginning that people find it difficult to make it work is true.

The theory gives a lot of grip on the situation. Fortunately, the organization is trying to use the available knowledge in the field. Only the situation in the organization (culture and knowledge) makes it more difficult to get off the ground. The connection between deployed activities and organization goals needs attention. Also the coordination and controls to the right direction are important aspects which are still missing.

6 Recommendations

The goal of this research was to develop a clear model for project teams. The problem and the different methods appeared to be comprehensive and complex. The current changes and developments of the organization are all part of a total solution which is indicated in this report. There are a lot of dependencies with the current initiatives and improvements. The result of this thesis approaches the purpose but further developments will be needed. To be able to apply the SE method at the best way the following activities are required:

- Implementation and development of KPI's;
- Further development of IPM;
- Implementation of the development approach;
- Arrangement of support for teams;
- Development and implementation of project processes;
- Descriptions of activities for role fillings.

All subjects are treated in this report but require some clear choices. This will give more focus in the organization. Now there are a lot of people and managers who have their own priorities. The quality of individuals is not appropriate for applying the method on a large scale and within a short period. A realistic program is needed for the improvement of different type of projects (simple, normal and complex). Also an implementation program is required for a strategic implementation of the improvements in phases. Because the field is comprehensive and the organization of RWS is complex not all parts of the changes are expected to be implemented fully and at once. So it should be necessary to make a selection of changes for the short period. First the organizational goals have to be set and aligned. Decision making about changes must be made explicitly and consequences and effects need to be examined and resolved. Other interventions should planned for the mid range period (2 – 3 years). Some changes need to be passed towards the long range period (3-5 year).

The lack of central and modern information systems and asset management makes it almost impossible to be in control and cost efficient. To improve the basis information for projects and the project scopes the implementation of asset management is required. This will be a major operation for the maintain departments. However it must have a high priority. This transition must not be underestimated! The SE approach demands a good facilitation by systems. The development of modules, standards and appropriate project tools is required to achieve the organizational goals. This development should be centrally controlled. Else every project remains inventing building blocks without proper controls and knowledge re-use.

To change the (traditional) approach of project teams and maintenance departments' expert are needed to help to direct the changing process.

7 The acknowledgements

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List of references

Literature:

1. Een onderzoek voorbereiden, Heinze Oost;
HBuitgevers / eerste druk, vierde oplage / 2006, ISBN 9055743739
2. Improving Performance, Geary A. Rummler and Alan P. Brache;
Jossey-Bass / Second edition / 1995, ISBN 0787900907
3. De kleine CMMI voor ontwikkeling, Jan Jaap Cannegieter en Rien van Solingen; Academic Service / 3e druk / 2009, ISBN-13: 9789012581288
4. Lopen over water, Prof. J. Boonstra;
Vossiuspers; (2000), IBN 90-5629-125-4
5. 50 checklisten voor project- en programmamanagement, Wijnen G. en R. Kor;
Kluwer, 2001, ISBN-13: 9789014079905 / ISBN-10: 9014079907
6. Projectmatig creëren 2.0, J. Bos & E. Harting;
NUR 801 – Management / herziene editie / 2006, ISBN 90 5594 399 1

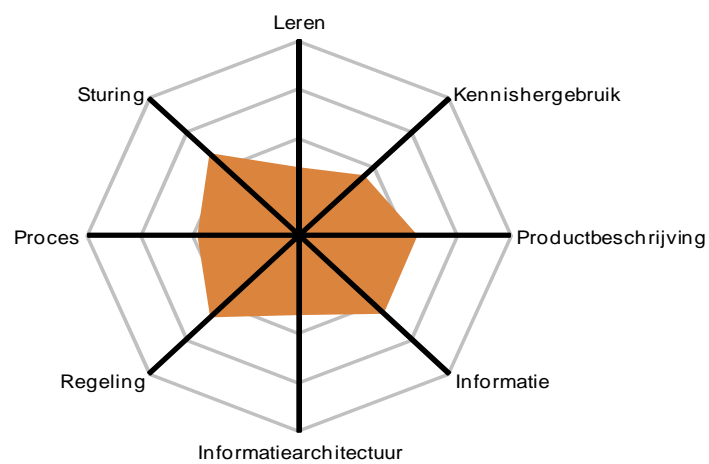
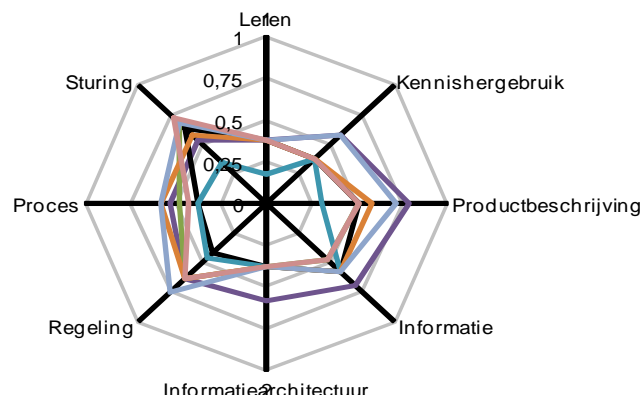
Internet:

7. Ondernemingsplan Agenda 2012, RWS;
Ministerie Verkeer en Waterstaat, June 2008, link;
http://www.rijkswaterstaat.nl/images/Agenda_2012_tcm174-224939.pdf
8. Rijkswaterstaat Toonaangevend opdrachtgever, RWS;
Ministerie Verkeer en Waterstaat, november 2008, link;
http://www.rijkswaterstaat.nl/images/Visie_toonaangevend_opdrachtgever_tcm174-230624.pdf
9. Leidraad SE, GWW-sector;
Werkgroep Leidraad SE / versie 2.0 / 2009, link;
http://www.leidraadse.nl/images/stories/RWS/bestanden/leidraadse_def_lowres%20%282%29.pdf;
10. Chaos report;
Standish Group / version 1995, link;
<http://www.projectsart.co.uk/docs/chaos-report.pdf>
11. Stappenplan Systems Engineering voor RWS projecten, RWS;
DI – RWS / Version 1.0 / 2009, link;
<http://www.leidraadse.nl/images/stories/RWS/bestanden/reader%20stappenplan%20se%20definitief%2020091127.pdf>
12. Balanced scorecard;
Balanced scorecard institute, link;
<http://www.balancedscorecard.org/Home/tabid/36/Default.aspx>
13. Platform project management;
ipma-nl, link;
<http://www.ipma-nl.nl/>
14. International council of systems engineering;
INCOSE, link;
<http://www.incose.org/>

Appendix 1 Three Levels of Performance

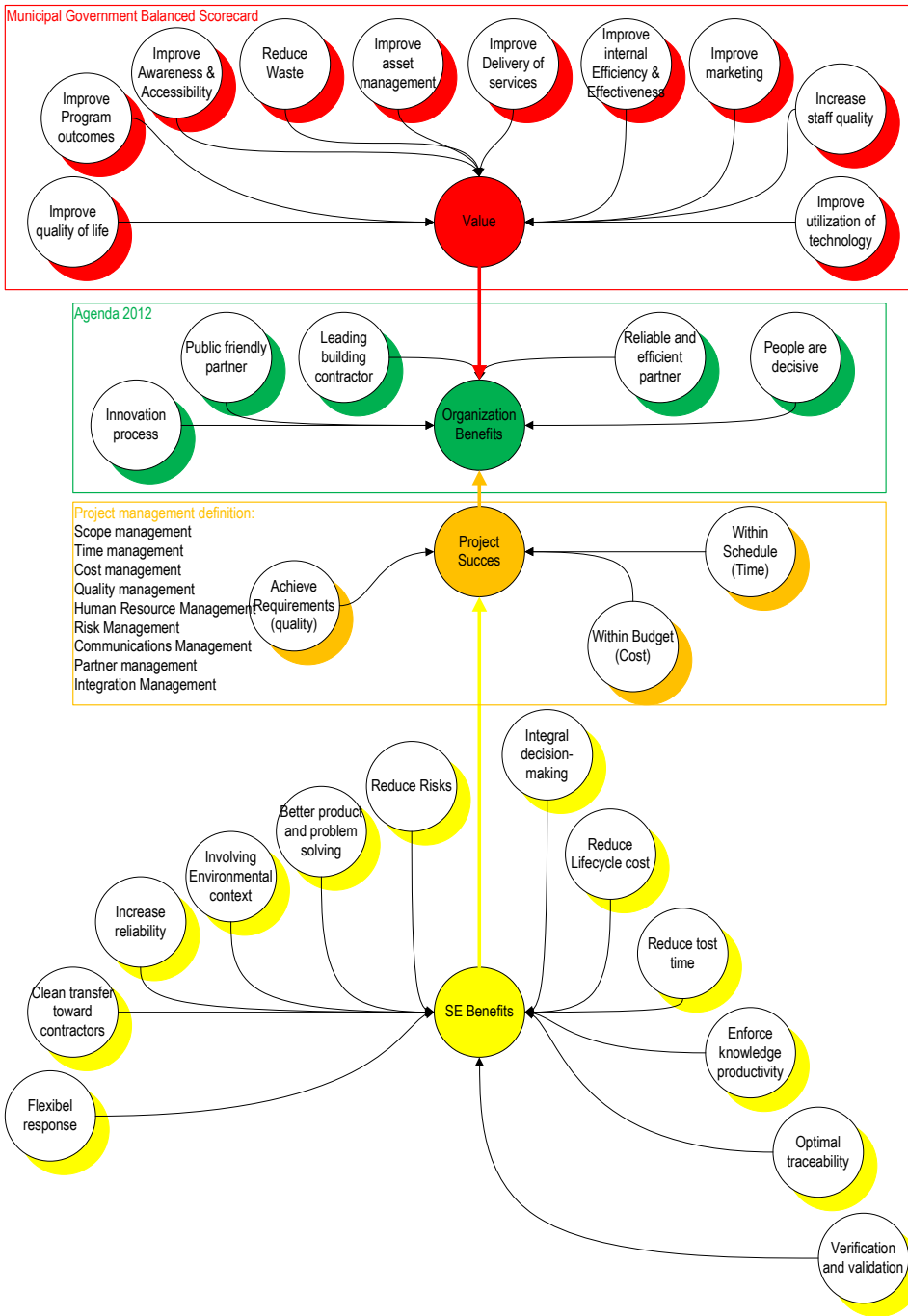
Performance Needs (Building infrastructure during preparation phase)			
Performance Levels			
	GOALS	DESIGN	MANAGEMENT
	<p>1. Goals are clearly incorporated in the Realization plan 2012. RWS is determined to become the leading, public friendly, sustainable contractor in the field.</p> <p>2. Strategy is based on political urgency to improve predictability, innovation and effectiveness of the organization.</p> <p>3. Strategy is translated into concrete goals for optimizing the project processes knowledge based productivity. Measurement of the results is done by the introduction of SLA's and management contracts.</p>	<p>4. A new triple ladder function house for project managers, staff and advisers let to transparent groups of jobs.</p> <p>5. Functions and departments in the building departments are based on the integral project management model.</p> <p>6. The flow of input and outputs in the building process are not determined. Interfaces and responsibilities are only determined for the integral project management roles.</p> <p>7. The formal organization structure is based on the tasks. The efficiency of the organization is improved but not optimal designed on the building processes.</p>	<p>8. Goals on gaining focus on the core, cost reduction, less but better manpower, improvement of purchase process and quality are set in the Action Plan 2012.</p> <p>9. The performance is only generally measured. Functions, jobs, sales, numbers are present but quality of people must be improved. A management dashboard is still in development.</p> <p>10. Resources are allocated in the tool Capplan. Information about skills and competences are not available for the organization. For ratios and needs are no accepted standards.</p> <p>11. Interfaces are generally or on IPM team roles managed...</p>
	<p>12. Goals for key processes and the building process are not clear and linked to the organization requirements. RWS is improving their processes. A verification and validation procedure is missing.</p>	<p>13. The processes are still not optimally designed and controlled.</p>	<p>14. Processes are not connected to business objectives and do not have clear goals.</p> <p>15. For controlling performance gate reviews, QCF checks and corporate tender boards are introduced at phase transitions. Monitoring and controlling is not standardized, uniformed and structurally arranged.</p> <p>16. Resources are not linked towards processes. The allocating is done on individual estimations.</p> <p>17. Interfaces management and risk management are not structurally embedded.</p>
	<p>18. No job outputs are linked by standards to process or organizational requirements.</p>	<p>19. Process requirements or organization goals are only reflected in the appropriate IPM jobs.</p> <p>20. Job steps are not unified, standardized or sequenced for people.</p> <p>21. Supportive policies and procedures or not available.</p> <p>22. The job environment is ergonomically sound.</p>	<p>23. The performers determine their goals not on expectations, produces and standards.</p> <p>24. For performers no clear signals and priorities are available.</p> <p>25. There are no good measures or tools to determine the needed quality and amount of recourses.</p> <p>26. Rewards are not based achieving clear goals for integration of processes.</p> <p>27. For people it is difficult to decide when the meeting job goals can be reached.</p> <p>28. The needed necessary knowledge/skill to achieve the Job Goals is difficult to determine.</p> <p>29. Performers have physical, mental, and emotional capacity to achieve the Job Goals.</p>

Appendix 2 Results of the IO scan



Numeriek resultaat	A	B	C	D	E	F	G	Gemidd.
Leren	38%	38%	38%	17%	38%	38%	38%	35%
Kennisgergebruik	38%	38%	58%	38%	38%	58%	38%	44%
Productbeschrijving	51%	51%	79%	31%	58%	72%	51%	56%
Informatie	58%	48%	69%	58%	58%	58%	48%	57%
Informatiearchitectuur	38%	38%	58%	38%	38%	38%	38%	41%
Regeling	42%	63%	63%	46%	63%	75%	63%	59%
Proces	38%	48%	53%	38%	58%	58%	43%	48%
Sturing	63%	68%	54%	35%	58%	68%	72%	60%

Appendix 3 Combined values for RWS



Appendix 4 Results of the interviews

Result from the interviews

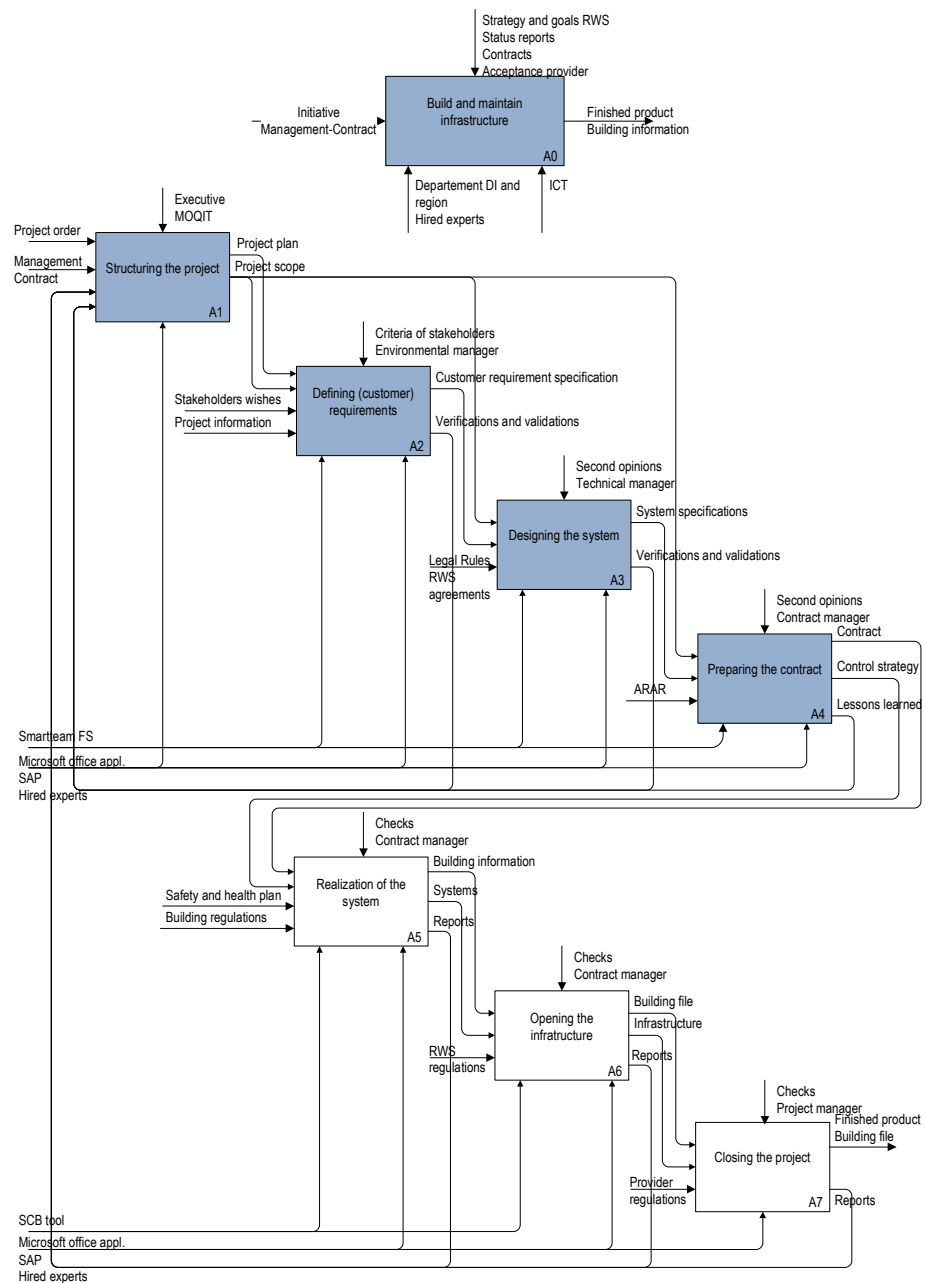
To get a clear view at the current situation of the use of SE in IPM teams several interviews took place with involved technical managers, advisers and project managers. The interviews took place on a confidential basis so this paragraph will illustrate the common situation at RWS building projects.

- Less supervision on the building site is applied by introducing integrated contract forms with a different division of responsibilities;
- The design process in project is transferred to the contractors. The core-tasks of the departments are changed. People are more acting in decisive tasks;
- RWS has no organizational quality system;
- No standards modules, requirements, approaches or generic project information is available for project teams;
- Reuse of practices or knowledge is not sufficient;
- In order to implement changes extra activities and initiatives of people need to take place. Now people mainly focus on their projects and let this opportunities pass;
- Available trainings do not facilitate changes;
- New project phasing is necessary for the interactive top-down process;
- People and staffs do not have a clear overview and awareness of the organizational situation and matters going on. The development of people and teams are not structural managed and measured (HRM). No comparisons are possible. The development of numbers and ratios are needed;
- A proper control of the projects is essential. Decision making is still difficult and not integral addressed. The key is to make the performances measurable;
- Many decisions about changing are made implicitly and additional consequences and effects are examined and resolved;
- Before the start of the project team often decisive decision making already took place and positions were taken. The teams should be earlier involved. The most advantages are at the beginning of projects;
- The innovative SE approach must be developed. Goals and expectation must be shared. For project no organizational models and information is available;
- Information of assets is not present and accessible. When adjustments are required the SE approach difficult to apply because there is no information (reverse engineering);
- Most teams are not ready or capable to execute changes. First SE must be understood to use the method. An abstract approach requires a higher level of work and thinking;
- The benefits of SE are not clear. The proper use of SE must be demonstrable;
- Teams need a visual tool that helps to give a clear insight in the SE method for IPM;

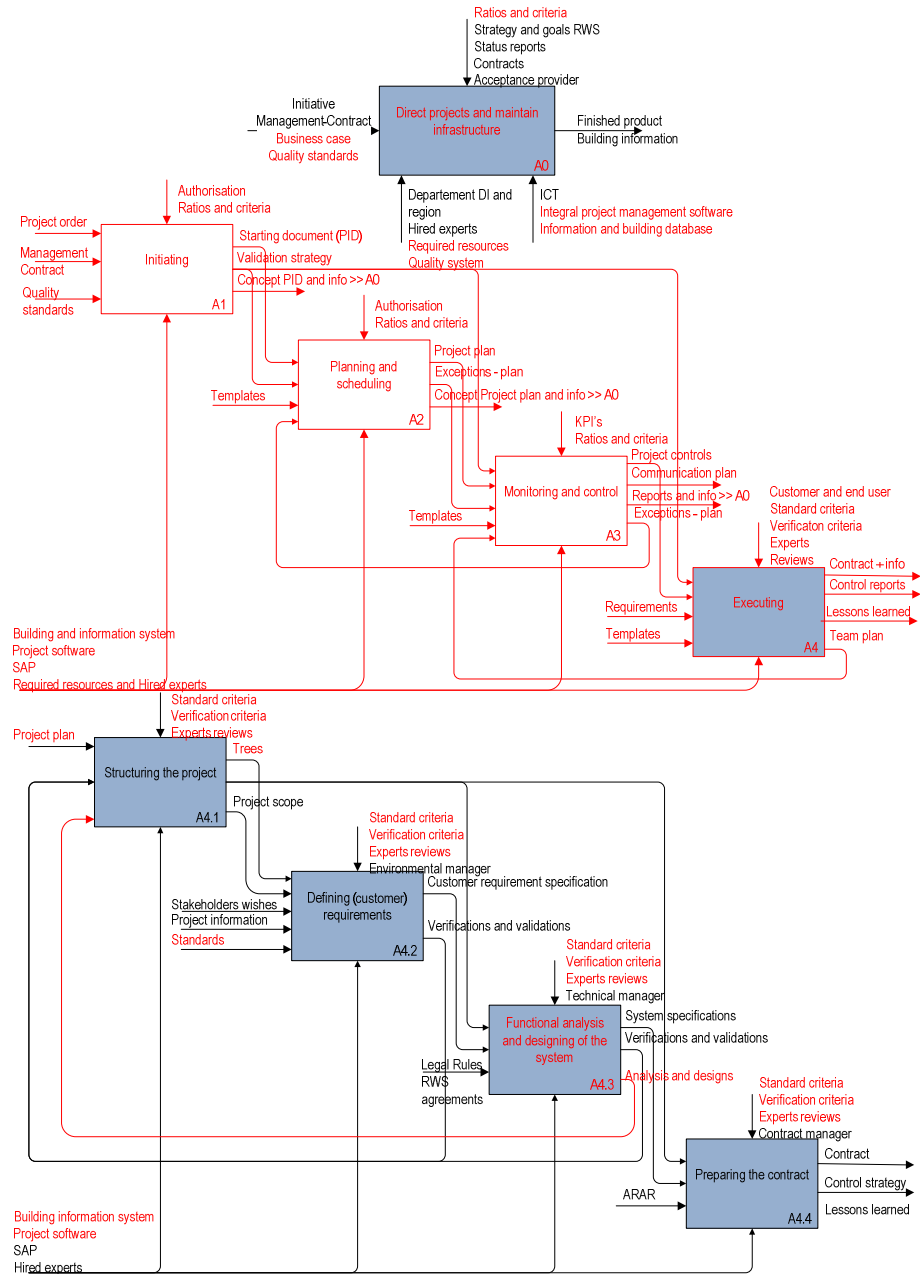
- SE is still too much a technical management matter. Alignment and collaboration within the IPM roles and the teams need to be improved;
- The problem definition and analysis of customer requirements is not done properly;
- Life cycle thinking is not a part of the processes;
- Managing workflows and concurrent processes is still difficult and no common practice;
- Input and output of processes are matched;
- The influence and involvement of the end-user is not secured;
- Project managers and directors are still managing only on the traditional aspects time, budget and Quality.

Appendix 5 Results of IDEF0 analysis

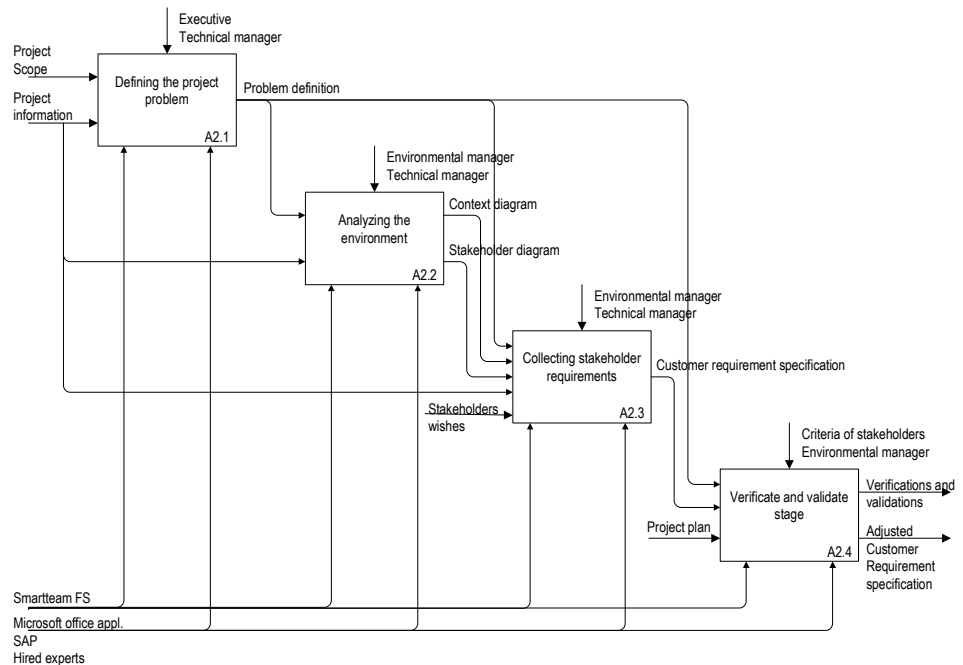
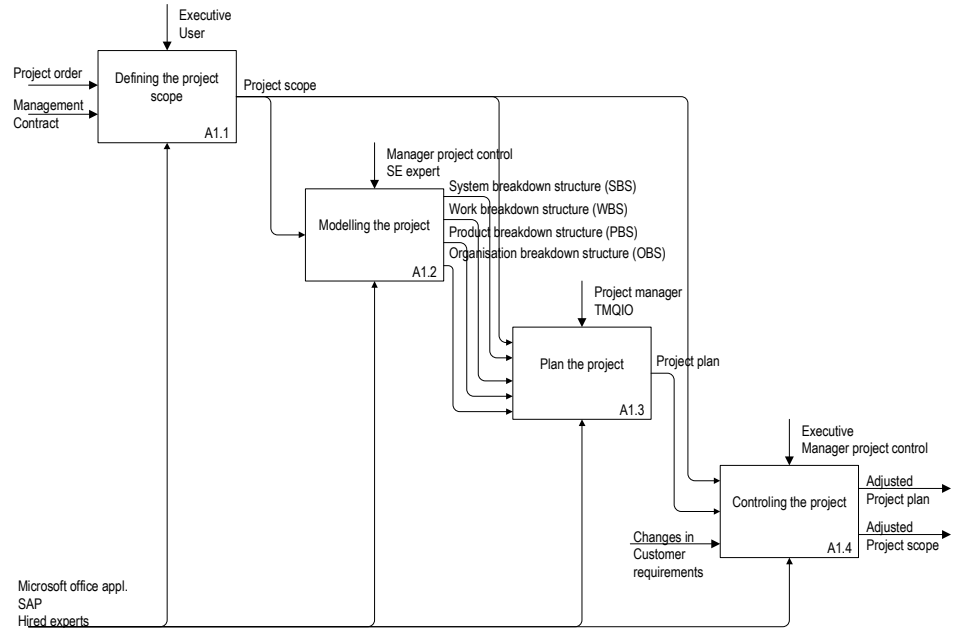
1. Current situation main processes



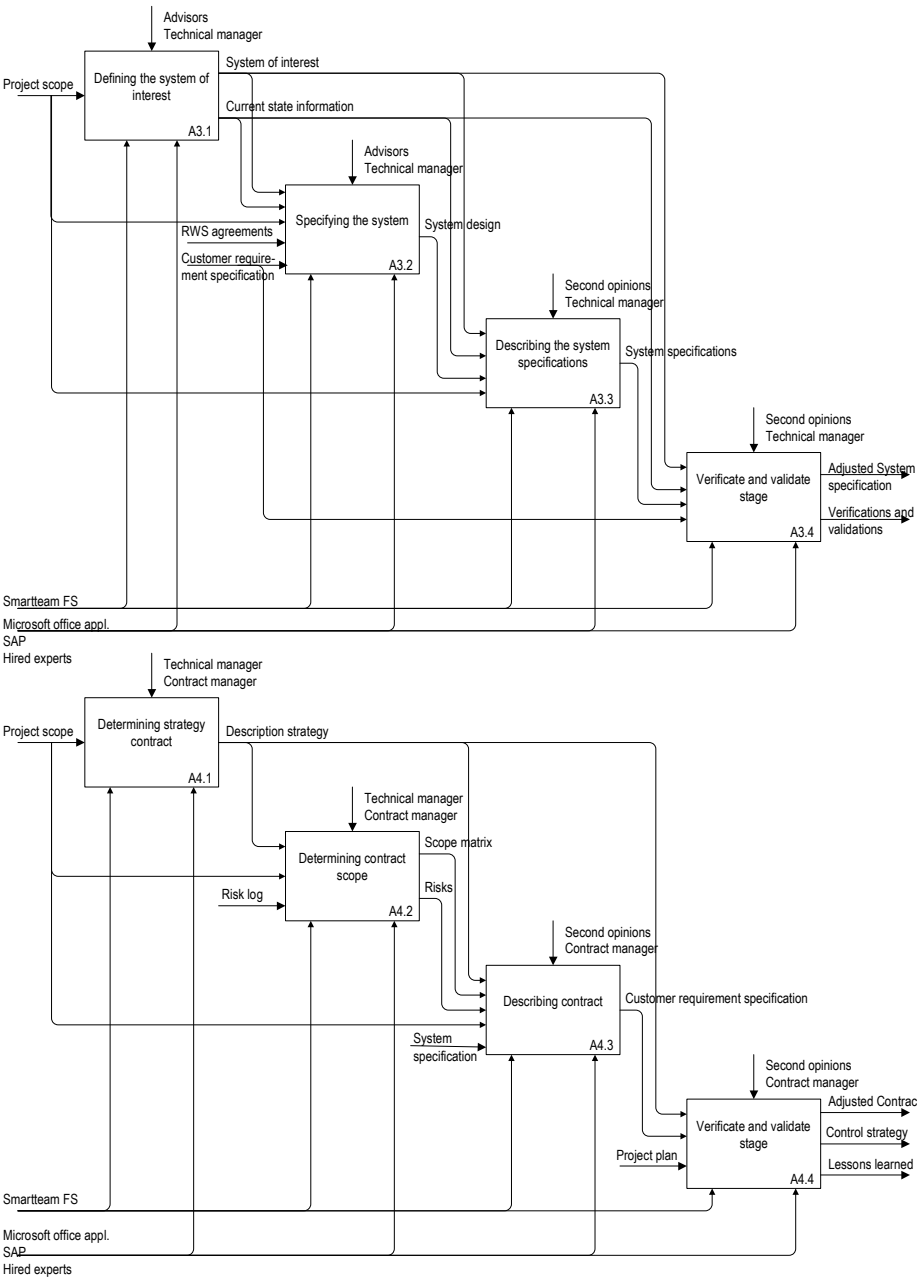
2. Desired situation main processes



3. Current situation sub processes -1

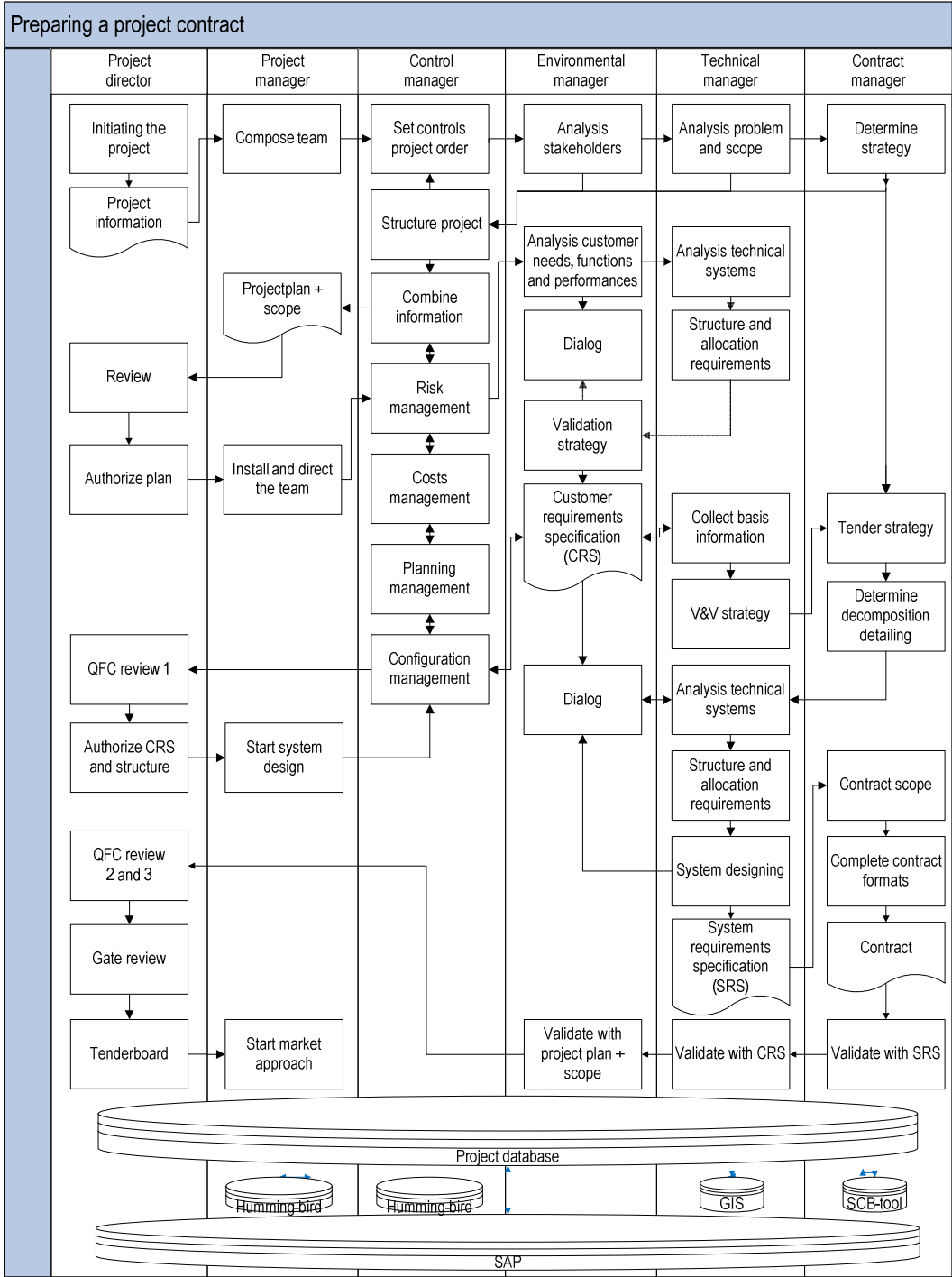


4. Current situation sub processes -2

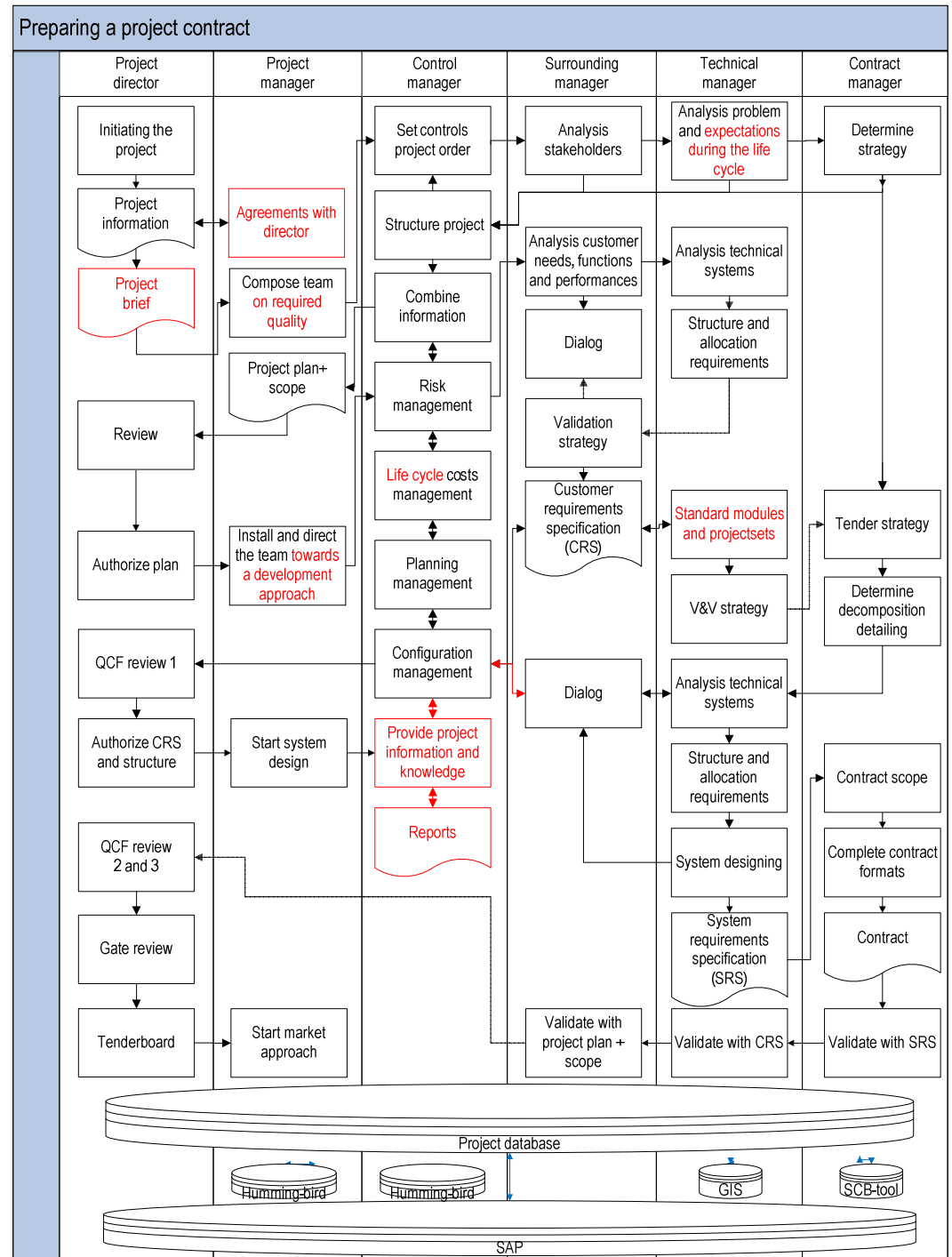


Appendix 6 Results of Activity analysis

1. Current situation project activities

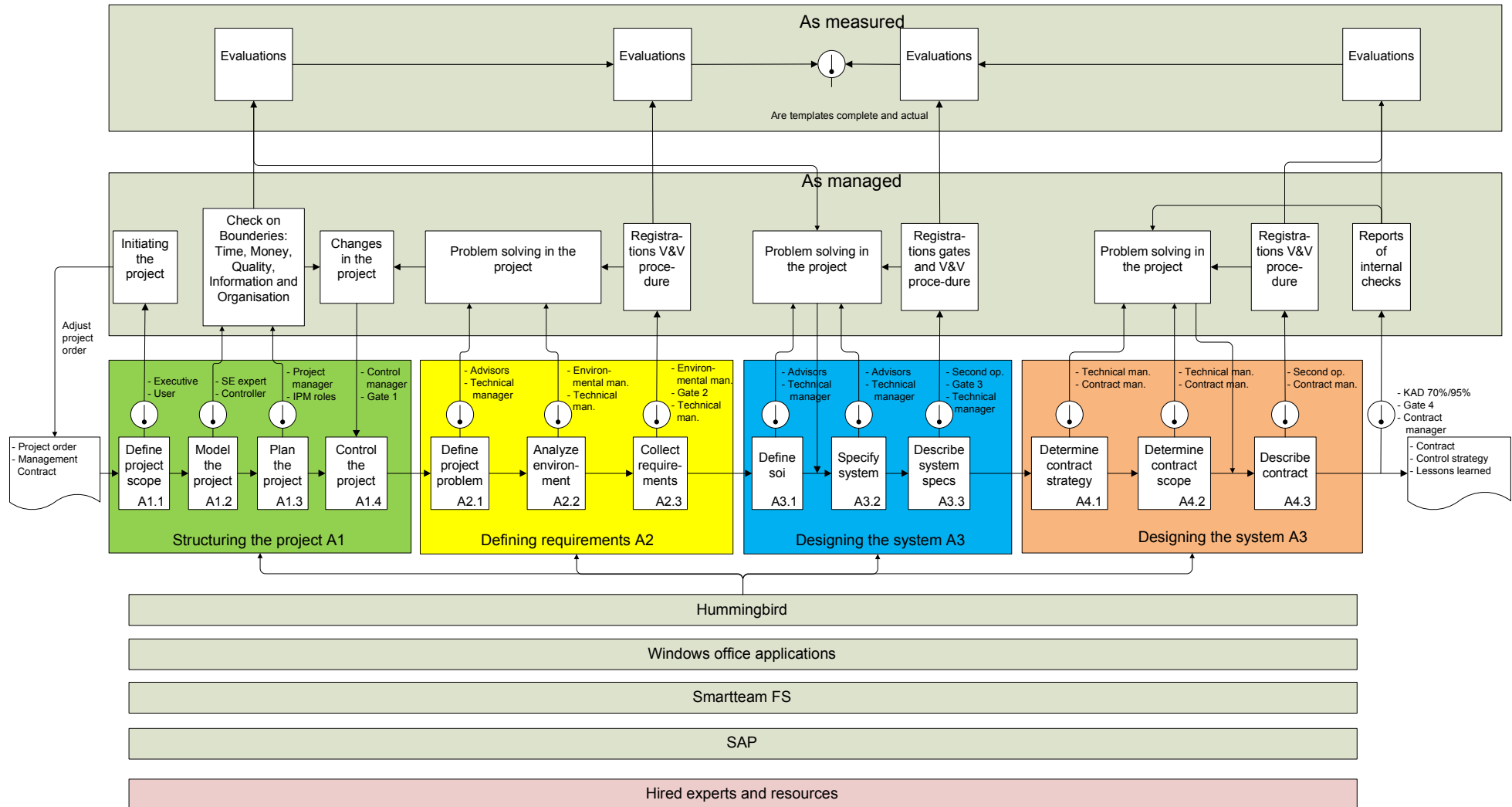


2. Desired situation project activities

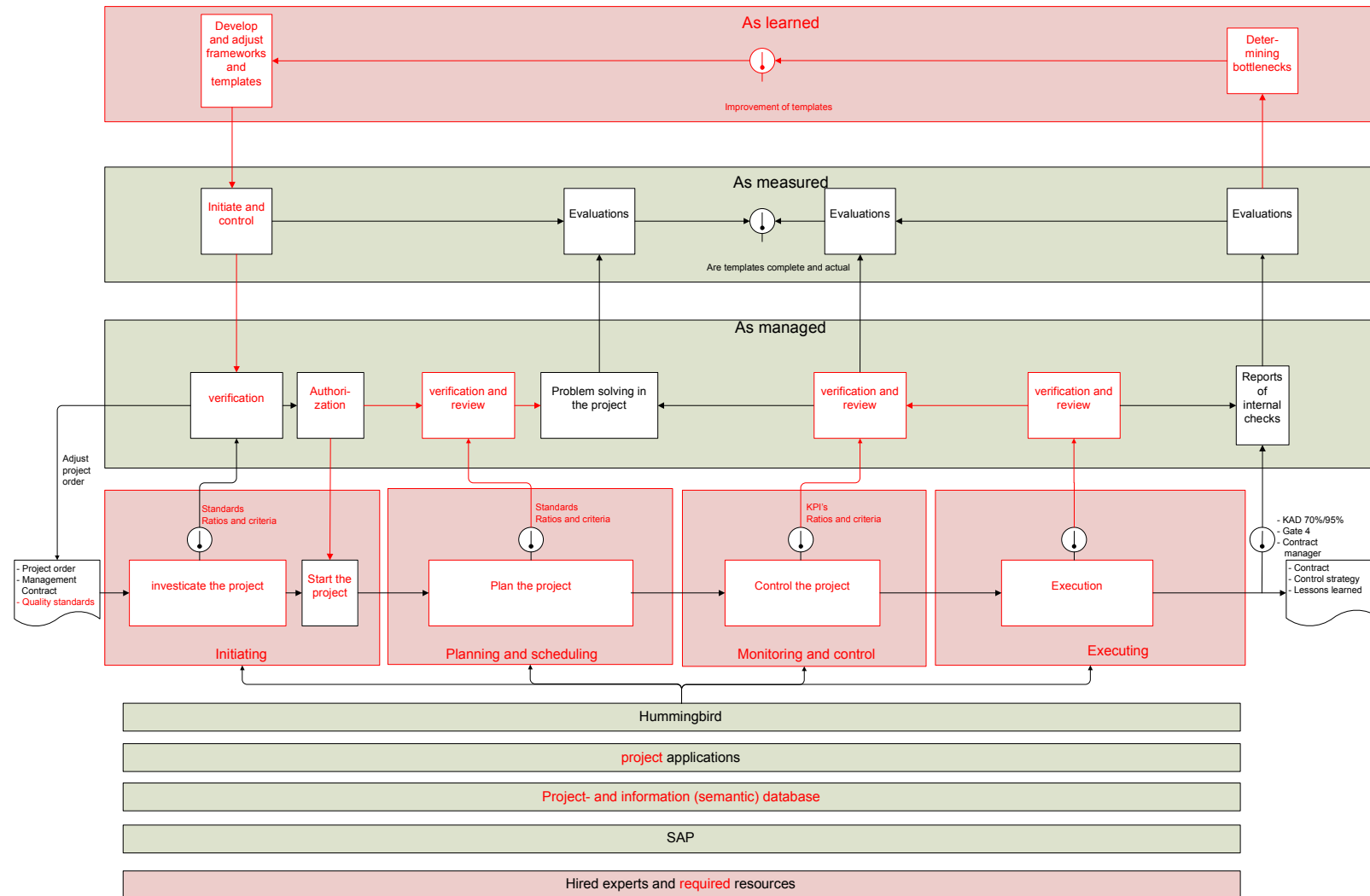


Appendix 7 World class performance model

1. Current situation World class performance



2. Desired situation World class performance



Appendix 8 Samenvatting in het Nederlands

De wijze van aantonen van de voordelen van de SE-methode voor alle projecten is nog steeds controversieel. Bruikbare richtlijnen en kaders voor een betere prestatie in de projecten zijn niet beschikbaar voor projectleden. Ook het verband tussen het IPM-model en SE en de prestaties van de verschillende methoden is niet duidelijk. De belangrijkste vraag is hoe kunnen IPM-project teams van RWS hun resultaten verbeteren door optimaal gebruik te maken van de methode van Systems Engineering?

Een multi-layer ontwikkeling-aanpak is vereist voor het behalen van project successen en een goede toepassing van SE. Het verbeteren van de kennisproductiviteit moet zich met name richten op het verbeteren van het lerend vermogen, het hergebruik van kennis en de informatie-architectuur. Projecten hebben leiderschap nodig om ze op een gestructureerde en rendabele manier te kunnen aansturen en beheersen. Voordat een project begint dienen eerst de uitgangspunten moeten worden vastgelegd. Projectleden moeten de organisatorische eisen begrijpen en moeten hun bijdrage voor de organisatie weten. Door de invoering van KPI's zal de regie, het toezicht en de controle verbeteren zal het gebruik van de vereiste methoden worden gestimuleerd. Degelijk projectmanagement processen zijn nodig in aanvulling op de huidige SE-georiënteerd proces beschrijvingen. De rol van mensen is beslissend voor een goede uitvoering van de processen.

Het was binnen dit onderzoek niet haalbaar om een duidelijke allesomvattende beschrijving voor de toepassing van SE voor projectteams te maken. De ontwikkeling van best practices, modellen en kaders is nog steeds een grote uitdaging. De aanwezige expertise binnen RWS in het werkveld moet worden gebruikt voor de verdere ontwikkeling van nuttige hulpmiddelen. Hoe dan ook heeft dit proefschrift geresulteerd in proces, activiteit en controle modellen met bijbehorende beschrijvingen, die zeer nuttig zijn voor IPM-teams. Ze zijn een eerste stap naar een betere prestatie in projectteams door gebruik te maken van SE. Door het geven van meer inzicht in de rol invullingen worden de ontbrekende kennis en vaardigheden zichtbaar, zodat zij adequaat kunnen worden opgelost.

Ter verbetering van het leervermogen van de organisatie en individuen is de ontwikkeling van informatie systemen en feedback controle loops nodig. Kennis moet worden gemodelleerd en gecombineerd om verder te worden ontwikkeld. Het ontwerp van flexibele en modulaire bouwstenen kunnen de basiskwaliteit van de organisatie verbeteren. Dit is een goede start voor verdere verbeteringen. Project- en bouwinformatiesystemen moeten centraal worden beheerd en beschikbaar worden gesteld voor de project- en beheerorganisatie. Informatie over prestaties en cijfers worden niet bijgehouden en centraal verwerkt. Hierdoor was niet mogelijk om kwantitatieve analyses met grafieken weer te geven. In de toekomst zal het steeds belangrijk zijn om de gevolgen van veranderingen aan te laten zien en te bewijzen door de toepassing van een management dashboard. De resultaten hebben een brede impact aan effecten in de organisatie en bieden een degelijke ondersteuning voor projectleden en het management. De meeste veranderingen zijn al op kleine schaal in de organisatie in gang gezet. De ingrediënten zijn al beschikbaar, maar de samenhang en de verbindingen ontbreken. Algemene coördinatie en concentratie is vereist op korte termijn. Ter verbetering van de rol van de eindgebruiker zal de verbetering van areaal informatie en Asset Management een centrale rol spelen in de organisatie. Dit veld is nog onderontwikkeld en een punt van zorg. Om de hele organisatie in een korte periode te veranderen is onmogelijk. Een gefaseerd aanpak naar de verhoging van de volwassenheid van de organisatie lijkt een realistischere en acceptabele route die past binnen de huidige aanpak. Ook voor de daarmee gepaard gaande cultuurverandering is extra tijd nodig.