NTNU – Trondheim
Norwegian University of
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Managing a small innovative time-limited project with high level of uncertainty

Balancing of traditional and agile project management

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SUMMARY

Master Thesis provides research about balancing Traditional and Agile Project Management approaches for managing a small, time limited project with high level of uncertainty. Focus in report is on the Planning and Control process for Scheduling and Risk Management methods. Case study is NTNU student project DNV Fuel Fighter – creating of energy efficient car for annual Shell Eco Marathon competition. Theoretical models for balancing the Traditional and Agile approaches match the practical management approach in project. Results of work are theoretical and empirical findings for balancing agility and discipline within project for successful outcomes.


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ABSTRAKT

Masteroppgave gir forskning om å balansere tradisjonell og agile prosjektledelse for å ledelse en liten, tidsbegrenset prosjekt med høy grad av usikkerhet. Fokus i rapporten er på plan-og kontrollprosess for planlegging og metoder for risikostyring. Case study er NTNU student prosjektet DNV Fuel Fighter - skaper av energieffektiv bil for årlige Shell Eco Marathon konkurranse. Teoretiske modeller for å balansere den tradisjonelle og agile tilnærminger matche praktisk tilnærming i prosjektet. Resultater av arbeidet er teoretiske og empiriske funn for å balansere agile og disiplin innen prosjekt for suksess resultater.


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PREFACE

This report is Master Thesis at Department of Engineering Design and Materials, Faculty of Engineering Science and Technology within the Norwegian University of Science and Technology (NTNU) Trondheim, Norway. Official name of the course is TMM4901 - Engineering Design, Calculation and Manufacture, Master Thesis.

Master Thesis is final result of Master of Science in Project Management international program study (MSPROMAN) and practical student project DNV Fuel Fighter (participation in Shell Eco Marathon competition 2013).

Master Thesis as research paper contains theoretical overview of research topic, overview of case study, practical results of applying theory, findings with following discussion and suggestions for improvement.

The author has participated as a Project Manager of NTNU's DNV Fuel Fighter team, who has spent two semesters designing and producing an energy-efficient car for the Shell Eco Marathon competition in May 2013.

CONTENT OF CHAPTERS

Theoretical part consists of short problem formulation and few models for selection and balancing of traditional and agile project management approaches. There are approaches by the most relevant researchers in modern project management field: Turner R., Boehm B., Wisocki R., Shenhar A. Dvir D, Laufer A., Levitt R. and other. There are 4 models: Solution-Goal model by Wisocki R.; 5-dimentions model by Boehm B. and Turner R.; Uncertainty-Complexity model by Little T. and Diamond model by Shenhar A. and Dvir D.

Case study part contains introduction to DNV Fuel Fighter project and overview of how practically project management deals with balancing of traditional and agile approaches with focus on risk management and scheduling in terms of planning and control processes.

Last part is findings and discussion of theoretical and practical models for balancing traditional and agile project management approaches.

KEY WORDS:

project management, agile, balancing agility and discipline, scheduling, risk management, planning and control, innovative project.

FOREWORD

This project would not have been possible without NTNU supervisor and professors, family, friends and all stakeholders of DNV Fuel Fighter project. I would like to thank everyone who has support me. I would like specially to thank:

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DEPARTMENT OF ENGINEERING DESIGN
AND MATERIALS

MASTER THESIS FALL 2013
FOR
STUD.TECHN. NIKITA SINIANSKII

MANAGING A SMALL INNOVATIVE PROJECT WITH HIGH LEVEL OF UNCERTAINTY

Ledelse av et småskala innovativt prosjekt med stor grad av usikkerhet

The Shell Eco-marathon project at NTNU is an example of a very realistic development project performed by students as a part of their study. A team of students with very diverse expertise together designs, builds and races a car with the objective of low fuel consumption. The car has to fit within a strict set of rules set by Shell.

Managing such a project has its own set of challenges. Managing time is crucial, since not being ready by the time of the race is not an option. Managing resources is challenging, since there is all the time issues which require knowledge or competence outside of the specialties of the team members. The team is multicultural – anything from three to five mother tongues have been represented in the team – and that also is challenging. And last but not least: This is a project which requires a large budget, and the money must be acquired and managed. In the project, DNV has been the main sponsor.

All in all, this is not a typical student project, but a very representative project for what goes on in smaller industrial companies.

This thesis will examine the management of such projects. The effects of the project size will be examined, as will the all the other aspects mentioned above. Relevant theory will be studied and the experiences of the project on the applicability of these theories will be discussed.

The report should include the following:

1. Introduction, including problem formulation
2. Theory
3. Case study of the Eco-marathon project
4. Findings
5. Discussion of findings
6. Proposal for improved methodology for such projects
7. Conclusion

The thesis should include the signed problem text, and be written as a research report with summary both in English and Norwegian, conclusion, literature references, table of contents, etc. During preparation of the text, the candidate should make efforts to create a well arranged and well written report. To ease the evaluation of the thesis, it is important to cross-reference text, tables and figures. For evaluation of the work a thorough discussion of results is appreciated.

Three weeks after start of the thesis work, an A3 sheet illustrating the work is to be handed in. A template for this presentation is available on the IPM's web site under the menu "Masteroppgave" (http://www.ntnu.no/ipm/masteroppgave). This sheet should be updated one week before the Master's thesis is submitted.

The thesis shall be submitted electronically via DAIM, NTNU's system for Digital Archiving and Submission of Master's thesis.

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og materialer

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LIST OF ABBREVIATIONS

ALARP	As Low As Reasonably Possible
APM	Agile Project Management
CPM	Critical Path Method
EiT	Expert in Teamwork (NTNU course)
FB	FaceBook
ID	IDentification (document)
MCS	Monte-Carlo Simulation
MoSCoW	Must, Should, Could and Would not – principle
MSDS	Material safety data sheets
NKF	Norges Kreative Fagskole
NTNU	Norwegian University of Science and Technology
PERT	Program Evaluation and Review Technique
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
PMLC	Project Management Life Cycle
PR	Public Relations
R & D	Research and Development
SEM	Shell Eco Marathon
SMART	Specific, Measurable, Attainable, Relevant and Time-bound
SSP	Successive Schedule Planning
TPM	Traditional Project Management
WBS	Work Breakdown Structure
xPM	Extreme Project Management

1. INRODUCTION

There is specific type of projects with curtain time limitation and high level of uncertainty both internal and external. Time limitation means that project team has to deliver some result on the specific time. Delay in project duration is not possible. External uncertainty is unpredictable environment with rapid changing and aggressive actions from competitors. Internal uncertainty is unclear technical solutions, not professional enough team members (both management and primary project competences), resource limitation and others. For example, it could be event-projects, education with exams or competitions. Simple birthday-party, traveling for Easter vacation, Norwegian language course with final test, musical concert in Nidarosdomen cathedral, cross-country ski world championship, Olympic games, political elections, online TV translations, Amundsen's trip to South Pole are examples for such type of projects.

These projects need appropriate approach in terms of Project Management – quite flexible and adaptive agile approach to deal with uncertainty and, on the same time, quite discipline traditional approach to deal with critical time limitation.

Traditional Project Management approach with structured and disciplined methods is basic for education in Project Management field. Agile approach is more modern alternative from Software industry with fast growing and developing. Present research work is about balancing both approaches with aim to have the most efficient management for success in project.

Research topic within Project Management field in this Master Thesis is limited to small-size project and team. In small projects is easier to explore basic research hypothesis.

"Managing a small innovative project with high level of uncertainty" is general topic for the thesis. Because project management is wide and multi-level concept the research topic is limited to the two most critical areas for small, time limited project with high level of uncertainty – Scheduling and Risk Management in terms of planning and control process.

There are two narrow research questions:

- Is there effective to use different Project Management approaches: Traditional and Agile together in small, time limited project with high level of uncertainty?
- If a balancing of Agile and Traditional approaches is effective, what is the method to choose the most relevant one for which element of a project?

2. THEORY

Theoretical part shows overview of traditional and agile project management approaches and concepts for balancing both approaches. Focus is on the planning and control process and scheduling and risk management methods for small time limited, uncertain projects.

There are two narrow research questions:

1. Is there effective to use different Project Management approaches: Traditional and Agile together in small, time limited project with high level of uncertainty?
2. If a balancing of Agile and Traditional approaches is effective, what is the method to choose the most relevant one for which element of a project?

2.1 TRADITIONAL PROJECT MANAGEMENT

Traditional project management is a science based on the large civil and military projects with focus on detailed planning and documentations.

Project and Project Management definitions

Project definitions are quite similar and have basic parameters such uniqueness, temporary, coordination of resources and people for common goal within 'iron triangle' – time, money and scope through quality and resources.

> "A project is a temporary endeavor undertaken to create a unique product, service or result". PMBOK Guide (2004). An American National standard and 'Bible' of traditional project management.

> "A project is a unique venture with beginning and end, conducted by people to meet established goals within parameters of cost, schedule and quality" Pinto J.K. (2010)

> "A project is a sequence of unique, complex, and connected activities that have one goal or purpose and that must be completed by a specific time, within budget, and according to specification" Wysocki R.K. (2009)

> "Project - in business, science, etc.: a collaborative enterprise, freq. involving research or design that is carefully planned to achieve a particular aim" Oxford English Dictionary definition used in WiKipedia.

Project Management obviously defined as science and art of managing the projects for achieving the project goals and satisfaction of stakeholders needs.

> Project Management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements. Project management is accomplished through the application and integration of the project management processes of initiating, planning, executing, monitoring and controlling, and closing. The project manager is the person responsible for accomplishing the project objectives. Managing a project includes: identifying requirements; establishing clear and achievable objectives; balancing the competing demands for quality, scope, time and cost; adapting the specifications, plans and approach to the different concerns and expectations of the various stakeholders. (PMBOK Guide (2004) p. 8)

Wysocki R.K. (2009) defines Project Management simply as "organized common sense" with answer for the six basic questions:

- What business situation is being addressed?
- What do you need to do?
- What will you do?
- How will you do it?
- How will you know you did it?
- How well did you do?

Success Factors and Goals

Project success is defined by success factors and has to be evaluated from the very beginning. This is answer for the question "How could we know when a project a successful? and How to measure it?" By project nature main constraints for project success are time, cost and performance by Pinto J.K. (2010). It means that successful project has to be done on time, on budget and deliver desired scope (goal) on the acceptable level of quality (performance). Quite often project success is equal project plan successful implementation without variance. Other 4-th dimension is client acceptance or satisfaction of customers' needs through the initial requirements. This is project short-term definition of success as project efficiency. More broad and long-term definition of success is described by Shenhar A.J. and Dvir D. (2007). This project success model contains 4 phases that begins after project finalization: project efficiency, impact on customers, business success and preparing for the future.

Traditional Project Management methodology

PMBOK Guide (2004) as standard from Project Management Institute (PMI) defines five main process groups based on the Deming Plan-Do-Check-Act circle:

Table 1. PMBOK Guide (2004) five main process groups

Process group	Explanation
Initiating	Defines and authorizes the project or a project phase.
Planning	Defines and refines objectives, and plans the course of action required to attain the objectives and scope that the project was undertaken to address.
Executing	Integrates people and other resources to carry out the project management plan from the project.
Monitoring and Controlling	Regularly measures and monitors progress to identify variances from the project management plan so that corrective action can be taken when necessary to meet project objectives
Closing	Formalizes acceptance of the product, service or result and brings the project or a project phase to an orderly end.

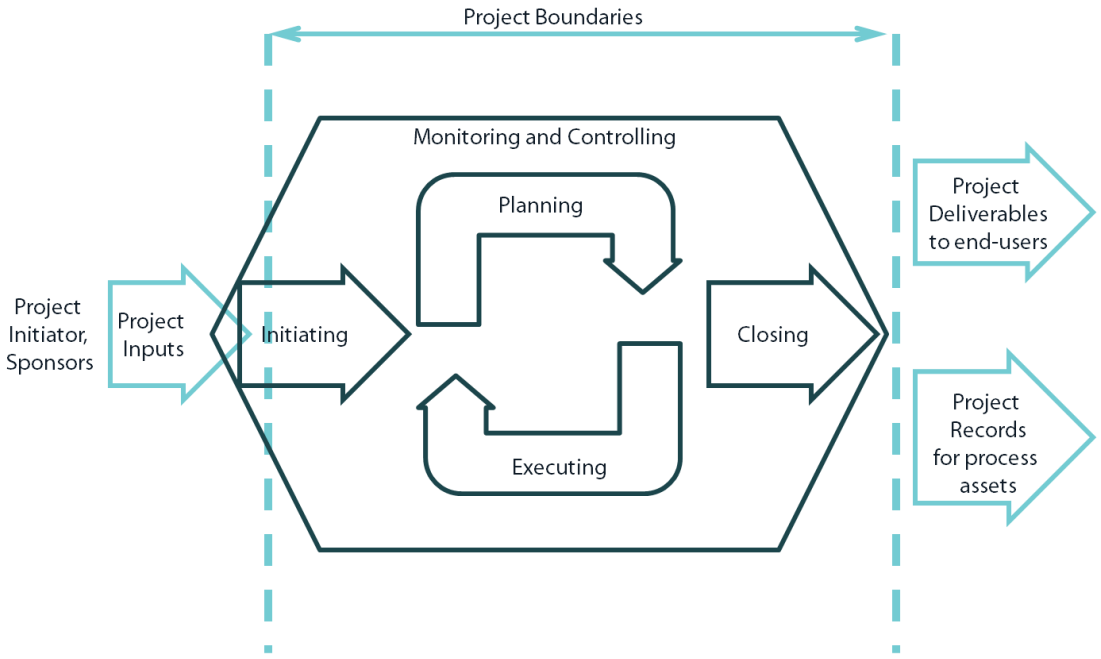


Figure 1. PMBOK Guide (2004) five main process groups

PMBOK Guide (2004) defines nine Project Management Knowledge Areas for 44 project management processes:

Table 2. PMBOK Guide (2004) Project Management Knowledge Areas

Knowledge area	Parameters
Integration Management	processes and activities that integrate the various elements of project management, which are identified, defined, combined, unified and coordinated within the project management process groups
	> Develop project charters > Develop preliminary project scope statement > Develop project management plan > Direct and manage project execution > Monitor and control project work > Integrated change control > Close project
Scope Management	processes involved in ascertaining that the project includes all the work required, and only the work required, to complete the project successfully
	> Scope planning > Scope Definition > Create WBS > Scope verification > Scope control
Time Management	processes concerning the timely completion of the project
	> Activity definition > Activity sequencing > Activity resource estimating > Activity duration estimating > Schedule development > Schedule control
Cost Management	processes involved in planning, estimating, budgeting, and controlling cost so the project is completed within the approved budget
	> Cost estimating > Cost budgeting > Cost control
Quality Management	processes involved assuring that the project will satisfy the objectives for which it was undertaken
	> Quality planning > Perform quality assurance > Perform quality control
Human Resources Management	processes that organize and manage the project team
	> HR planning > Acquire project team > Develop project team > Manage project team

Communication Management	processes concerning the timely and appropriate generation, collection, dissemination, storage, and ultimate disposition of project information
	> Communication planning > Information distribution > Performance reporting > Manage stakeholders
Risk Management	processes concerned with conducting risk management on a project.
	> Risk management planning > Risk identification > Qualitative risk analysis > Quantitative risk analysis > Risk response planning > Risk monitoring and control
Procurement Management	processes that purchase or acquire products, services or results, as well as contract management processes.
	> Plan purchase and acquisitions > Plan contracting > Request seller responses > Select sellers > Contract administration > Contract closure

Planning and Control

Planning and Control processes are heart of the project management. Traditional Project Management idea behind Planning and control is creating detailed plan for a whole project. Planners group that has proper competence (experience and knowledge) establish and carry out of 'baseline plan' in terms of time, money and resources as roadmap for a project execution. Any deviation from the baseline plan should be corrected. It means that project team, tasks and resources have to be controlled as comparing with ideal baseline plan. All processes have to be as closely as possible for a plan to achieve project success. Levitt R.E. (2011) defines it as "The baseline plan was, is, and will remain a good and valid plan". Main assumption for the Traditional Project Management is predictability. According Wysocki R.K. (2009) it means that goal, solution, requirements, functions and features are complete and clearly defined. Traditional project management assumes also just few scope and requirements changes due to complex change management process, usually routine and repetitive activities and using of established templates and standards. (Wysocki R.K. ,2009).

Scheduling

Traditional Project Management scheduling is complex process connected to needed scope, available resources and other constraints on the timeline. The classical method of scheduling is waterfall top-down method. Whole project scope, first, are divided into work breakdown structure packages and activities. After that, sequences and dependencies between activities are defined. Last action is evaluating duration of each activity and counting all together. The most common graphical method is Gantt chart. Harvey Gantt in 1917 established and developed a time-phased project network with link between project activities and schedule baseline.

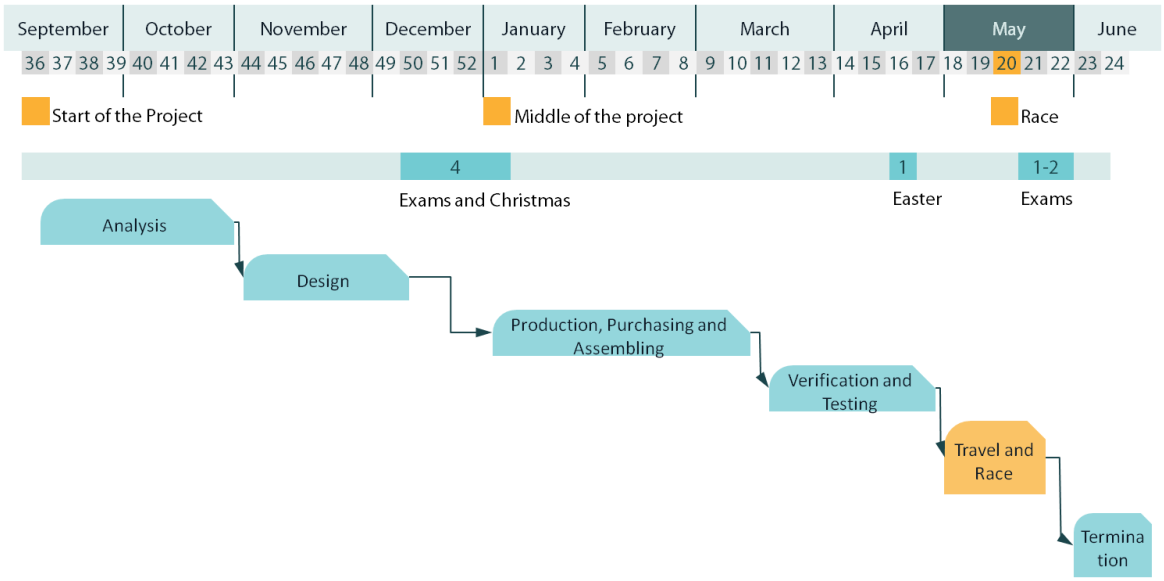


Figure 2. Gantt chart example for TPM

According Vatn J. (2013) there are four the most widely used modern methods for project scheduling in Traditional Project Management. There are three analytical methods: Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), Successive Schedule Planning (SSP); and Monte-Carlo Simulation (MCS) method. Below very short explanations of methods are provided. More detailed information is on the Vatn J. (2013).

Critical Path Method (CPM) is simplest and assumes that duration of all activities are predicted as the most likely meaning. After that all possible paths in project network diagram are calculated for total duration. The longest path duration shows the critical path and it equal to the total project duration.

Program Evaluation and Review Technique (PERT) is also defines on a critical path but duration of each activities includes uncertainty and described by a low (L), most likely (M) and high (H) values. Duration of activity is assumed as PERT distributed. Expected Value (μ) and Variance (σ^2) of each activity is given by formulas:

$$\mu = \frac{L+4M+H}{6}; \sigma^2 = \frac{(\mu-L)(H-\mu)}{7} \quad (1)$$

Successive Schedule Planning (SSP) is considering all paths and activities, not only critical as in PERT method. In case of parallel activities final duration is a maximum of the duration of these parallel activities.

Monte-Carlo Simulation (MCS) is computer based method. Similar to PERT and SSP each activity has PERT distribution of duration with low, most likely and high values. After that randomized simulation gives different values for each activity and calculates after that total project duration. This method based on the Microsoft Excel tool.

Risk Management

Definition of Risk by Vatn J. (2013) is “Risk is uncertainty regarding occurrence and severity of future events”. Specialized Risk Management literature use definition “risk is combination of the frequency, or probability, of occurrence and the consequence of a specified hazardous events” (Rausand M. ,2011). Most definitions comprise the elements of probabilities and consequences. Pinto J.K. (2010) simply defines Risk in project management as “any possible event that can negatively affect the viability of a project”.

Generally, risk management is defined as a “systematic application of management policies, procedures and practices to the tasks of analyzing, evaluating and controlling risk” (Vatn J. ,2013). PMBOK Guide (2004) defines objectives of Risk Management as “increase the probability and impact of positive events and decrease the probability and impact of events adverse to the project”. Definition by Pinto J.K. (2010) is “Risk Management as art and science of identifying, analyzing and responding to risk factors throughout the life of a project and in the best interest of its objectives”.

Risk Management as process contains few elements. Vatn J. (2013) defines Risk Management as two-stages process:

- **Risk assessment**:
  - **Risk analysis** (Systematic use of available information to identify hazards and to estimate the risk to individuals or populations, property or the environment)
  - **Risk evaluation** (Process in which judgments are made on the tolerability of the risk on the basis of risk analysis and taking into account factors such as socio-economic and environmental aspects)
- **Risk reduction/control** (decision making, implementation and risk monitoring)

PMBOK Guide (2004) provides six processes for Risk Management:

- **Risk Management Planning.** Deciding how to approach, plan and execute the risk management activities for a project.
- **Risk Identification**. Determining which risk might affect the project and documenting their characteristics.
- **Qualitative Risk Analysis**. Prioritizing risks for subsequent further analysis or action by assessing and combining their probability of occurrence and impact.
- **Quantitative Risk Analysis.** Numerically analyzing the effect on overall project objectives of identified risks.
- **Risk Response Planning.** Developing options and actions to enhance opportunities and to reduce threats to project objectives.
- **Risk Monitoring and Control.** Tracking identified risks, monitoring residual risks, identifying new risks, executing risk response plan and evaluating their effectiveness throughout the project life cycle

Pinto J.K. (2010) describes Risk Management as a four-stage process:

- **Risk Identification**. Determining the specific risk factors that can reasonably be expected to affect a project
- **Analysis of probability and consequences**. The potential impact of these risk factors, determined by how likely they are to occur and the effect they would have on the project if they did occur.
- **Risk mitigation strategies.** Steps taken to minimize the potential impact of those risk factors deemed sufficiently threatening to the project.
- **Control and documentation.** Creating a knowledge base for future projects based on lessons learned.

In project risk management there is acceptance criteria (Vatn J., 2013) related to two types of events:

- Events with severe consequences related to **health, environment and safety**.
- Events with severe consequences related to project **costs**, project **quality**, project **duration**, or even **termination** of the project.

2.2 Critics of Traditional Project Management

A plenty of authors and researchers in different project management areas last two decades criticize a Traditional approach mainly because it does not work and projects often fails nowadays. Software development and research projects are the most non-traditional projects today. That is why researchers trying to analyze successful software and innovative project and find reasons why classical tools useless and how to improve project performance.

Turner R., Ledwith A., Kelly J. (2010,2012) shows that the most of micro, small and medium companies cannot employ dedicated project managers and establish traditional project management practices. Instead of that companies use or want to use "a light project management" that usually very simple, less bureaucratic and reasonably rational. Full traditional project management required too much resources and efficiency of full approach is too small.

Levitt R.E.(2011) agree about strength of traditional project management as disciplined, detailed and centralized approach, but shows that traditional project management is not agile, does not engage all available knowledge and more operational, not a strategic. There are few challenges with detailed planning of project by Levitt R.E.(2011):

- Planners do not have enough competence to create realistic and feasible plans;
- In fast changing world key assumptions behind plan could invalid baseline plan;
- Gap between planning and execution teams. Especially in judgment of execution performance, when reality and status reports are too different.
- Low personal motivation for execution team. People have to implement plans without any variance and could not use own creativity or actual knowledge and experience for the best results.

Boehm B., Turner R. (2002, 2003, 2004) provides five critical factors and describes how plan-driven methods work on it:

- **Size**. Methods evolved to handle large products and teams. Hard to tailor down to small projects.
- **Criticality**. Methods evolved to handle highly critical products. Hard to tailor down to low-criticality products.
- **Dynamism**. Detailed plans and Big Design Up Front excellent for highly stable environment, but a source of expensive rework for dynamic environment.
- **Personnel**. Needs a critical mass of skilled experts during project definition, but can work with fewer later in the project – unless the environment is highly dynamic.
- **Culture**. Thrives in a culture where people feel comfortable and empowered by having their roles defined by clear policies and procedures. Thriving on order.

Boehm B., Turner R. (2004) also shows few misconceptions and realities about traditional plan-driven methods:

Table 3. Misconceptions and realities about plan-driven methods. Boehm B., Turner R. (2004)

Misconceptions	Reality
plan-driven methods are uniformly bureaucratic	overly bureaucratic cultures and methods can stultify project, team and organization
having documented plans guarantees compliance with plan	not necessary
plan-driven methods can succeed with a lack of talented people	plan-driven methods can succeed with a smaller percentage of talented people
high maturity guarantees success	explicit, documented plans provide more of a safety net than tacit plans
there are no penalties in applying plan-driven methods when change is unforeseeable	plan-driven methods work best in accommodating foreseeable change

Shenhar A.J. and Dvir D. (2007) trying to find reasons for often failing of traditional project management in basic “management-as-planned” philosophy: the triple (time, money, quality) constraints and “one size fits all” principle. Project managers and project teams believes that success is just in meeting project requirements (on time, on budget, within performance goal) and does not focus on high level goals as customer satisfaction and achieving business goals. When management and team follow to standardized set of methods, they often use wrong approach for own specific project. Traditional model fits only few project types nowadays. Shenhar A.J. and Dvir D. (2007) names modern projects are uncertain, complex and changing, they affected by dynamics of environment, technology and markets. Changes will happen and plans will have to be adapted to the changes. Some projects are even not possible to plan and rigid, linear, predictable model for planning and managing projects completely does now work.

Wysocki R.K. (2009) shows that Traditional project management is able to apply only in comfort situation when Goal and Solution are clearly defined in terms of project complexity and uncertainty. Traditional projects are plan-driven, process heavy, documentation-heavy, very structured. This process involves resources (people and time) on activities that do not add business value to the final product or process. Requirements changes, flexibility, adaptability, risk, team cohesiveness, communications, client involvement, scope-specification-solutions changes, business value are areas where traditional project management have strong disadvantages by Wysocki R.K. (2009).

DeCarlo D. (2004) describes reasons for changing the paradigm of project management as high-speed, change-driven environment. Changing has to be in two levels – basic project management approach and human perception of reality and relationship to it. Reality by DeCarlo D. (2004) is not possible to recognize as stable, predictable, controllable and knowable. As result project management needs tools where change is normal, rapid and unpredictable. “Adaptability is more important than predictability. Attempt to change the world to fit your plan is fiction” conclude author. Another basic problem of Traditional Approach by DeCarlo D. (2004) is “lifeless” or approach without human, motions and emotions dynamic focus.

Apello J. (2011) analyses leadership in terms of the traditional-agile management style. He shows that main reason of traditional command-and-control approach is in power distribution from the top to the bottom. This approach centralized almost all power in organization for few top managers and gives tool to control and secure whole processes. Low level employee has little money, few responsibilities and no motivation for effective work. Main reasons for new approach Apello J. (2011) describes in terms of causality, complexity, non-linear, hierarchical reductionism, holism of modern projects.

Cohn M. (2006) finds five main reasons for Traditional approach falling in planning and control process:

1. Planning Is by Activity Rather Than Feature
    - > focus on the completion of activities rather than on the delivery of features
    - > after a traditional schedule has been created and is being reviewed. When we review a schedule showing activities, we do so looking for forgotten activities rather than for missing features
    - > activities don’t finish early.
    - > lateness is passed down the schedule.
    - > activities are not independent.
2. Multitasking Causes Further Delays
3. Features Are Not Developed by Priority
4. We Ignore Uncertainty
5. Estimates Become Commitments

2.3 AGILE PROJECT MANAGEMENT

Approach that helps to avoid disadvantages of Traditional Project management named Agile or Adaptive project management.

Agile Project and Agile Project Management definitions

DeCarlo D. (2004) has established two keys for success in modern environment: "a change-tolerant mind-set, you are choosing a worldview that is in sync with chaos and unpredictability; and one that puts the emphasis on people and interactions more so than on processes and tools". He explains that we should adopt our mind for disorder as reality basis and facilitate the flow of interactions, emotions and satisfactions for successful creating a valued outcome.

New definitions of project and project management were proposed by DeCarlo D. (2004) that includes environment dynamics, human elements and energy flow.

> "A **project** is a localized energy field comprising a set of thoughts, emotions, and interactions continually expressing themselves in physical form. A **project**, in sum, is a process throughout which thoughts and emotions take form. I'm suggesting that a **project** is a living thing that is organic and fluid. …**Agile project** is a complex, high-speed, self-correcting venture during which people interact in search of a desirable result under conditions of high uncertainty, high change, and high stress." DeCarlo D. (2004) pp32-33.

> "**Project management** is the art and science of facilitating and managing the flow of thoughts, emotions, and interactions in a way that produces valued outcomes. **Agile Project Management** is the art and science of facilitating and managing the flow of thoughts, emotions, and interactions in a way that produces valued outcomes under turbulent and complex conditions: those that feature high speed, high change, high uncertainty, and high stress." DeCarlo D. (2004) pp.34-35.

Agile is a project management methodology that breaks big and heavy projects into small increments, each of which adds value and is delivered in a short cycle. Instead of planning and working by detailed master plans, agile projects are incremental, adaptive and evolutionary. Agile approach has basically five general ideas by (Cohn M.,2006):

1. Work as one team
2. Work in short iterations
3. Deliver something each iteration
4. Focus on business priorities
5. Inspect and adapt

Work in one small, co-located team does not required special communication tool for sharing knowledge, information, decision making process etc. Working in short iterations with delivering of something sufficient gives motivation for team as important and creative. Organizational structure in agile team is usually flat and self-regulated. Focus on the satisfaction of client and business priorities needs continuous monitoring and adjustment of current work.

There are a lot of advantages for Agile Project Management in the most modern life situations. For example, by Wysocki R.K. (2009) a list of advantages is:

> It is a new mind-set— one that thrives on change rather than one that avoids change.
> It is not a ‘‘one size fits all’’ approach — it continuously adapts to the unique character of the specific business situation as it learns more about that business situation.
> It utilizes a just-in-time planning approach.
> It adapts tools and processes from TPM
> It is based on the principle that you learn by doing.
> It guarantees ‘‘if we build it, they will come.’’
> It seeks to ‘‘get it right’’ every time.
> It’s client-focused and client-driven.
> It is grounded in a set of immutable core values.
> It ensures maximum business value for the time and dollars expended.
> It is a framework that has squeezed out all of the non-value-added work that it possibly could.
> It meaningfully and fully engages the client as the primary decision maker.
> It creates a shared partnership with shared responsibility between requestor and provider.

Success Factors and Goals

Most of the authors write that formally agile project management has started from software development industry by formulation of Agile Manifesto (2001) by 17 singers - “lightweight methodologists,” as they were called at the time:

Principles behind the Agile Manifesto (2001):

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4. Business people and developers must work together daily throughout the project.
5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.

6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7. Working software is the primary measure of progress.
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity--the art of maximizing the amount of work not done--is essential.
11. The best architectures, requirements, and designs emerge from self-organizing teams.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly

There are few values on it (Cohn M.,2006) that reduce risk and uncertainty, support better decision making, establish trust and conveying information :

1. **Individuals and interactions over processes and tools** because they know that a well-functioning team of great individuals with mediocre tools will always outperform a dysfunctional team of mediocre individuals with amazing tools and processes
2. **Working software over comprehensive documentation** because it leads to s stable, incrementally enhanced version of the product at the end of each iteration.
3. **Customer collaboration over contract negotiation** because agile teams would like all parties to the project to be working toward the same set of goals.
4. **Responding to change over following a plan** because the ultimate focus is on delivering as much value as possible to the project's customer and users.

Additionally Cohn M.(2006) describes "Declaration of interdependence" that was formulated by group of managers within agile approach:

> Declaration of interdependence. Agile and adaptive approaches for linking people, projects and value. We are community of project leaders that are highly successful at delivering results. To achieve these results:
> > We increase return of investment by making continuous flow of value our focus.
> > We deliver reliable results by engaging customers in frequent interactions and shared ownership
> > We expect uncertainty and manage for it through iterations, anticipation and adaptation
> > We unleash creativity and innovation by recognizing that individuals are the ultimate source of value and creating an environment where they can make a difference
> > We boost performance through croup accountability for results and shared responsibility for team effectiveness
> > We improve effectiveness and reliability through situational specific strategies, processes and practices.

Wysocki R.K. (2009) describes core values of Agile Project Management as:

> client-focused
> client-driven
> incremental results early and often
> continuous questioning and introspection
> change is progress to a better solution
> don't speculate on the future

On the same time Wysocki R.K. (2009) shows team limitations for Agile Project management. It has to be small, self-organized, most skilled and experienced, collocated team versus traditional project team.

DeCarlo D. (2004) describes Agile project management as holistic, people centered, humanistic, business focused and reality based. Based on it Success in Agile Project is that customers receive value throughout the whole project life cycle and the project team feels nice about experience. "On agile projects the key to success is other people" DeCarlo D. (2004). Critical success factors as part of the basic model for agile project management by DeCarlo D. (2004):

> The 5 Critical Success Factors (the essential skills and tools and the environment that make it possible to take action in a way that produces valued results for the project's customers):
>
> > Self-mastery
> > Leadership by commitment
> > Flexible project model
> > Real-time communication
> > Agile organization

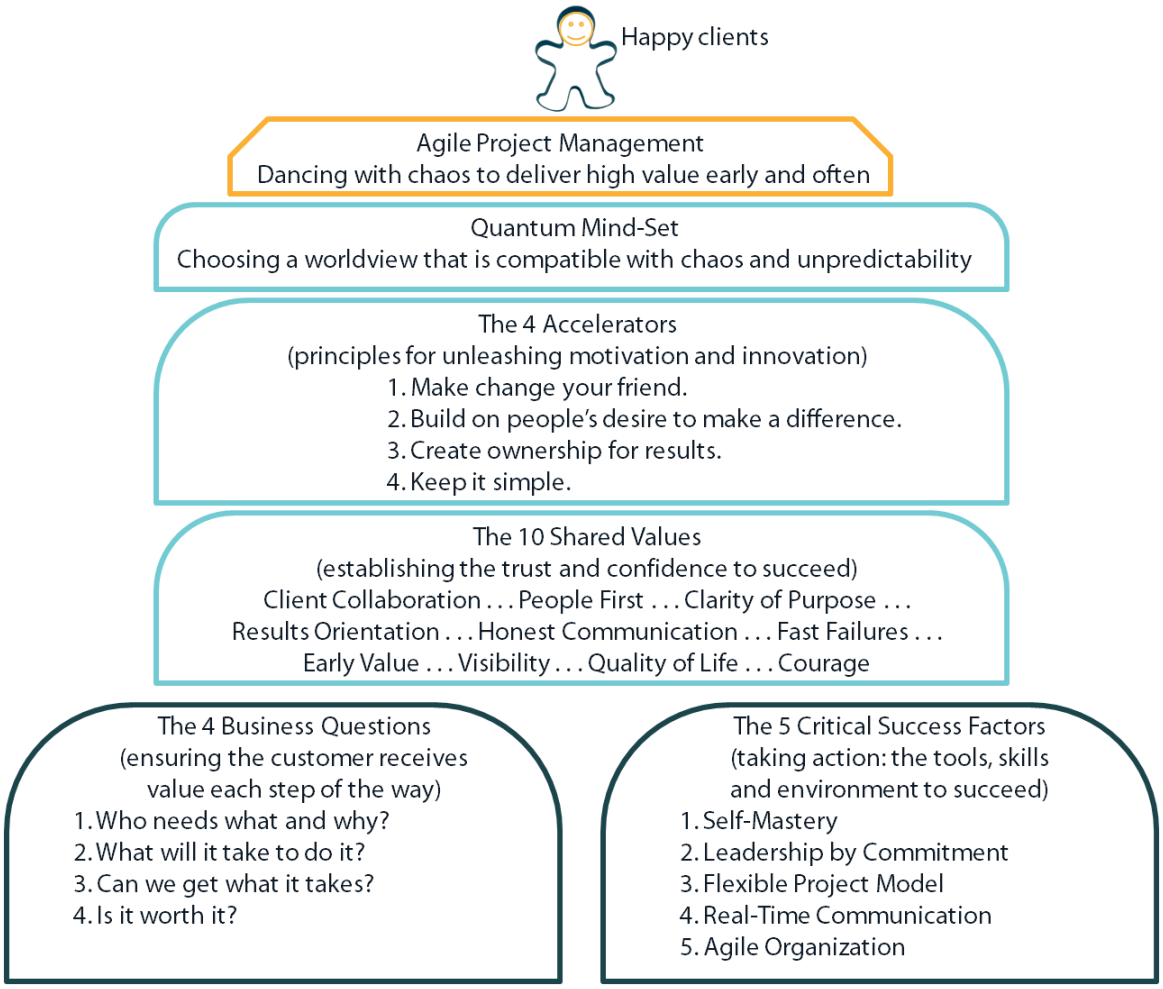


Figure 3. Success model for agile project management by DeCarlo D. (2004)

Research by Chow T., Cao D.-B. (2008) in agile project management within software industry shows similar critical success factors:

Delivery strategy	> Regular delivery of software > Delivering most important features first
Agile software engineering techniques	> Well-defined coding standards up front > Pursuing simple design > Rigorous refactoring activities > Right amount of documentation > Correct integration testing
Team capability	> Team members with high competence and expertise > Team members with great motivation > Managers knowledgeable in agile > Managers who have adaptive management style > Appropriate technical training to team

Project management process	> Following agile-oriented requirement management process > Following agile-oriented project management process > Following agile-oriented configuration management process > Good progress tracking mechanism > Strong communication focus with daily face-to-face meetings > Honoring regular working schedule
Team environment	> Collocation of the whole team > Coherent, self-organizing teamwork > Projects with small team > Projects with no multiple independent teams
Customer involvement	> Good customer relationship > Strong customer commitment and presence > Customer having full authority

Agile Project Management methodology

Planning approach in agile project management named Planning Onion (Cohn M., 2006) and have basically 5 levels: day, iteration, release, roadmap, vision. Vision is top-level view of the business objectives. This is strategic level with exciting, inspirational, aggressive and ambitious parameters for a few years. Roadmap is a set of main deliverables for achieving the Vision. Each deliverable is large and workable product which documented from the customer point of view. The scope of Roadmap is between few months to 1-2 years. Release is set of the most important on this time Roadmap “stories” that able to complete in a reasonably from business perspective short time. Collection of the stories is prioritized for completion. Iteration is a short cycle of work in few weeks. Stories have to be small enough to be done within iteration. Iteration begins with planning and on the end with retrospective (continuous improvement) and reviewing of completed work. Every day team has a short meeting for coordination and actual status of progress synchronization.

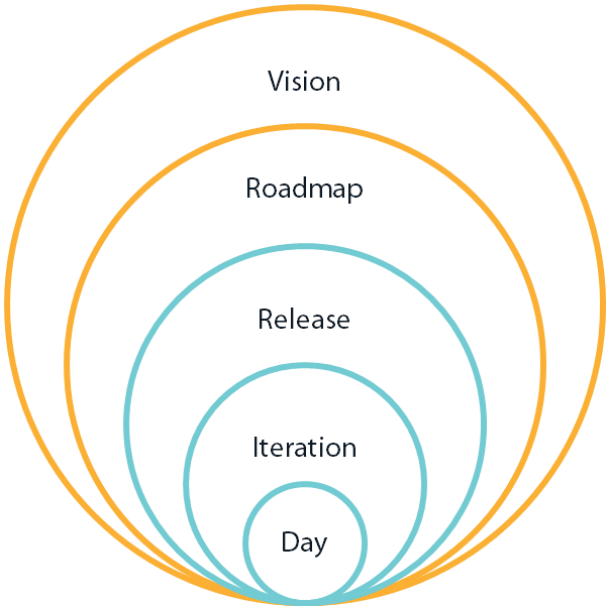


Figure 4. Agile Planning Onion

There are three main roles in agile project management: product owner, iteration master and team member. Product owner creates the Vision together with stakeholders, manages the roadmap and releases. Iteration master is more like administrator for meetings, maintain everyday process and teamwork.

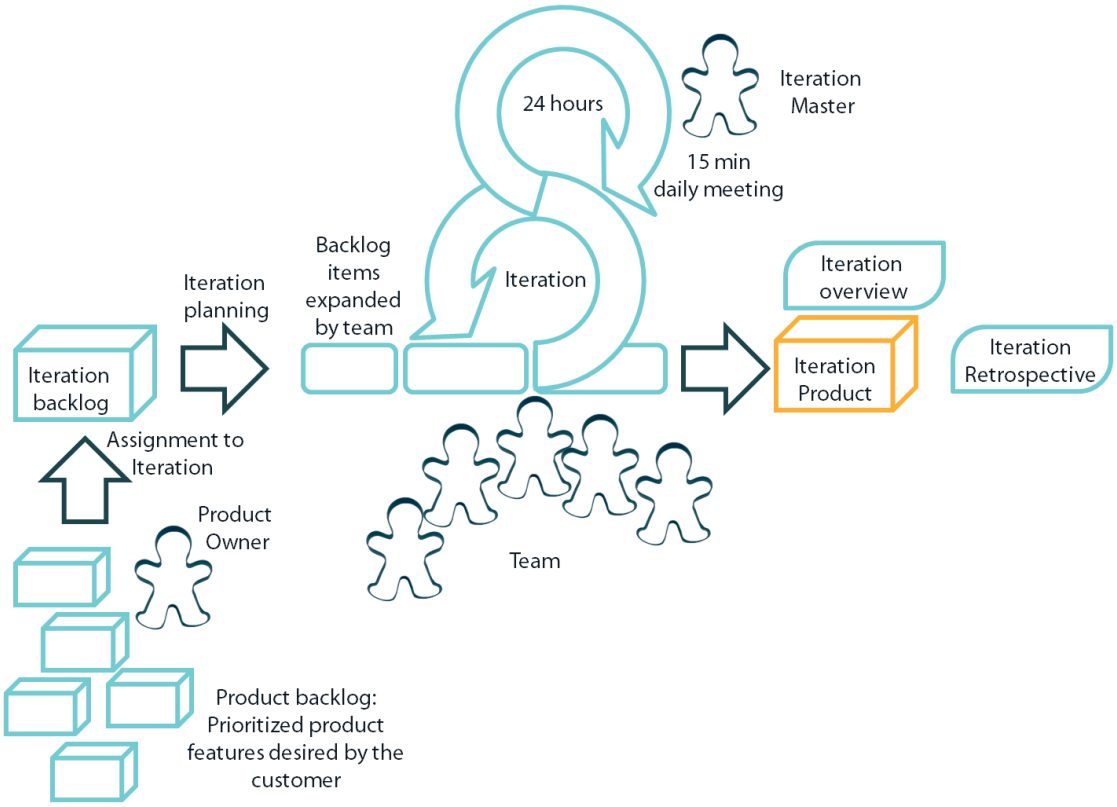


Figure 5. Agile iteration process flow

Planning and Control

Planning in agile project management uses “planning driven” approach rather than “plan driven”. Because assumptions for plan have short actuality, plans also have short actuality within iteration. Planning is process of collaboration, evaluation and balancing of priorities involving whole team and customers. Planning in terms of “iron triangle” project constraints (cost, time, scope) has fixed time and cost, but the scope is flexible and could be changed from iteration to iteration.

Planning process is multilevel approach described by Agile Planning Onion: informal daily planning, iteration detailed planning for increments within fixed time-box, release planning as prioritized tasks with focus on working completed part of product, roadmap planning (work break down structure analog) as decomposition of whole product in very general formulation. All planning in agile approach involves team and customer representatives.

Estimating process in agile project management uses special measurement – story points. There are two main approaches to estimate story or work break down package: comparing scale and ideal days. Both approaches use the Fibonacci sequence (1,2,3,5,8,…) as estimation sequence. The reason for that is human psychological ability of comparing. It’s difficult to estimate difference between 7 and 8, but difference between 5 and 8 is better to imagine and plan. Story points in comparing basics just find the shortest and easiest story and estimate it as 1, others stories compare with it 1-rating story. Story points in ideal days assume that story will be implemented in ideal working days when all team have to focus only on this task. Estimation in story points or planning poker made by all team together using three the most common techniques: expert opinion, analogy and disaggregation (Cohn M.,2006). Planning poker brings together multiple expert opinions in lively dialogue and it is fun and honest process. After estimating, story points are the main progress parameter to measure project velocity and efficiency of project execution.

Prioritization is another important process within Planning. There are four main factors for prioritization by (Cohn M., 2006): value (the financial value of having the features), cost (the cost of developing (and perhaps supporting) the new features), new knowledge about the product – what to deliver and project – how to deliver (the amount and significance of learning and new knowledge created by developing the features) and risk (the amount of risk removed by developing the features). The result of prioritization has to be ranked critical tasks for the first priority to do in the next iteration. This is key process to reduce uncertainty and to do right job first for the best project value in current situation.

There are different techniques for prioritization. The Kano model of customer satisfaction gives three categories of tasks: must-have, the more-the better (linear), exciting and delight features. This is customer satisfaction prioritization process, based on the broad survey with usually like/expect/neutral/could live with/dislikes categories. (Cohn M., 2006).

Wysocki R.K. (2009) advices to use one of the four prioritization approaches: ranked matrix (simple multi-ranks table for each item), paired comparison (compares only two items), MoSCoW (must, should, could and would not categories) and scope triangle ranking matrix (scope, quality, time, cost, resource availability with criticality evaluation for each task).

Basic principle for planning after tasks prioritization and evaluation is “bucket planning” process. Project team has fixed time-boxes (bucket with certain size) for each iteration and release as set of iterations. Scope tasks aggregated, prioritized and evaluated as water volume have to find proper bucket or time-box.

Monitoring and Control in the Agile Project Management is process through the frequent delivery, collocation, daily team meeting and time-box (iteration and release) review. Basically this is monitoring and control of planned story points completion. Usually it is simple burn-down diagram where every day number of completed story points reported and “burn” from the total iteration scope.

Scheduling

Previously two phases was covered: estimating the size of each package of functionality (WBS), and then prioritizing so that the team could to create the best possible product. This is creating a schedule part. Schedule has to be defined for the iteration and release. Daily scheduling is defined by team except 15-minutes meeting.

Release plan is roadmap to end-product for team and for the sponsors and product owner with expectations about how long it will be. Typical steps in release planning process (Cohn M., 2006) contain determination for the conditions of satisfaction, estimation the user stories, selection on iteration length, estimation of velocity, prioritization and selection stories and release dates.

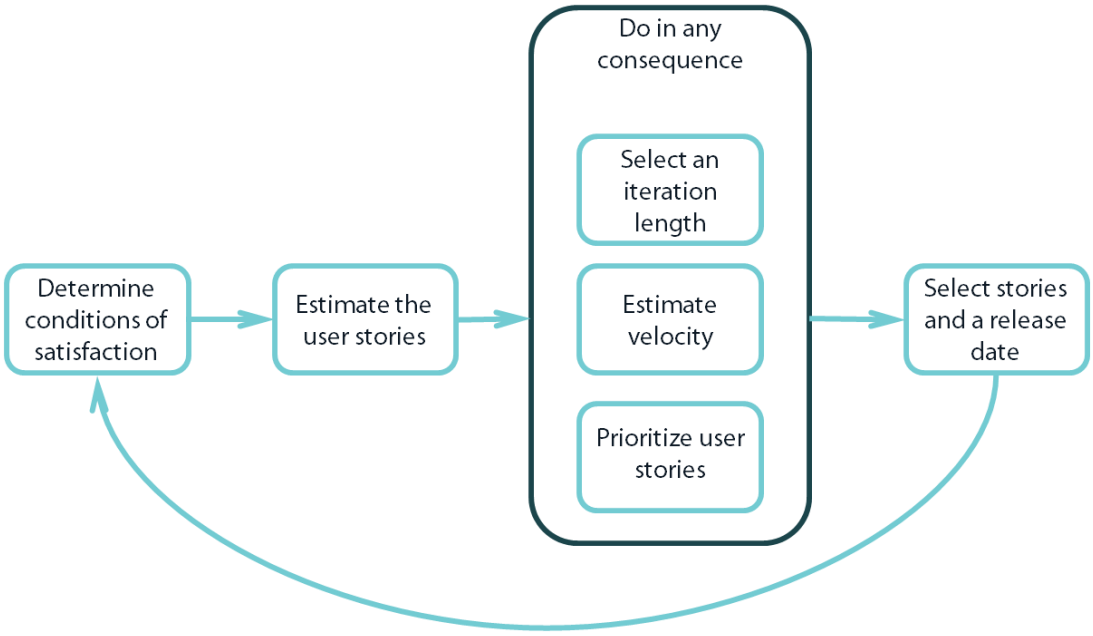


Figure 6. Release planning steps. Cohn M.(2006)

Final step is selection of product release date or main phases total length. In time-critical projects, where final date is fixed, planning gives opportunity to estimate scope or functionality in prioritized list of works that could be delivered on time. Release plan is high-level detailed plan and could be updated from iteration to iteration.

Iteration planning is detailed process to define how to implement chosen pieces of work. It is usually very simple list of tasks with estimations in hours for finalizing each task.

Table 4. Main differences between a release and an iteration plan. Cohn M.(2006)

	Release plan	Iteration plan
Planning horizon	3-9 months	1-4 weeks
Items in plan	user stories	tasks
Estimated in	story points or ideal days	ideal hours

Main factors that guide release planning by Cohn M., (2006) are:

> How often the product elements can be shown (in potentially shippable form) to users and customers.
> How often progress can be measured. It's possible to get a sense of a team's rate of progress during iteration, but only at the end of iteration can we truly measure how much work has been truly completed.
> How often the product owner and team can refine their course, because priorities and plans are adjusted between iterations.

Iteration planning steps is velocity determined. Velocity is defined as average or last iteration velocity (story point achieving speed per iteration time-box). There are few steps in iteration planning (Cohn M., 2006): adjustment of priorities, determination of target velocity, identification an iteration goal, selection of user stories, splitting user stories into tasks and estimation of tasks.

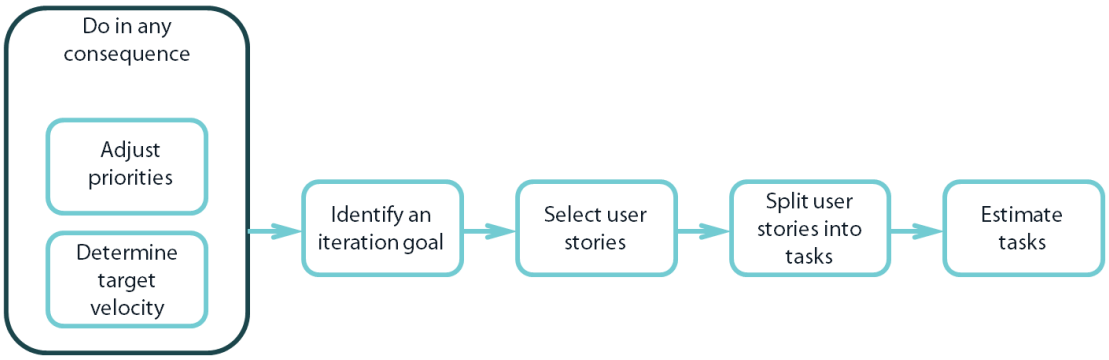


Figure 7. Iteration planning steps. Cohn M.(2006)

Selecting of iteration length is essential question for a scheduling. Usually the length of iteration is 2-4 weeks. This is team and experience based process with guidance by factors (Cohn M., 2006):

- The overall length of the release
- The amount of uncertainty
- The ease of getting feedback
- How long priorities can remain unchanged
- Willingness to go without outside feedback
- The overhead of iterating
- How soon a feeling of urgency is established

Velocity team determination is process which could be defined through the historical data (comparing with previous experience), run a first test-iteration and forecasting. Forecasting has to define expected available time work for each member, total number of hours for iteration and each user story, adjustments for risks and interdependences.

Risk Management

Risk management is process built-in the agile project management. Small and often pieces of project delivering, client and business focus, often re-planning on the few levels, small, self-organized and self-motivated team etc. – all these reduce organizational risks. Risk in agile project management is mainly goal and solution oriented. (Wysocki R.K.,2009). Risk management stages are the same as in traditional Project management: risk identification, risk analysis, risk prioritization, risk management planning, risk resolution and risk monitoring. Practically the most of risk

management activities are implemented by task and user stories prioritization and schedule buffers because of estimation errors.

Schedule buffers protect a project schedule against uncertainty and usually are empirical for each context. Buffer size could be defined by two main approaches – empirical suggestions by the task or project type (Shenhar A.J. and Dvir D., 2007) or by project stage (Cohn M., 2006) and 50-90% rule for probability distribution function (Wysocki R.K., 2009 and Cohn M., 2006). Cohn M.(2006) suggested that the project buffer should represent at least 20% of the total project duration for agile projects.

Table 5. Combined project uncertainty and its impact. Shenhar A.J. and Dvir D. (2007)

Uncertainty	Technology	Number of iterations	Number of prototypes or redundancy	Time buffer
low	low	few (1-2)	none	5%
medium	medium	several (2-3)	few (1-2)	5%-10%
high	high	many (3-4)	many (3-4)	10%-25%
super-high	super-high	multiple (>4)	multiple (>4)	25%-50%

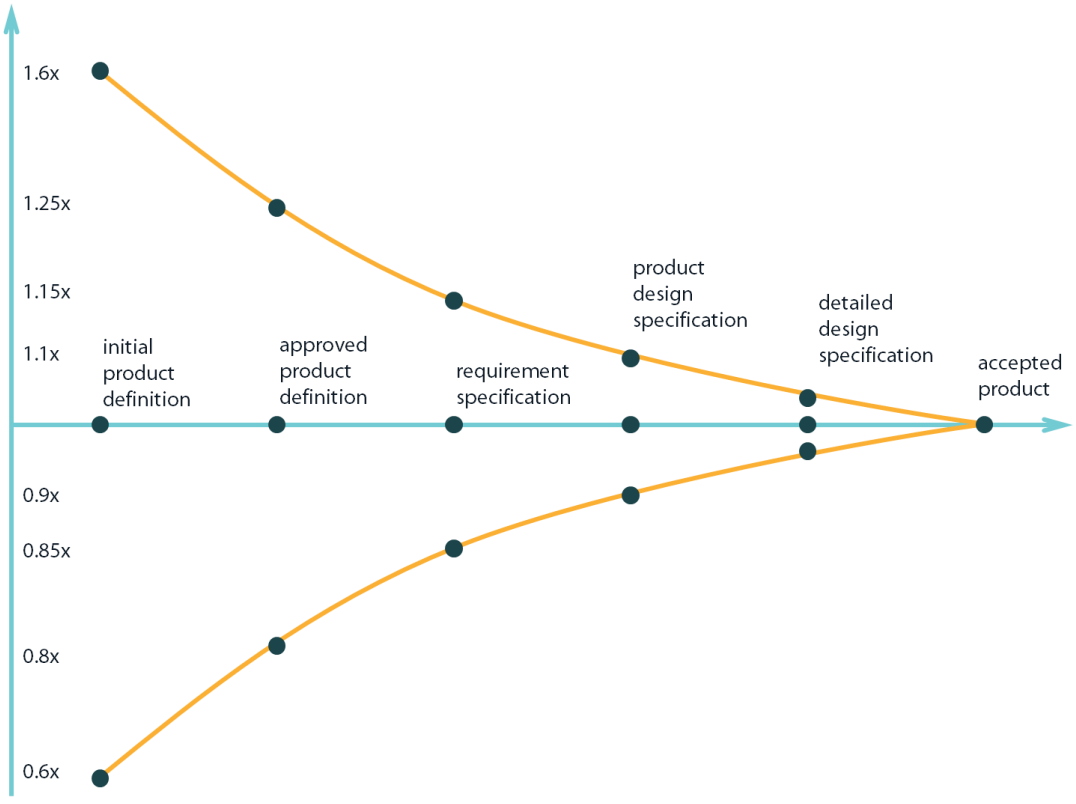


Figure 8. The cone of uncertainty around schedule estimates. Cohn M.(2006)

Selection-prioritization of tasks or work break down structure packages is another risk management tool for scope constraints. Agile project management as value focused approach could be simply defines risk management as Risk-Value matrix with priority for Value.

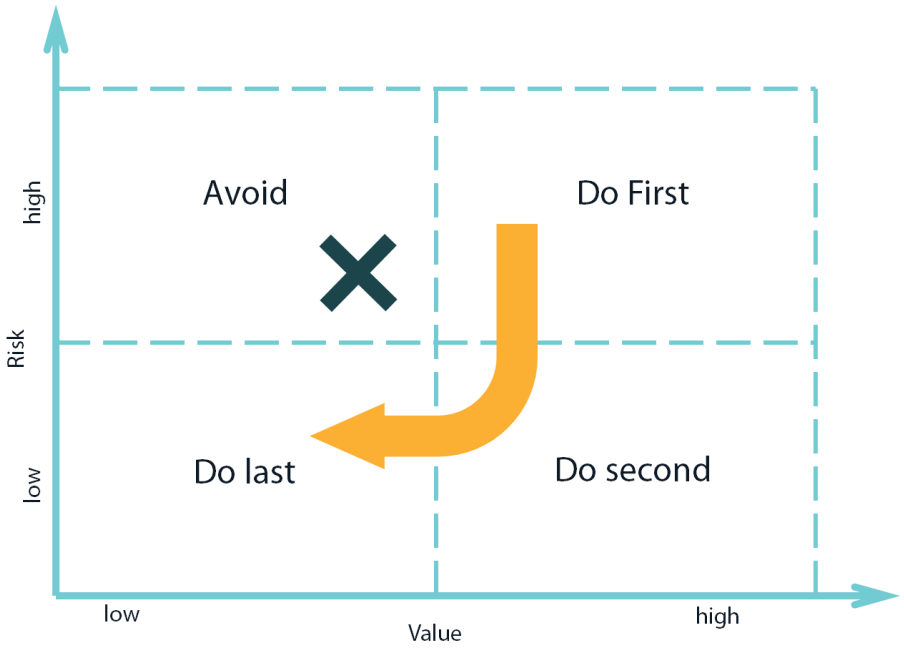


Figure 9. Risk-Value matrix for prioritization

2.4 ONE MODEL AGAINST MULTI-MODELS

Modern Project Management has a lot of new concepts related to agile approaches. Mainly, it is more empirical than theoretical, well defined frameworks. Most of the agile methods advice to forget traditional project management concept, because they based on the wrong assumptions about dynamism of reality and not flexible for uncertainty. From the other hand still are very strong positions of traditional project management organizations with well defined education and certification for project management office employee. And just few of researchers are trying to use advantages of both approaches and find the most effective balance for the project success. There are opinions of such researchers below.

Turner R., Ledwith A., Kelly J. (2010, 2012) in few articles shows result of research in project management field for small and medium companies. They find that micro, small and medium companies are successfully using basic traditional project management techniques. The most popular top-5 techniques are: requirements management, status reports for cost and time, risk and issue management and work breakdown structure, roadmap or milestones. Combination of agile and basic simplified traditional project management approaches gives practically the best result. Light version of project management is essential for such projects. Light traditional project management should be based around requirements management as the core element for delivering of needs to customers. It must also be simple and clearly show value to founders, sponsors and top management.

Table 6. Comparing of traditional approach and reality in small and medium companies
Turner R., Ledwith A., Kelly J. (2010, 2012)

	traditional	small and medium companies
Processes	are formal and bureaucratic	simple planning and control systems and informal reporting
Procedures	encourage specialization and formal decision making	low degree of standardization with idealistic decision making
Structure	roles are well defined and traditional project management stifles innovation	because of the high consequence of failure, preference of tested techniques. low degree of specialization with multi-tasking, but a high degree of innovativeness.
People	system rather than people focused	focus on people. strong sense of family with low specialization and people able to undertake a range of duties.

Boehm B., Turner R. (2002, 2003, 2004) agree about using a mix of approaches for real life projects. They wrote a book and few research articles for software development projects. Research based on comparing different agile and traditional approaches shows that it is efficient to and even necessary to use balancing approach for the most of situations. They are also trying to answer for a "How much is enough?" questions by balancing the risks of doing too little of something with the risk or doing too much.

Table 7. Combining agile and plan-driven methods: misconceptions and reality
Boehm B., Turner R. (2004)

Misconception	Reality
Agile and plan-driven methods are completely unmixable	Agile and plan-driven methods have been successfully combined in a variety of situations
There are one-size-fits-all process templates for balancing agile and plan-driven methods	Variation in project risks and stakeholder value propositions lead to different balances of agile and plan-driven methods
Balancing agile and plan-driven methods is a one-dimensional pure-management, or pure-personnel activity	Balancing agile and plan-driven methods involves multidimensional consideration of technology, management and personnel factors

Top six conclusions from Boehm B., Turner R. (2002, 2003, 2004):

1. Neither agile nor plan-driven methods provide a silver bullet.
2. Agile and plan-driven methods have home grounds where one clearly dominates the other.
3. Future trends are toward application developments that need both agility and discipline.
4. Some balanced methods are emerging.
5. It is better to build your method up than to tailor it down.
6. Methods are important, but potential silver bullets are more likely to be found in areas dealing with people, values, communications and expectations management.

Shenhar A.J. and Dvir D. (2007) in their research described on the book "Reinventing project management: the diamond approach to successful growth and innovation" also show that *one size does not fits all* and projects have to adjust management style to the environment, the task and the goal. Adaptive project management approach is response for uncertainty and complexity versus traditional one. Shenhar A.J. and Dvir D. (2007) made a comparison between two different styles of management presented in table.

Table 8. Traditional vs. Adaptive project management
Shenhar A.J. and Dvir D. (2007)

Approach	Traditional	Adaptive
project goal	getting the job done on time, on budget and within requirements	getting business results, meeting multiple criteria
project plan	a collection of activities that are executed as planned to meet the triple constraint	an organization and a process to achieve the expected goals and business results
planning	plan once at project initiation	plan at outset and replan when needed
managerial approach	rigid, focused on initial plan	flexible, changing, adaptive
project work	predictable, certain, linear, simple	unpredictable, uncertain, nonlinear, complex
environment effect	minimal, detached after the project is launched	affects the project throughout its execution
project control	identify deviations from plan and put things back on track	identify changes in the environment and adjust the plans accordingly
distinction	all projects are the same	projects differ
management style	one size fits all	adaptive approach; one size does not fits all

On the same time Shenhar A.J. and Dvir D. (2007) wrote that balancing of traditional and agile approaches are important for successful project performance.

> "We do not suggest, however, that you should eliminate the traditional approach. Rather, the adaptive approach builds on it. Many elements of traditional project management will continue to be essential" (Shenhar A.J. and Dvir D. ,2007, p.12)

Levitt R.E. (2011) describes way from traditional to modern project management as evolution. Modern "project management 2.0" by Levitt is more agile, engage more available knowledge and more strategic than operational. But on the same time he agrees that traditional discipline methods necessary for high risk projects especially with major health and environmental consequences of project failures. Also he suggests traditional techniques for very big and/or geographically distributed organizations (difference in time, nationalities, languages, cultures etc.). Last one main reason to safe and combine traditional management by Levitt is people professional growth. Traditional hierarchical structures give better specific education and experience in depth of chosen specialization field.

Apello J. (2011) in the book 'Management 3.0' has analyzed the most common management models and made own models but at the end wrote that "all models are wrong, but some are useful". He discuss that useful to have multiple models for

different situations in modern complex and non-linear projects which could be complementary and even conflicting between each other. Apello J (2011) also provides advice to understand difference between agility and agile methods. “Agility is about staying successful in ever-changing environment”. At the end of book author establish “pamphlet for complex projects”.

Pamphlet for complex projects. (Apello J.,2011, p. 379)

- **Each problem has multiple solutions**. There is not one best way to run a project
- **Solutions depend on the problem’s context**. The best practices depend on the project Environment
- **Changing context requires changing solutions**. When project environments change, project change accordingly
- **Each strange solution is the best one somewhere**. There is always a place and time for less popular practices.
- **Solutions change the context and themselves**. Practices change environments and how we use practices.
- **Simplicity necessitates understanding complexity**. One must understand complexity before applying simple solutions
- **We cannot predict the best solution**. We have to try practices to know if they work in our context.

2.6 Balancing of TPM and Agile

There are few methods to balancing of two styles of project management: traditional and agile in one project: Wysocki method, Boehm and Turner method, Little method, Diamond method. There are methods for selection activities for the proper management style.

Wysocki method

Wysocki R.K. (2009) in his book describes conceptual classification by project landscape (solution and goal). Traditional Project Management (TPM) defines Quadrant 1 (clear goal and clear solution); Agile Project Management (APM) defines Quadrant 2 (clear goal, but not clear solution); Extreme Project Management (xPM) defines Quadrant 3 (not clear goal and solution); and Emertxe Project Management (MPx) defines Quadrant 4 (not clear goal, but clear solution).

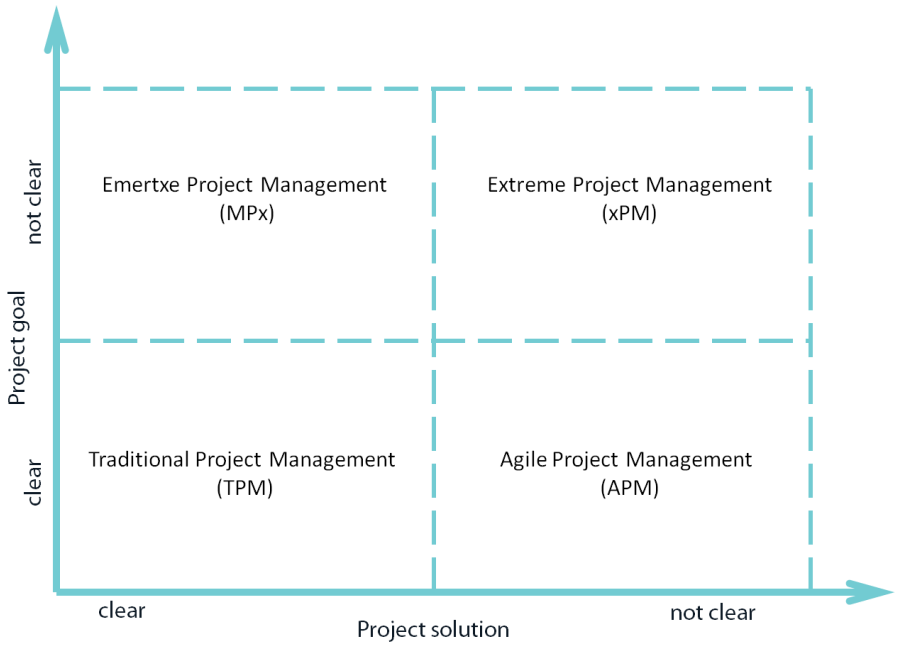


Figure 10. Wisocki project classification

Traditional Project Management (TPM) has following characteristics: low complexity, few scope change requests, well-understood technology infrastructure, low risk, experienced and skilled project teams, plan-driven methods.

Agile Project Management (APM) includes iterative and adaptive approaches. Author evaluates that APM is the majority (70%) of all modern projects. APM has following characteristics: a critical problem without a known solution, a previously untapped business opportunity, critical to the organization, meaningful client involvement is essential, small co-located teams.

Extreme Project Management (xPM) and Emertxe Project Management (MPx) are usually research and development projects with very high risk of success for innovative solutions.

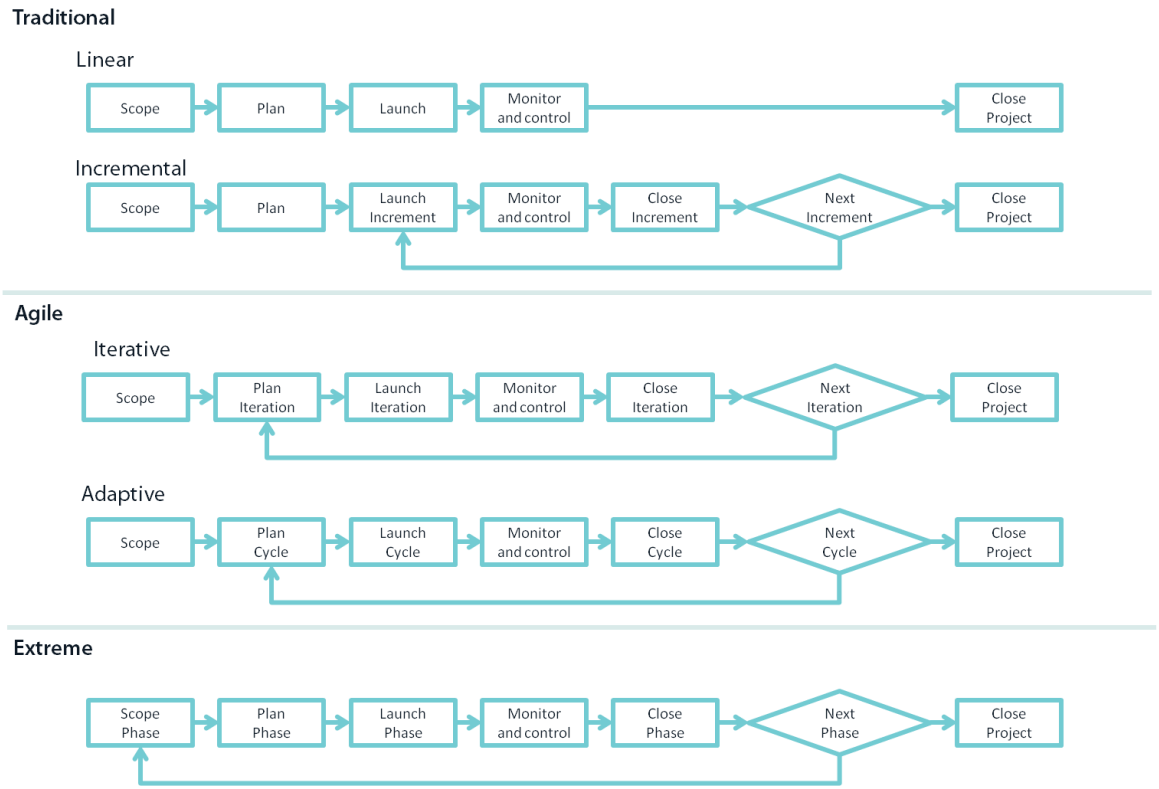


Figure 11. PMLC Model

Five project management life cycles (PMLCs) presented in Wysocki R.K. (2009) theory are constructed based on the five process groups originally defined by the Project Management Institute (PMI) in their standards guidelines called the Project Management Body of Knowledge (PMBOK). In Table there is a list of the project characteristics that guide choice of PMLC model.

Table 9. Project Characteristics as a Determinant of Which PMLC Model to Use. Wysocki R.K. (2009)

PMLC model type	When to use it
Traditional Linear	The solution and requirements are clearly defined. You do not expect too many scope change requests. The project is routine and repetitive. You can use established templates.
Traditional Incremental	Same conditions as the Linear approach, but the client wants to deploy business value incrementally. There may be some likelihood of scope change requests

Agile Iterative	You feel that requirements are not complete or may change. You will learn about remaining requirements in the course of doing the project. Some features of the solution are not yet identified.
Agile Adaptive	The solution and requirements are only partially known. There may be functionality that is not yet identified. There will be a number of scope changes from the client. The project is oriented to new product development or process improvement. The development schedule is tight and you can't afford rework or replanning.
Extreme	The goal and solution are not clearly known. The project is an R & D type project.

Boehm and Turner method

Boehm B., Turner R. (2002, 2003, 2004) has established method of balancing Agile and Traditional approaches for projects. They use 5 steps decision model with focus on the risk analysis.

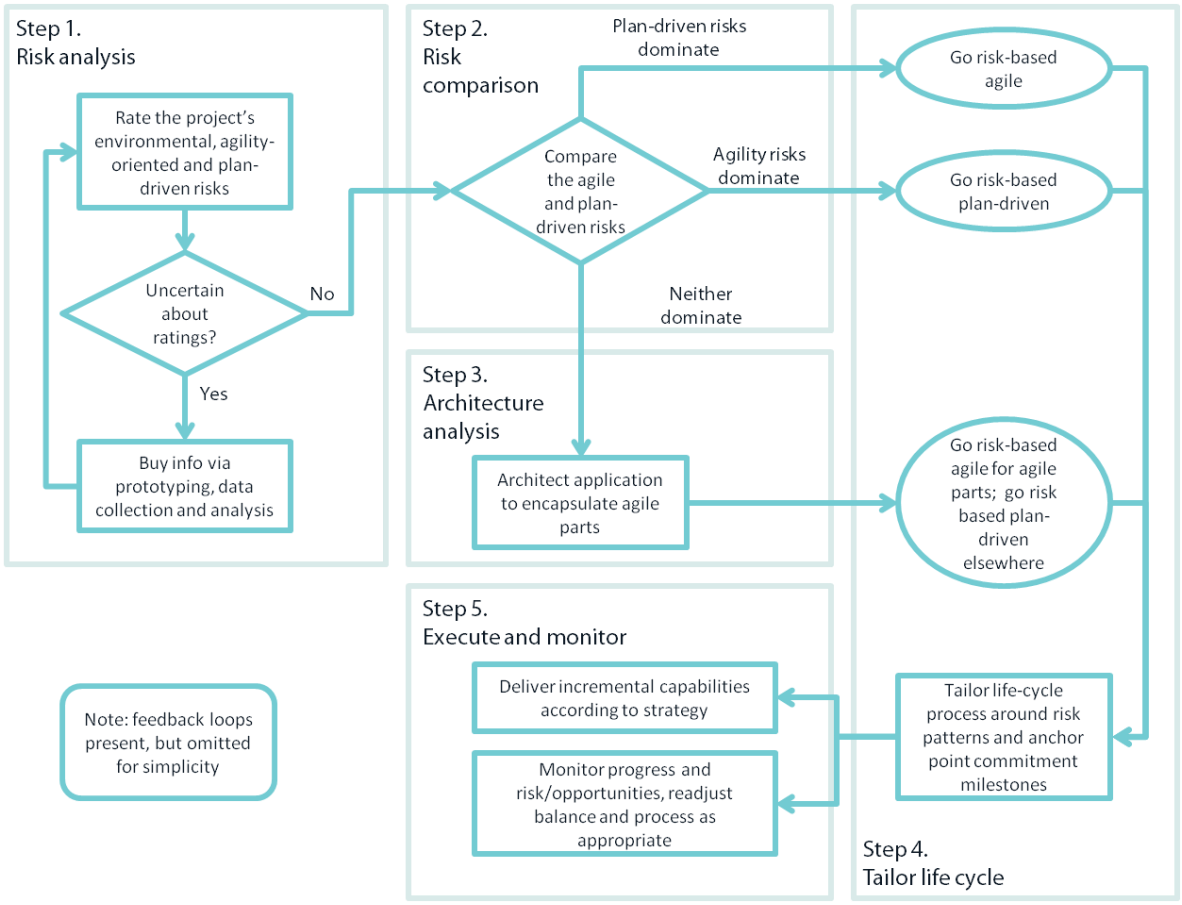


Figure 12. Boehm and Turner balancing method

Step 1. Risk analysis.

Risk analysis includes risk ratings within three categories (Environmental, Agile and Plan-driven) for providing the basis for making decision on the next steps.

Environmental risks: risks that result from the project's general environment

> E-Tech. Technology uncertainties
> E-Coord.Many diverse stakeholders to coordinate
> E-Cmplx. Complex system of systems

Agile risks: risks that are specific to the use of agile methods.

> A-Scale. Scalability and criticality
> A-Churn. Personnel turnover or churn
> A-Skill. Not enough people skilled in agile methods

Plan-driven risks: risk that are specific to use of plan-driven methods

> P-Change. Rapid change
> P-Speed. Need for rapid results
> P-Emerge Emergent requirements
> P-Skill Not enough people skilled in plan-driven methods

Boehm and Turner use 5 comparable risk rating scales for each category:

> Minimal risk
> Moderate risk
> Serious but manageable risk
> Very serious but manageable risk
> Showstopper risk

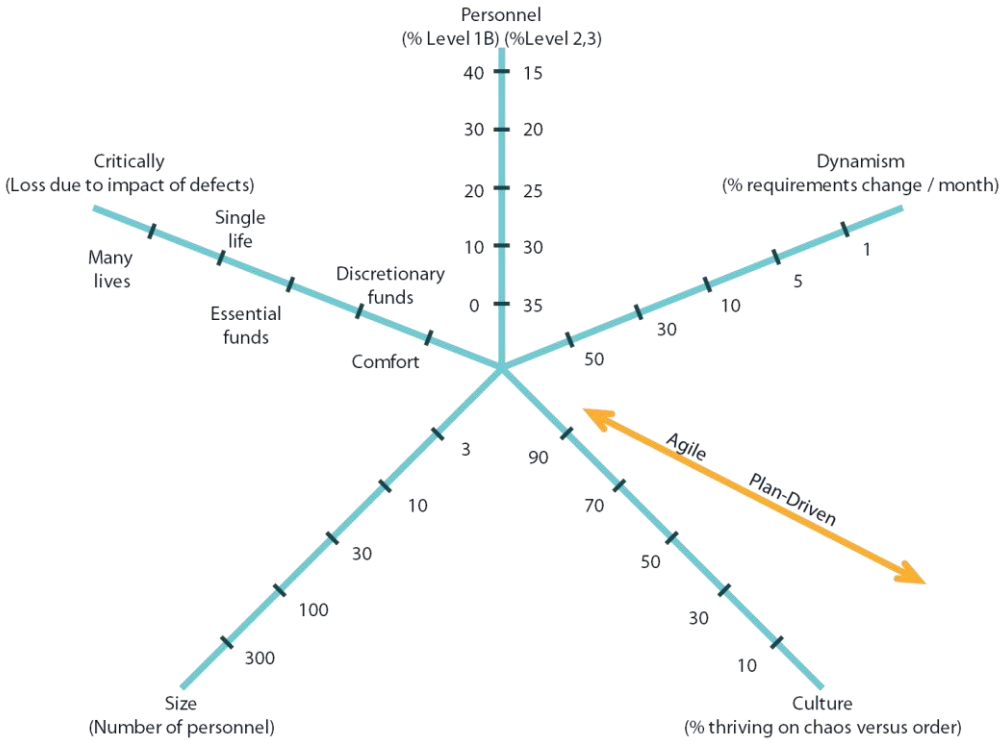


Figure. Boehm and Turner balancing polar chart

Step 2.

On the next step risk analysis results are evaluated into domination for one of approaches – Traditional or Agile. There is 5-factors (Personnel, Dynamism, Culture, Size, Criticality) home ground chart help to make final decision.

Table 10. The five critical agility and plan-driven factors.
Wysocki R.K. (2009)

Factor	Agility discriminators	Plan-driven discriminators
Size	Well matched to small products and teams; reliance on tacit knowledge limits scalability	Methods evolved to handle large products and teams; hard to tailor down to small projects.
Criticality	Untested on safety-critical products; potential difficulties with simple design and lack of documentation	Methods evolved to handle highly critical products; hard to tailor down efficiently to low-criticality products.
Dynamism	Simple design and continuous refactoring are excellent for highly dynamic environments, but present a source of potentially expensive rework for highly stable environments.	Detailed plans and "big design up front" excellent for highly stable environment, but a source of expensive rework for highly dynamic environments
Personnel	Require continuous presence of a critical mass of scarce Cockburn Level 2 or 3 experts; risky to use non-agile Level 1B people	Need a critical mass of scarce Cockburn Level 2 and 3 experts during project definition, but can work with fewer later in the project—unless the environment is highly dynamic. Can usually accommodate some Level 1B people.
Culture	Thrive in a culture where people feel comfortable and empowered by having many degrees of freedom; thrive on chaos	Thrive in a culture where people feel comfortable and empowered by having their roles defined by clear policies and procedures; thrive on order.

For personnel category a classification of project team members from Alisrair Cockburn (2001) was used. People was classified both in ability to use agile or traditional methods and proportion of different groups in team.

Table 11. Levels for personnel. Cockburn (2001)

Level	Characteristics
3	Able to revise a method (break its rules) to fit an unprecedented new situation
2	Able to tailor a method to fit a precedent new situation
1A	With training, able to perform discretionary method steps. With experience, can become Level 2
1B	With training, able to perform procedural method steps. With experience, can master some Level 1A skills
-1	May have technical skills, but unable or unwilling to collaborate or follow shared methods.

Step 3.

If project does not snow pure agile or pure traditional nature, architecture application for balancing both approaches is used. There is selection of project elements for the best effort from applied management approach.

Step 4.

Focus on overall project strategy, which methods within management approach to use. After that Scheduling with Risk Management are planned.

Step 5.

Execution and monitoring processes gives reactive action for changes.

Little method

Little T. (2005) in empirical research article describe own method as extension and simplifying Boehm and Turner method. Research gives more attributes, but then simplify by grouping them into two categories – complexity and uncertainty. Complexity includes team size, mission criticality, team location, team maturity, domain knowledge gaps and dependencies. Uncertainty includes market uncertainty, technical uncertainty, project duration and other projects' dependencies on that project and scope flexibility.

Table 12. Complexity score.
Little T. (2005)

Complexity score					
Attribute	1	3	5	7	10
Mission criticality	Speculative	Small user base	Established market	Mission-critical with large user base	Safety critical with significant exposure
Team size	1	5	15	40	100

Team location	Same room	Same building	Within driving distance	Same time zone +/- 2 hrs	Multisite, worldwide
Team capacity	established team of experts	New team of experts	Mixed team of experts and novices	Team with limited experience and a few experts	New team of mostly novices
Knowledge gaps	Developers know the domain as well as expert users	Developers know the domain fairly well	Developers require some domain assistance	Developers have exposure to the domain	Developers have no idea about the domain
Dependencies	None	Limited, well insulated	Moderate	Significant	Tight integration with several projects

Table 13. Uncertainty score, Little T. (2005)

Uncertainty score					
Attribute	1	3	5	7	10
Market uncertainty	Known deliverable, possibly defined contractual obligation	Minor changes in market target expected	Initial guess of market target likely to require steering	Significant market uncertainty	New, unknown, and untested market
Technical uncertainty	Enhancements to existing architecture	We think we know how to build it	We're not quite sure if we know how to build it	Some incremental research involved	New technology, new architecture; might be some exploratory research
Project duration	1–4 weeks	6 months	12 months	18 months	24 months
Dependencies, scope flexibility	Well-defined contractual obligations or infrastructure with published interfaces	Several interfaces Scope isn't very flexible	Scope has some flexibility	Some published interfaces Scope is highly flexible	No published interfaces

After evaluating process a project take a place in Houston Matrix quadrant assessment. Each quadrant has associative names and gives strategy what type of management approach would be relevant. Dogs (simple projects with low uncertainty) are projects with pure agile approach for small self-driven team, simple and not very critical result. Colts (simple projects with high uncertainty) are also agile approach but with more formal procedures as Scrum. Small team has a lot of freedom but within controlled edges by management. Cows (complex projects with low uncertainty) are large and not fast project with the best possibility for traditional plan-driven approaches. Bulls (complex projects with high uncertainty) are projects for balanced approaches. They need to be quite agile to deal with uncertainty and required some process ceremony to manage complexity. Projects are large but can get out of control quickly if team is not effective.

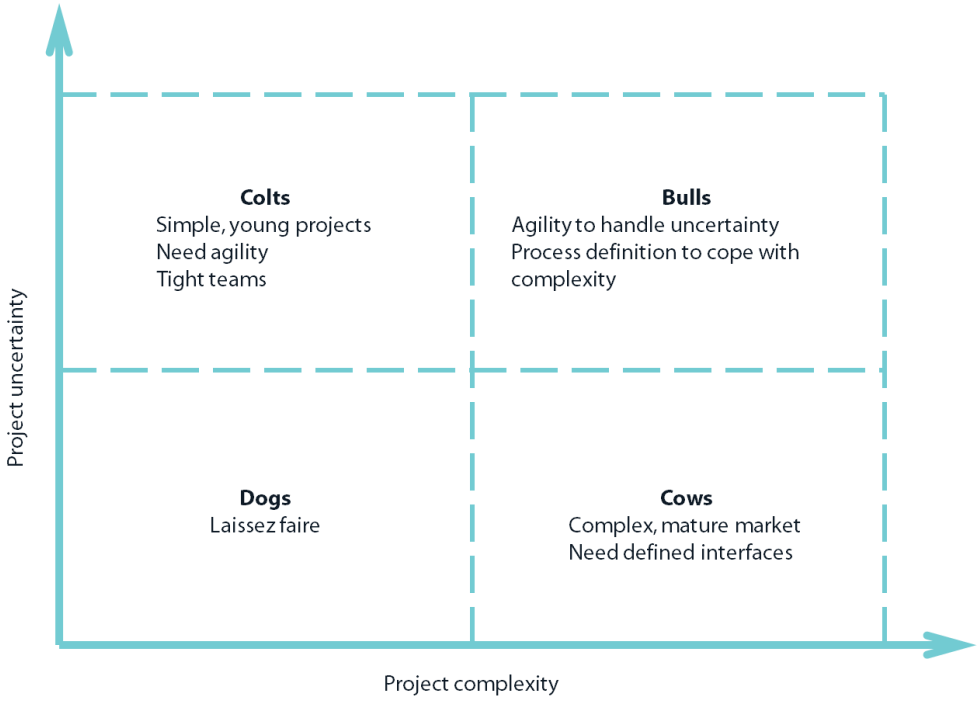


Figure 13. Little matrix

Diamond method

Result of research by Shenhar A.J. and Dvir D. (2007) is diamond model – diamond shaped framework with four dimensions: novelty, technology, complexity and pace. Details of diamond model see on the figure and table. Each project or work package has own 4-dimensions figure and define risk, style of management and planning and other project management actions.

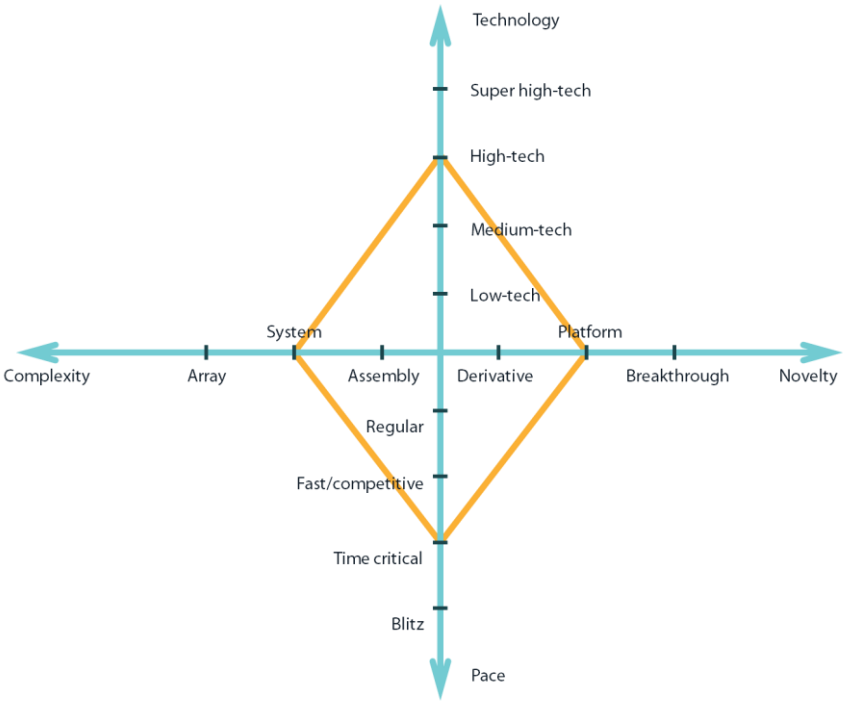


Figure 14. Diamond model

Table 14. Definitions of basic elements in diamond model. Shenhar A.J. and Dvir D. (2007)

Dimensions	Definition
Novelty	Represents the uncertainty of the project's goal, the uncertainty in the market, or both. It measures how new the project's product is to customers, users, or to the market in general and thus how clear and well defined the initial product requirements are. Novelty includes three types: derivative, platform and breakthrough
Technology	Represents the project's level of technological uncertainty. It is determined by how much new technology is required. Technology includes four types: low, medium, high and super high tech.
Complexity	Measures the complexity of the product, the task and the project organization. Complexity includes three types: assembly, system and array (system of systems)
Pace	Represents the urgency of the project – namely, how much time there is to complete the job. Pace includes four types: regular, fast/competitive, time-critical, blitz

Using the diamond model for risk management was suggested by authors of method. Risk assessment represented on the figure. Risk assessment is mix of four risk dimensions. Novelty risks are misunderstanding of customers' needs and requirements; technology risks are implementation risk, for example, availability of the needed technology to complete product; complexity risks are coordination of many components and the mutual effects among them; pace risks are time constraints. In diamond model bigger diamond shape means more risk. Shenhar A.J. and Dvir D. (2007) used ideas of Laufer A. (1996) about project as a process whose goal is to reduce uncertainty. There are two types of uncertainty by Laufer A. – "what" uncertainty and "how" uncertainty.

Balancing of traditional and adaptive management styles is process with edge as "what" (requirements) and "how" (design and specifications) uncertainties. After freezing both requirements and design better to use traditional project management method with discipline, controlled and the best quality end-products approach advantages. Before freezing of requirements and design, is better to use adaptive style of project management with flexible and agile nature.

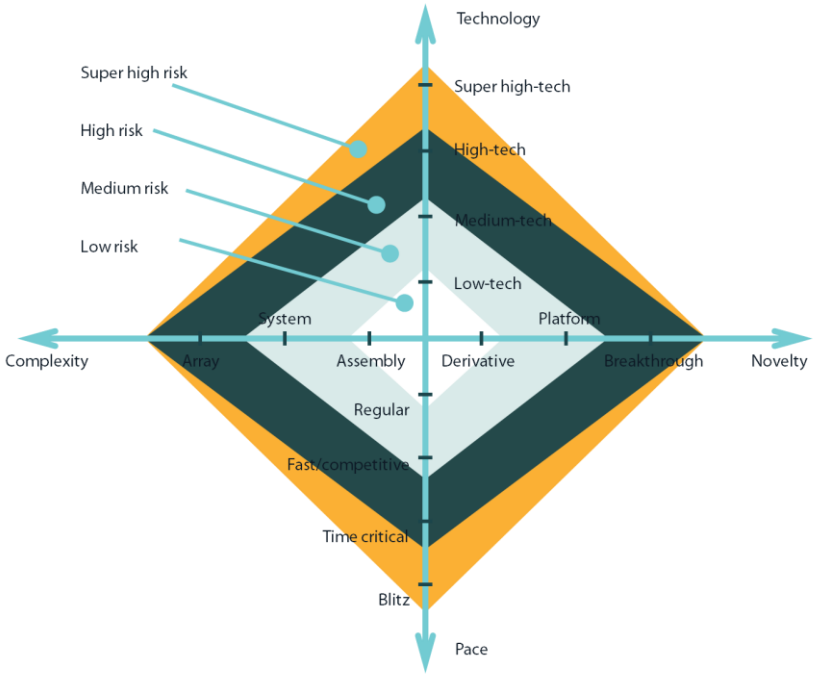


Figure 15. Diamond model risk assessment

Project planning in Diamond model is process with few levels. Balanced solution is follow "plan some of your work, work that plan and then replan the next piece of your work" concept rather than traditional "plan your work and work your plan". This process names Rolling wave of planning and Laufer A. (1996) suggested three

hierarchical plans instead of one – Master plan, Medium detail plan and Detailed work plans.

The highest level plan is Master plan that describes whole project life-cycle and contains only general details. It combines major milestones and phases. Master plan gives a big picture and important for project management and sponsors. There is just little possible changes and usually general time, money and requirements critical. Traditional methods are relevant for that master plan. Middle level plan is more detailed and contains events and actions between milestones and phases. New version of that plan is builds every phase based on previous phases and actual project progress. Detailed work plan is the most detailed plan for 1-2 weeks and used by project team and individual team members. This is plan for every person and every activity and prepared each short-term period.

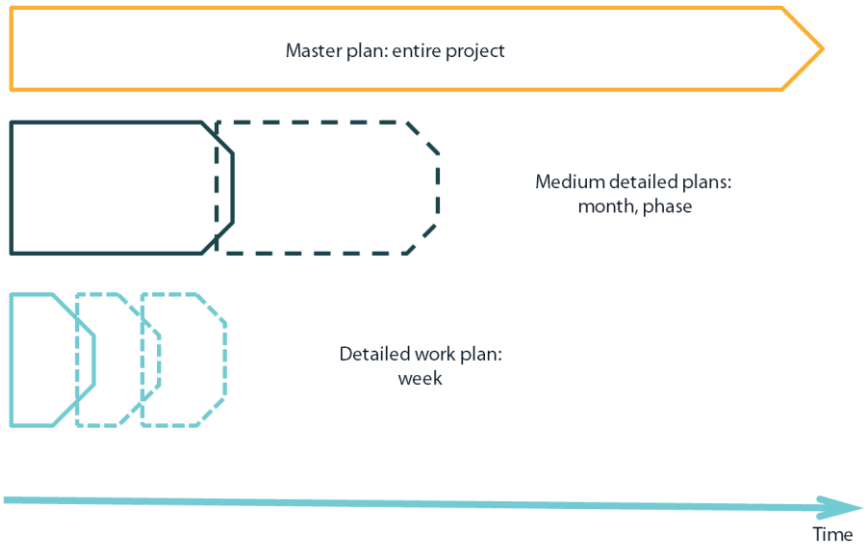


Figure 16. Rolling wave planning concept

Authors of method suggest to use proper project management style depend of defined project type. Each dimension has impact on part of project management style: more Technology – more design cycles and less design freeze; more Novelty – less market data and later requirements freeze; more Pace – more autonomy; more Complexity – more complex organization and more formality.

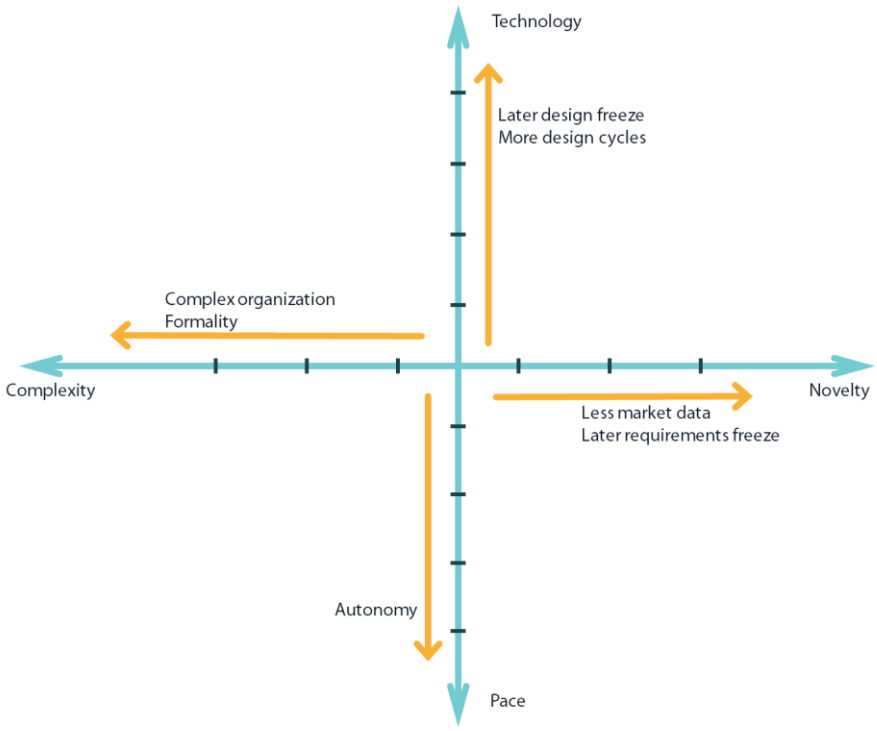


Figure 17. Diamond model dimensions impact to Project Management

Overview of methods

Table below is overview of different methods for selection of projects or work packages. The final result of selection is proper project management approach and basic for risk management and planning & control methodology.

Table 15. Overview of methods

method	parameters	scale of parameters
Wisocki	Solution	clear-not clear
	Goal	clear-not clear
Boehm and Turner	Personnel	% of agile/not agile people in team
	Dynamism	% of requirements changes per month
	Culture	chaos - order
	Size	how many people
	Critically	cost of failure from economical to human lives
Little	Uncertainty	mix of: > market uncertainty > technological uncertainty > project duration > scope flexibility, dependencies
	Complexity	mix of: > mission criticality > team size > team location > team capacity > knowledge gaps > dependencies
Diamond Shenhar and Dvir	Novelty	derivative, platform and breakthrough
	Technology	low, medium, high and super high tech
	Complexity	assembly, system and array (system of systems)
	Pace	regular, fast/competitive, time-critical, blitz

3. DNV FUEL FIGHTER PROJECT

Shell Eco Marathon is an annual competition for student teams from universities around the world. America, Asia and Europe are three geographical areas for competition. Each team has to design, produce and race their energy efficient cars. First place win car that consume minimum of energy on the same distance.

Shell as organizer have aim to develop future of mobility and inspire young professionals. Also this type of project is unique chance for student to implement real product from idea to real car.

Norwegian University of Science and Technology, Trondheim, Norway has taken part in Shell Eco-marathon competition in urban category with a hydrogen fuel cell car in 2008-2011.

New 2012 car has a very big potential for improvement. NTNU's 2013 team decided to continue use of previous year car design with the most of mechanical solutions and focus mainly on the improvement of engine and control systems, solar cells and driving strategy.

Name of the team and Project in 2013 is DNV Fuel Fighter. Main Sponsor as last years is DNV AS. DNV Fuel Fighter is only one Norwegian team in Shell Eco Marathon Europe Race.

DNV Fuel Fighter is unique project for students. This is mix of learning, new product development, entrepreneurs, working teams and game approaches. World-wide competition, representing of University and Country, multinational interdisciplinary team, complex system and innovative eco nature are challenges that make project extremely ambitions. Team has to implement full product life cycle from idea scratches to sustainable and competitive complex system. Project is excellent opportunity for students to get practical overview of real national and local industry within professional field, develop contacts with organizations and increase attractiveness for future employers.


Shell
John Ola Buoy
Andreas Severinsen
NTNU
SKF
733
DNV
MICHELIN

3.1 PROJECT ESSENTIALS

Shell Eco Marathon

Shell Eco Marathon is an annual competition for student teams from universities around the world. America, Asia and Europe are three geographical areas for competition. Each team has to design, produce and race their energy efficient cars. First place win car that consume minimum of energy on the same distance.

Shell as organizer have aim to develop future of mobility and inspire young professionals. Also this type of project is unique chance for student to implement real product from idea to real car.

Almost 200 the best student teams, around 3 000 students from Europe arrives to Rotterdam for competition in the middle of May. Teams, first, have to pass technical inspection that judges all technical, safety and formal requirements. Second, teams could test car on the track. Third, join the competition. During the competition any team could be disqualifying for some reasons if unfair or unsafe behavior was demonstrated.

Shell Eco-marathon is a unique competition that challenges students to design, build and drive the most energy-efficient car.

What is it?

Car competition

Who?

Organizer
Shell

Participants
Student teams

Win criteria?

The most energy-efficient car

Why?

The events spark debate about the future of mobility and inspire young engineers to push the boundaries of fuel efficiency.

www.shell.com/home/content/ecomarathon/

At three events around the world hundreds of student team compete to travel the furthest on the least amount of energy.

Location: Rotterdam

Figure 18. Shell Eco Marathon essentials

Regulations

Shell as organizer develops and controls Rules and Requirements for competition.

The Shell Eco-Marathon features two different classes for the participants to compete in. Those two classes are the “Urban Concept Car” and the “Prototype”-class. Both categories comply with their own rules and requirements towards car and driver.

The prototype class reflects the original spirit of the competition. That is to engineer a car that achieves the best mileage possible. Even though there are some rules regarding safety and dimensions to be obeyed, the participants have almost complete freedom in the design to achieve that goal. This means that special emphasis is put on minimizing the driving resistances of a prototype class car. The usual outcomes are very lightweight cars that resemble droplets in order to minimize the air drag, rolling resistance and inertia losses during acceleration. Successful teams often have cars made of carbon fiber, which allows competing in operable cars that weigh less than 35 kilograms.

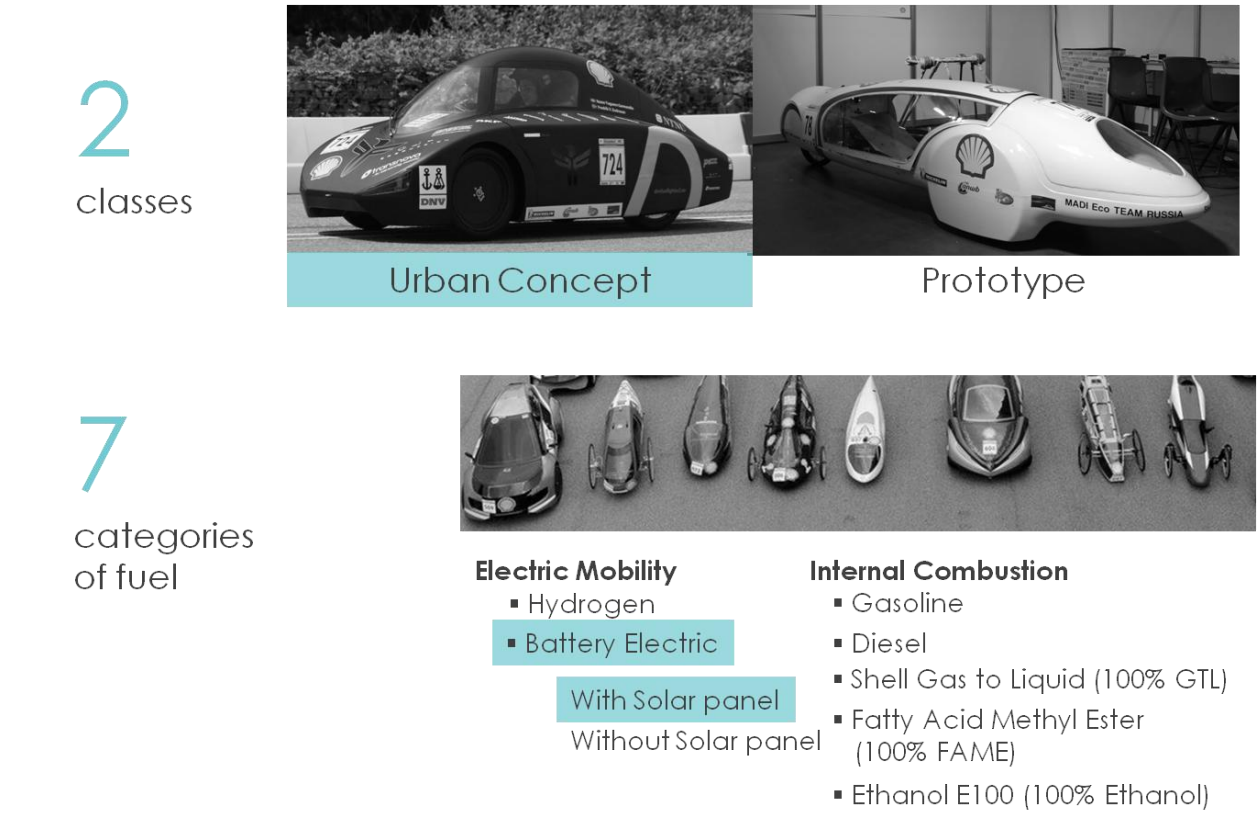


Figure 19. Classes and Categories of fuel

The Urban Concept Car class is a relatively new competition group that was introduced in 2003. The motive was to shift the exclusive focus from the solemn pursue of diving efficiency towards the inclusion of needs for everyday driving. That is the reason why urban concept class cars are close to the appearance of today's passenger cars. The urban concept class regards the basic requirements of an everyday vehicle. The door, which is very rare among prototype cars, must have specified size to enable the driver to comfortably enter and exit the car. Among other things, a luggage compartment, functional windshield wipers and operational head- and taillights must be realized in the car.

Another point is the course of the competition itself. Prototype class cars drive on the track at a constant pace in order to achieve maximum fuel efficiency. The urban concept class driving course however, resembles the stop and goes traffic in cities. This is implemented by having each car to stop at the finish line before it is allowed to start the next lap. This procedure implies a special attention towards a sophisticated racing strategy of controlled accelerations and decelerations.

The requirements for each class are revised every year to keep pace with technical developments and encountered problems during the events. The fulfillment of these requirements is checked during a technical and a safety inspection prior to the race. Additionally, comprehensive technical documentation has to be handed in preliminarily. A failure to comply with the specific requirement table results in an exclusion from the race.

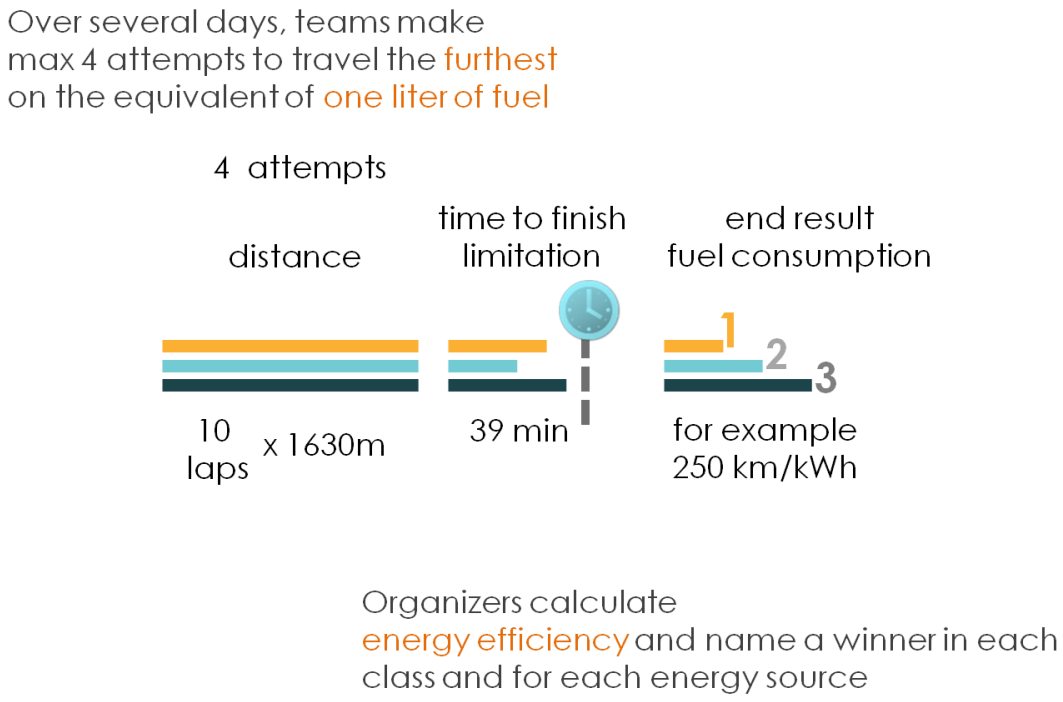


Figure 20. On-track award rules

Awards

The primary acknowledgement of participating in a race is to win the prize. The commendations awarded at the Shell Eco-Marathon can be divided into two categories, the “on-track award” and the “off-track awards”.

The on-track award is being commended to each car with the best energy efficiency within its fuel class. The main reason for awarding each fuel class separately is to avoid comparing cars whose propulsion systems have different degrees of efficiency inherit to their functional principle

The off-track awards do not focus on the result of the race itself. They commend the technical, aesthetical and collaborative implementation of the car. Most notably is the Design Award. This award praises impressive aesthetical design such as bodywork, paintjobs and creative graphics. The simultaneous consideration of aerodynamics is also part of this award.

While pioneering and peculiarly creative solutions are honored with the Innovation Award, exemplary nontechnical achievements are also dignified. The Public Relations Award for instance acknowledges outstanding communications efforts supporting a team’s participation of the Shell Eco-Marathon. A carefully

planned and conducted long-term campaign with appearance on television, radio and newspapers besides the professional use of social media and the internet in general is honored with this award.

In 2013 Shell established obligatory for teams the Student Energy Challenge additional award. Each team should submit at least one infographic that answers one of three energy-related questions provided by Shell.

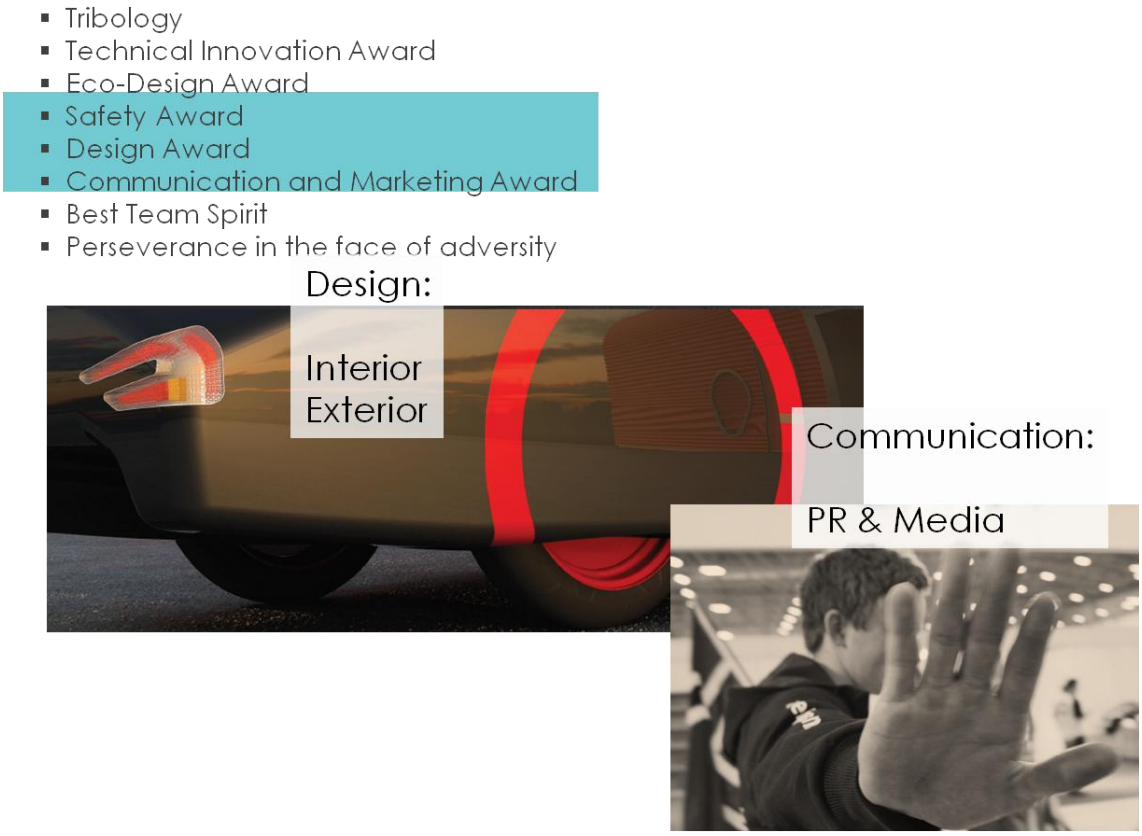


Figure 21. Off-track awards

DNV Fuel Fighter

Norwegian University of Science and Technology, Trondheim, Norway has taken part in Shell Eco-marathon competition in urban category with a hydrogen fuel cell car in 2008-2011.

The 2012 team decided to make a new vehicle from scratch for battery-electric class. Battery-electric class of urban category is more innovative and popular as more environmental friendly class. NTNU's 2012 team finished the competition by achieving the 5th rank in battery-electric class.

New 2012 car has a very big potential for improvement. NTNU's 2013 team decided to continue use of previous year car design with the most of mechanical solutions and focus mainly on the improvement of engine and control systems, solar cells and driving strategy.

Name of the team and Project in 2013 is DNV Fuel Fighter. Main Sponsor as last years is DNV. DNV Fuel Fighter is only one Norwegian team in Shell Eco Marathon Europe Race.

Figure 22. DNV Fuel Fighter. Who is Who

Figure 23. History of NTNU participation in SEM

Stakeholders

DNV Fuel Fighter team is mainly self-organized. Team decide by itself what to do, how to do and when to do. Academic supervisors have just consultations help without direct leading the project. Anyway, most of students in team have to write Academic reports using the project as practical case in interaction supervisor. Project use NTNU resources (room, workshop, labs, financial, IT etc.). Sponsors as financial as non-financial are main economical forces for the non-commercial project. There are non-direct stakeholders on the local, regional, national and global level.

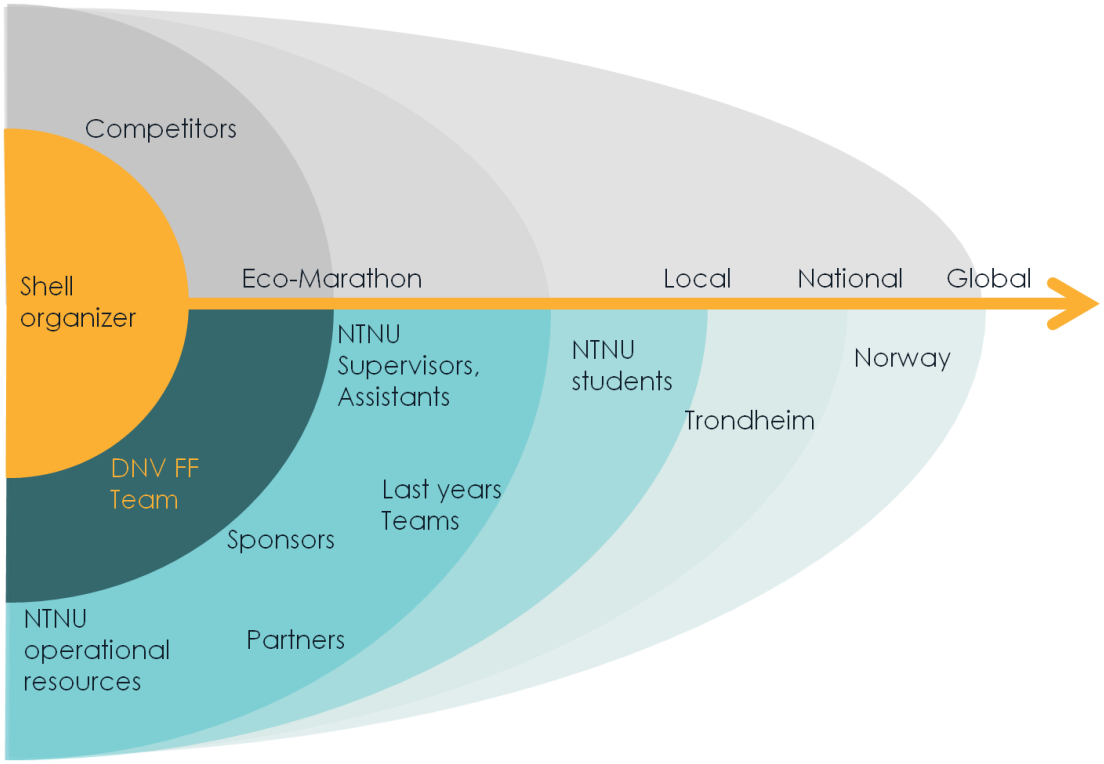


Figure 24. Stakeholders

Team

Project has mainly voluntarily basis but most of the members write Master Thesis based on the project contribution. Team by strategic learning goals is interdisciplinary, multinational, with different years of study and both genders. Core team members were recruited by responsible supervisors early in April-May 2012, some members comes during the project (academic semester). Few student have just part-time participation (first or second academic semester) due to different reasons.

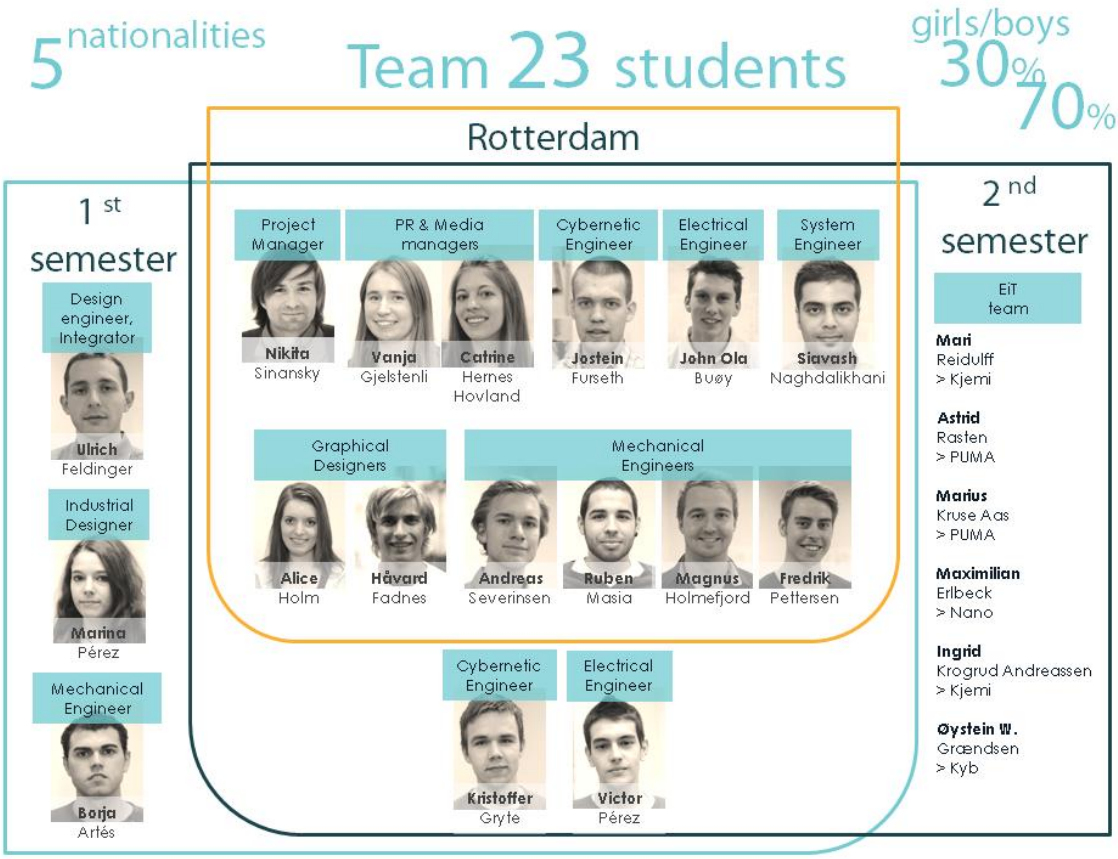


Figure 25. DNV Fuel Fighter Team

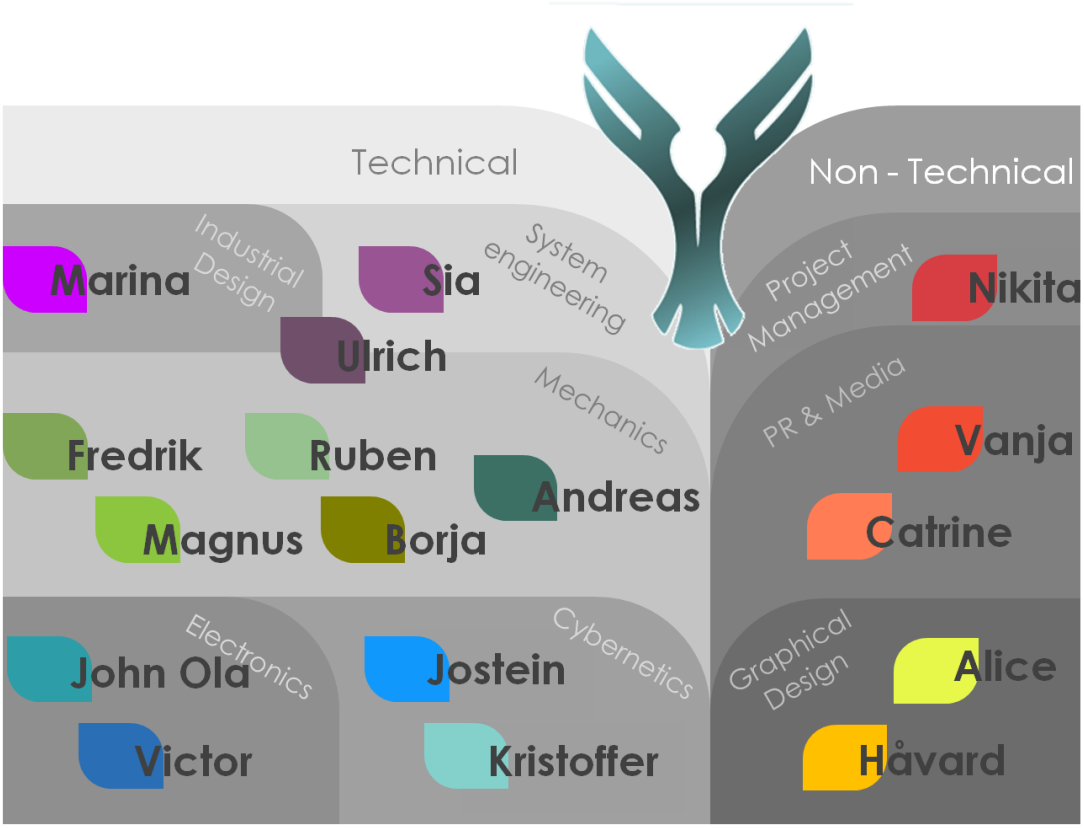


Figure 26. Team Member Competences

Team has 23 members with classifications for 8 competences (study programs):

> Project Management
> Media, communication and IT
> Graphic Design
> Industrial Design
> Product development and materials (Mechanics)
> Production management (System Engineering)
> Automotive Engineering
> Cybernetic engineering
> Electrical engineering

Expert in Teamwork group has 4 competences including Nano, Chemical, Cybernetics and Mechanics

5 nationalities:

> 16 Norwegians
> 4 Spanish
> 1 Iranian
> 1 German
> 1 Russian

2 High Schools:

> 2 graphical designers from Norges Kreative Fagskole (NKF),
> 21 others are Norwegian University of Science and Technology (NTNU) students.

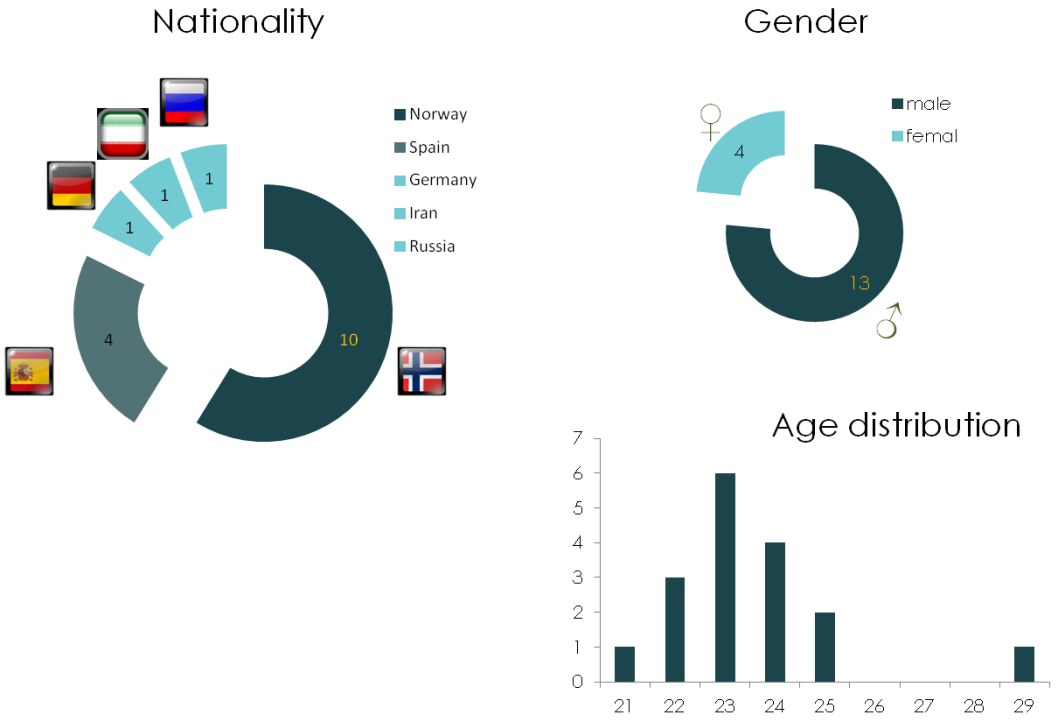


Figure 27. Team diversity on the 1st semester by Nationality, Gender and Age

Team: DNV Fuel Fighter
Race Number: 733
Vehicle Category: Urban Concept
Energy Source: Battery Electricity
Country: Norway
University: Norwegian University of Science and Technology (NTNU)

Table 16 . List of the team members

#	Name, Surname, info	Shell Official Role Team Role	Presence in Rotterdam
1	Knut Einar, Aasland	Faculty Advisor Project Leader	No
2	Jan Magnus Granheim, Farstad	Member Responsible teacher	Yes
3	Nikita, Sinianskii	Manager Project Manager	Yes
4	John Ola, Buøy	Driver Power electric engineer (Motor)	Yes
5	Andreas, Severinsen	Reserve Driver Race Manager, Mechanical engineer (Suspension/Steering)	Yes
6	Fredrik, Pettersen	Member Mechanical engineer (Interior, Exterior, Motor, Wheels)	Yes
7	Magnus, Holmefjord	Member Mechanical engineer (Solar Panel, Motor, Wheels)	Yes
8	Ruben, Masia	Member Mechanical engineer (Brakes, Manual for Assembly - Documentation)	Yes
9	Siavash, Naghdalikhani	Member Technical manager, System Engineer	Yes
10	Vanja, Gjelstenli	Member PR and Media Manager	Yes
11	Catrine Hernes, Hovland	Member PR and Media Manager	Yes

12	Jostein, Furseth	Member Cybernetic Engineer (Control System, Dashboard)	Yes
13	Alice, Holm	Member Graphical Designer	Yes
14	Håvard, Fadnes	Member Graphical Designer	Yes
15	Ulrich, Feldinger	Member System designer	No
16	Marina, Pérez	Member Industrial designer	No
17	Victor, Pérez	Member Electrical Engineer	No
18	Kristoffer, Gryte	Member Cybernetic Engineer	No
19	Borja Artés, Artés	Member Mechanical Engineer	No

Goals , Success Criteria and Results

DNV Fuel Fighter is unique project for students. This is mix of learning, new product development, entrepreneurs, working teams and game approaches. World-wide competition, representing of University and Country, multinational interdisciplinary team, complex system and innovative eco nature are challenges that make project extremely ambitions. Team has to implement full product life cycle from idea scratches to sustainable and competitive complex system. Project is excellent opportunity for students to get practical overview of real national and local industry within professional field, develop contacts with organizations and increase attractiveness for future employers.

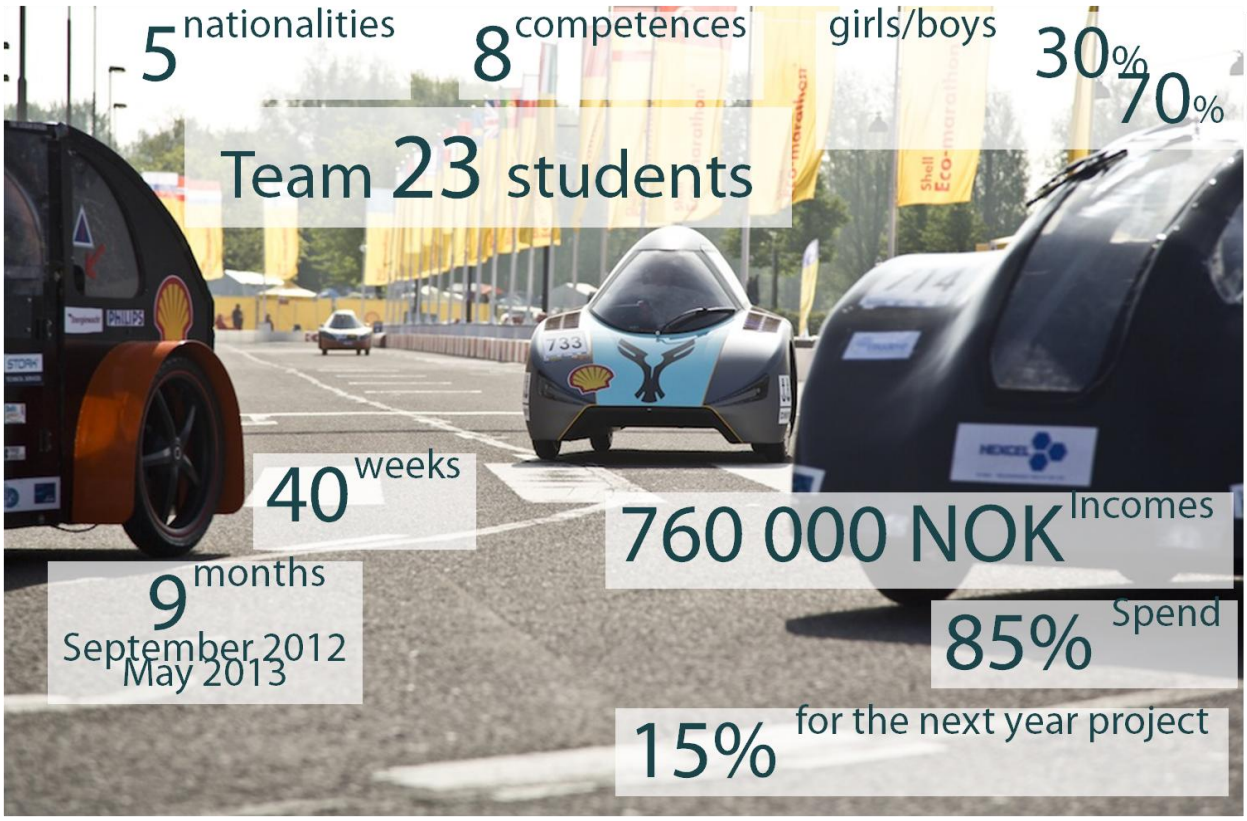


Figure 28. People, Time, Money of the project

From global point of view project's goals are eco- and technological progress in the enterprise world.

University and Norwegian society expect to see the team on the respectable position comparing other High Schools and countries in the world-wide competition.

Learning goals for University and Students mainly have “Learning by doing” concept and help to develop as professional as organizational personal skills in world-wide environment reality.

Project has very simple main success criteria – position of the team on the competition (on-track award) with additional opportunity to win off-track awards (PR&Media, Design, Safety, etc). Additionally, history of NTNU participation in Shell Eco Marathon since 2008 create “historical context”. Comparing previous teams results the current one expect to achieve better results or at least put significant impact for next generations.

Result of the project is 3rd place in Race, winner in Design award and Communication award. Additionally was 2nd place in Safety award and Infographic was in top 5.

Number of teams in Battery Electric Urban class was 30 from 16 countries. It was almost twice more than previous year.

Project was successful considering success criteria. Project was on time and on budget and on safety level.

Figure 29. Project Success Criteria and Result

Figure 30. Project Results

3.2. BALANCING OF TPM AND AGILE.

Theoretical part shows overview of traditional and agile project management approaches and concepts for balancing both approaches. Focus in this section is on the planning and control process, scheduling and risk management methods as the most critical areas for small time limited, uncertain projects. DNV Fuel Fighter project experience is presented.

3.2.1 Work Breakdown Structure.

Tasks in project have multilevel structure and were classified into few logical categories. Each category has own goal and responsible team members and level of importance. Categories are not independent in reality, but classification helps to manage the project and simplify tasks chaos.

Table 17. WBS categories

WBS category	Description
Technical	Car (build reliable competitive car), Trailer to transport car, Frame and tolls for transportation and field work
Driver and Driving Strategy	training a driver and prepare optimal strategy how to drive
Shell Eco Marathon	registration, regulations, formalities
Travel and Race	travel to Rotterdam and organizing of team on event
Sponsors	direct and indirect financial and technical project support
PR and Media	sponsors satisfaction, publicity of the project, social events
Graphical Design	project and car graphical design
Partners	Expert in Team, Revolve, other support projects
Management	technical and non-technical management, administration
Finance	economical management, cash flow control, procurement
Academic Reports	specialization project and master thesis as project reports
Safety	economical, environmental and health threats preventing
Project Improvement	continuous project improvement including recruitment, knowledge transfer, documentation for next generations of team

Technical category includes car as the main project result, trailer and frame for transportation and maintenance. Car is the most complex and innovative system of systems. WBS for the car with responsible people present on the Figure.

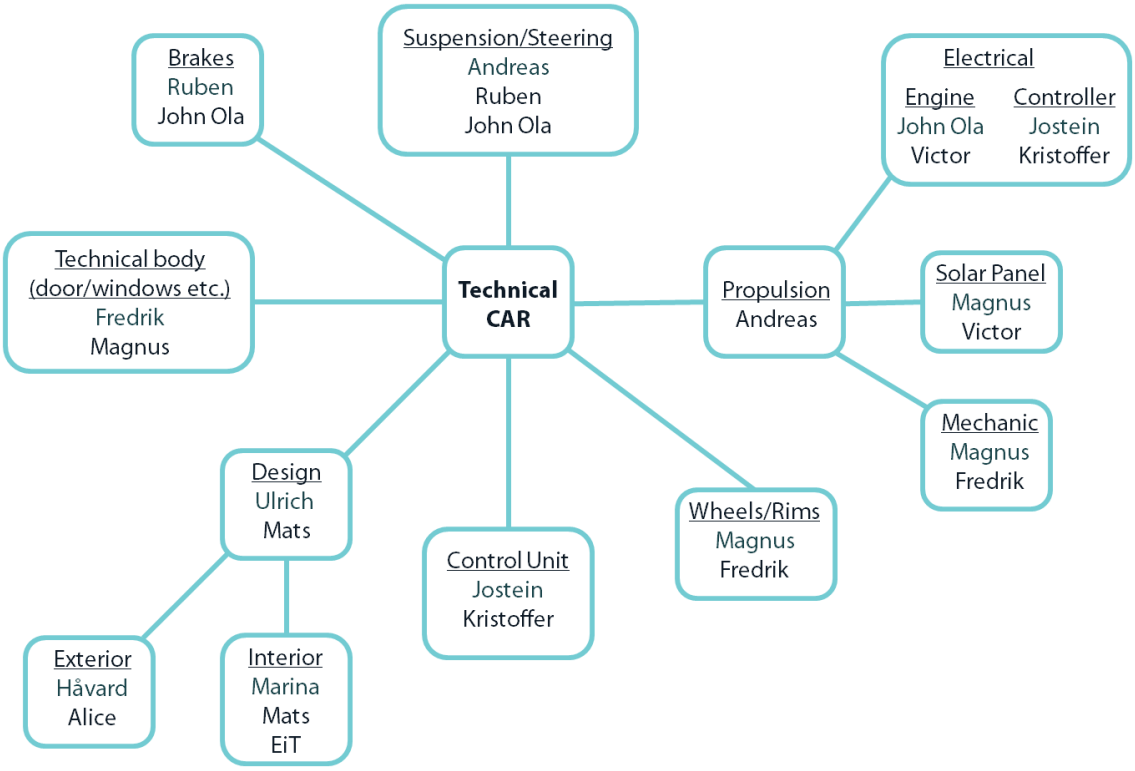


Figure 31. WBS for the car subsystems with responsible people

3.2.2 Prioritization.

Time limitation, people and their competence, uncertainty are main constraints for DNV Fuel Fighter. For this reason main management task is rational distribution of tasks between available resources (people, money, tools etc.) with continuous time control. Risk management was main process to define priority, importance for each WBS elements and to make decision about management style, detailed planning and resources allocation. For the first, preliminary prioritization very simple MoSCoW principle was used (guided by approach from Wysocki R.K. (2009)). Acronym MoSCoW means ‘Must have’, ‘Should have’, ‘Could have’ and ‘Won’t have’ and means requirements for project.

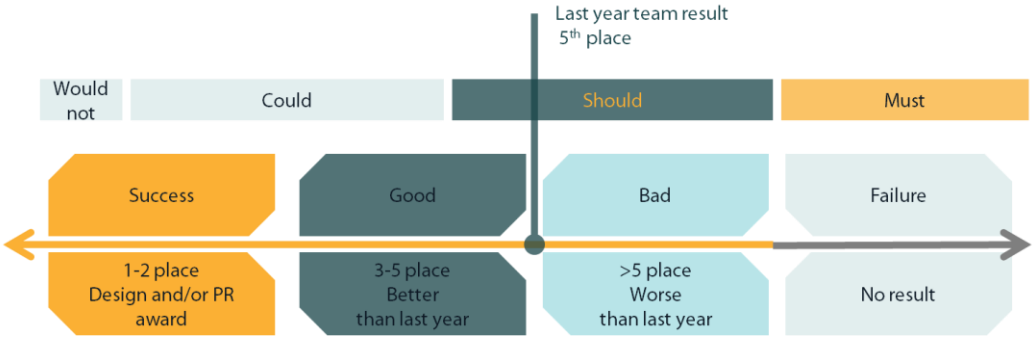


Figure 32. Project goals and MoSCoW prioritization

Task prioritization is relevant to project goals. The most important category is 'Must' that shows critical tasks for project result and team has no choice. 'Should' tasks necessary for bad or good results depend of quality and scope. 'Could' is not very important category but gives the best result if previous tasks are successfully done.

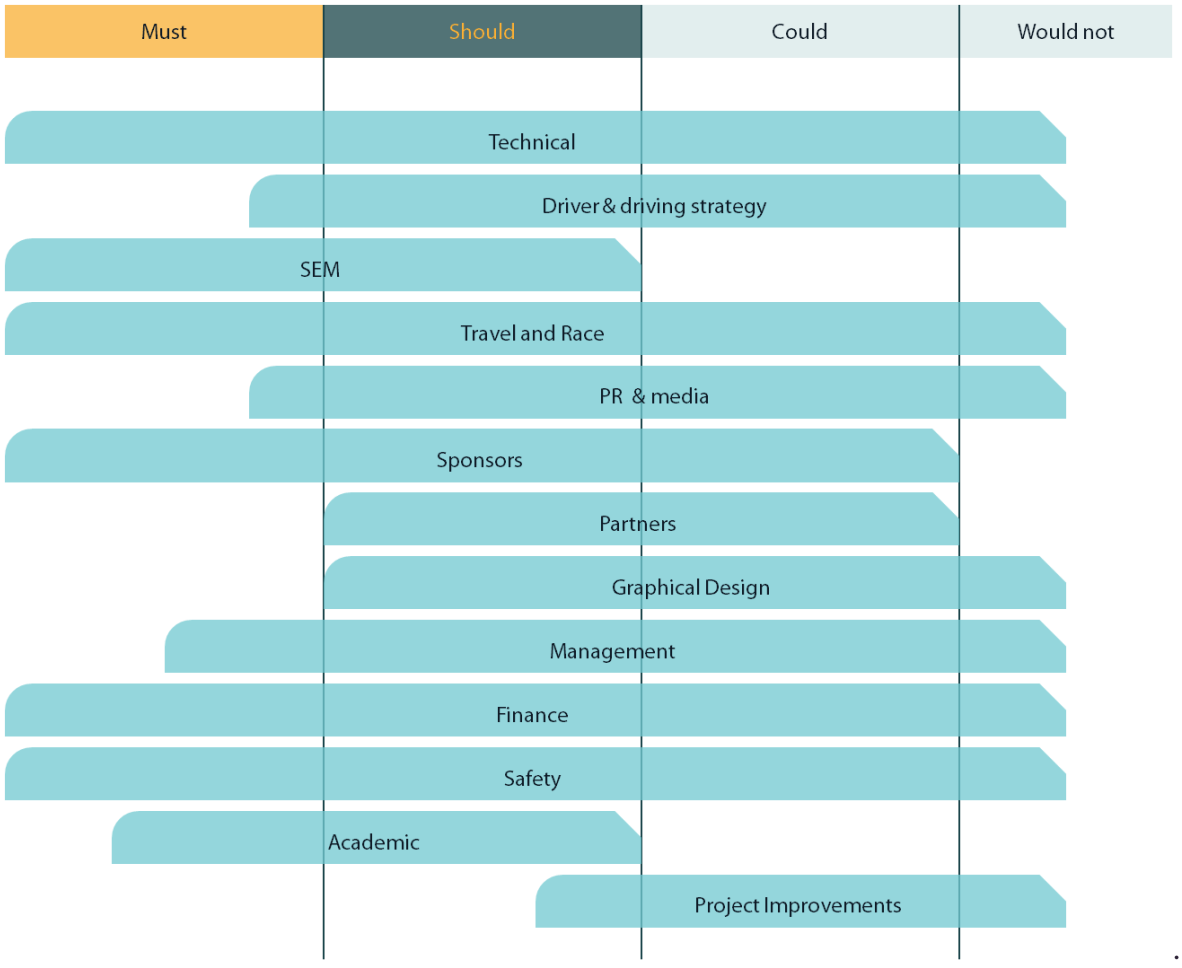


Figure 33. MoSCoW prioritization

‘Must’ tasks are project result essentials and related to zero-result to avoid project failure. Minimum detailed goals are in Table below. Other categories ‘Should’, ‘Could’ are containing team ambitions and relevant for level of quality and final project result. ‘Would not’ category is for wishes that nice to have but decided does not do in project and clearly show it for all team and suggest it for next project generations.

Table 18. Overview of critical tasks

WNS category	Critical tasks
Technical	car has to pass technical and safety inspection and successfully finish at least one attempt, trailer has to be on working conditions for transportation, frame and set of tools have to have minimum for corrective technical actions in Rotterdam
Driver	driving at least on safety and on rules way
Shell Eco Marathon (SEM)	pass registration selection fill and submit on time all applications submit on time all mandatory documentation and formalities
Travel and Race	travel for core team with car to Rotterdam and back accommodation and food in travel and in Rotterdam minimal event procedures as registration, paddock, inspections, briefings, race itself, etc.
Sponsors	receive necessary financial and non-financial support
PR & Media	public activity with main aim at least satisfaction of Sponsors
Management	minimal responsible coordination and administration of project processes
Finance	control of money, formal procedures, procurement
Safety	no any sufficient incidents
Academic	delivering of two reports in December and June

3.2.3 Time

DNV Fuel Fighter project has one the most critical parameter – time. Competition of car solutions by 200 teams from Europe is happened at few specific days, specific timeslots and result of whole project depend on it. Project delay is not possible. Planning the time carefully and rational is the main task for management.

First of all, available time for project is defined. The total duration of the project is 9-10 months from September 2012 to June 2013. Project has started early on September 2012 when team members first time meet each other. Available time is limited from project start to race date excludes national holydays and exam period. After race is project termination time and it is not so critical in terms of delays. Total number of potentially working weeks is just 30-31.

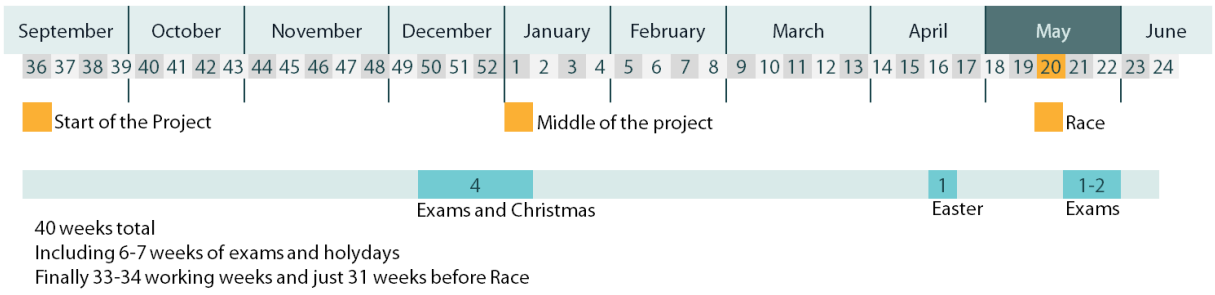


Figure 34. Available time for the project

Next step in time planning is establishing of the main project phases. Combination of traditional project management stages Pinto J.K. (2010), Shell Eco Marathon official processes and milestones and system engineering V-model Fabrycky W. J. Blanchard B. S. (2011) for creation of complex system is used for planning. .The V-model is relevant because project main outcome is innovative energy efficient car. This is full product lifecycle from idea to reliable solution. One important parameter defined in traditional project management as 'Quality' in this project is part of technical solution and includes in V-model through the Verification, Validation and Acceptance. Another 'Quality' parameter is Race result - energy consumption of car and off-track awards results.

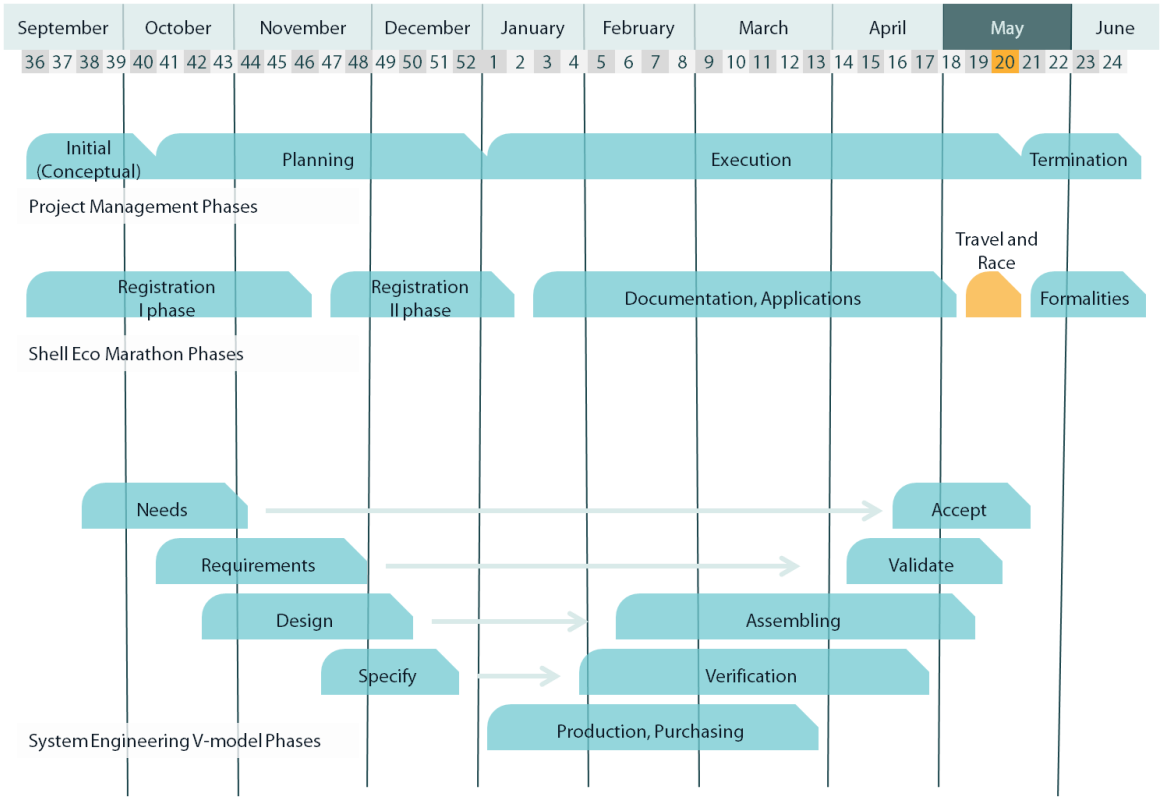


Figure 35. Combination of project phases

3.2.4 Risk Management

Risk management is essential part of project management for both traditional and agile approaches. In DNV Fuel Fighter risk management was classified in two categories: safety and project result. Risk management in terms of safety contains human health and life, environment damages and economical losses. Safety is part of work breakdown structure and controlled not only by project team but also University, National and International standards and services. You could find details about project safety in Appendix. In this chapter risk management means project result consequence: from failure to success. Project goals and success criteria were defined later.

For preliminary risk identification used the Bowtie model Rausand M. (2011) for the project result. Model contains cause, hazard and consequence areas and answers for the question “what can goes wrong?” In project case study consequence is result of whole project from the most undesired project failure before travel to competition to the most desired project success. Negative result (failure before travel, not passing inspection before race, technical or behavior disqualification and technical critical fault) team has to avoid. Positive result as mentioned before has three categories: bad, good and success. Hazard sources of positional problems according Rausand M. (2011) are Human, Technical, Organizational and Environment. In DNV Fuel Fighter project Human source was divided into two categories: Human Resources including recruitment of enough people and personal motivation and competence (knowledge and experience). Environment source contains four main categories: Sponsors, Shell Eco Marathon as organizers of the Race, NTNU as basic office and production facilities, Competitors. Cause-area contains 10 the most critical work breakdown structure groups.

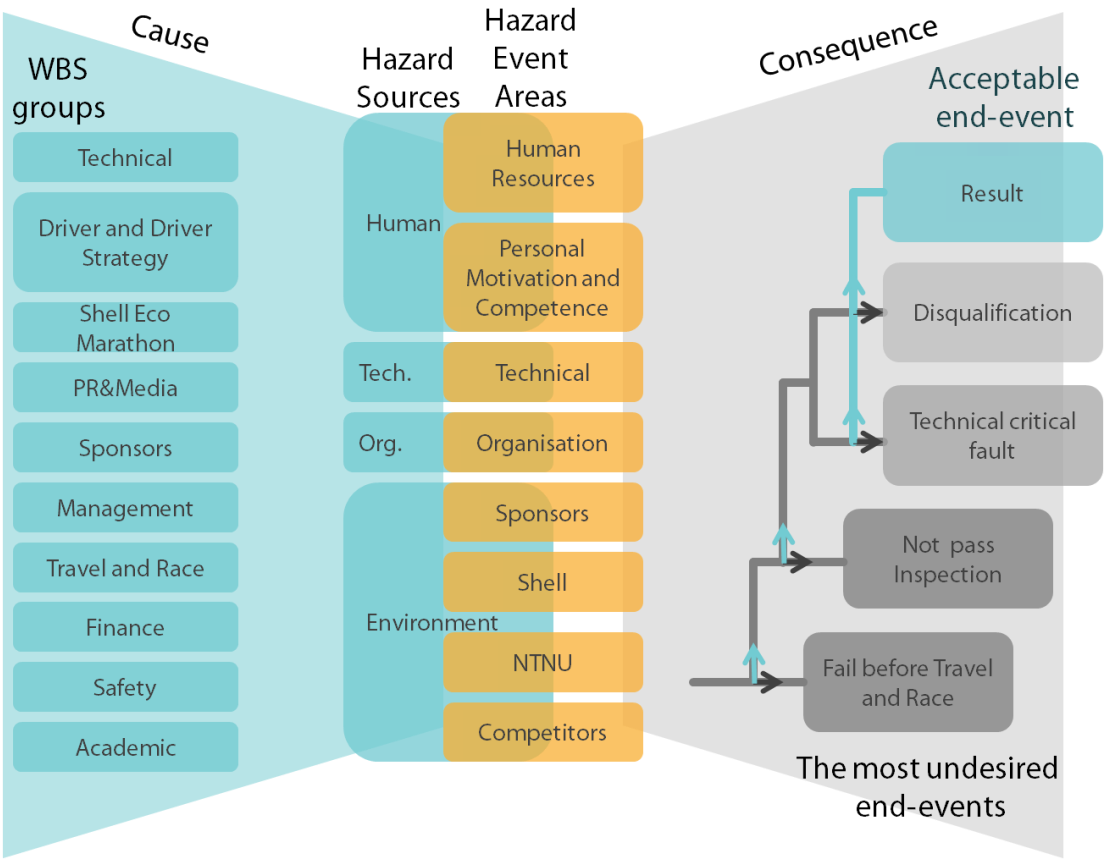


Figure 36. Bowtie model for the project result

During the full project Lifecycle there are few possible results of the project in order from the most desired to the less:

- Success project. 1-2 place on the competition and winning additionally Design and/or PR & Media off-track awards.
- Good project. 3-5 place. Team achieves better result than previous one.
- Bad project. More than 5th place. Team achieves worse result than previous one.
- Failure project. No any formal result. It could be happened as during the competition (disqualification or failure to finish) as during the inspection. The worst case doesn't even arrive to Rotterdam for different reasons.

Risk acceptance level is on the failure project result level and negligible level is between good and success results.

Risk type has influence to which type of management and planning to choose for each WBS group. For example, unacceptable risks in terms of safety, finance, formal registration, travel to Rotterdam etc. needs disciplined and maximum attention and control management approach.

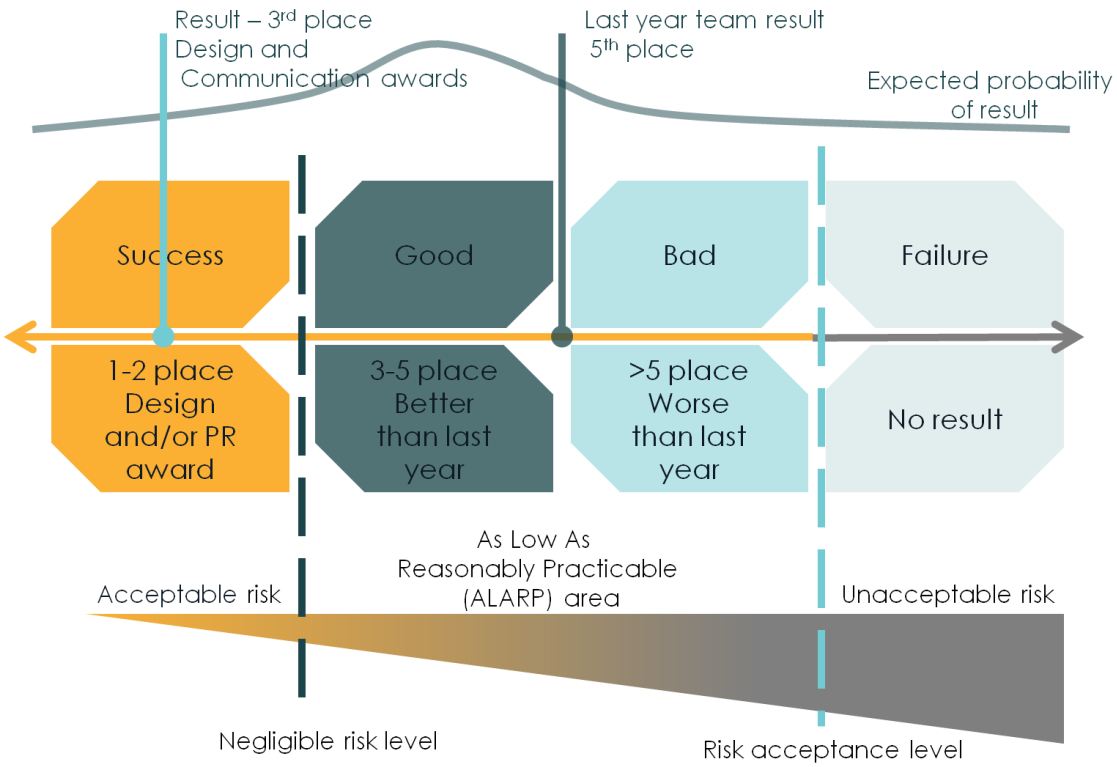


Figure 37. Risk acceptance criteria

In the project the most critical risks are in these areas:

- Human resources. Project need necessary number of people that have necessary competence and experience and that could spend necessary number of working hours to implement most critical tasks.
- Personal motivation. Project is non-commercial and in the nature more practical than academic. Students-team members don't get direct financial benefits or academic grades from this project. That is why personal motivation is main driver for team members and project as well.
- Organizational. Teamwork, Management, Decision-Making, etc. Team members are not high level professionals with great ambitions and lack of time resources. Define most important tasks and control progress as on personal as on inter-elements levels are main goal for managers.
- Shell (organizer) formalities. Registration, Rules, Technical and Safety Inspections, Right behavior in Rotterdam.
- Sponsors. Only one economical resource for non-profit project.
- NTNU. Academic support and Operating Resources.
- Technical

Actions to avoid risk are preventive and reactive. Preventive actions, in general, are proper planning, testing, redundancy, and support for the personal motivation, facilitating, teamwork and regular communications.

3.2.5 Management approach

"How to choose the best management approach for the project?" question has few levels.

In nature project are definitely agile in terms of small self-regulated team of student-volunteers, informal decision making and communication, high uncertainty, innovation and education. Practically it is not possible to make detailed plan for whole project because too much of uncertainty – team (who will do it?), innovation engineering project (what to do? and how?), time critical (matter result only on the Race) etc. But on the same time, is possible to increase uncertainty and risks by dividing project scope into smaller and better controlled areas – WBS groups. MoSCoW prioritization, goals and risk levels classification could help to select WBS groups by criticality and uncertainty.

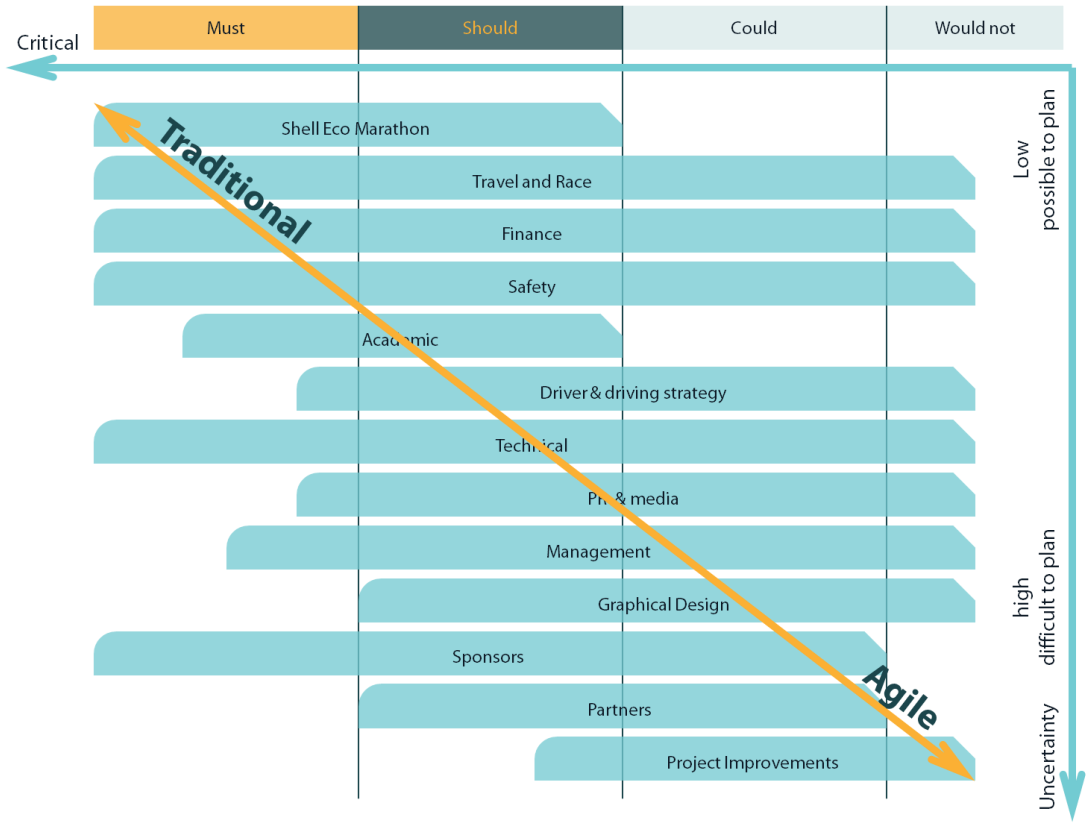


Figure 38. WBS groups classification for management approach

For the most critical WBS groups with low uncertainty that possible to plan more reasonable to use traditional disciplined project management approach. For the critical but highly uncertain WBS groups team use agile approach but with high

attention and with redundancy in solution and resources to complete task. For the not very critical tasks agile methods are used with usually just personal responsibility of 1-2 people small sub-groups.

Another management approaches classification is three-levels of planning and control similar to rolling wave planning model by Laufer A. (1996). The highest level is Master-plan for whole project. It contains just general project information and related to Shell Eco Marathon organizers phases and regulations such Registration phases, travel and race schedules. Middle-plan is more related to System Engineering V-model phases for creation of complex system. Phases are strongly depend of each other and difficult to create detailed plan and control implementation. Low level plan is weekly or 2 weeks-based or everyday based (during the competition).

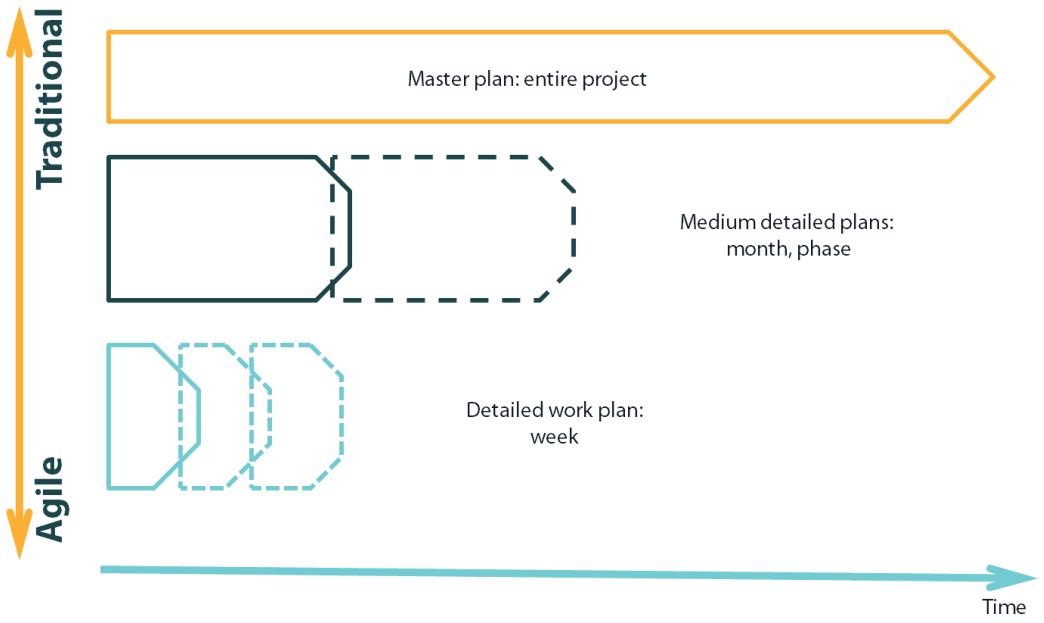


Figure 39. Rolling wave planning and management approach

Management approach depends also of planning level. High level planning for whole project, with must-critical tasks involves whole team and use traditional project management. Medium level planning of project phases and sub tasks involve as whole team as sub groups by specializations with responsible person use mix of traditional and agile methods. Low level planning for day or week with person or sub group attention use pure agile approach. The event planning is exception from this rule. PR events, meetings, days in Rotterdam are subject for the detailed, traditional planning.

3.2.6 Traditional project management approach

Two examples of scheduling from the both traditional and agile approaches are presented in this section. For traditional planning there are Shell Eco Marathon phase's registration and Travel and Rotterdam activities. For the agile approach there are Technical part of car development and PR& Media activities planning.

Shell Eco Marathon Formalities

Formalities are quite well described by organizers and there is no too much uncertainty about what to do and how to do it. Also this is the most project critical tasks. There are reasons to apply traditional project management approach on it. This is important, possible to plan and execute on time task.

Regulations and official documents

There are few official documents from Organizers of the Shell Eco Marathon Europe that contain Regulations (Rules and Requirements). Communication channels between Organizers and Teams are three:

> Official web-site with uploaded documents and useful information
> www.shell.com/global/environment-society/ecomarathon.html
> Closed web-site for the online registration (Roadmap) with a Project Manager access only
> www.ecomarathon.shell.com/registration/europeteam
> Project Manager as official liaison through the e-mail contact
> Facebook 'Shell Eco Marathon Europe' closed group for all participants
> www.facebook.com/groups/386073911480166/

There is Official Web-shop from Organizers (www.eshopsem.com) with Project Managers access only. It is possible to buy just few products: Tires, Fuel tanks, Horn, Joulemeter, Dinner vouchers. Team bought dinner vouchers, a horn and a one tire for the engine wheel from this web-shop.

List of the official documents from Organisers:

1. Official Rules 2013. Chapter I. (Published in September 2012)
2. Official Rules 2013. Chapter II. (Published in April 2013)
3. The Schedule for the Event. (Published in January 2013)
4. Participant Handbook. (Published few days before the Race)
5. Off-track awards and the Shell Student Energy Challenge (Infographics) Rules (Published in March 2013)
6. Mandatory documents forms for the Event (Published in March 2013)
7. Additional information about the Track (detailed map) and Team Logistics (FAQ)

All regulations content could be divided into few categories:

> Safety
> Organizational
> Car, Driver, Paddock requirements
> Behavior rules for the team and the Driver during the Race

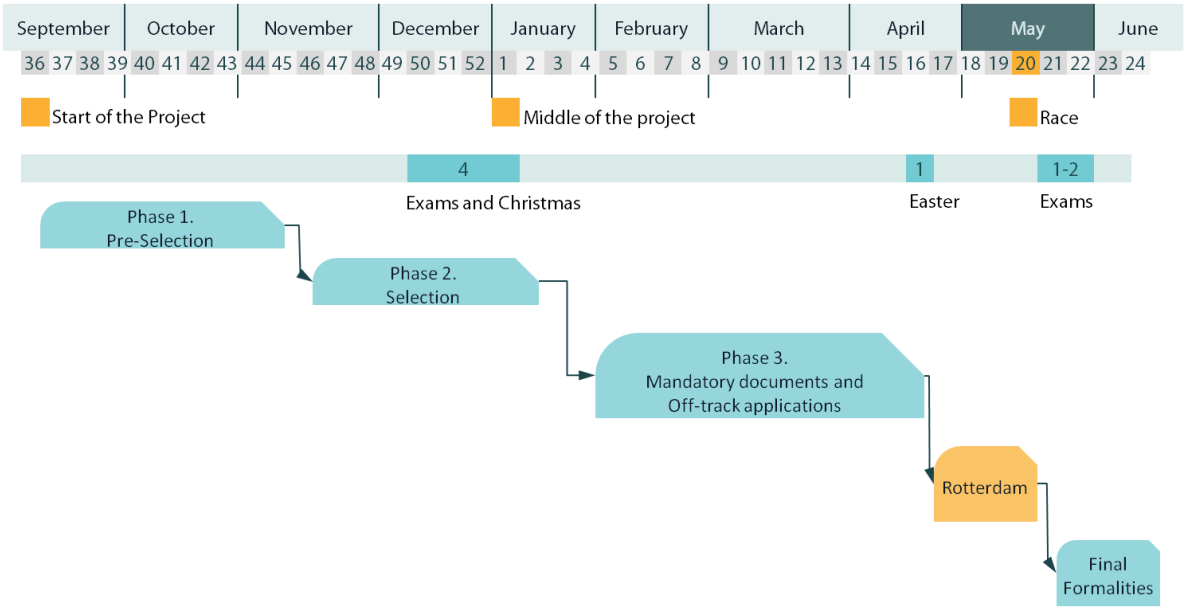


Figure 40. Gantt chart for SEM formalities

Registration and Applications

Registration for the Shell Eco Marathon Europe contains few phases:

1. Phase 1. Pre-Selection.
   Deadline for applications 31 October 2012
   Planned Results 15 November 2012
   Actual Results 19 November 2012

   This is simple online form for general information about team, project and designed vehicle.

2. Phase 2. Selection.
   Planned deadline for applications 17 December 2012
   Actual deadline for applications 9 January 2013
   Actual results 22 January 2013

   This is online form (roadmap) with detailed information about team, project and car with drawings/photos in few categories:

   1. Team details
   2. Team members (including ID photos)
   3. Project details

4. Vehicle information
5. Vehicle technical details (including drawings and a photo of the car's body and a solar panel location)
6. Propulsion System (including drawing/photo of energy compartment)
7. Fuel/Hydrogen supply system (not relevant for electrical car)
8. Electrical Circuity (including detailed computer made technical drawing of the electrical circuitry)
9. Project Objective

3. Phase 3. Mandatory documents for the Event and Off-track awards.

Planned deadline 22 April 2013
Actual deadline 03 May 2013

Mandatory documents for the Event contain formal filled forms:

> Terms and Conditions – signed form for each team member
> Travel Allowance form for the return of travel expenses
> Guarantee letter. Deposit will charge from the team in case of damage the property during the Event.

Forms have to be downloaded, filled, signed and uploaded through the online roadmap.

Deadline is before to arrive, but was suggested to send to Organisers in advance to reduce registration time on Arena.

> Off-track awards applications

Off-track awards have one obligatory and max 2 or 3 (if Safety award included) elective applications. The Shell Student Energy Challenge is obligatory for all teams off-track award. Each team should submit one infographic that answers one of three world-wide energy-related questions provided by Shell. Infographic was created by Graphic Designers Alice Holm and Håvard Fadnes. Infographic from DNV Fuel Fighter was selected to top 5 and present during the Event for public.

The list of possible off-track awards:

> Shell Student Energy Challenge (obligatory)
> Tribology,
> Safety,
> Technical Innovation,
> Eco-friendly,
> Design,
> Communication and Marketing,
> Best Team Spirit
> Perseverance in the face of adversity.

DNV Fuel Fighter team chooses the maximum number of application: the Safety award, the Design award and the Communication award. Submissions were question-answer based documents created in one style.

4. Rotterdam Documentations. Have to be presented on the Arena in Rotterdam.

> Technical documentation for the Technical and Safety Inspection. Electrical, Batteries and Engine Controller documentations.
> Material safety data sheets (MSDS). All teams should be able to provide the MSDS of any products they use in their paddocks, e.g. solvents, cleaning agents, chemicals, etc.
> Off-track presentations (if team selected)

After delivering the application judges chose the best applications and visited teams in paddock on Friday 17th May and Saturday 18th May for the final decision. All three awards were selected as one of the best and responsible people present project for different judges in paddock. Finally DNV fuel Fighter won the Design award and the Communication award. The Safety award got the 2nd place mainly because in paddock engineers work almost 24 hours with not perfect order of tools and instruments around when judges took a visit.

5. After Rotterdam formalities.

Travel allowance return and financial details for getting prizes money. (if applicable) There are no special deadlines but suggested delivery time by Organizers 1 month after the Race. Forms have to be downloaded, filled, signed and sent to organizers by e-mail.

There are 5 phases for SEM Formalities task. Each of them has curtain deadline and project result critically depends on phase's implementation. Scheduling in this situation is mainly process to define when to start and what is the safe time-buffer size to choose.

Table 19. WBS time estimations

#	WBS categories	WBS processes	Time estimations, days		
			L	ML	H
1	Phase 1. Pre-Selection				
1.1.	Online form	idea, data gathering	1	3	10
1.2		filling	1	3	7
1.3		checking and approval	1	3	5
1.4		submission	1	2	3
1.5		results			
2	Phase 2. Selection				
2.1	1. Team details	idea, data gathering	1	3	5
2.2	2. Team members	idea, data gathering	5	10	14
2.3	3. Project details	idea, data gathering	1	3	5
2.4	4. Vehicle information	idea, data gathering	3	7	10
2.5	5. Vehicle technical details	idea, data gathering	3	7	10
2.6	6. Propulsion System	idea, data gathering	3	7	10
2.7	7. Fuel/Hydrogen supply system	idea, data gathering	1	1	1
2.8	8. Electrical Circuitry	idea, data gathering	5	10	14
2.9	9. Project Objective	idea, data gathering	1	3	5
2.10		filling	1	3	5
2.11		checking and approval	1	3	5
2.12		submission	1	2	3
2.13		results			
3	Phase 3. Mandatory documents				
3.1	Terms and Conditions	idea, data gathering	5	10	14
3.2	Travel Allowance	idea, data gathering	1	2	3
3.3	Guarantee letter.	idea, data gathering	1	2	3
3.4		filling	1	3	5
3.5		checking and approval	1	2	3
3.6	Off-track awards applications				
3.7	Safety	idea, data gathering	7	14	21
3.7.1		draft	1	3	5
3.8	Design	idea, data gathering	7	14	21
3.8.1		draft	1	3	5
3.9	PR and Media	idea, data gathering	7	14	21
3.9.1		draft	1	3	5
3.10	Infographic	idea, data gathering	10	21	35
3.10.1		draft	1	3	5
3.11		style and document creating	1	3	5
3.12		checking and approval	1	3	5

3.13		submission	1	2	3
3.14		results			
4.	4. Rotterdam Documentations				
4.1	Technical documentation				
4.1.1	Electrical	idea, data gathering	5	10	14
4.1.2	Batteries	idea, data gathering	5	10	14
4.1.3	Engine and Solar Panel Controllers	idea, data gathering	5	10	14
4.1.4		combining into one document	1	3	5
4.2	Material safety data sheets (MSDS)	data sheets gathering	1	3	5
4.2.1		Printing	1	2	3
4.3	Off-track presentations				
4.3.1	Safety	preparation	1	3	5
4.3.2	Design	preparation	1	3	5
4.3.3	PR and Media	preparation	1	3	5
5	5. After Rotterdam formalities				
5.1	Travel allowance	filling a form	1	2	3
5.2	Prize money	filling a form	1	2	3
5.3		sending	1	2	3

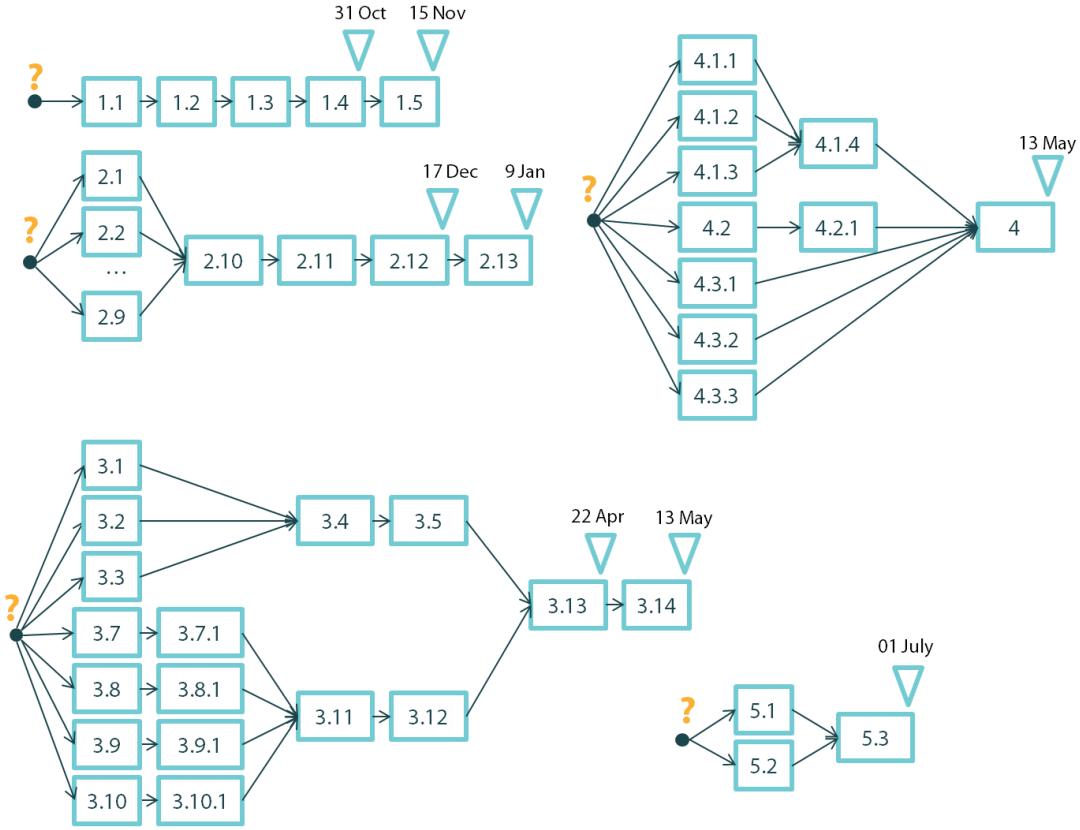


Figure 41. Network diagrams for scheduling

Calculation of the start data with safe buffer uses few methods: CPM, PERT, SSP and MCS (Vatn J., 2013). CPM is the simplest and does not use uncertainty of non-critical paths and uncertainty of duration for each activity, only the most likely values. PERT method includes uncertainty of duration for each activity but only for the critical path. SSP and MCS are better to deal with the highly uncertain situation, but in our context of very simple network diagrams it is not sufficient to use it. Results for start date calculations are presented in Table. CPM with 25% buffer and 90% probability in PERT method are very close to each other and was the basis for the actual start date.

Table 20. Results for date to start calculation.

WBS categories	Deadline	CPM		PERT	
			+25% buffer	50% (μ)	90% ($\mu+2\sigma$)
1. Phase 1. Pre-Selection	31.10.12	20.10.12	17.10.12	18.10.12	14.10.12
2. Phase 2. Selection	17.12.12	09.11.12	04.11.12	09.11.12	05.11.12
3. Phase 3. Mandatory documents	22.04.13	14.03.13	06.03.13	13.03.13	03.03.13
4. Rotterdam Documentations	13.05.13	30.04.13	26.04.13	30.04.13	26.04.13
5. After Rotterdam formalities	01.07.13	27.06.13	26.06.13	27.06.13	25.06.13

Travel and Rotterdam activities

Travel for the team and the car to Rotterdam, accommodation, transport and food are activities that possible to predict and plan. Time-table in Rotterdam is hour-by-hour is defined by organizers with possible changes due to weather only. All these activities are the most critical for project result and there is low uncertainty about what to do and how to do it. This is the reason to apply traditional disciplined approach for planning and control.

Travel

Travel to Rotterdam was in 3 groups:

1 - 3 people in the rented car + trailer with race vehicle and tools. 11 May-13May with overnight in Oslo and ferry Oslo-Kiel, Germany.

2 - Core team 5 people with Team Manager – Plane (Trondheim-Oslo-Amsterdam) and train (Amsterdam-Rotterdam). 13 May

3 - Rest of the team 5 people – Plane (Trondheim-Stockholm-Amsterdam) and train (Amsterdam-Rotterdam). 15 May

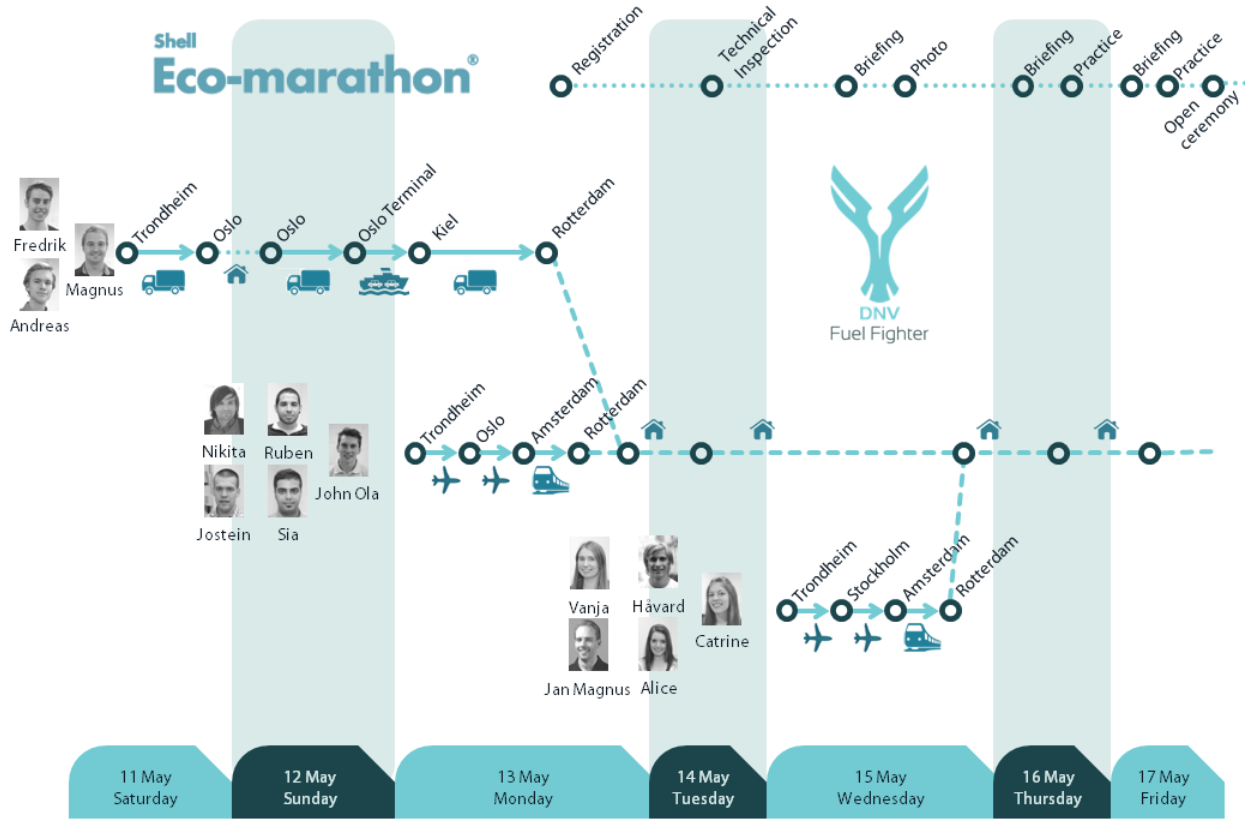


Figure 42. Way to Rotterdam

In Rotterdam team stay from 13 May to 21 May in Hotel Rotterdam in triple and double rooms. Shell Eco Marathon Europe was one week 13May-19May including Technical and Safety Inspection, Team Stands, Practice, Race, Exhibition and Winning Ceremony all in Ahoy Arena, Rotterdam. Team uses public transport (mainly metro) to travel between Hotel and Arena. Travel card with unlimited number of journeys for all week for all transport including metro, tram and bus was bought on the first day and shared trough the team. From project budget for each team member was breakfast in Hotel (6.30-10.00) and Lunch in Ahoy Arena (19.00-21.00).

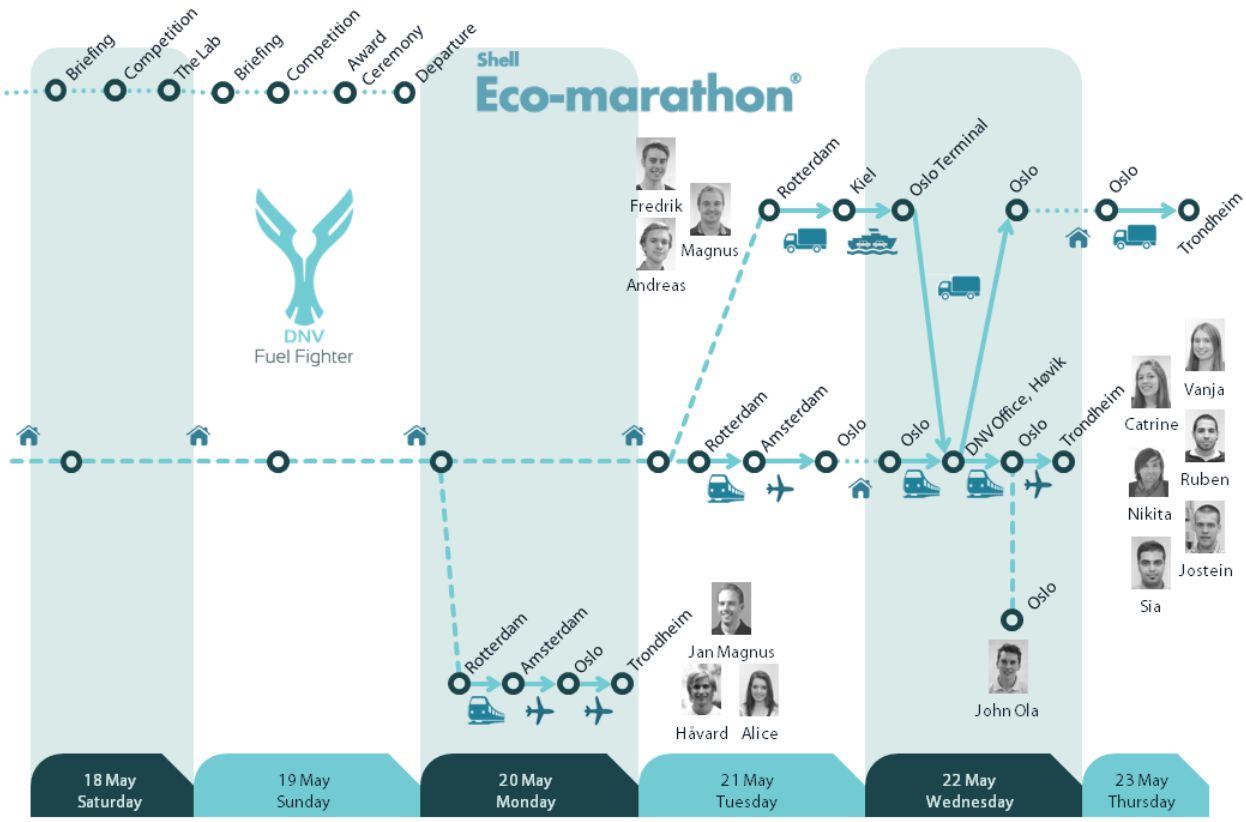


Figure 43. Way back to Trondheim

Travel back was also in 3 groups:

1 - 3 people in the rented car + trailer with race vehicle and tools. 21 May-23 May with overnight stay on ferry Kiel, Germany - Oslo and in Oslo.

2 - Core team 7 people with Team Manager – Train (Rotterdam –Amsterdam) and Plane (Amsterdam - Oslo - Trondheim). 21-22 May with overnight stay in Oslo

3- Rest of the team 3 people – Train (Rotterdam - Amsterdam) and Plane (Amsterdam – Oslo –Trondheim). 20 May

For travel each team member has a brochure with all information about tripl to/from Rotterdam and Information about event and locations in Rotterdam.

Structure of the travel brochure:

>General
>List of members
>All flights
>Travel route
>Group 1 – Andreas, Fredrik, Magnus
Travel route
Budget
SEM team arrival registration

Parking info
DNV office visit
>Group 2 – Nikita, Ruben, Sia, Jostein, John Ola
Travel route
Budget
Bus to Trondheim Airport
Flights
Train Amsterdam-Rotterdam
Train to/from Oslo Airport
Hotel in Oslo
DNV office visit
>Group 3 – Jan Magnus, Håvard, Alice, Vanja, Catrine
Travel route
Budget
Bus to Trondheim Airport
Flights
Train Amsterdam-Rotterdam
DNV office visit

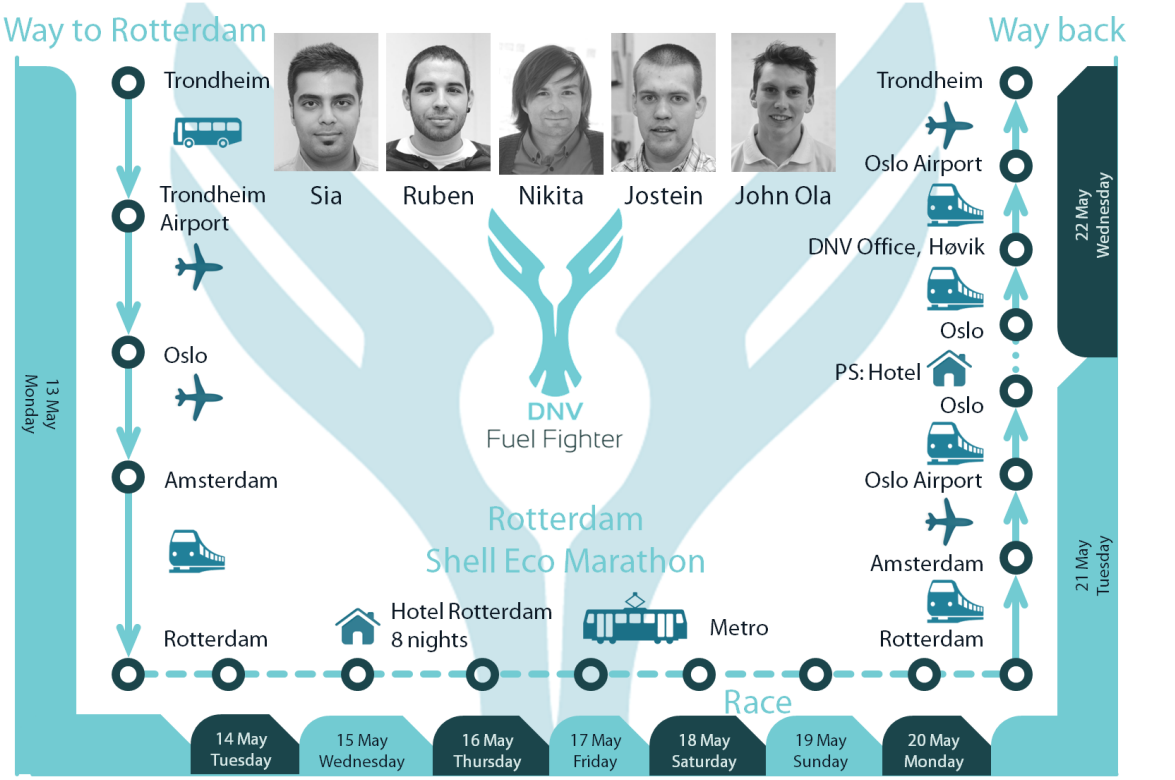


Figure 44. Example from Travel Brochure.

Structure of the Rotterdam brochure:

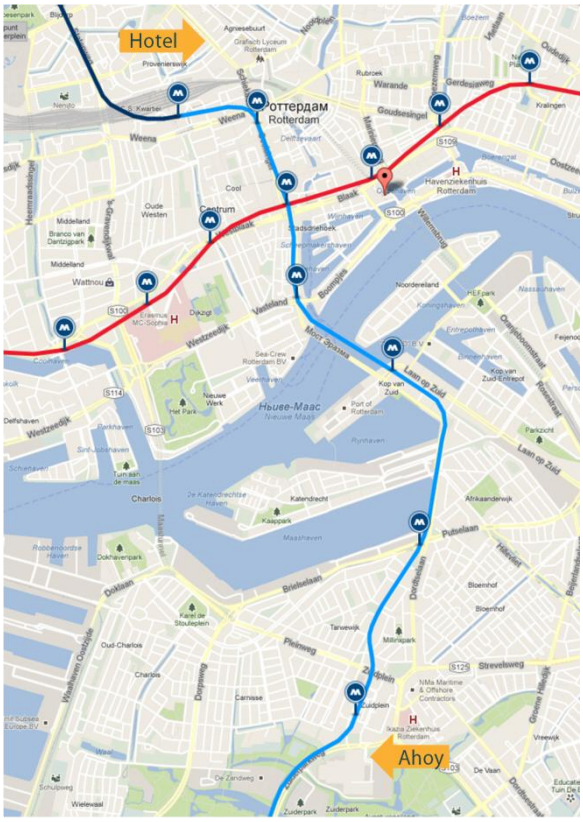
>Hotel
- Room needs
- Location of the hotel, metro, central station
- Facilities
- Reservation documents

>Metro
- Route Hotel-Ahoy
- Metro map

>Food
- Plan
- Voucher reservation document

Hotel Rotterdam
Schiekade 658
3032 AK Rotterdam,
(The Netherlands)

Tel: +31(0)10.466.33.44
Fax: +31(0)10.467.52.78
E-mail: info@hotel-rotterdam-city.nl



Hotel – Arena route

Figure 45. Example from Rotterdam Brochure

Each group has own financial responsible person. All travel expenses paid by personal credit cards of Nikita, Andreas and Jan Magnus with financial report afterwards.

All travel was according the plan, time and budget except one fault with rented car and trailer. It was forbidden by road rules to use this type of the car with this type of trailer. The car was stopped near Oslo by Police and Driver got a penalty. Hopefully

one of the team members fined a solution to continue the journey. Rented car was changed to other car. New car was team member father's car from Oslo. On the way back cars were changed again.

SEM Competition activities

Shell Eco Marathon was in Rotterdam from 13 May to 19 May. Schedule for the Event was published by organizers in January 2013.

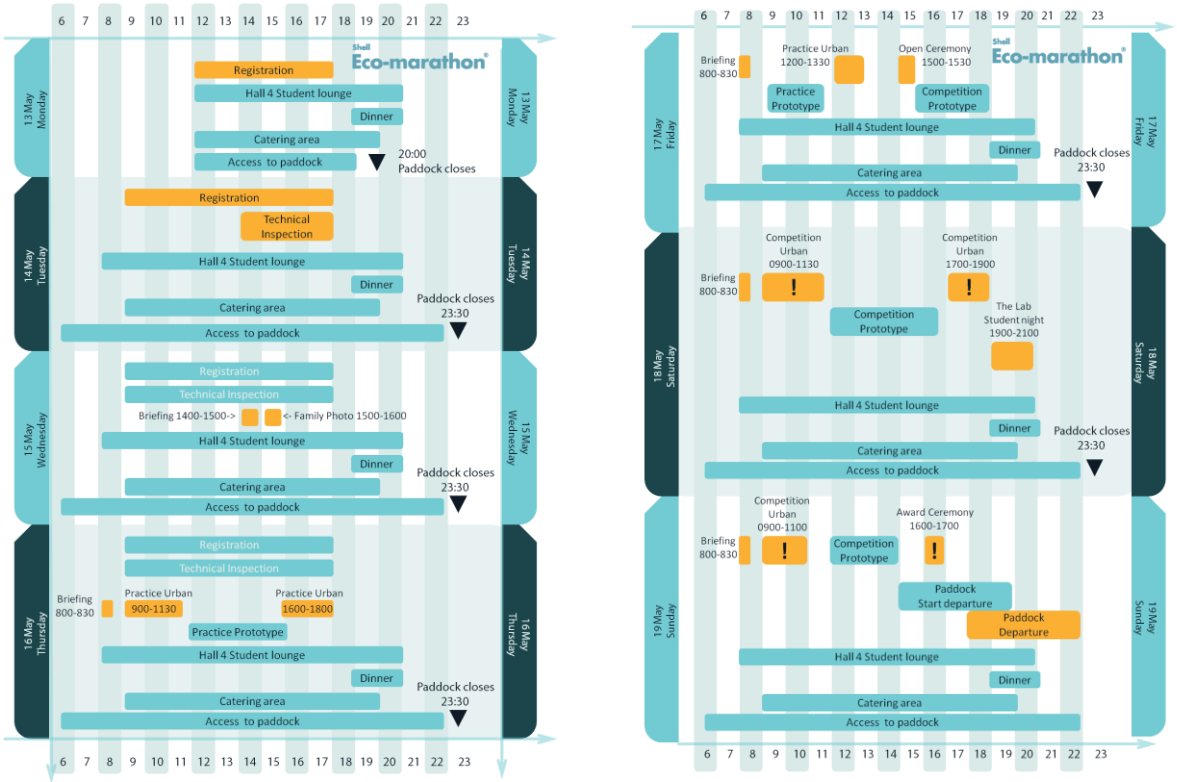


Figure 46. Schedule adapted for our car's class.

Actual schedule was changed by Organisers because of weather conditions. Friday 17th of May was additional competition day. Maximum number of attempts was increased from 4 to 6.

> Arena

Ahoy arena is located in the southern part of Rotterdam, Netherlands near of Zuidplein park. Public transport stop (Metro, bus), big shopping mall, private parking is just 5 minutes walk from Arena.

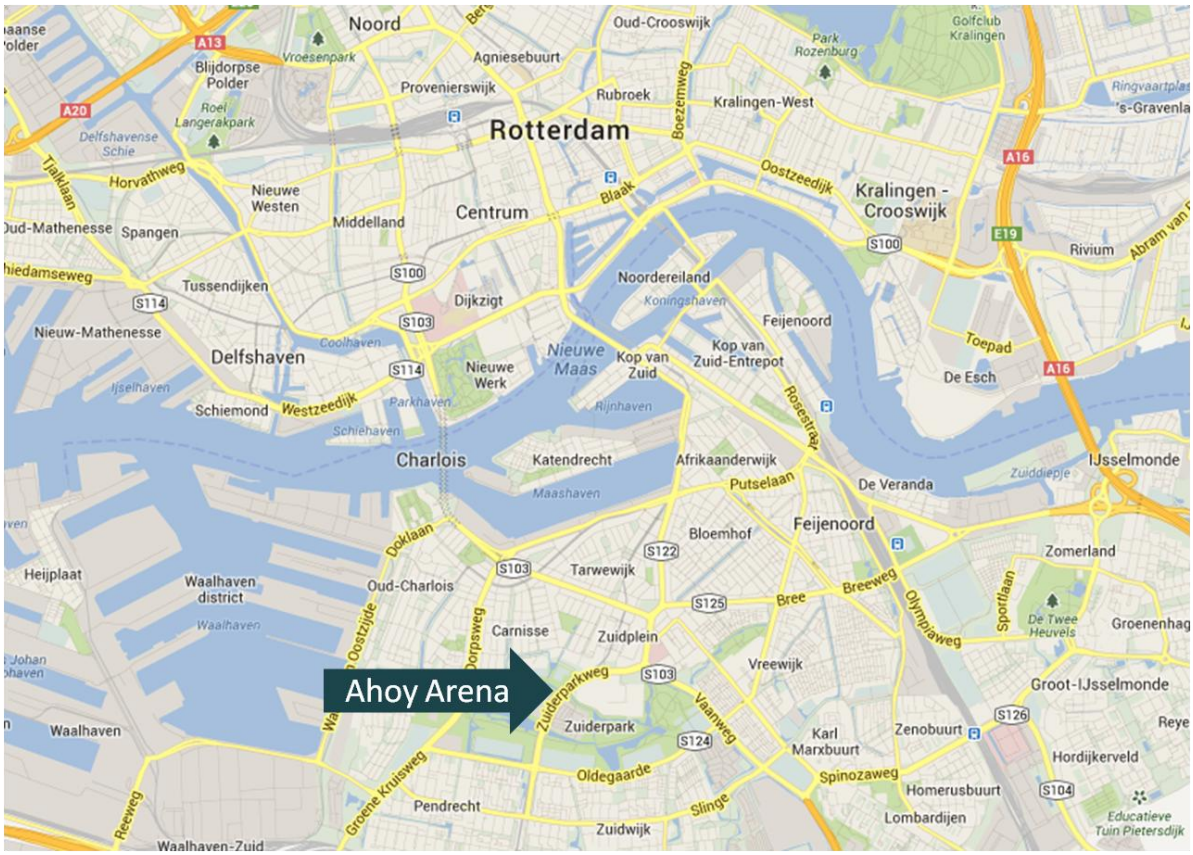


Figure 47. Ahoy Arena location

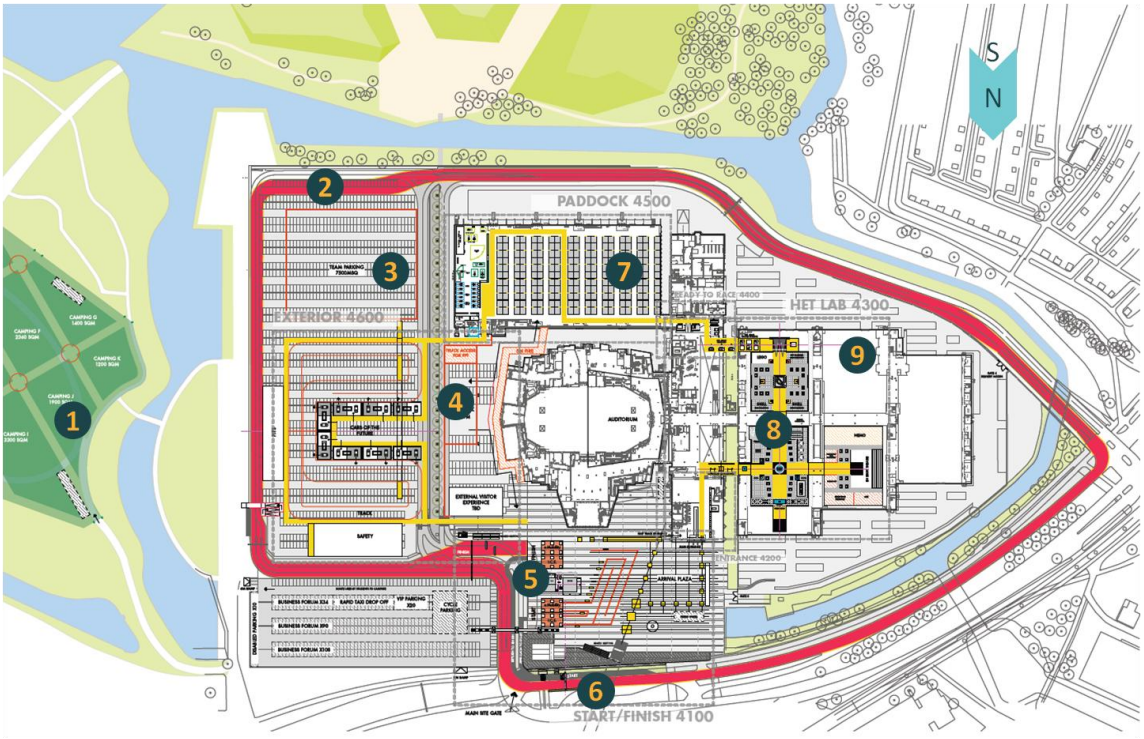


Figure 48. Ahoy Arena map

There are few main areas for the Shell Eco Marathon event:

1. Camping site. Place where the most of teams stay during the Event in tents. Catering tent also located here and could be used for cooking food. Team used it for the waffles.
2. Track. Distance around 1 mile or 1.6 km.
3. Parking for the private cars and trailers. It's not possible to go out and in by car during the practice and competition days
4. Testing area is only one for driving cars before the main track access. Testing area open only when the Track opens with control of 2 safety marshals.
5. Start/Finish area. Three tents with marshals: one for the Fuel car start check and fill the fuel, one for the Electric car check and Joulemeters reset, one for the finish result measure. Before tents is queue area.
6. Entrance Bridge to Arena. During the Event with small bridge from Camping site are only one way to enter.
7. Hall 1. Participants paddock. Technical Inspection. Information desk. EShop.
8. The Lab (main public area for external visitors). Registration desk.
9. Hall 4. Obligatory briefings. Lunch

> Track

The track is not specially built track for the Race. This is a usual urban part of public roads limited red and white boxes along the track with everyday life lines on it. Track is almost flat and has five 90 degree turns.

Figure 49. Car on the Track

During the practice and competition there are a lot of marshals along the track. In case of accidents marshals immediately take all necessary actions for safety reasons. If the car stop and could not start again more than 2 minutes marshals towing a car out of the track. Public access to stay near of track is only in few places: Start/Finish area, Panel area, Bridges.

Access to the track is from the Entrance tent with queue of participants. Marshals check Technical and Safety Inspection stickers, Driver's weight, scan bar-codes and reset joulemeters. Access to area between Entrance tent and Start is only for two people maximum excluding the Driver. Urban class cars have to stop each lap on the special Stop-line. In case of overtaking car have to use a horn signal. After Finish a car comes to Measurement tent to calculate final result for attempt.

Testing track is only one for driving cars except main track. This area is located near the entrance to Hall 1. Testing area works only when the main Track opens. There is control of 2 safety marshals. At least safety inspection sticker has to be on the car for the access.

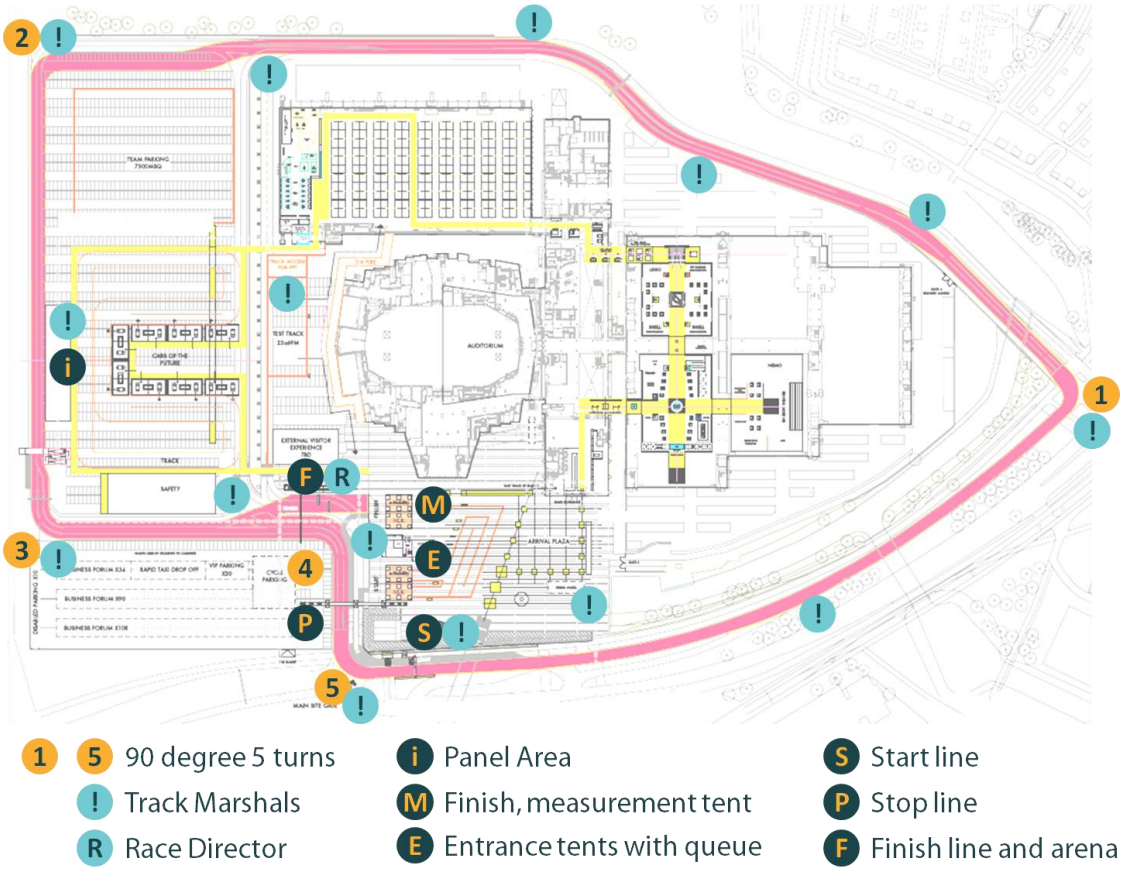
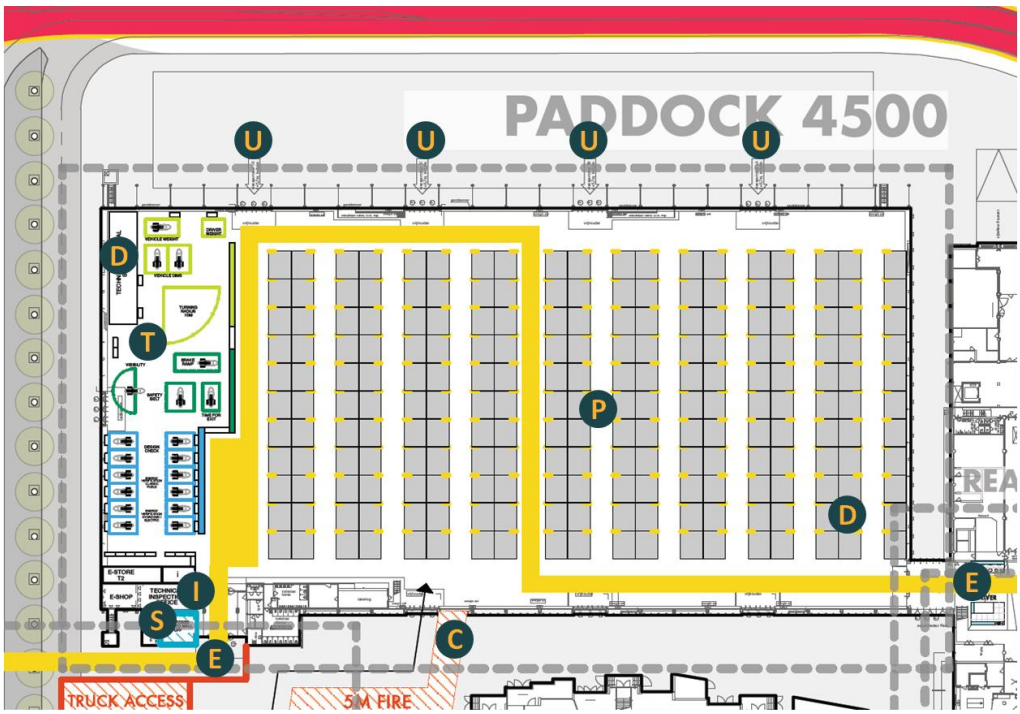


Figure 50. The Track map

> Paddock

Paddock is special area for the team to present the project, work on the car and just stay during the Event. Paddocks of almost 200 teams are in Hall1. On the same Hall 1 are situated also technical inspection area, informational desk with organizers, e-shop. To carry stuff to/from paddock it is possible to park temporary the trailer near of the back doors. For the access to track there is special door near of the main Entrance to Hall1. Hall 1 open only 6:30 – 23:30 but overnight work in paddock accepted without exit from Hall.



D Main Display
T Technical Inspection
C Car's way Paddock-Track
I Information desk
E Entrances to Hall
S E-Shop
U Parking for unload trailers
P Team's paddocks
D DNV Fuel Fighter Paddock

Figure 51. Hall 1 map

Team paddocks are located according to the fuel type.

Individual paddock for team is 4m x 5m. Each paddock is equipped with:

> 2 x Chairs
> 1 x 2m x 0.8m Table
> 1 x Locked storage unit
> 1 x Waste paper bin
> 2 x 13a 240v socket
> 6 x Spotlights
> WiFi

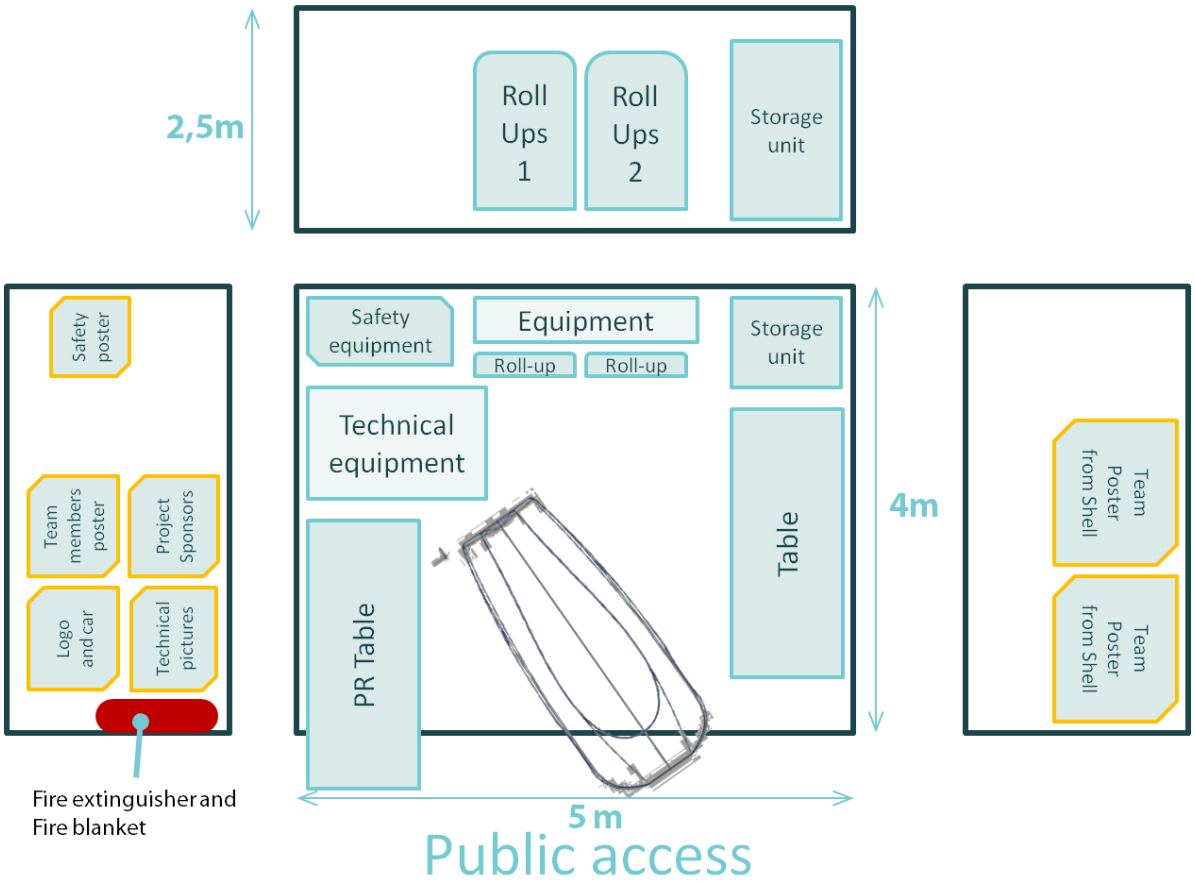


Figure 52. DNV Fuel Fighter Paddock plan

First, paddock was equipped PR and Safety stuff and after that technical stuff and car arrives. In paddock is forbidden to use usual tape and any damage of panels will cost penalty for the team. Special type of tape spots are provided by organizers. Electrical cables have to be taped to the floor as well as carpet from public access side for the safety reasons. Fire extinguisher and Fire blanket have to be visible and accessible in case of accidents. When team arrives to paddock one of the team posters from Shell was with wrong photo and after few days new correct poster was printed by Organizers. Spotlights position was adjusted to emphasize lights for the Roll-ups, Posters on the wall and the car.

Figure 53. Empty paddock

Figure 54. Paddock with PR and Safety equipment

Figure 55. Paddock work condition

> Technical and Safety Inspection

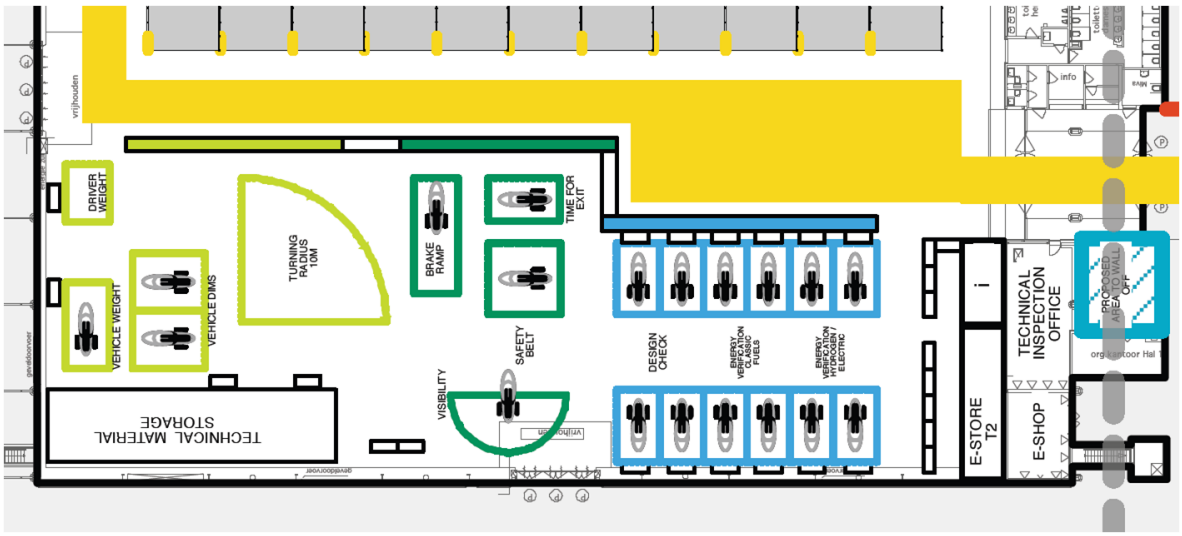


Figure 56. Technical Inspection map

Technical and safety inspection is on the Hall1. Inspection has few stages that car with Manager, Drivers and one more team member have to pass.

Check list before Technical inspection:

- Car matched the technical requirements. Check list was created after detailed analysis of the Regulations. Before official inspection it was internal inspection.
- Identification on the car (logos, race numbers). All necessary stickers team got from registration. Before foiling the car graphic designer leave special places for these stickers.
- Driver suit, gloves, helmet, glasses
- Transponder installed in the car
- Joulemeters installed in the car
- Bar codes for a car, manager, drivers
- Technical documentation. This is printed documentation that needed mainly on the last stage and contain description of the electrical system, propulsion battery and accessory battery, motor controller and solar panel.

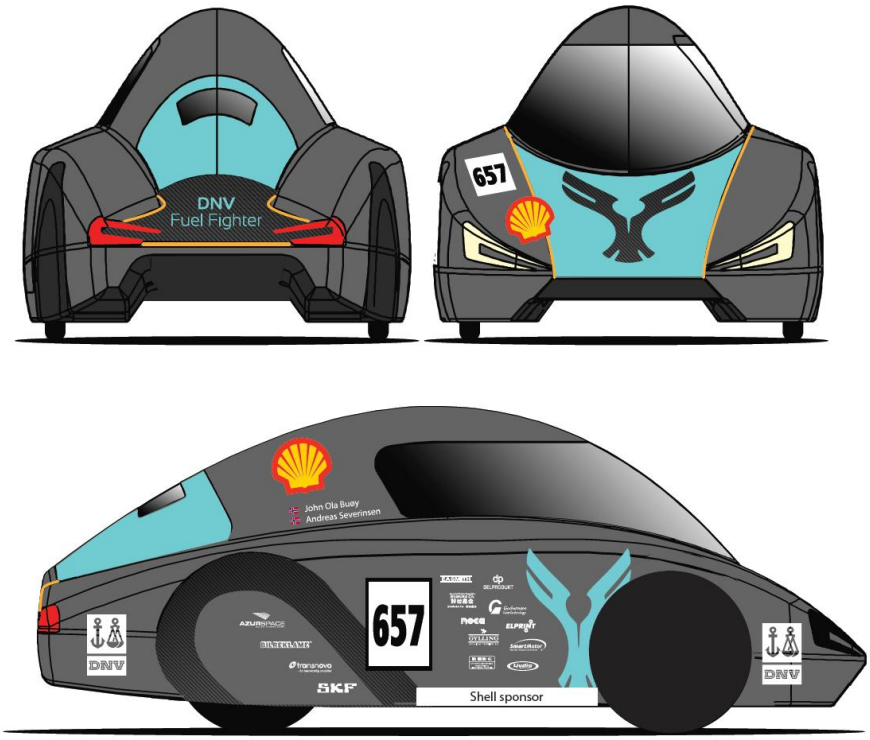


Figure 57. Car identification

Figure 58. Technical Inspector

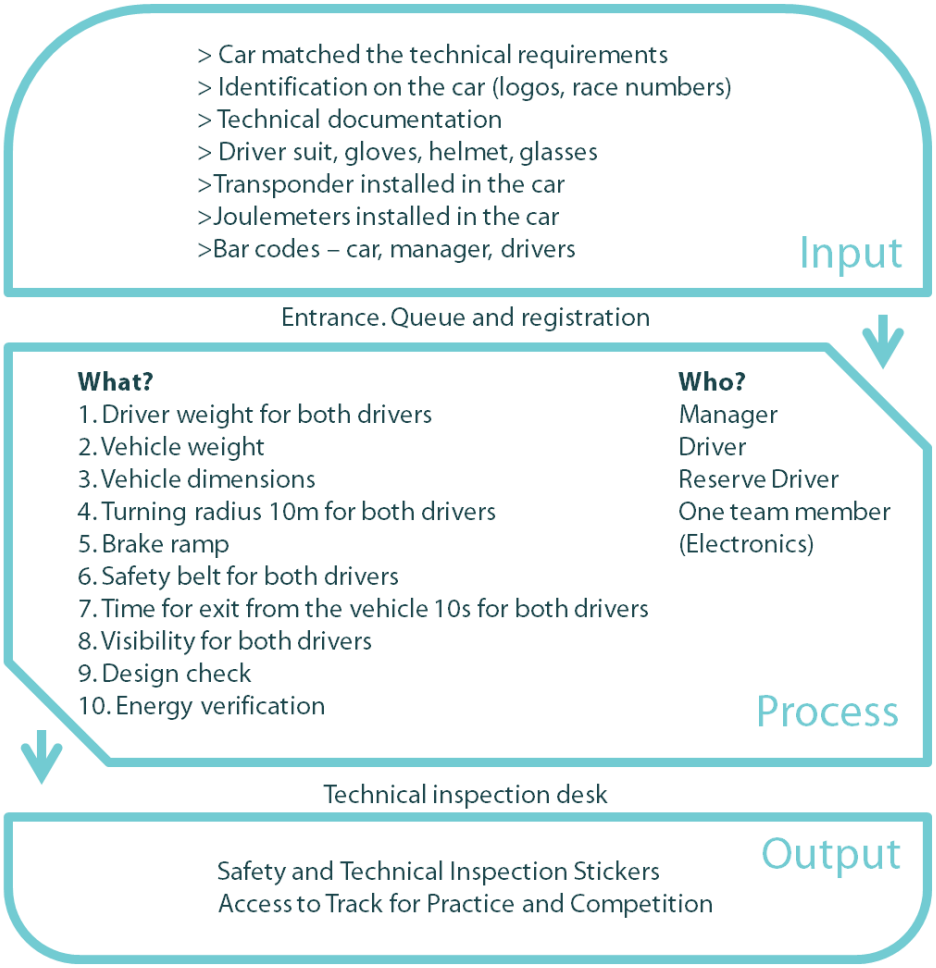


Figure 59. Technical Inspection Process

Stations during the Inspection:

1. Entrance. Queue and registration
2. Driver weight for both drivers. Including Clothes, Helmets, Luggage and additional weights
3. Vehicle weight. Car stay on the 4 platforms for weight measures
4. Vehicle dimensions. Special gates and sticks to measure all required dimensions outside and inside of the car.
5. Turning radius 10m for both drivers. Each driver have to turn car follow shape on the floor in both directions (left and right turn)
6. Brake ramp. Platform with angle to check the brakes efficiency.
7. Safety belt for both drivers. Check the clearance and reliability of belts.
8. Time for exit from the vehicle 10s for both drivers.
9. Visibility for both drivers. Inspectors show the numbers or colors around the car to check visibility of windows and rear mirrors.
10. Design check. Stickers, logo and race numbers check. Mechanical check of the Suspension/Steering, Wheels/Rims, Door, Luggage space etc.
11. Energy verification. Solar Panel check. All electronics including joulemeters, wires, labeling of the components and wires, Batteries. Emergency stop buttons test. Technical Documentation.
12. Technical inspection desk (Transponders, Joulemeters, Stickers).

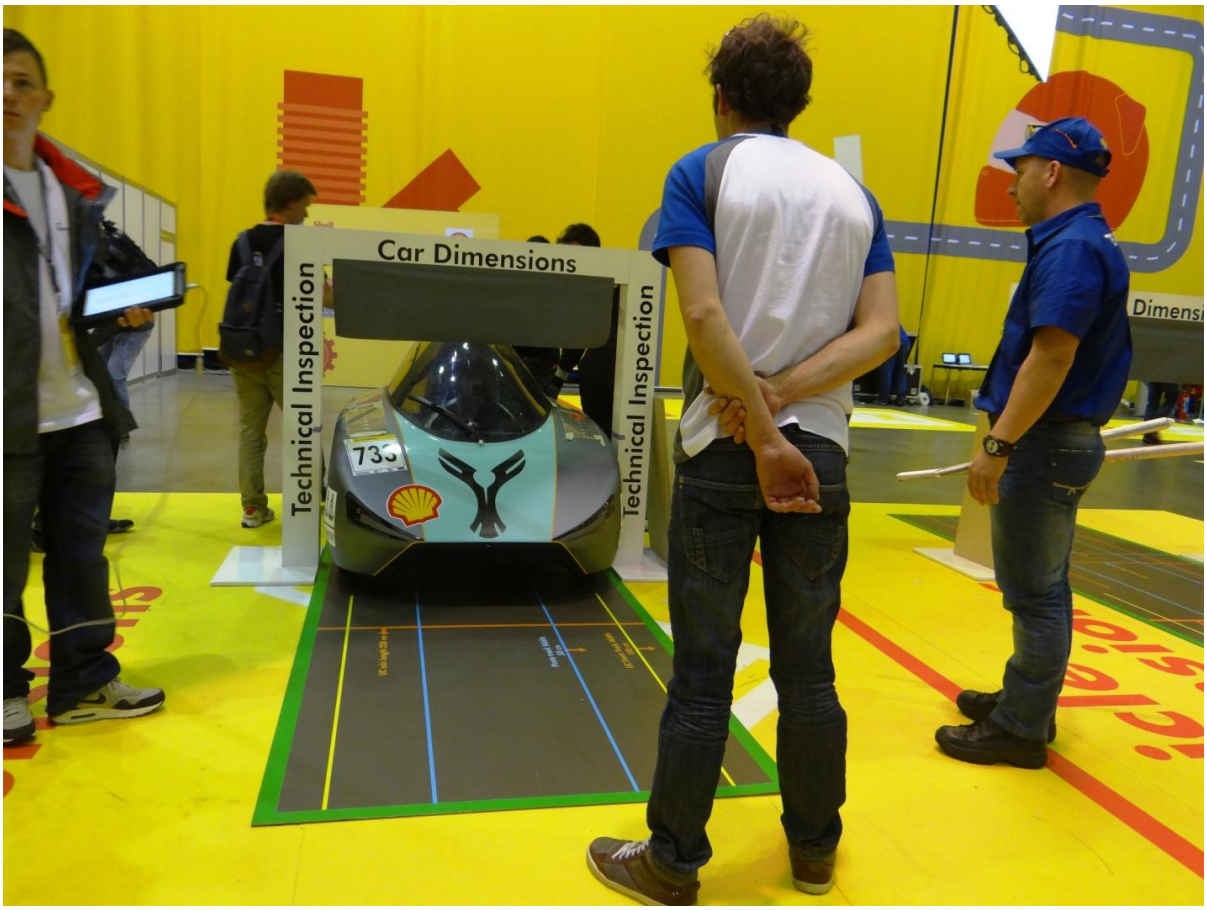


Figure 60. Dimensions test

Result of the Inspection is stickers – Technical Inspection and Safety Inspection. Stickers give the access to the Track for practice and competition.

Figure 61. Technical and Safety Inspection stickers

3.2.7 Agile project management approach

Agile project management approach is effective when uncertainty about goal and solution is quite high and time, people and resources are very limited. Technical car development process and PR&Media WBS categories are good examples of agile methods. Daily and weekly routine work days for teams were in agile rhythm. Basically, project is very agile – small self-motivated and self-organized team, freedom in decision making and whole process organization, team members is students with low level of competence (knowledge and experience), innovative project product etc. Traditional approach is method to reduce total uncertainty in project and absolutely necessary for some WBS categories (Financial operations, Safety regulations of NTNU and Organisers). In others situations, when is not possible to plan and time, people or other resources are very limited an agile approach was used.

Main constraints for the projects are people and time. Team members are regular student with normal educational load. Participation in project is voluntarily and only few in team have found a way to include project results as educational study points. First challenge is to find a time for meetings and for collocation of working groups. Solution was to use Google calendar as tool for planning team routines and team members' availability. Each team member has to fill time slots for own availability every week. For people who want to arrange a meeting for some team members is easy to find proper time and day. Main project events and meetings are also available to see on Google project calendar.

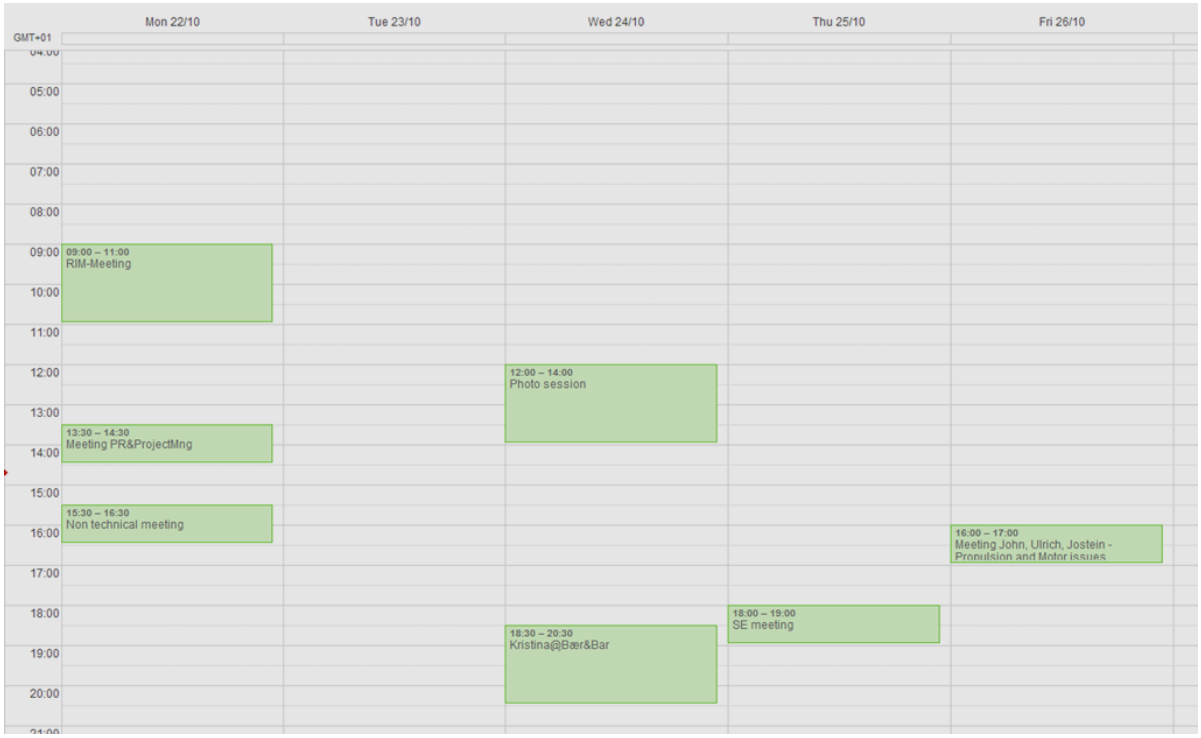


Figure 62. Google calendar for weekly planning

Additionally, Facebook group tool was used very extensively for communication and discussions. Facebook group contains also previous project team members and also professors for helping and knowledge transferring. Often in FB group events are announced and even some organizational activities could be done by this powerful online tool.

Team used a server for files storage (documentations, photos, templates etc…). Structure of server folders are maintaining by responsible person and management.

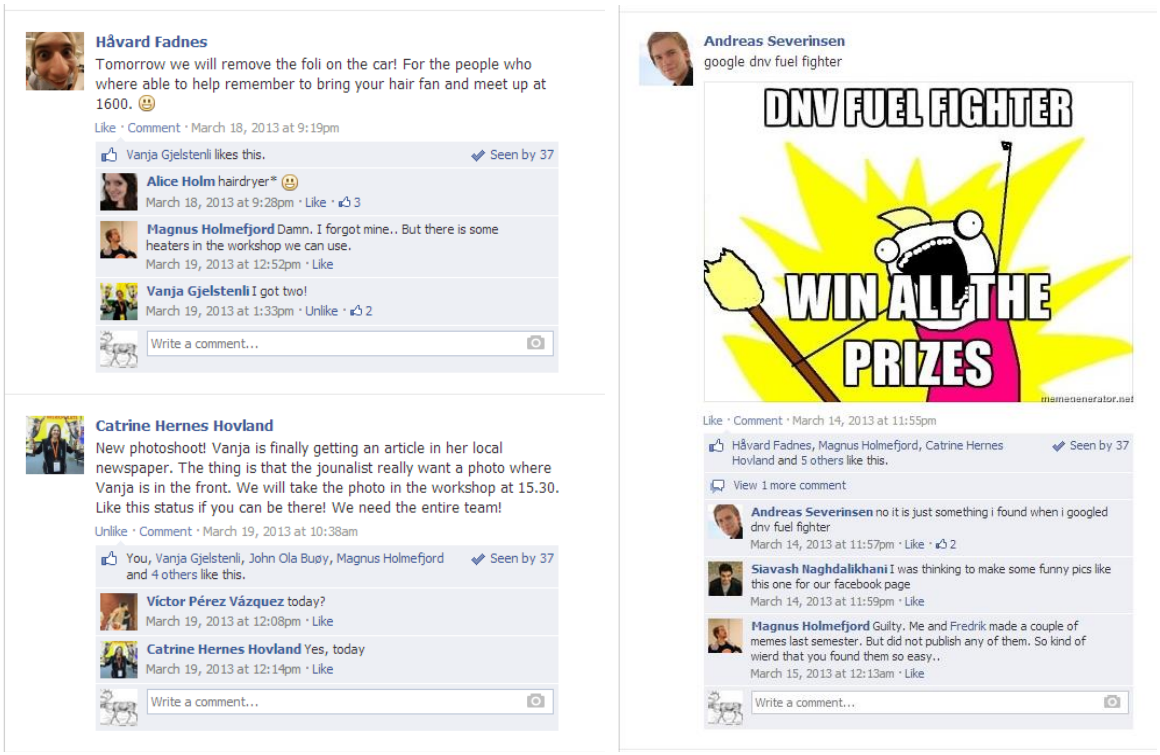


Figure 63. Facebook closed group is powerful team communication tool

Office and workshop are available 24 hours and only team use and organized own everyday activities. Office has kitchen facilities and relax zone with 2 sofas and big screen. One of the walls in office is whole whiteboard for planning and discussions. Whole project timeline and plans for the 2 weeks are presented on the board. Some general and actual project info is on the wall-whiteboard also. Board weekly updated by project manager or team members usually after meetings.

Weekly meetings were decided by team to divide in two categories – technical and non-technical (project management, PR and Media, Design). This decision helps better to use team members time and easier to arrange and manage meetings. Info from the meetings was posted in FB group and short report as document uploaded on the server.

Technical car development

Innovative complex technological system development process by not-enough-experienced and skilled team in strong time limitation is difficult process for detailed and predicted planning and control. Agile project management is necessary here. Planning starts by high-level master plan or roadmap. System Engineering science suggests to use V-model for project (Fabrycky W. J. Blanchard B. S., 2011). There are a lot of loops in this model in reality, but for simplicity dependencies and loops are not showed. V-model has few phases or Releases in agile project management terminology:

> Analysis of needs (SEM regulations, team ambitions, previous project status and current resources availability)
> Requirements (structured and defined list of requirements)
> Design (Plan for future system include resources and outsources)
> Specification (detailed documentation about each subsystem or elements)
> Purchasing and production (Supply of elements and assembling subsystems)
> Verification (testing of elements or subsystems)
> Assembling (elements and subsystems into one system - car)
> Validate (Testing of whole car)
> Acceptance (Technical and safety inspection in Rotterdam)

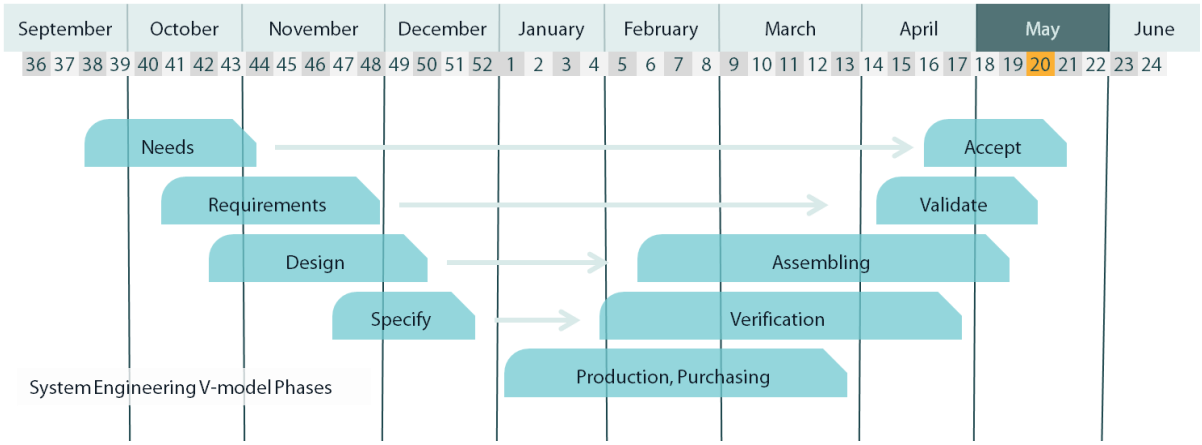


Figure 64. V-model as Roadmap

Time limitation as main constrain in project is basic point for planning – car has to be done before competition and has to have at least one successful attempt out of few. Roadmap milestones could be flexible except last one and during the project were few corrections.

Iterations in project were 1-2-3 weeks. On the very beginning it was long 3 and even 4 weeks iterations due to mainly theoretical tasks and general information gathering, In the middle of project 2 weeks iterations was effective because sub-groups works mainly internally on sub-systems with few integration activities. At the end of the project 1 week iteration was established because of a lot of integration and testing works. On the very end – 1 week before Rotterdam and in Rotterdam iteration size was 24 hours with stand-up meetings for whole team. Project due to different reasons was near to fail – delays in elements transportation from suppliers, technical fails during testing, reworking etc. In May 2012 was 3 weeks of extreme or crisis project management.

PR & Media

PR & Media is another example of agile project management approach. It is difficult to define SMART (specific, measurable, attainable, relevant and time-bound) goals for that and also difficult to plan work. Main critical PR & Media goal was satisfaction of sponsors and NTNU through the maximum publicity. Publicity related to the project reputation, attractiveness for students as main resources, sponsors and opportunity for students. Goal finally was ambitiously defined as "Our goal is 150 articles, appearances on television and radio. We will also participate in 15 events and stunts. In addition our goal is to tell about the progression of the car, and tell about events and our stunts, on social media platforms such as Facebook, Twitter and on our homepage" Result was around 100 articles, around 20 events, 3 video, over 1600 likes official Facebook page, few photo sessions and PR and Media Off track Prize as the best PR and Media team in Europe. DNV Fuel Fighter project was the most recognizable on the SEM 2013 event with high attention from public, competitors and organizers.

Management approach was quite different from others WBS categories. On the high level planning it was pure agile approach. But each event, each article or other contacts outside the team was very carefully planned using more traditional disciplined approach.

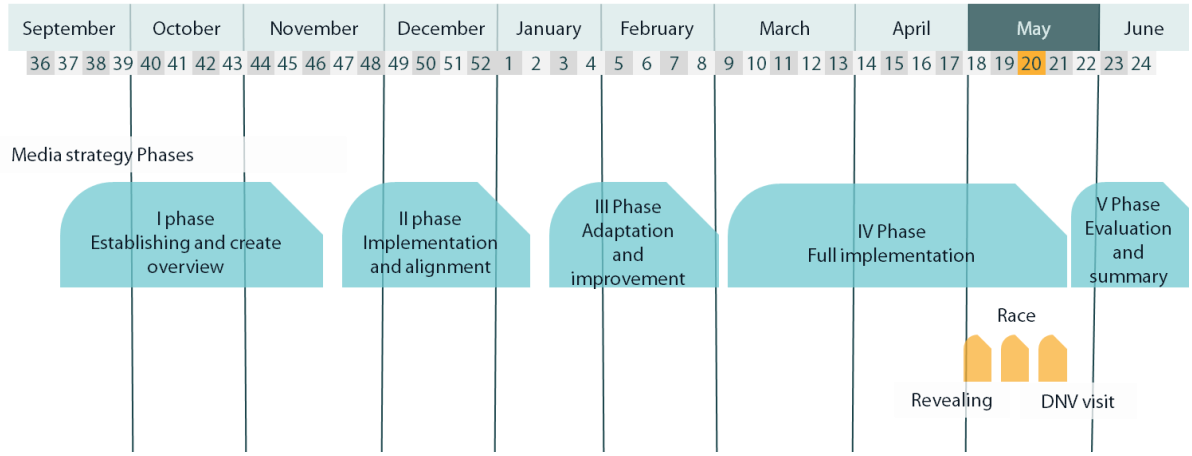


Figure 65. PR&Media Roadmap

Roadmap for PR and Media was defined as few phases:

Phase 1:Establishing and create overview (September– November)

> Identify what the team believes can be achieved in the Project Timeline.
> Objectives of the number of newspaper articles and media coverage.
> Start work to and events that will be exciting to participate in.
> Start making a media kit (Photos of the team members, text, logo etc).

> Establishing contact with sponsors (the guys building the car should do this), the sponsor contact will be maintained by PR- and media team.
> An informal Facebook group will be made, because communication between team members.
> Meet the department of information at NTNU, get them to help us.
> Contact Fotofagskolen and Norges Kreative Fagskole about pictures to press releases.
> Brainstorming with the entire team, what we can to do to get as much attention as possible about the project.

Phase 2: Implementation and alignment (November – January)

> The media profile should be finished.
> Establish a social media platform (Facebook, Twitter and homepage) (when the logo is done). Continuous updates and news in all our channels.
> We need to be informed about the deadline of every part of the car. So we know when to make a story/video about it.
> Make a presentation of each team member.
> Start establishing contacts/deals in media, send press releases to local press and student medias.

Phase 3: Adaptation and improvement (January-March)

> Sell stories to the press (twisting techniques: what makes a story sexy, how many stories can be told)
> Adjust measures in the media: what gives best result according to statistics
> Make a strategy for the revealing of the car (send invitations to the media, the sponsors etc.)
> Make a video for launch of the car «This is the team».
> Produce a mini- series on youtube about the project, try to promoting this in the media, or send it on adressa.no
> Establish contact with NRK and TV2: is there some shows we can tell/show our car?
> Keep our Facebook, Twitter and web page updated.

Phase 4: Full implementation (March-June)

> Competition phase: sell in the voltage aspect with a new touch in advance.
> During the competition: keep the media informed write stories, send pictures (ready for press)
> After the competition: How did it go?
> Loss = damage control.
> Victory = rekindle the same for maximum output.
> Keep our Facebook, Twitter and web page updated.

Phase 5: Evaluation and summary (June-August)

> How did it really go? Measure the effect of the work
> Inform the sponsors about the result
> Transfer knowledge to next year's generation.
> Keep our Facebook, Twitter and web page updated.

Release in PR and Media could define as every event or article. Iteration is every week. Every week PR and Media managers on the non-technical meeting provided information about tasks and events for team with short organizational solutions (who, when, what to do could make). The most important were Project Revealing in Trondheim week before Rotterdam, PR actions on the Ahoy Arena and DNV presentation in Oslo after Rotterdam.

3.2.8 Overview of theoretical methods

Table 43 contains overview of different methods for selection of work packages within WBS. There are different parameters and different scales for better decision about effective project management approach. In DNV Fuel Fighter such parameters were:

- Critical task (SEM Registration, Technical Inspection vs Project Improvements)
- No choice for traditional approach (Financial operations, Safety, Regulations vs. PR&Media)
- Possibility to plan or low uncertainty (Travel and Race vs. Technical car development)
- Availability of Human Resources and Time
- Planning level
- Common sense in general or “to do the best as we can in specific context” principle

In practice, actually, it was even three approaches: traditional disciplined approach, agile approach and “survive in the chaos” approach. Last one was mainly at the Rotterdam, when technical problems with car was a reason for very close failure and team tried to do the best almost 24 hours per day.

There are theoretical approaches (Wisocki, Boehm and Turner, Little, Diamond by Shenhar and Dvir) for choosing the project management approach within 13 WBS groups:

1. Technical
2. Driver and Driving Strategy
3. Shell Eco Marathon
4. Travel and Race
5. Sponsors
6. PR and Media
7. Graphical Design
8. Partners
9. Management
10. Finance
11. Academic Reports
12. Safety
13. Project Improvement

Wisocki method with solution-goal parameters gives selection result into Traditional (3,4,10,11,12) and both Agile and Extreme Project Management approaches (1,2,5,6,7,8,9,13).

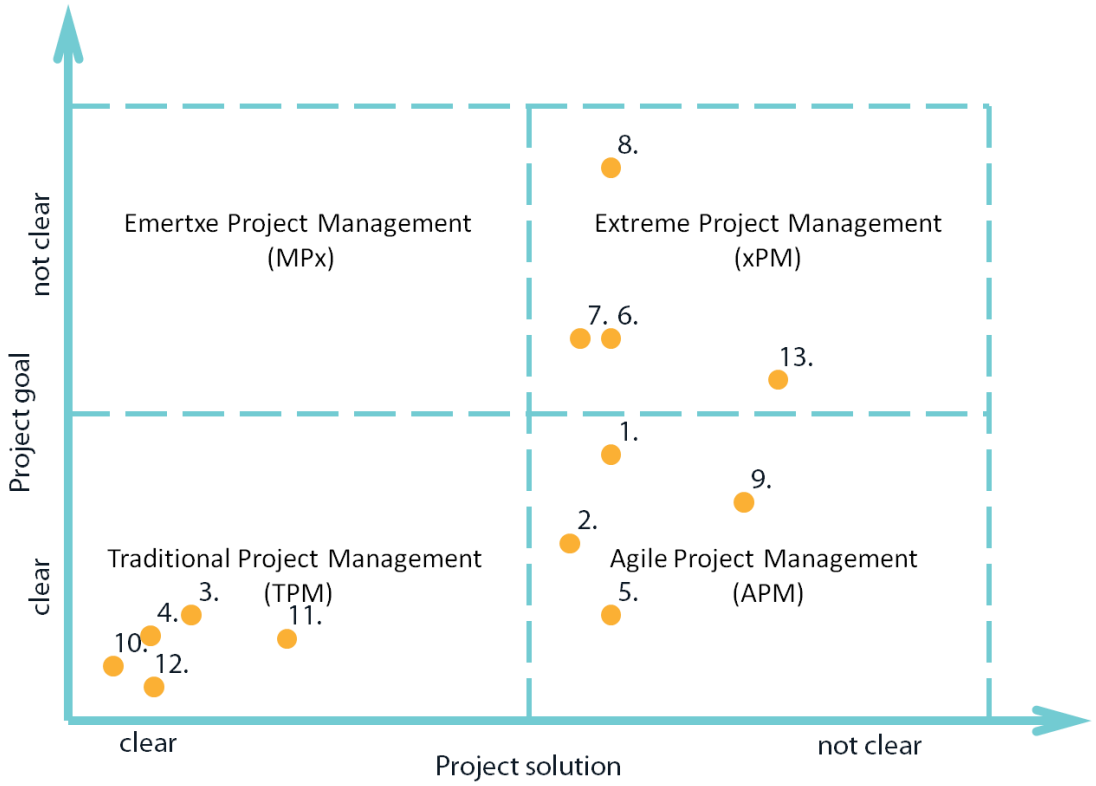


Figure 66. Wisocki method for 13 WBS categories

Boehm and Turner model with Personell, Dynamism, Culture, Size, Critically parameters gives in DNV Fuel Fighter case only Dynamism and Critically changes because Personell, Culture and Size are quite similar for each WBS categories – team and small working groups have very similar people. Method gives results: Traditional approach –3,4,8,10,11,12 WBS categories, Agile approach – 1, 2, 5, 6, 7, 9, 13 WBS categories.

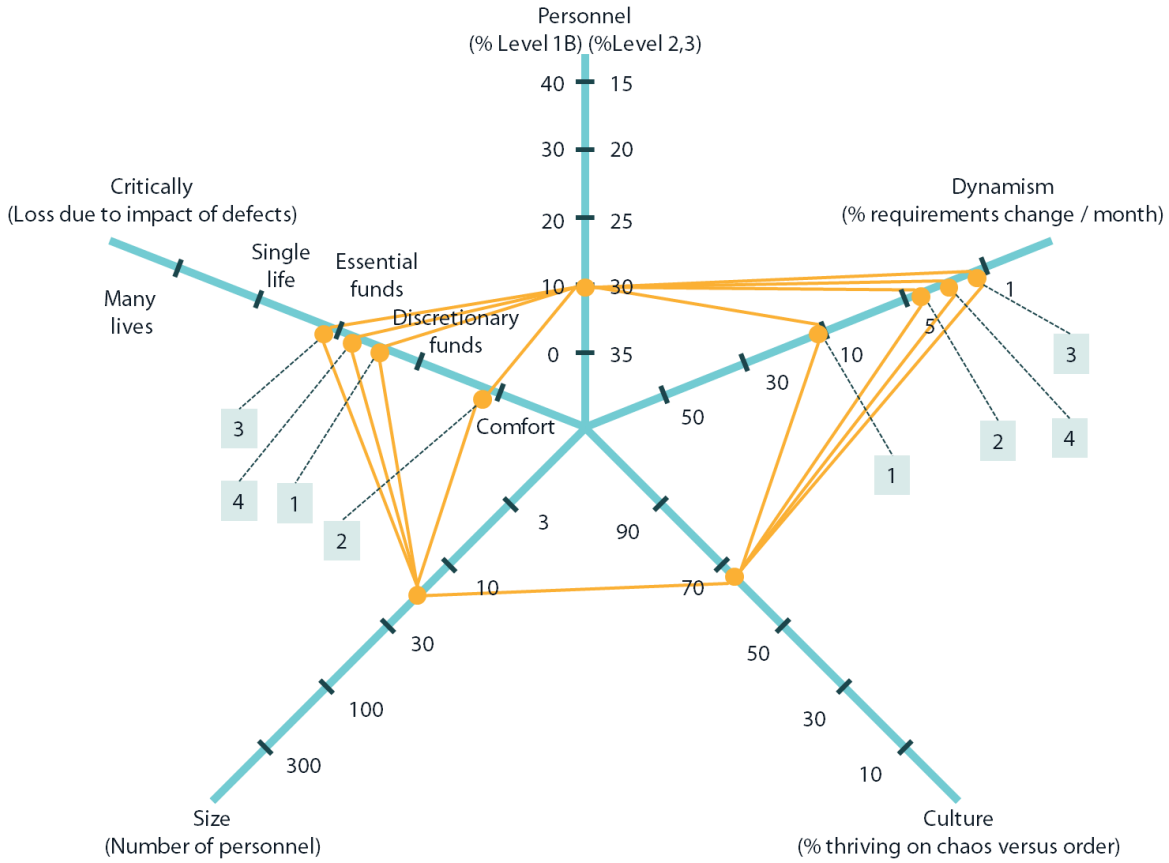


Figure 67. Boehm and Turner method for 1-4 WBS categories

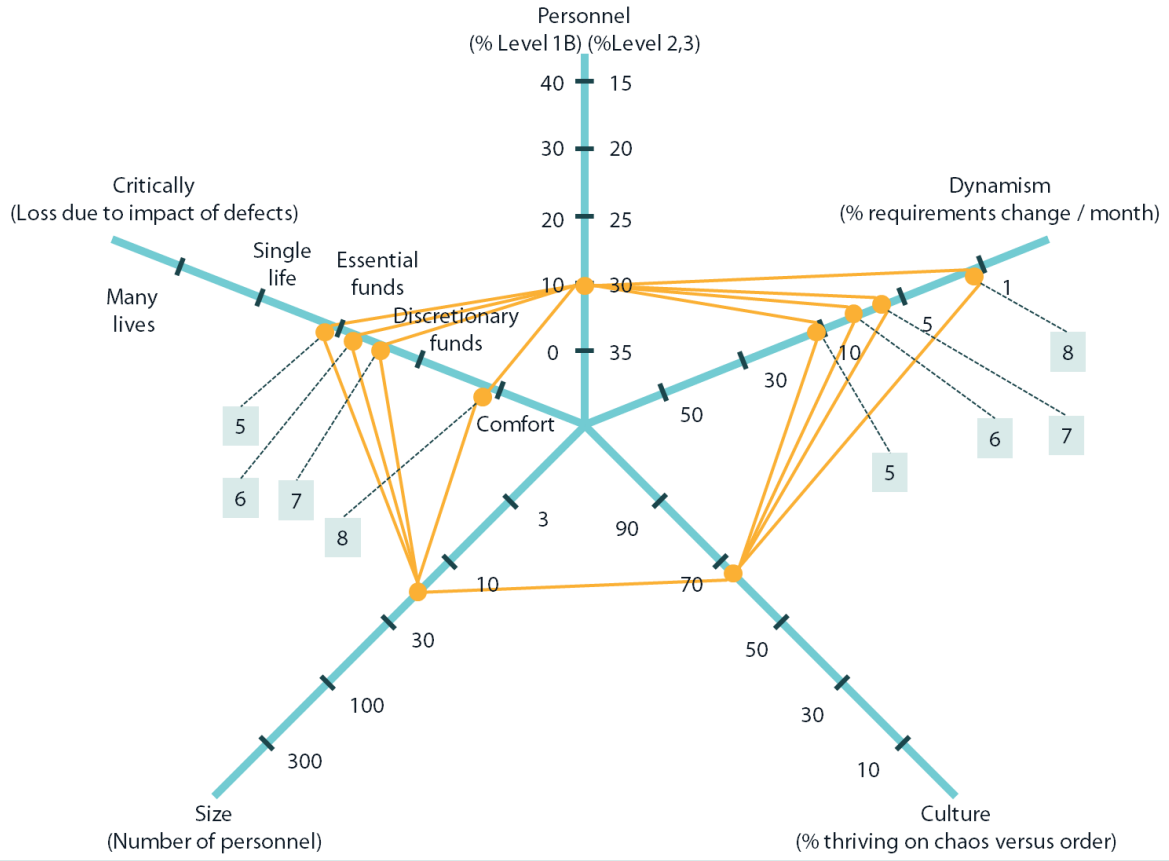


Figure 68. Boehm and Turner method for 5-8 WBS categories

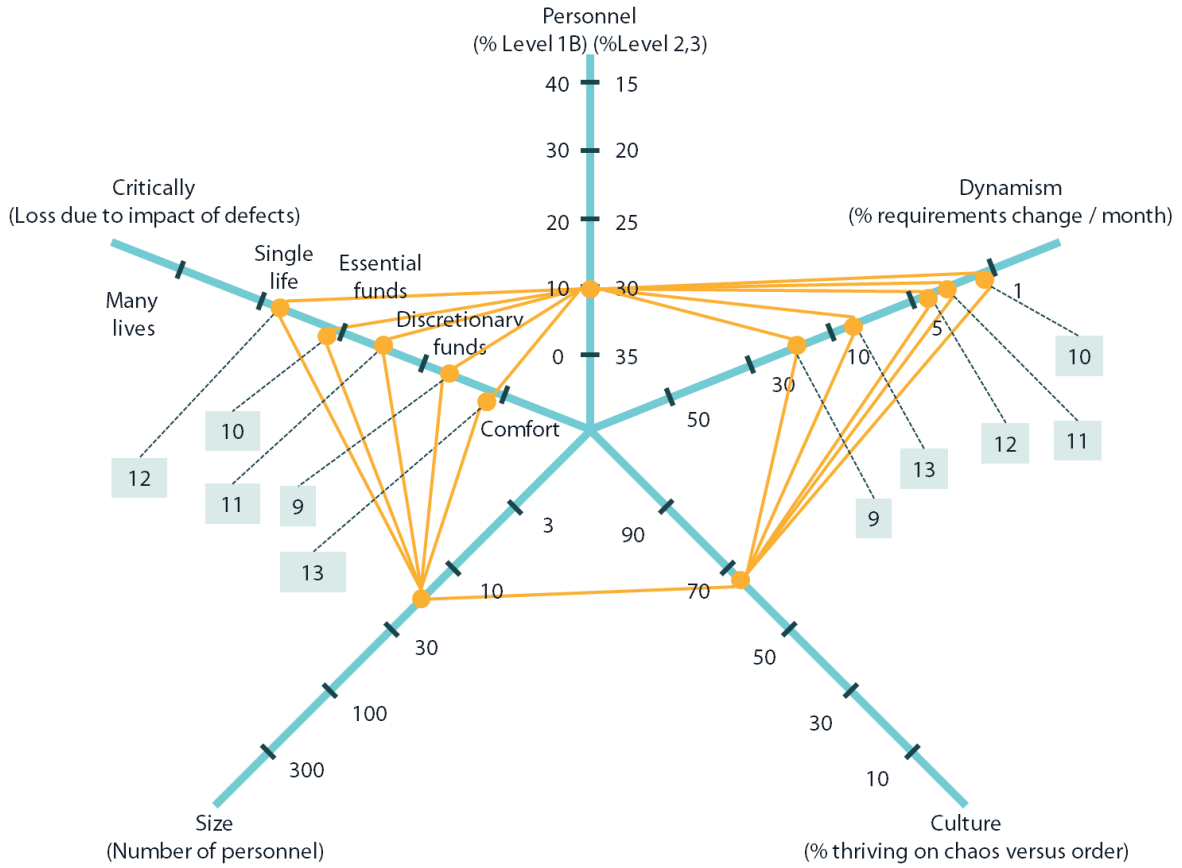


Figure 69. Boehm and Turner method for 9-13 WBS categories

Method by Little T. uses complexity and uncertainty parameters for selection. Complexity and Uncertainty is multi-parameters categories defined in Table 21-22 with final scoring as average calculation in Table 23. Final results of selection are presented in Figure. Agile approach by Little T method is more relevant for 1,2,5,6,7,8,13 WBS groups and more Traditional for 3,4,9,10,11,12 WBS groups.

Table 21. Complexity score, Little T. method

Complexity score					
Attribute	1	3	5	7	10
Mission criticality	Speculative	Small user base	Established market	Mission-critical with large user base	Safety critical with significant exposure
	8	**6,7,13**	**5,9,11**	**1,2,3,4,10**	**12**
Team size	1	5	15 **all**	40	100
Team location	Same room	Same building **all**	Within driving distance	Same time zone +/- 2 hrs	Multisite, worldwide
Team capacity	established team of	New team of experts	Mixed team of experts	Team with limited	New team of mostly

	experts		and novices	experience and a few experts **all**	novices
Knowledge gaps	Developers know the domain as well as expert users	Developers know the domain fairly well	Developers require some domain assistance	Developers have exposure to the domain **all**	Developers have no idea about the domain
Dependencies	None	Limited, well insulated	Moderate	Significant **all**	Tight integration with several projects

Table 22. Uncertainty score, Little T. method

Uncertainty score					
Attribute	1	3	5	7	10
Market uncertainty	Known deliverable, possibly defined contractual obligation	Minor changes in market target expected	Initial guess of market target likely to require steering	Significant market uncertainty	New, unknown, and untested market
	3.4,10,11,12	**1,2,5,6,9**	**7.8,13**		
Technical uncertainty	Enhancements to existing architecture	We think we know how to build it	We're not quite sure if we know how to build it	Some incremental research involved	New technology, new architecture; might be some exploratory research
	3,4,10,11	**9,12**	**5,6,7,**	**1,2**	**8,13**
Project duration	1–4 weeks	6 months	12months **all**	18 months	24 months
Dependencies, scope flexibility	Well-defined contractual obligations or infrastructure with published interfaces	Several interfaces Scope isn't very flexible	Scope has some flexibility	Some published interfaces Scope is highly flexible	No published interfaces
	10,11,12	**3,4**	**2**	**1,5,9**	**6,7,8,13**

Table 23. WBS categories scoring in Little T. method

WBS category	Complexity	Uncertainty
1.Technical	7,5,3,7,7,7= 6	3,7,5,7 = 5.5
2.Driver and Driving Strategy	7,5,3,7,7,7= 6	3,7,5,5 = 5
3.Shell Eco Marathon	7,5,3,7,7,7= 6	1,1,5,3 = 2.5
4.Travel and Race	7,5,3,7,7,7= 6	1,1,5,3 = 2.5
5.Sponsors	5,5,3,7,7,7= 5.7	3,5,5,7 = 5
6.PR and Media	3,5,3,7,7,7= 5.3	3,5,5,10 = 5.8
7.Graphical Design	3,5,3,7,7,7= 5.3	5,5,5,10 = 6.3
8.Partners	1,5,3,7,7,7= 5	5,10,5,10 = 7.5
9.Management	5,5,3,7,7,7= 5.7	3,3,5,7 = 4.5
10.Finance	7,5,3,7,7,7= 6	1,1,5,1 = 2
11.Academic Reports	5,5,3,7,7,7= 5.7	1,1,5,1 = 2
12.Safety	10,5,3,7,7,7= 6.5	1,3,5,1 = 2.5
13.Project Improvement	3,5,3,7,7,7= 5.3	5,10,5,10 = 7.5

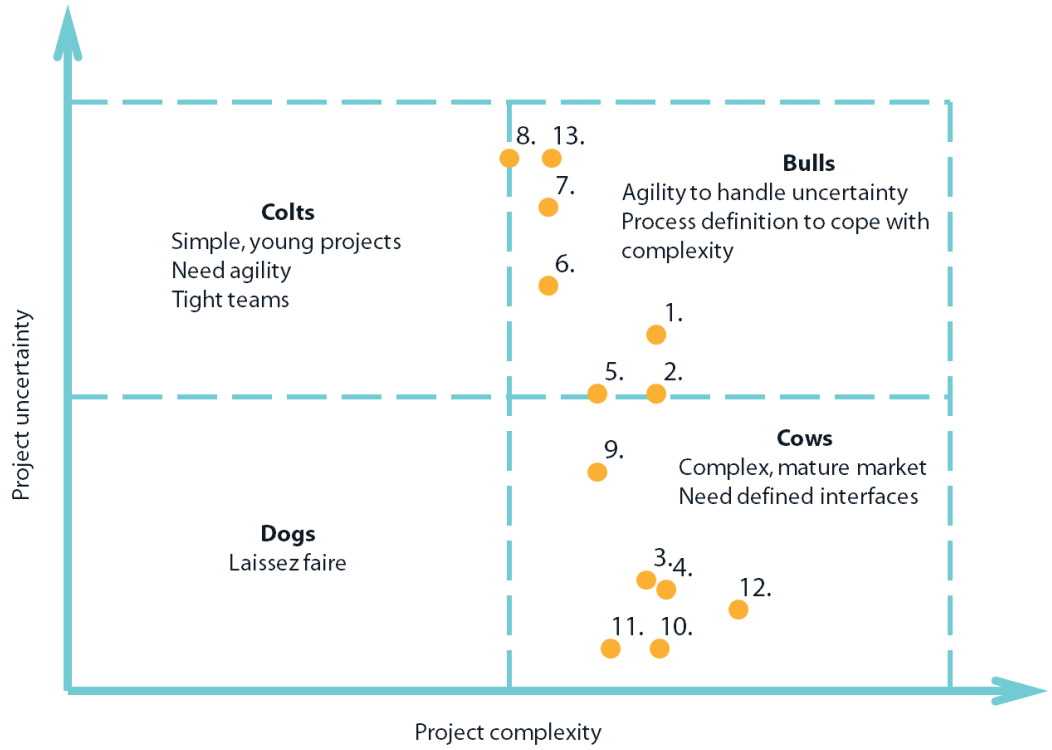


Figure 70. Little T. method for the WBS categories

Diamond method uses Complexity, Technology, Novelty and Pace parameters for selection. Results are quite similar, but time-criticality of WBS categories very strong and 1,2,5,6,7,8,11,13 WBS categories are more agile and the rest are traditional approach needs.

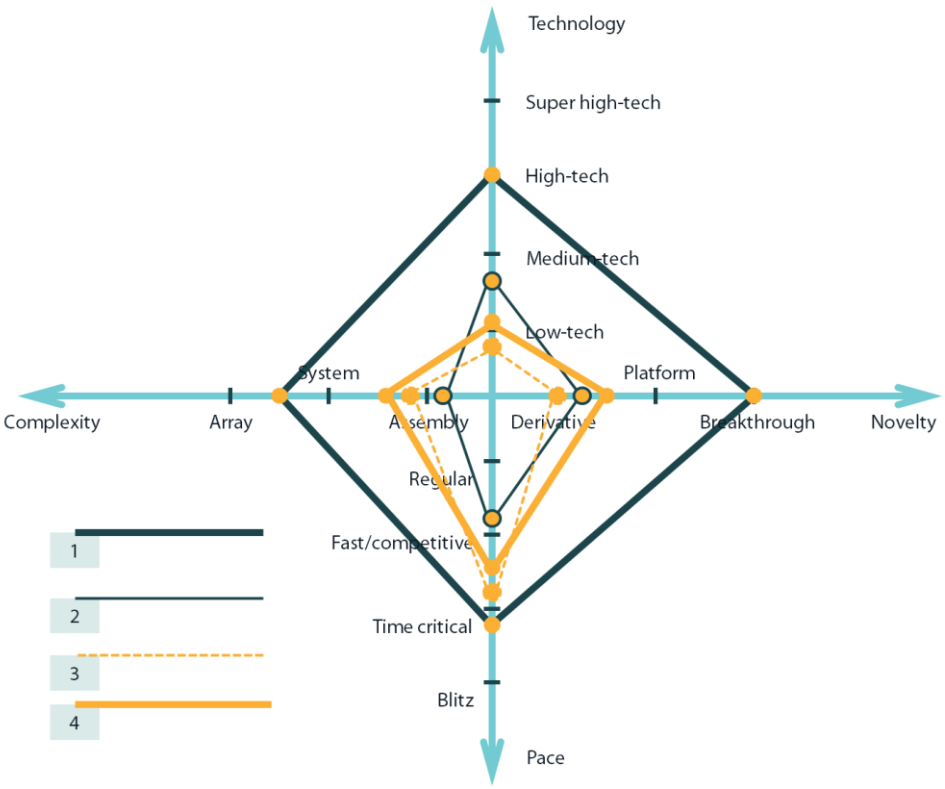


Figure 71. Diamond method for the 1-4 WBS categories

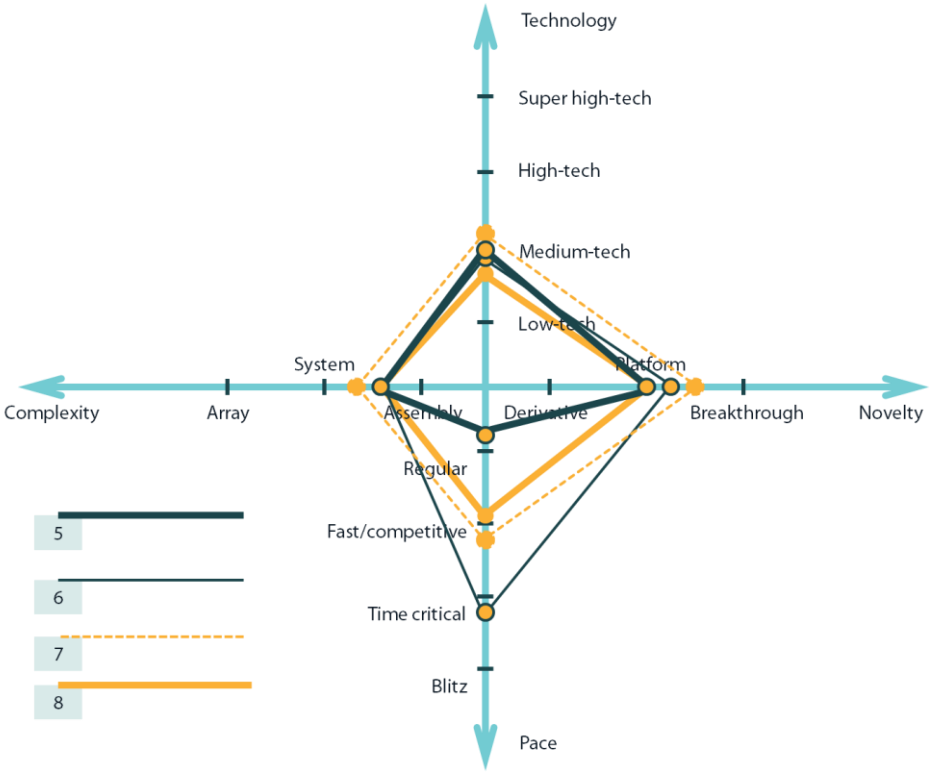


Figure 72. Diamond method for the 5-8 WBS categories

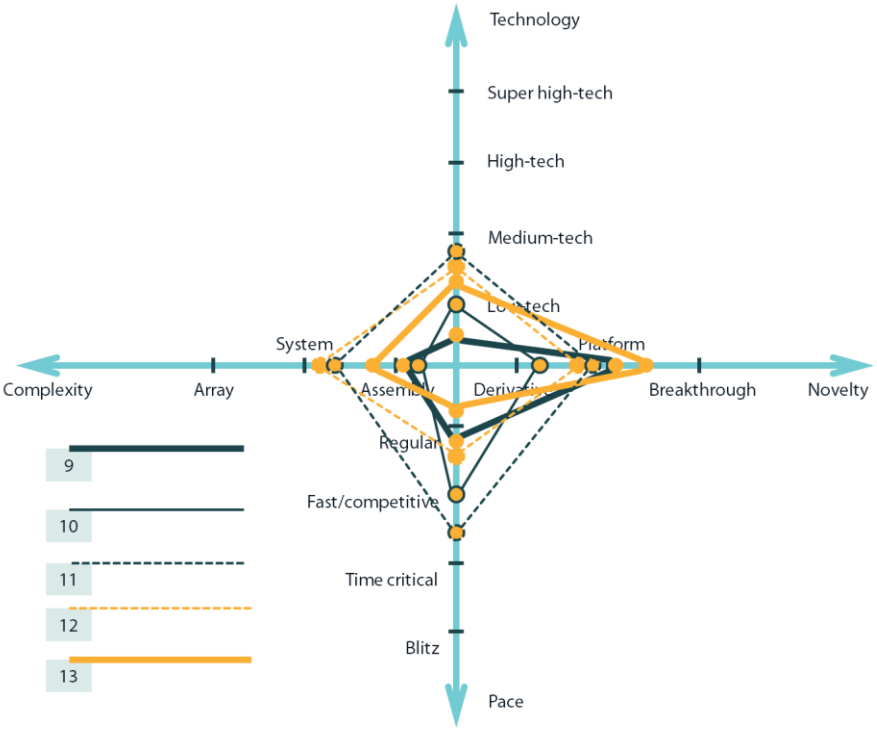


Figure 73. Diamond method for the 9-13 WBS categories

4. FINDINGS

Research topic in this Master Thesis is: “Managing a small innovative project with high level of uncertainty”. Because project management is wide and multi-level concept the research topic is limited to the two most critical areas for small, time limited project with high level of uncertainty – Scheduling and Risk Management in terms of planning and control process.

There are two narrow research questions:

1. Is there effective to use different Project Management approaches: Traditional and Agile one together in small, time limited project with high level of uncertainty?
2. If a balancing of Agile and Traditional approaches is effective and what is the method to choose the most relevant one for which element of a project?

Theoretical chapter of Thesis describes basics of Traditional and Agile approaches, advantages and disadvantages of each and few methods for selections right project management approach for the projects or projects elements: Wisocki, Boehm and Turner, Little, Diamond. There are different parameters for each method with quantities and/or qualitative comparison.

Practical chapter is based on the DNV Fuel Fighter student energy efficient car project in 2012-2013 accommodated on the NTNU, Trondheim. Car was made for the Shell Eco Marathon annual competition in Rotterdam in May 2013between almost 200 teams from Europe. Master Thesis contains some practical information about the project which not necessary for the pure research report but could be very useful for the next generation of management in DNV Fuel Fighter projects. The first part of practical chapter contains DNV Fuel Fighter project essentials – what is the project, competition, goals, results, stakeholders, team, facilities etc. The second part shows how the project was managed in terms of Scheduling, Risk Management, Planning and Control and how Traditional and Agile approaches were combined together. The last part provides overview of theoretical methods and practical methods for selection appropriate management approach for each work breakdown structure categories:

1. Technical
2. Driver and Driving Strategy
3. Shell Eco Marathon
4. Travel and Race
5. Sponsors
6. PR and Media
7. Graphical Design
8. Partners
9. Management
10. Finance
11. Academic Reports
12. Safety
13. Project Improvement

First research question about efficiency to mix different approaches on the one project for the same team has answer “Definitely, YES!” In practice it was only one possible and necessary way to achieve project goals and to manage project into successful results.

Second research question about what methods to use for selection between Agile and Traditional approaches has few levels for answer. Results both practical and theoretical are very similar with difference only in some specific practical situations when suggested by theory methods could not be applied. Overview of the methods for selection the right approach is presented on the Table. One category #9 ‘Management’ was quite close at the edge between Traditional and Agile approaches in all theoretical methods. In practice it was also art of balancing between not only within WBS categories but also within each task.

Table 24. Practical and Theoretical results for selection

Method	Parameters	Traditional	Agile
DNV Fuel Fighter	Critical task	**3,4,10,11,12**	**1,2,5,6,7,8,9,13**
	No choice for traditional approach		
	Possibility to plan or low uncertainty		
	Availability of Human Resources and Time		
	Planning level		
	Common sense in general or “to do the best as we can in specific context” principle		

Wisocki	Solution	**3,4,10,11,12**	**1,2,5,6,7,8,9,13**
	Goal		
Boehm and Turner	Personnel	**3,4,8,10,11,12**	**1, 2, 5, 6, 7, 9, 13**
	Dynamism		
	Culture		
	Size		
	Critically		
Little	Uncertainty (multi)	**3,4,9,10,11,12**	**1,2,5,6,7,8,13**
	Complexity (multi)		
Diamond Shenhar and Dvir	Novelty	**3,4,9,10,12**	**1,2,5,6,7,8,11,13**
	Technology		
	Complexity		
	Pace		

Event-oriented activities within Management and PR and Media WBS categories were exceptions from the general rule – low level planning and control have to be disciplined process with detailed definition and managing who will do what at which time. But in general, at high-level planning it were agile processes without clear goals but with extremely high influences on the whole project result.

Practically, different methods to manage team and individuals were used on the same time. Quite obvious approach was used: first, to define the best theoretically approach; second, trying to apply; if it does not work or team disagrees to use it; change the approach until results are comes. Trust and personal responsibility for each critical part of work were the key success factors in project. Second key success factor was agile risk management with simple phases and questions:

Risk Identification (What can go wrong?);
Risk Evaluation (What is the probability and consequence?);
Risk Prevention (How to avoid risk?).

As result – proper task prioritization, personal responsibility, resources allocation, redundancy in solution and human resources, time and budget buffers were the most effective techniques to reduce risk and secure success project implementation.

Last, but the most efficient but difficult to define and measure key success factor is leadership or human relationship and communications management. Team members did their work only because of personal interest – there is no salary, or academic marks or something else as direct benefits. Team members are just students with regular education workload and intensive private life.

5. DISCUSSION

The master thesis has focus on the project management field and on the project type with high uncertainty and time limitation.

First research question is related to mixing or balancing between two different project management approaches. Traditional approach is disciplined, plan-driven and classical for project management field. Modern projects in our fast, unpredictable world could not use full traditional project management approach since often practical failings. A critic of traditional methods contains arguments: it does not agile, flexible, adaptive, fast; it does not use all available knowledge and it does not motivate people for creative work. (Wysocki R.K. (2009), Shenhar A.J. and Dvir D. (2007), Boehm B., Turner R. (2002, 2003, 2004), Turner R., Ledwith A., Kelly J. (2010,2012), Levitt R.E. (2011), Apello J. (2011), DeCarlo D. (2004)). Agile methods were established in software industry for dealing with those disadvantages of traditional approach. Balancing of different approaches depends of current context and current task is key success factor for modern projects. Theoretical (Apello J. (2011), Boehm B., Turner R. (2002, 2003, 2004)) and practical (DNV Fuel Fighter – case study for the Master Thesis) information show that using of proper method for proper situation is efficient and even necessary for the project. High uncertainty needs agility and creativity, but time-limitation needs discipline and detailed planning. So for our research type of project – time limited with high uncertainty needs both approaches on the same time.

Second research question is related to method how exactly to balance different project management approaches within one project and team. Narrower question is how to select project elements within agile and traditional work packages categories. Four theoretical models (Wisocki, Boehm and Turner, Little, Diamond) and practical findings (DNV Fuel Fighter – case study for the Master Thesis) were discovered. Results were quite similar (see Table). Anyway it was some exceptions – event-based activities in PR&Media and Management WBS categories. The reason for exception is specific goal – event organizing where detailed plan have to be completed and disciplined implementation have to be managed.

Exceptions show that theoretical methods have to be first checked by management for the rationality and feasibility in specific project situation. After that method could be applied but with care and control for the status.

Four theoretical models have different parameters for selections. Only half of them – Boehm and Turner and Little models have direct focus on the team parameters. Wisocki and Diamond models are more projects related. Anyway all researchers emphasize the critical meaning of the team and personal team members' competence. Competence here is not only professional knowledge and experience but mainly personal ability to work in agile, self-organized and self-motivated team.

Practical findings show that quite often management does not have too much freedom to choose management style. Managers need to focus first on the most critical and the most fragile on the same time project element – on the team. Proper leadership style have to be not a project constraint at least, it has to be support for the team to achieve a desired goal. After that proper solution how to achieve that desired goal will arrive on the natural way as teamwork result. All these findings very close to some very popular last year's books with attempt to find the best way to manage organizations and projects:

> DeCarlo D. (2004) eXtreme Project Management. Using Leadership, Principles, and Tolls to Deliver Value in the Face of Volatility. Jossey-Bass. USA

> Apello J. (2011) Management 3.0. Leading Agile Developers, Developing Agile Leaders. Addison-Wesley

> Collins J.C. (2001) Good to Great: Why Some Companies Make the Leap... and Others Don't. HarperBusiness

> Collins J.C. Hansen M.T. (2011) Great by Choice. How to Manage Through Chaos. HarperBusiness

These books does not have pure scientific prove of ideas and methods as the most of authors also wrote at the beginning. Books contain a general ideas, paradigms and emphasize attention on the leadership and understanding reality rather than give detailed methodologies with qualitative and quantitative evaluations. Books based on the modern organizations and project experience and successful results.

Finally, there are three main areas by author opinion in projects with high uncertainty and time limitation:

> Proper leadership style and balancing of discipline and agility (team and management)

> Scheduling (time-limitation)

> Risk Management (high uncertainty)

6. PROPOSAL FOR IMPROVEMENT

Research questions in the Master Thesis are quite interesting and important for actual today projects. DNV Fuel Fighter project is one example of the time-limited project with high uncertainty. Manage this type of project now is more art than science but scientific and business publication and knowledge transferring step by step establishing more and more scientific approaches. General proposal is quite obvious but very important – to read and to understand basic ideas of the new way to manage projects. First, basic ideas are in books like presented earlier

- DeCarlo D. (2004) eXtreme Project Management. Using Leadership, Principles, and Tolls to Deliver Value in the Face of Volatility. Jossey-Bass. USA
- Apello J. (2011) Management 3.0. Leading Agile Developers, Developing Agile Leaders. Addison-Wesley
- Collins J.C. (2001) Good to Great: Why Some Companies Make the Leap... and Others Don't. HarperBusiness
- Collins J.C. Hansen M.T. (2011) Great by Choice. How to Manage Through Chaos. HarperBusiness

Second, is to read and understand basic literature from both traditional and agile project management approaches. List of literature you could find in Reference List.

DNV Fuel Fighter project is annual NTNU project. Every academic year new team is defined to compete other student teams from Europe. Suggestions for the management of this or similar projects are:

- Carefully analyze reports and experience from the previous generations. List of the main documents from DNV Fuel Fighter 2012-2013 you could find in Reference list. Private or online communication with previous team is also very useful.
- Proper leadership style and balancing of discipline and agility (team and management)
- Focus on Scheduling (time-limitation)
- Focus on Risk Management (high uncertainty)
- Simple, collaborative, informative tools are the best
- Balance between technical and non-technical project areas and team members

7. CONCLUSION

The Master Thesis is about balancing Traditional and Agile Project Management approaches for managing a small, time limited project with high level of uncertainty with focus on the Planning and Control process for Scheduling and Risk Management methods. Case study is NTNU student project DNV Fuel Fighter – creating of energy efficient car for annual Shell Eco Marathon competition. Theoretical chapter of Thesis describes basics of Traditional and Agile approaches, advantages and disadvantages of each and few methods for selection a right project management approach for the projects or projects elements: Wisocki, Boehm and Turner, Little, Diamond. Theoretical models for balancing the Traditional and Agile approaches (Wisocki, Boehm and Turner, Little, Diamond) match the practical management approach in case study project. Result of work gives one more step to understand and to improve implementation a time-limited projects with high uncertainty for successful achieving desired goals and both team and customers satisfactions.

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APPENDIX 1.SAFETY AND RISK ANALYSIS

Safety and Risk Analysis

Safety is an essential consideration for the team, NTNU and Shell as organizer of the Shell Eco Marathon. Regulations for the work environment in office and workshop in NTNU had a great effect in avoiding undesired hazards during the project implementation. Shell Regulations and Actions for the Race and whole event also are additional barrier for the safety. Team tried its best to avoid any risks during the project lifecycle.

Safety Manager and Engineer

In project we have the Safety Manager and the Safety Engineer. This is new titles in this year project. Because of the small team our Project Manager also has the title Safety Manager. Nikita Sinansky is student of 2-years Master program in Project Management in our University. He has both educational background and work experience related with safety and risk management. Nikita Sinansky is also the oldest person (30 years) in the team. He responsible for the whole cycle related with risk and safety issues in project: Analysis -> Plan -> Do -> Check -> Improve

Safety Engineer is Systems Engineer Siavash, Naghdalikhani. He is a student of 2-years Master Program in Production Management. He also has both educational background and work experience related with safety and risk management.

Complex approach for Risk and Safety will maximize protection against undesired consequences.

Safety Manager and Safety Engineer were on the Shell Eco Marathon event and with team during the travel to event to avoid any risks.

Project Safety Risk Analysis

For preliminary risk identification used the Bowtie model for the safety project:

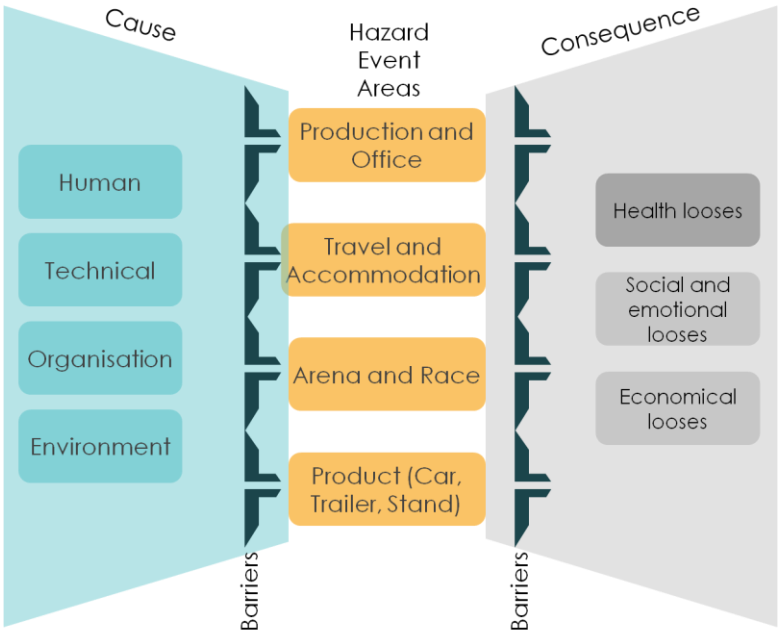


Figure 1. Bowtie model for the project safety

Risk Identification (What can go wrong?)

Hazards sources we could classify in four categories:

> Technical (car and support systems, resources for production, technology etc.),

> Human (personal errors, motivation, skills, experience, etc.),

> Organizational (teamwork, management, decisions, priority, etc.),

> Environmental (Organisers, Competitors, Public, Sponsors, Weather, etc.).

Hazard event areas are:

> Production and Office (NTNU, Trondheim)

> Travel to/from Rotterdam, Ahoy Arena

> Accommodation in Rotterdam and Oslo

> Arena and Race (whole Shell Eco Marathon event in Ahoy, Rotterdam)

> Product (car, trailer, stand)

Risk Evaluation (What is the probability and consequence?)

Probability of undesired event has a low level in Production and Office because NTNU has strictly regulations and control the process using internal actions. Arena and Race (whole Shell Eco Marathon event in Ahoy, Rotterdam) and Product (car, trailer, and stand) also have a low level of probability because of additional control from Shell by Regulations for event and Requirements for the Product. Travel to/from Rotterdam, Ahoy Arena and Accommodation in Rotterdam and Oslo have the most probability of the accidents. For travel category was the main detailed planning with the risk assessment.

Consequences classified as:

Grading		Human	Environment	Economy/material
E	Very critical	May produce fatality/ies	Very prolonged, non-reversible damage	Shutdown of work >1 year. More than project budget
D	Critical	Permanent injury, may produce serious health damage/sickness	Prolonged damage. Long recovery time.	Shutdown of work 0.5-1 year. From half to full project budget
C	Dangerous	Serious personal injury	Minor damage. Long recovery time	Shutdown of work < 1 month Less than 1/10 of the project budget
B	Relatively safe	Injury that requires medical treatment	Minor damage. Short recovery time	Shutdown of work < 1week Less than 1/50 of the project budget
A	Safe	Injury that requires first aid	Insignificant damage. Short recovery time	Shutdown of work < 1day Less than 1/350 of the project budget

Risk Prevention (How to avoid risk?)

1. University-based facilities

University (NTNU) has strict rules and regulations both for the work conditions in workshop and fieldwork (travel and competition in Rotterdam). Line managers in University in cooperation with DNV Fuel Fighter team managers ensured that all HSE provisions are made known and adhered by all employees, contacted personnel, visitors and students.

The office is located in the University Campus which has 8 desks and sofa area. As any other room in University safety regulations and actions are important. Access, electricity, ventilation, cleaning, fire protection are with a high standard. So University regulations, National regulations for the schools and other standards are the barriers to avoid the most of the risks.

To increase the comfort in working conditions we changed the position of desk, bought the modern powerful computers with two big screens in the beginning of the project. The sofa area also improved with a big screen on the wall for the team rest.

Workshop is special room where the car and tools are located. This is private room in University Camus on the ground floor which is accessible just for the team members with the key. Workshop is a University room and all Norwegian national and University regulation helped to protect people and property. Workshop mainly used for the assembling, testing and technical adjustments. The team has own wide set of tools.

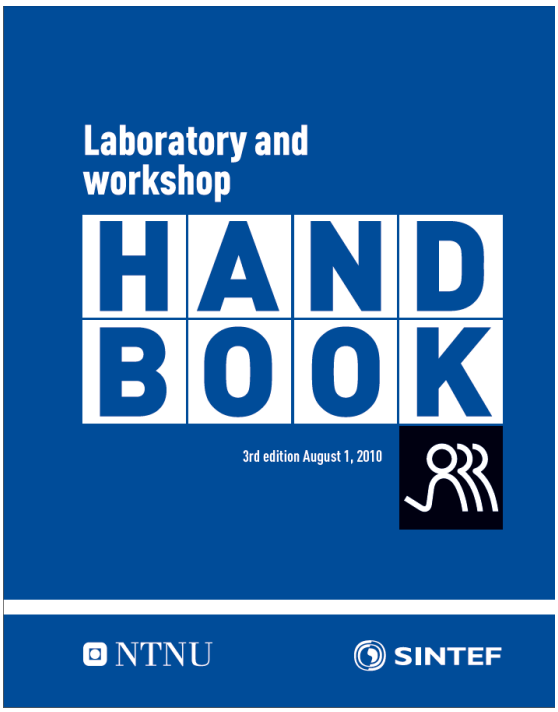


Figure 2. HSE handbook

Improvements from last year:

>Implementing the 5S in the workshop in this year.

These 5S principals are:

- Sorting
- Setting in Order
- Sweeping
- Standardizing
- Sustaining

Safety is really behind these principles and Secure in the limited access to workshop. The team tried to follow 5S principles in workshop are, but of course as any new principal it's not happened immediately, this was a continuous process.

> Shell Trondheim provided high-visible orange suits with reflection stripes to increase the team members' visibility and safety in workshop.

> Special labs and machining in University.

The most dangerous tasks in production at the University were chemical composite tasks and mechanical machining. The students who needed to work in these areas in labs had to pass special courses before they allowed using any equipment. Beside that student had to have proper clothes and other safety features. Labs have special certified facilities as ventilation, emergency signalization etc.

2. <u>Outsourcing productions</u>

Partners, Sponsors and Suppliers helped the project to produce high-quality details and to avoid additional risks for team members.

3. <u>Travel and accommodation</u>

Beside production, transportation is actually the most risky area for the team members. In this section all the risks that are related with the transportation of the car and team to public events in Norway, Shell Eco-marathon event and accommodation of the team in Rotterdam are considered.

Improvement in this year

> 2013 team used rental cars to carry the trailer instead of private cars. Rental cars have additional safety by definition because of the service intervals of the rental firms.

> The team will use the ferry from Oslo to Kiel to reduce risks by taking the route with the least driving.

> Three people will share the driving and an extra night will be spent in Norway to reduce the chance of human errors caused by lack of sleep. This is more expensive, but the team considered the increased safety level as a gain.

> Risk assessment for the "fieldwork" (travel and competition in Rotterdam) are created based on the University (NTNU) regulations by Safety Manager.

Insurance

The main sponsor DNV bought a special insurance for the car in case of damage outside the workshop. This will reduce economical risk for the possible incidents.

Shell as the organizer has insurance for large scale event.

The team members also informed about deposits that organizer could charge in case of damage to property of the organiser.

Flights, train rides and public transport.

The parts of the team that are not driving will arrive by plane and train. Internally in Rotterdam the whole team uses public transport to and from Ahoy Arena. Regulations of related companies are the main barriers to avoid risks.

Improvement in this year

>Well organised plan of travel and travel brochures with relevant information.

> All tickets and hotels booked few months before the event to reduce organizational risks in journey.

> In Rotterdam the team use transport card that gives flexibility in public transport.

Accommodation

The team chooses to use hotel for accommodation instead of camping to be sure about team member's comfort and reduce risks for health. Hotel regulations are additional barrier for risks.

Improvements in this year

The first driver will be in one separate room with the team manager because these people are the most important persons in the race and human errors could have bad consequences.

Figure 3. Safety Poster

4. Ahoy arena and race

The team members' behavior in Ahoy arena is the main source for risks. Shell as organizer has strict regulation for the event. Main task for Safety Manager is to carefully read all the regulations and inform all team members about small details. Preparing the infographics and other materials and test the knowledge of participants are main task for the Safety Manager. For the first time the team established new efficient approach for safety trough visual regulations informing for the people.

The manager used group and personal meetings, Facebook page, paper based in-fographics and brochures to make the people aware of safety rules. For example, in the private Facebook group, not only actual team members but also professors and last year's team members are ready to discuss the issues. This is a powerful source to share information with feedback and suggestions.

Additionally each team member has brochure with travel, safety and organizational information in Ahoy and all original regulations from Shell.

5. DNV Consultation

Main project sponsor provide not only financial support but also useful consultations for engineers as a help to produce right system in the right systematic approach. System Engineer apply the Technology Qualification Process approach according the DNV-RP-A203 recommended practice "Qualification of new technology" for the Solar Panel as the most innovative, important for result and expensive subsystem in the car.

PROJECT RESULT RISK ANALYSIS

For preliminary risk identification used the Bowtie model for the project result and for the safety project:

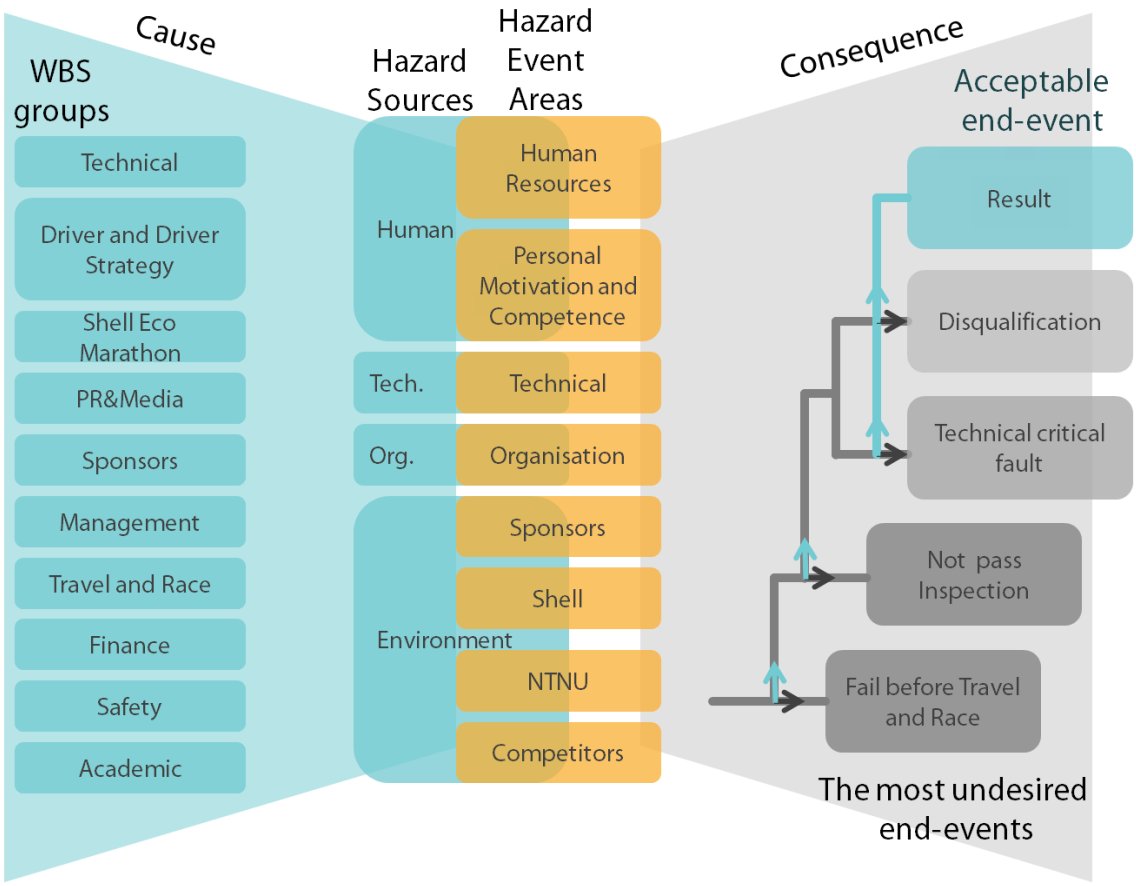


Figure 4. Bowtie model for the project result

There are also few phases for project: Analysis, Design, Production, Testing and Competition. There are few possible results of the project in order from most desired to less:

- Success project. 1-2 place on the competition and winning additionally Design and/or PR & Media off-track awards.
- Good project. 3-5 place. Team achieves better result than previous one.
- Bad project. More than 5th place. Team achieves worse result than previous one.
- Failure project. No any formal result. It could be happened as during the competition (disqualification or failure to finish) as during the inspection. The worst case doesn't even arrive to Rotterdam for different reasons.

Risk acceptance level is on the failure project result level and negligible level is between good and success results.

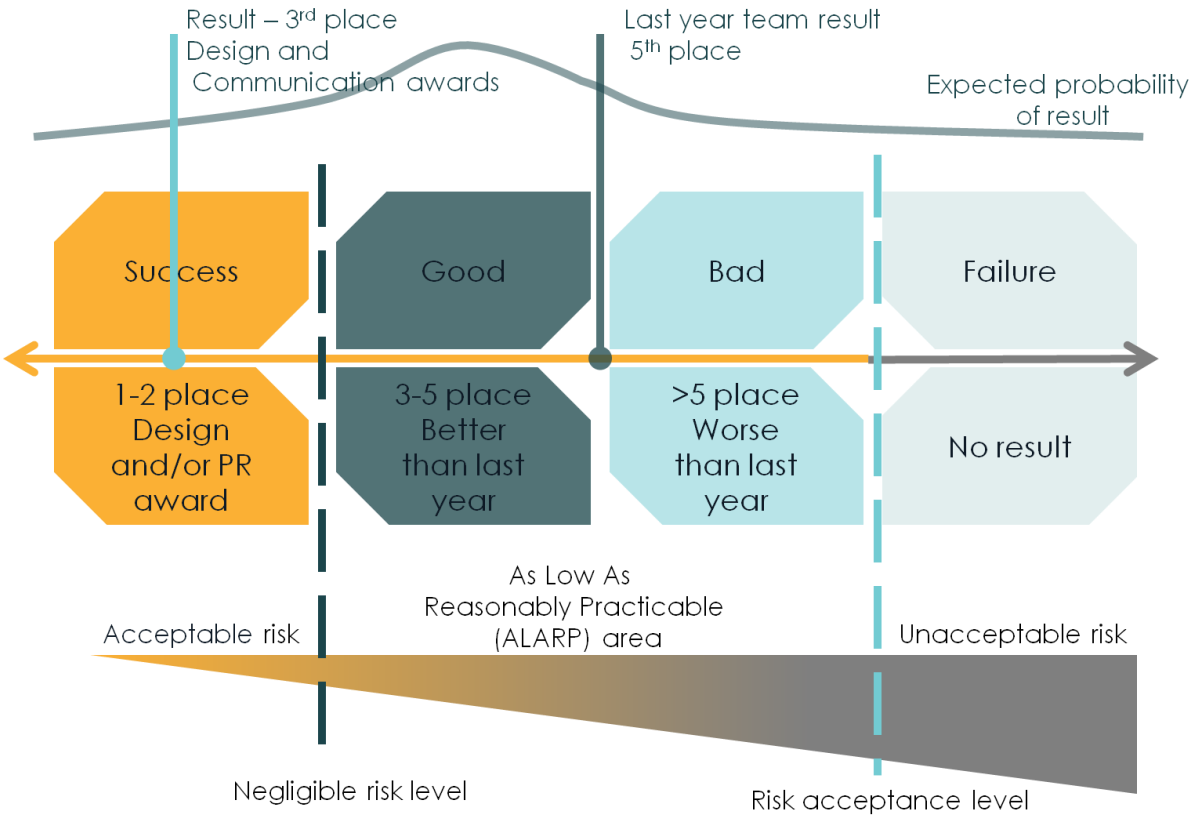


Figure 5. Risk acceptance criteria

Risk Identification (What can go wrong?)

In risk analysis we will focus only on the unacceptable risk area that could gives failure of the project. As presented on the Bowtie model classification of unacceptable end-events from first possible in time to last is:

> Failure before Rotterdam Race

> Failure to pass Inspection before Race

> Technical critical fault

> Disqualification or Organisational fault due to violation of the Rules

These four end-events have a dependency which shows on the simple Event-Tree on the Bowtie model figure. First, team has to arrive to Rotterdam with good enough car. If it possible as next step, team with car has to pass technical and safety inspection. If Inspection was successive passed during the Race could be technical fault or human behavior fault against rules. First, we make Preliminary Cause-Effect Analysis for 4 undesired end-events and define in each step it could happen.

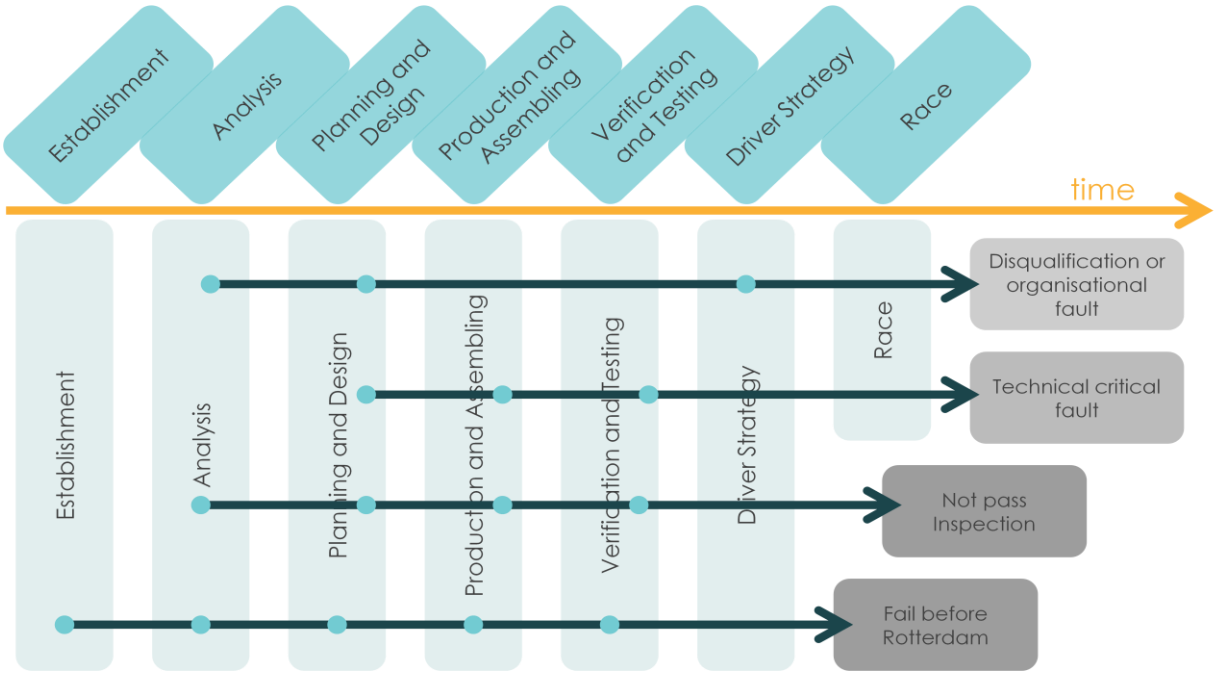


Figure 6. Cause-Effect Analysis

Risk Evaluation (What is the probability and consequence?)

Analysis of the whole life-cycle of product development from establishment phase to race phase is difficult process. Below present an example of analysis.

In each possible cause-effect step used two-level dimensions to identify the most critical factors: 4 Hazard sources and 7 WBS groups of process. Matrix of these two dimensions used to identify most probable hazards. After that Cause-Effect Diagram (Fish Bone Tree) used to identify cause of each hazard that was defined on the previous level.

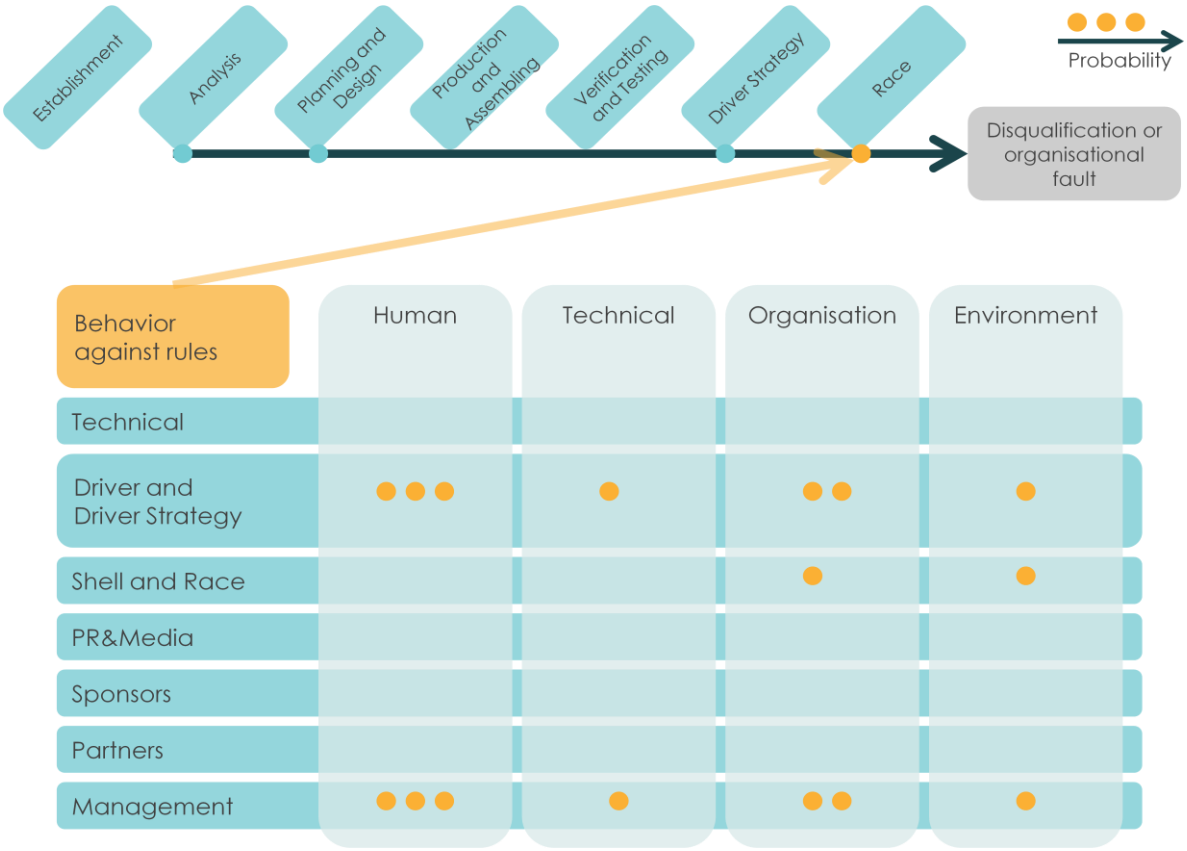


Figure 7. Framework for evaluation of Hazards

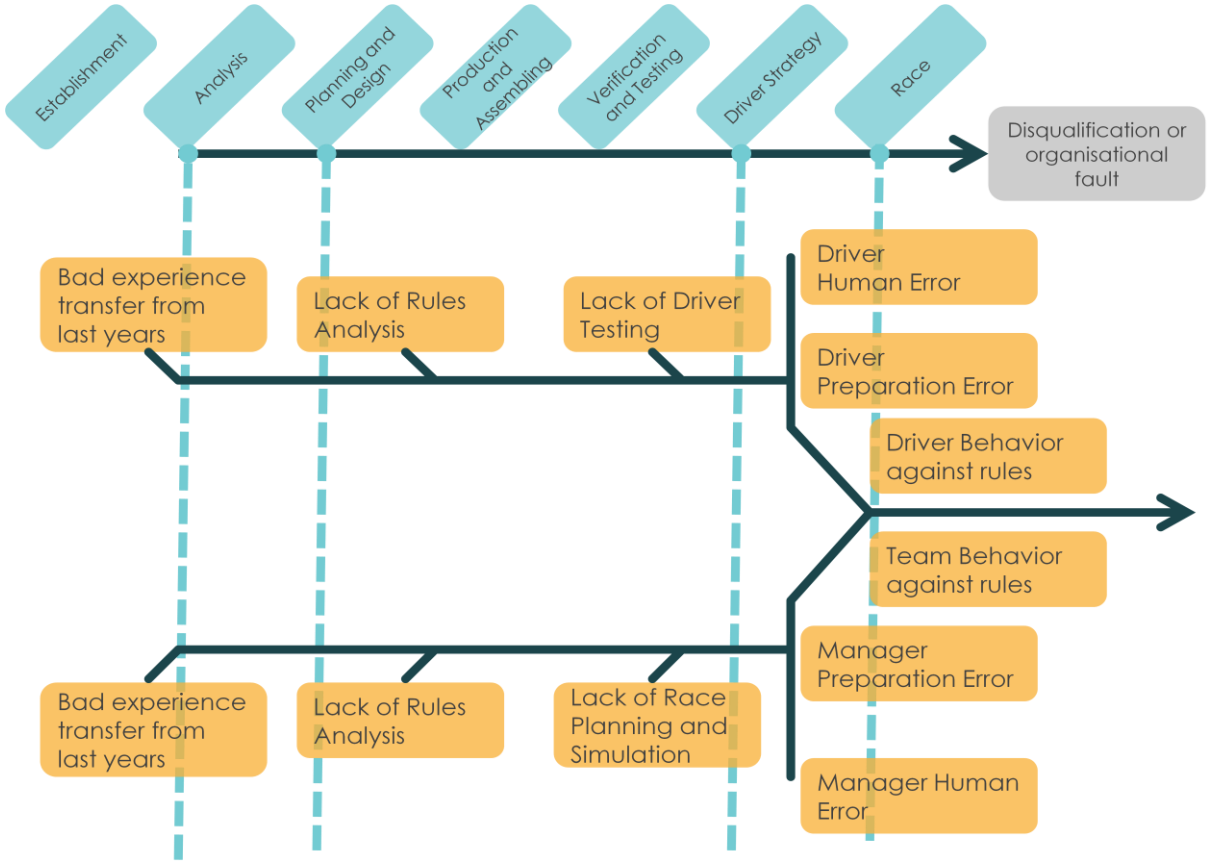


Figure 8. Cause-Effect Diagram for top event

Preliminary Hazard Analysis (PHA) table method used to classify and evaluate risk and also collect possible action to avoid risks. After that as result was interpretation of findings to the simple Risk Matrix. In this report published only main results of PHA analysis.

Table PHA for each top event

#	event	cause	how to reduce	probability	conseq.	risk

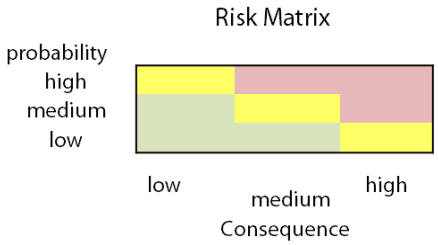


Figure 9. PHA method

Risk Prevention (How to avoid risk?)

In the project the most critical risks are in these areas:

> Human resources. Project need necessary number of people that have necessary competence and experience and that could spend necessary number of working hours to implement most critical tasks. Team spend time and if critical the budget to get necessary people. Because of lack in Industrial Designer and Programmer two people was hired.

> Personal motivation. Project is non-commercial and on the nature is more practical than academic. Students-team members don't get direct financial benefits or academic grades from this project. That is why personal motivation is main driver for team members and project as well.

> Organisational. Teamwork, Management, Decision-Making, etc. Team members are not high level professionals and have lack of time resources but with great ambitions. To define the most important tasks and control progress as on personal as on inter-elements levels are main goal for managers.

> Shell (organizer) formalities. Registration, Rules, Technical and Safety Inspections, Right behavior in Rotterdam.

> Sponsors. Only one economical resource for non-profit project.

> NTNU. Academic support and Operating Resources.

> Technical. System is innovative and need a lot of testing to get reliable solution.

Actions to avoid risk are preventive and reactive. Preventive actions, in general, are proper planning, testing, redundancy, support for personal motivation, facilitating teamwork and regular communications.

NTNU	Hazardous activity identification process	Prepared by	Number	Date	
		HSE section	HMSRV2601	22.03.2011	
		Approved by	Page	Replaces	
HSE		The Rector		01.12.2006	

Unit: *(Institute)* **Department of Engineering Design and Materials** **Date:** 30.04.2013

Line manager: *(responsible supervisor)* **Knut Aasland**

Participants in the identification process (incl. function):
(supervisor, student, co-supervisor, others) DNV Fuel Fighter team 13 people

Short description of the main activity/main process: DNV Fuel Fighter - NTNU student project for Shell Eco Marathon Europe 2013 energy efficient car race. Travel to Rotterdam, Netherlands

Signatures:

ID nr.	Activity/process	Respons-ible person	Existing documentation	Existing safety measures	Laws, regulations etc.	Comment
1	Travel to Rotterdam and back	Nikita Sinansky	Travel plan			
1.1	Rented car + trailer travel. 3 people	Andreas Severnisen				
1.1.1	Driving in Norway (Trondheim-Oslo)	Andreas Severnisen	Sixt reservation	Rented car and trailer	Driving regulations, Norway	all 3 people have driving licenses
1.1.2	Ferry Oslo - Kiel, Germany	Andreas Severnisen	Ferry reservation	Ferry		night ferry with sleeping room for people
1.1.3	Driving abroad (Germany, Netherlands)	Andreas Severnisen	Sixt reservation	Rented car and trailer	Driving regulations, International and national	all 3 people have driving licenses
1.2	Flight and train. 10 people	Nikita Sinansky, Jan Magnus Granheim Farstad	Travel plan			
1.2.1	Flights (Trondheim-Amsterdam)	Nikita Sinansky, Jan Magnus Granheim Farstad	SAS reservation	SAS	SAS regulations	
1.2.2	Trains (Amsterdam-Rotterdam)	Nikita Sinansky, Jan Magnus Granheim Farstad	Local trains timetable	local trains	train regulations	
1.2.3	Bus, Metro (Trondheim, Rotterdam)	Nikita Sinansky, Jan Magnus Granheim	Public transport timetable	Public transport	Public transport regulations	
2	Stay in Rotterdam and Oslo	Nikita Sinansky				
2.1	Accommodation in Rotterdam	Nikita Sinansky	Hotel reservation	Hotel	Hotel regulations	
2.2	Public transport in Rotterdam	Nikita Sinansky	Public transport timetable	Public transport	Public transport regulations	Metro
2.3	Accommodation in Oslo	Nikita Sinansky	Hotel reservation	Hotel	Hotel regulations	
2.4	Public transport in Oslo	Nikita Sinansky	Public transport timetable	Public transport	Public transport regulations	NSB trains
3	Arena and Race	Nikita Sinansky				
3.1	Arena Ahoy Rotterdam. Paddock	Nikita Sinansky	Shell Eco Marathon Regulations	Shell Eco Marathon, Paddock	Shell Eco Marathon Regulations	Team in paddock and public places
3.2	Practice and Race. Driving the car on the track with competitors	John Ola Buoy, Andreas Severnisen	Shell Eco Marathon Regulations	Shell Eco Marathon, Track	Shell Eco Marathon Regulations	Drivers

NTNU	Risk assessment	Prepared by	Nummer	Date
		HSE section	HMSRV2603	04.02.2011
		Approved by	Page	Replaces
HMS /KS		The Rector		09.02.2010

Unit: *(Institute)* **Department of Engineering Design and Materials** **Date:** 30.04.2013

Line manager: *(responsible supervisor)* **Knut Aasland**

Participants in the identification process (incl. function):

(supervisor, student, co-supervisor, others) DNV Fuel Fighter team 13 people

Risk assessment of: DNV Fuel Fighter - NTNU student project for Shell Eco Marathon Europe 2013 energy efficient car race. Travel to Rotterdam, Netherlands

Signaturer:

ID nr.	Activity from the identification process form	Potential undesirable incident/strain	Likeli-hood:	Consequence:				Risk value (human)	Comments/status Suggested measures
			(1-5)	Human (A-E)	Enviroment (A-E)	Economy/ material (A-E)			
1	Travel to Rotterdam and back								
1.1	Rented car + trailer travel. 3								
1.1.1	Driving in Norway (Trondheim-Oslo)	Road accident	1	D	B	D		**D1**	
1.1.2	Ferry Oslo - Kiel, Germany	Ferry accident	1	D	C	D		**D1**	
1.1.3	Driving abroad (Germany, Netherlands)	Road accident	2	D	B	D		**D2**	
1.2	Flight and train. 10 people								
1.2.1	Flights (Trondheim-Amsterdam)	Flight accident	1	E	C	B		**E1**	
1.2.2	Trains (Amsterdam-Rotterdam)	Train accident	1	D	C	B		**D1**	
1.2.3	Bus, Metro (Trondheim,	Public transport accident	2	C	B	B		**C2**	
2	Stay in Rotterdam and Oslo								
2.1	Accommodation in Rotterdam	Hotel incidents	2	B	A	B		**B2**	
2.2	Public transport in Rotterdam	Public transport accident	2	B	B	B		**B2**	
2.3	Accommodation in Oslo	Hotel incidents	2	B	A	B		**B2**	
2.4	Public transport in Oslo	Public transport accident	2	B	B	B		**B2**	
3	Arena and Race								
3.1	Arena Ahoy Rotterdam. Paddock	Arena incidents	2	A	A	C		**A2**	
3.2	Practice and Race. Driving the car on the track with competitors	Race accident	2	C	B	D		**C2**	

Risk value = Likelihood (1, 2 ...) x consequence (A, B ...). Risk value A1 means very low risk. Risk value E5 means very large and serious risk

Likelihood		Consequence					
Value	Criteria	Grading		Human	Environment	Economy/material	
1	**Minimal**: Once every 50 year or less	**E**	**Very critical**	May produce fatality/ies	Very prolonged, non-reversible damage	Shutdown of work >1 year.	
2	**Low**: Once every 10 years or less	**D**	**Critical**	Permanent injury, may produce serious health	Prolonged damage. Long recovery time.	Shutdown of work 0.5-1 year.	
3	**Medium**: Once a year or less	**C**	**Dangerous**	Serious personal injury	Minor damage. Long recovery time	Shutdown of work < 1 month	
4	**High**: Once a month or less	**B**	**Relatively safe**	Injury that requires medical treatment	Minor damage. Short recovery time	Shutdown of work < 1week	
5	**Very high**: Once a week	**A**	**Safe**	Injury that requires first aid	Insignificant damage. Short recovery time	Shutdown of work < 1day	

MATRIX FOR RISK ASSESSMENT - Human

CONSEQUENCE						
	Very critical	1.2.1				
	Critical	1.1.1, 1.1.2, 1.2.2	1.1.3			
	Dangerous		1.2.3, 3.2			
	Relatively safe		2.1, 2.2, 2.3, 2.4			
	Safe		3.1			
		Minimal	Low	Medium	High	Very high
		LIKELIHOOD				

MATRIX FOR RISK ASSESSMENT - Environment

CONSEQUENCE						
	Very critical					
	Critical					
	Dangerous	1.1.2, 1.2.1, 1.2.2				
	Relatively safe	1.1.1	1.1.3, 1.2.3, 2.2., 2.4, 3.2			
	Safe		2.1, 2.3, 3.1			
		Minimal	Low	Medium	High	Very high
		LIKELIHOOD				

MATRIX FOR RISK ASSESSMENT - Economy / material

CONSEQUENCE						
	Very critical					
	Critical	1.1.1, 1.1.2	1.1.3, 3.2			
	Dangerous		3.1			
	Relatively safe	1.2.1, 1.2.2	1.2.3, 2.1, 2.2, 2.3, 2.4			
	Safe					
		Minimal	Low	Medium	High	Very high
		LIKELIHOOD				

Explanation of the colors used in the risk matrix.

Color	Description
Red	Unacceptable risk. Safety measures must be implemented.
Yellow	Measures to reduce risk shall be considered.
Green	Acceptabel risk.

APPENDIX 2. FINANCE

FINANCIAL REPORT

DNV Fuel Fighter is non-commercial project. It means that members don't have aim to earn money and project don't have financial profit. All economical resources come from sponsors and NTNU Principal aid. Team find sponsorship by itself. There are two types of sponsors – financial and non-financial (materials, goods, professional resources, services, consulting, expertise etc.). Main sponsor of the Project is DNV. Budget was established at the end of Design Phase in December 2012.

Total Project direct Financial Income is 760 000 NOK. Project spends not all budget and leave 15% for the next year project.

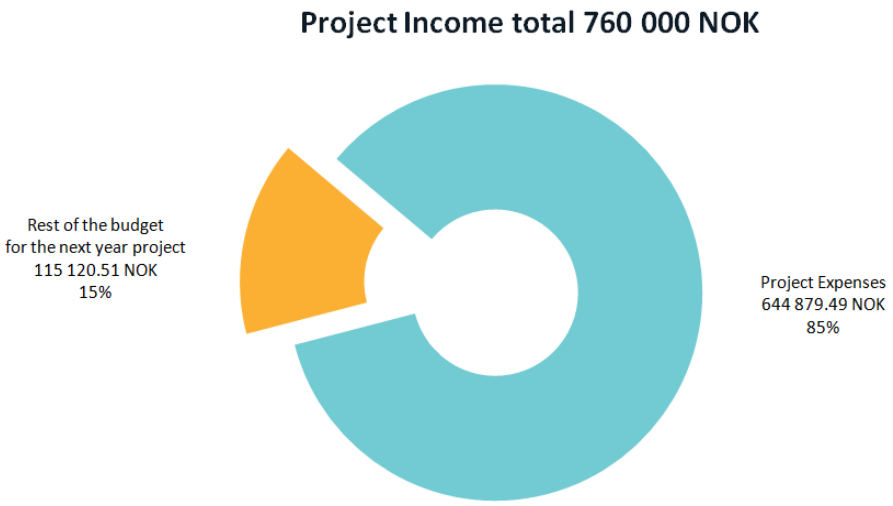


Figure 1. Project Finance

Cumulative project expenses (S-curve) for the monthly basis has almost perfect theoretical shape. Reasons for the rough shape around Christmas are Exams time, Holyday and late financial aid from sponsors.

Income for the Project is 760 000 NOK could be divided into 4 categories:

> Last year project – 120 000 NOK
> Financial sponsorship
DNV – 450 000 NOK
Transnova – 100 000 NOK
NTNU Principal – 60 000 NOK
> Shell travel money return – 7 500 NOK
> Prizes from the Race for the Design and Communication Awards – 22 500 NOK

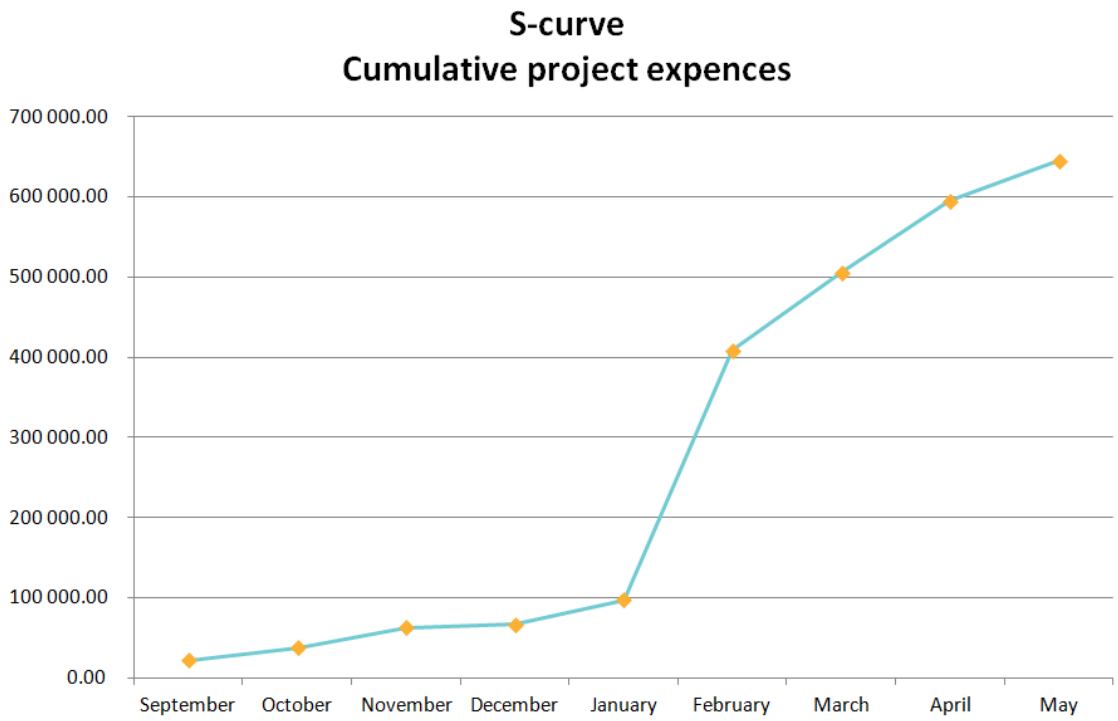


Figure 2. S-curve for project expenses

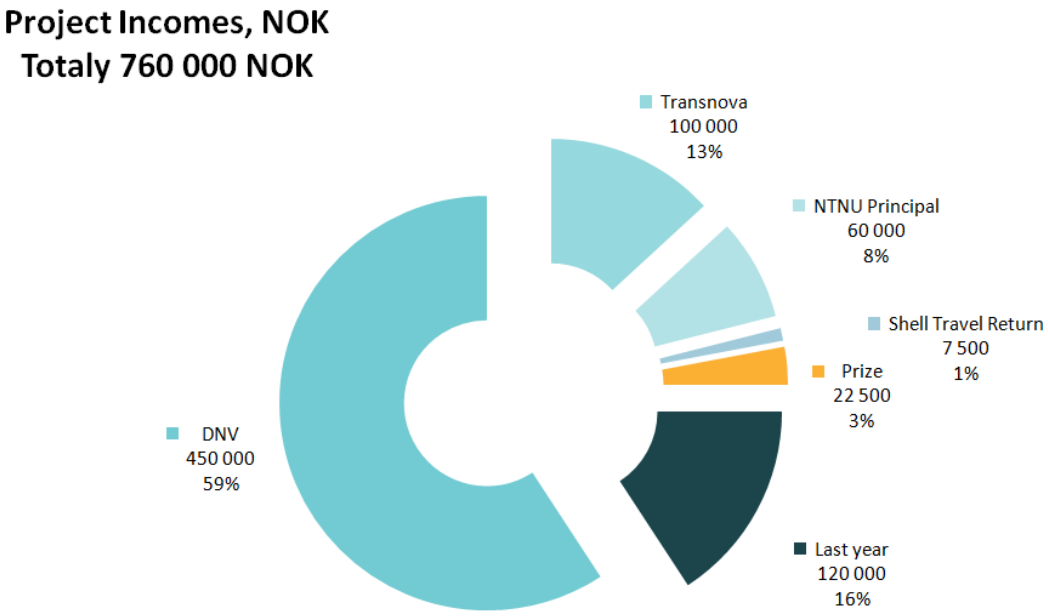


Figure 3. Main categories for project incomes

Project expenses is almost 645 000 NOK and has three main categories: Project Management (23%), PR & Media (6%) and Technical (71 %). The most expensive was high-efficient innovative Solar Panel (42% of total expenses). During the Project was hired two people – last year team member, Industrial Designer as consultant and Programmer to help finish the software part of the control unit.

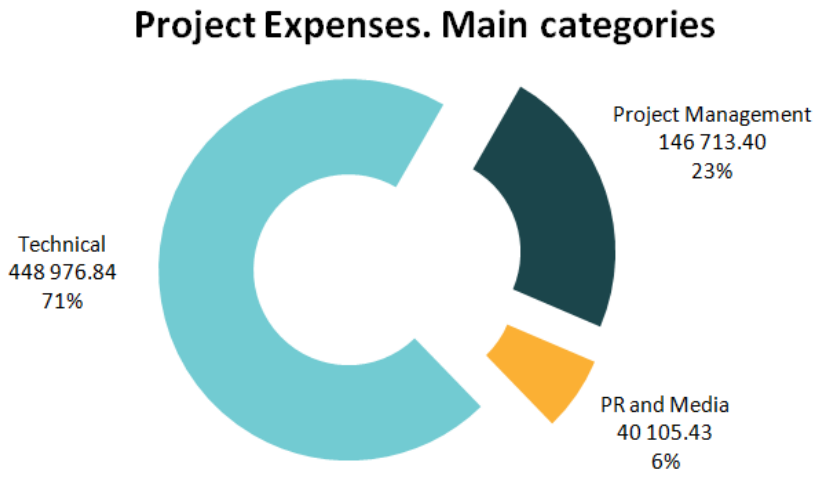


Figure 4. Main categories for project expenses

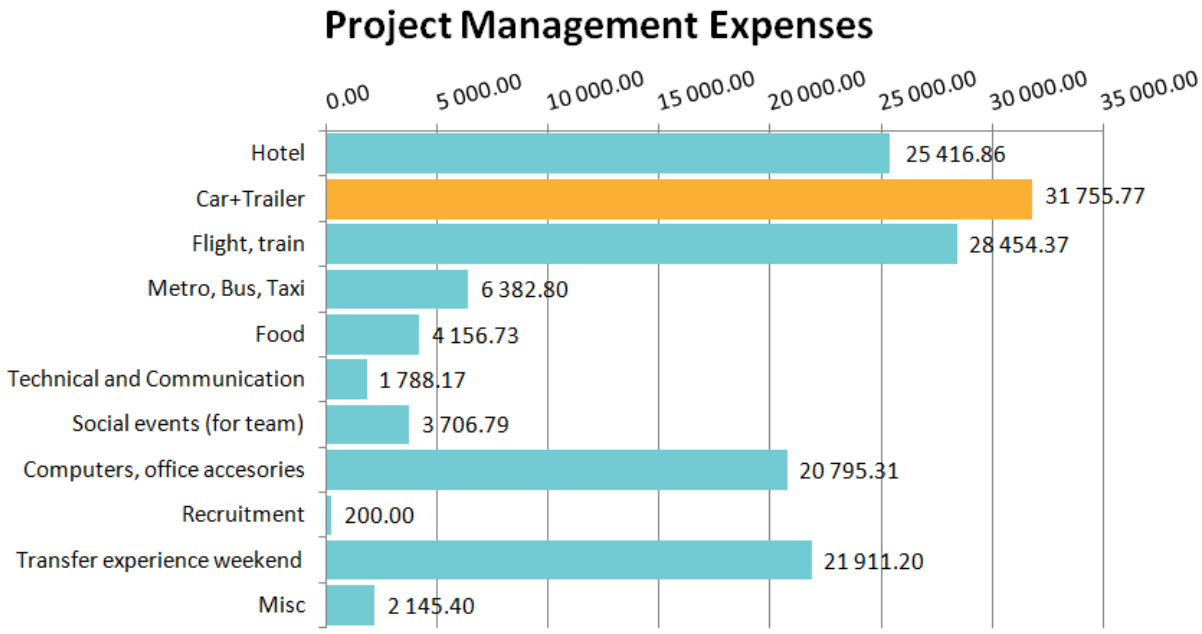


Figure 5. Project Management expenses

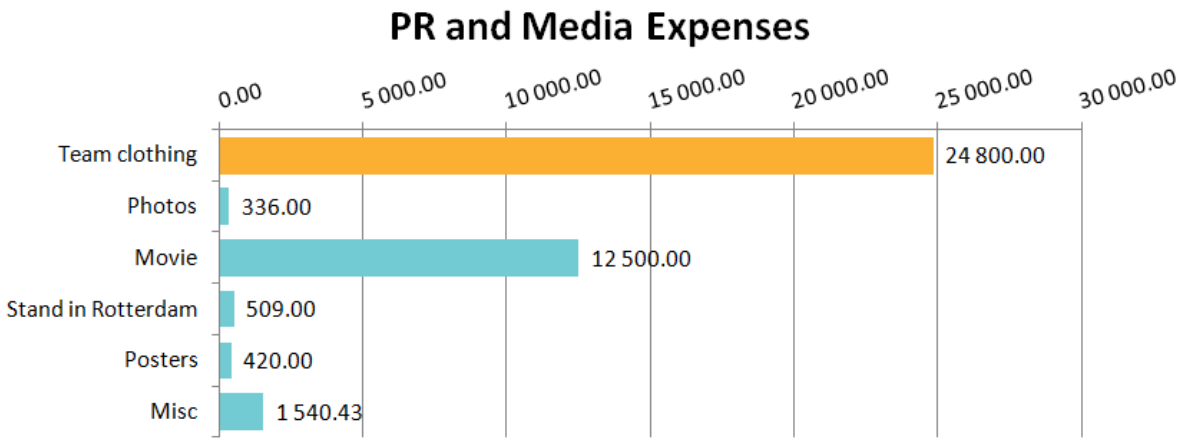


Figure 6. Project Management and PR&Media expenses

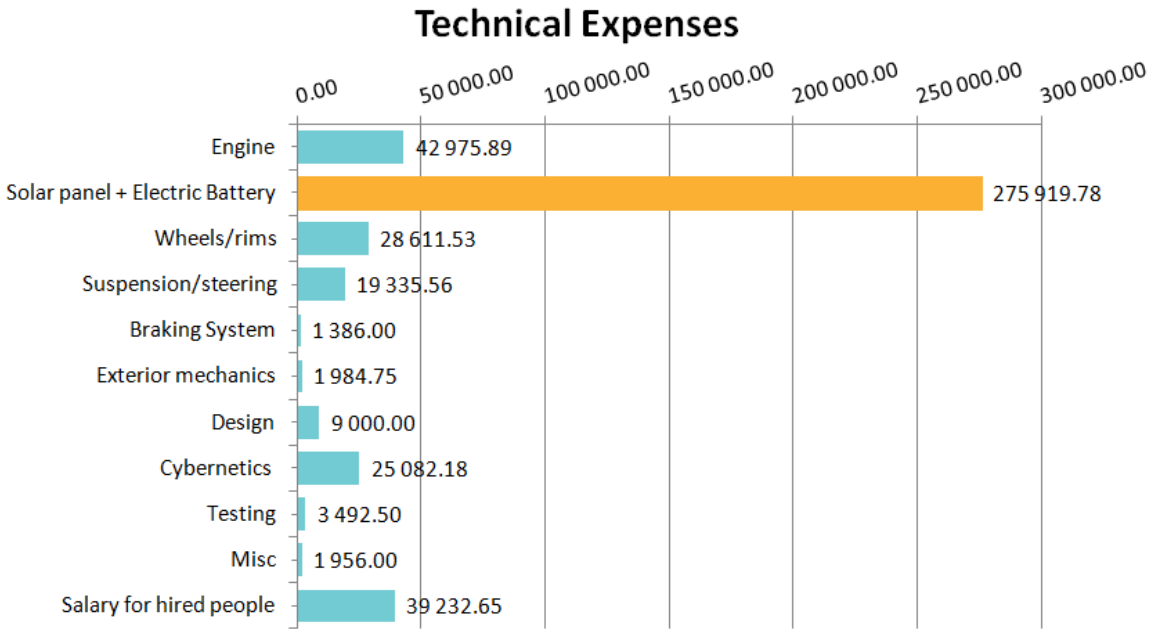


Figure 7. Technical expenses

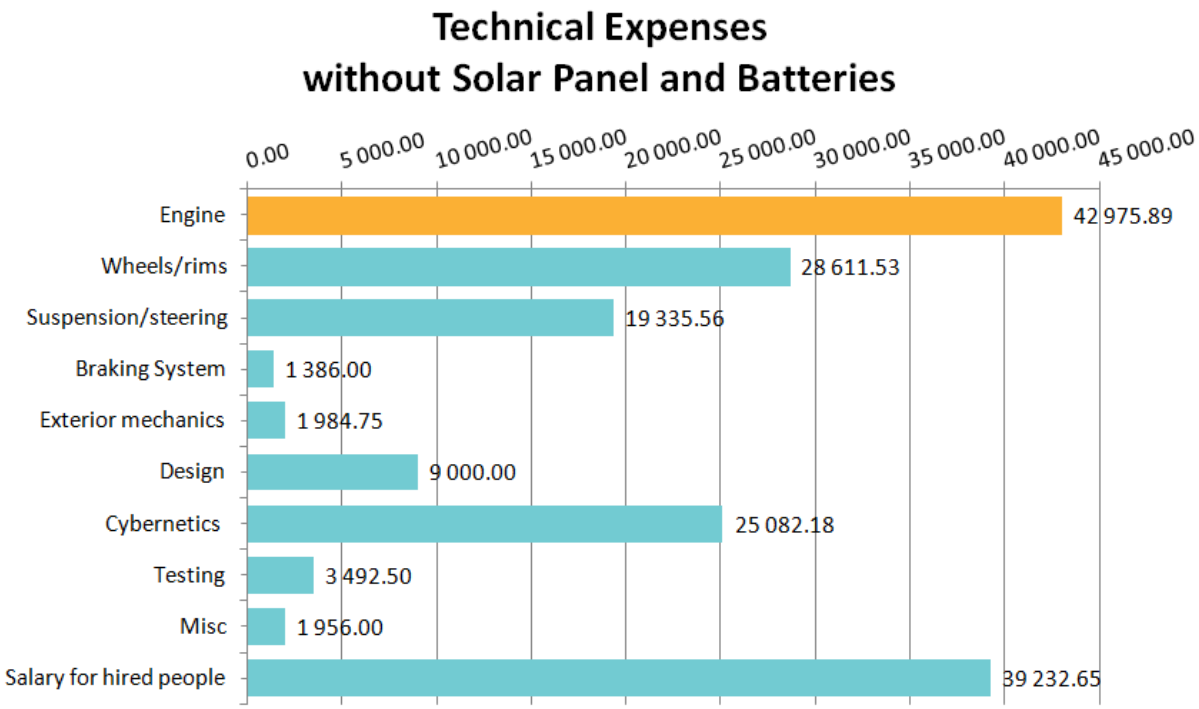


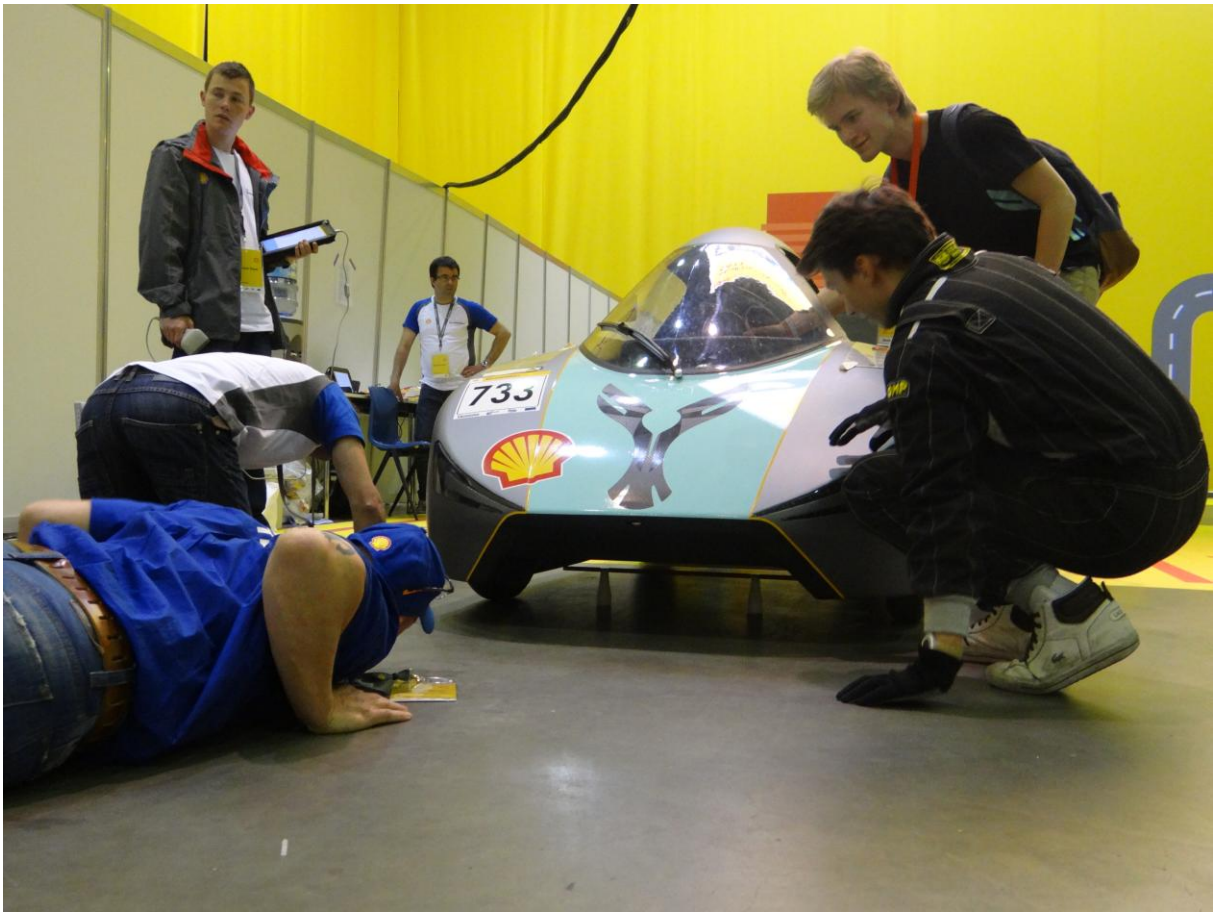
Figure 8. Technical expenses without solar and batteries

Full financial report by categories of expenses and with detailed info for every month of the project is in Table 1.

Category	Total	2012 September	October	November	December
DNV Fuel Fighter 2 (2011-12) debt	**9 083.83**		**8 596.33**	**487.50**	
DNV Fuel Fighter Project. NTNU team 2013 for Shell Eco Marathon					
Project Management					
Travel to Rotterdam					
Hotel	25 416.86				
Car+Trailer	31 755.77				
Flight, train	28 454.37				
Metro, Bus, Taxi	6 382.80				
Food	4 156.73				
Technical and Communication	1 788.17				
Social events (for team)	3 706.79		1 548.00		182.94
Computers, office accesories	20 795.31		550.00	20 245.31	
Recruitment	200.00	200.00			
Transfer experience weekend	21 911.20	21 911.20			
Misc	2 145.40			2 145.40	
Total PM	146 713.40	22 111.20	2 098.00	22 390.71	182.94
PR & Media					
Team clothing	24 800.00				
Photos	336.00		336.00		
Movie	12 500.00				
Stand in Rotterdam	509.00				
Posters	420.00				
Misc	1 540.43				651.00
total PR	40 105.43	0.00	336.00	0.00	651.00
Technical					
Car					
1. Propultion					
Engine					
Magnets	16 013.34				
Epoxy	5 657.50				
Kobber	2 900.00				
Workshop + professionals man-hours	16 056.75				
Motor controller	2 348.30				
Energy Source					
Electric Battery	1 778.00				
Solar cell system	274 141.78				
2. Wheels/rims	28 611.53				
3. Suspension/steering	19 335.56				756.60
4. Braking System	1 386.00				
5. Exterior mechanics	1 984.75				
6. Design (Exterior and Interior)	9 000.00				
7. Cybernetics	25 082.18				
Testing	3 492.50				
Misc	1 956.00				
Salary for hired people	39 232.65		4 579.39	2 325.38	2 327.88
total technical	448 976.84	0.00	4 579.39	2 325.38	3 084.48
Total project	**635 795.66**	**22 111.20**	**7 013.39**	**24 716.09**	**3 918.42**
Cumulative		**22 111.20**	**29 124.59**	**53 840.68**	**57 759.10**
Sponsorship and Incomes					
From last year budget + debt bills	-120 000.00	-70 000.00			
Travel return from Shell	-7 500.00				
Prizes	-22 500.00				
Sponsorship					
Transnova	-100 000.00				
DNV (main sponsor)	-450 000.00				
NTNU Principal aid	-60 000.00				
Total sponsorship	**-760 000.00**	**-70 000.00**	**0.00**	**0.00**	**0.00**
Total balance	**-115 120.51**	**-47 888.80**	**15 609.72**	**25 203.59**	**3 918.42**
Total cumulative		**-47 888.80**	**-32 279.08**	**-7 075.49**	**-3 157.07**

2013					
January	February	March	April	May	June
		19 732.25	3 428.06	2 256.55	
	18 885.60			12 870.17	
		21 883.00		6 571.37	
				6 382.80	
				4 156.73	
				1 788.17	
139.80	900.00		726.05	210.00	
139.80	19 785.60	41 615.25	4 154.11	34 235.79	
		24 800.00			
			12 500.00		
			509.00		
	420.00				
			678.43	211.00	
0.00	420.00	24 800.00	13 687.43	211.00	
	363.75	15 649.59			
	5 657.50				
	2 900.00				
3 394.25		2 525.00	1 557.50	8 580.00	
	2 348.30				
			1 778.00		
	273 220.90	264.88	656.00		
26 238.00	575.00		220.00	1 578.53	
843.75	2 053.25	12 456.25	3 225.71		
			1 386.00		
			1 984.75		
			9 000.00		
	305.00		20 100.00	4 677.18	
	3 492.50				
65.00		68.00	810.00	1 013.00	
			30 000.00		
30 541.00	290 916.20	30 963.72	70 717.96	15 848.71	
30 680.80	**311 121.80**	**97 378.97**	**88 559.50**	**50 295.50**	
88 439.90	**399 561.70**	**496 940.67**	**585 500.17**	**635 795.66**	
-50 000.00					
					-7 500.00
					-22 500.00
	-80 000.00				-20 000.00
-450 000.00					
	-60 000.00				
-500 000.00	**-140 000.00**	**0.00**	**0.00**	**0.00**	**-50 000.00**
-469 319.20	**171 121.80**	**97 378.97**	**88 559.50**	**50 295.50**	**-50 000.00**
-472 476.27	**-301 354.47**	**-203 975.51**	**-115 416.00**	**-65 120.51**	**-115 120.51**

APPENDIX 3. 5S IMPLEMENTATION



NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY (NTNU)

PROJECT REPORT

Topic **5S for the DNV Fuel Fighter project**

TRONDHEIM, NORWAY
AUTUMN 2013

Content

Summary

This is the project report about 5S methodology for improving the working place and safety and maintenance effects. First part of the report describes theoretical considerations about method including history, basic method description and suggestions for implementation from the best cases. Second part of the project gives overview of applying the 5S methodology in the student NTNU car project. There is also description of the challenges and lessons from the practical case.

Introduction

Project purpose.

Aim of the project is define theoretical essentials about 5S methodology and to show how it works in real project and research positive effect in terms of maintenance (continuous operational performance in required functionality for a technical system).

5S theory

5S is a workplace organization method with aims to minimize waste, save time and increase productivity and safety. Implementing of simple rules by whole team in practice is usually first step for the more wide Lean concept. Methodology was born in Japanese car manufacture company and was distributed all over the world for production.

Description of the project

Shell Eco Marathon is an annual competition for student teams from universities around the world. America, Asia and Europe are three geographical areas for competition. Each team has to design, produce and race their energy efficient cars. First place win car that consume minimum of energy on the same distance.

Shell as organizer have aim to develop future of mobility and inspire young professionals. Also this type of project is unique chance for student to implement real product from idea to real car.

Norwegian University of Science and Technology, Trondheim, Norway has taken part in Shell Eco-marathon competition in urban category with a hydrogen fuel cell car in 2008-2011.

New 2012 car has a very big potential for improvement. NTNU's 2013 team decided to continue use of previous year car design with the most of mechanical solutions and focus mainly on the improvement of engine and control systems, solar cells and driving strategy.

Name of the team and Project in 2013 is DNV Fuel Fighter. Main Sponsor as last years is DNV AS. DNV Fuel Fighter is only one Norwegian team in Shell Eco Marathon Europe Race.

DNV Fuel Fighter is unique project for students. This is mix of learning, new product development, entrepreneurs, working teams and game approaches. World-wide competition, representing of University and Country, multinational interdisciplinary team, complex system and innovative eco nature are challenges that make project extremely ambitions. Team has to implement full product life cycle from idea scratches to sustainable and competitive complex system. Project is excellent opportunity for students to get practical overview of real national and local industry within professional field, develop contacts with organizations and increase attractiveness for future employers.

5S methodology was established in project for the NTNU workshop and for the paddock area in Rotterdam. How 5S approach was implemented in NTNU project; what was successful, what not; which challenges, advantages and disadvantages were met for the team…all this information we are going to find from personal experience and from the 2 project reports as well as other documentation from the team.

Theory

History

5S methodology was invited and established in Japanese car production system in the 80-th. Toyota implements the Toyota Production System (TPS) as development of western mass production system and result was highly efficient from quality and financial points of view products on the whole life cycle. Method was described in few publications as attempt to investigate the productivity and quality of car manufacture and assembly methods used by Japanese car companies.

Books by Womack&Jones [1,2,3] and Taiichi Ohno [5,6] in 90's explained systematically concepts that helps Toyota to achieve increases in operational efficiency, quality, and profits. After that methodology was shared all around the world and many industries changed productions.

5S as a visual housekeeping technique is just one element of TPS and related to human workplace organization. General ideas of 5S were not new but the simple and structured method with focus on the human impact gives such great effect when all people have the same view on the working process on the shared production facilities instead of contradiction of assumptions.

5S principle has long story of development and implementing in different countries within different industries. Sometimes additionally to original 5S managers includes Safety and Security. Safety is part of HSE concept and wide labor and production regulations on the global and local levels. Security has origins from both competitive advantage and avoiding access to production areas for unwanted people.

5S method

The 5S basic principals or pillars are:

- Sort (Seiri)
- Set in Order (Seiton)
- Shine (Seiso)
- Standardize (Seiketsu)
- Sustain (Shitsuke)

All together they provide a methodology for organizing, cleaning, developing and sustaining a productive work environment. This lean method encourages workers to improve their working conditions and helps them to learn to reduce waste, unplanned downtime, and in-process inventory. 5S is a cyclical methodology and include sort, set in order, shine, standardize, sustain into the cycle. This results in continuous improvement.

A typical 5S implementation would result in significant reductions in the square footage of space needed for existing operations. It also would result in the organization of tools and materials into labeled and color coded storage locations, as well as kits that contain just what is needed to perform a task.

Target Outcomes and Benefits of using 5S methodology[10]

- Reduce non-value adding activity
- Reduce mistakes from employees and suppliers
- Reduce time for employee orientation and training
- Reduce search time in navigating the facility and locating tools, parts and supplies
- Reduce parts stored in inventory, and associated inventory carrying costs

- Reduce unnecessary human motion and transportation of goods
- Improve floor space utilization
- Improve employee safety and morale
- Improve product quality
- Extend equipment life through more frequent cleaning and inspection

Table 1. 5S pillars in details (adapted from [10] and [11])

Sort /Seiri/

Identification of the best physical Organisation of the workplace. It has been variously anglicised as Sort, Systematisation or Simplify.

Target Outcome - An uncluttered workplace.

What does it mean?	Why is it important?	What problems are avoided?
▪ Remove all items not needed for current production operations. ▪ Leave only the bare essentials: When in doubt, throw it out.	▪ Space, time, money, energy, and other resources can be managed and used most effectively. ▪ Reduces problems and annoyances in the work flow. ▪ Improves communication between workers. ▪ Increases product quality. ▪ Enhances productivity.	▪ The factory becomes increasingly crowded and hard to work in. ▪ Storage of unneeded items gets in the way of communication. ▪ Time wasted searching for parts/tools. ▪ Unneeded inventory and machinery are costly to maintain. ▪ Excess stock hides production problems. ▪ Unneeded items and equipment make it harder to improve the process flow.

Set in order /Seiton/

Series of steps by which the optimum organisation identified in the first pillar are put into place. The standard translation is Orderliness.

Target Outcome - A workplace that is visually instructive and is the source of minimal waste and human errors.

What does it mean?	Why is it important?	What problems are avoided?
▪ Arrange needed items so that they are easy to use. ▪ Label items so that anyone can find them or put them away.	Eliminates many kinds of waste, including: ▪ Searching waste. ▪ Waste due to difficulty in using items. ▪ Waste due to difficulty in returning items.	▪ Motion waste. ▪ Searching waste. ▪ Waste of human energy. ▪ Waste of excess inventory. ▪ Waste of defective products. ▪ Waste of unsafe conditions.

Shine /Seiso/

Cleanliness. The principle here is that people are happier and hence more productive in clean, bright environments. There is a more practical element in that if everything is clean it is immediately ready for use

Target Outcome - A clean workplace - one that shines, and that minimizes sources of contamination

What does it mean?	Why is it important?	What problems are avoided?
▪ Keep everything, every day, swept and clean.	▪ Turn the workplace into a clean bright place where everyone will enjoy working.	▪ Lack of sunlight can lead to poor morale and inefficient work. ▪ Defects are less obvious. ▪ Puddles of oil and water cause

	▪ Keep thing in a condition so it is ready to be used when needed.	slipping and injuries. ▪ Machines that do not receive sufficient maintenance tend to break down and cause defects.

Standardize /Seiketsu/

Standardised clean-up. Establish standards to maintain 5S improvements. Basically this involves setting a schedule by which all the elements are re-visited on a regular basis – usually referred to as the '5S Job Cycle.'

Target Outcome - Deveolp procedures, checklists, and other mechanisms established to maintain a work environment that is visually instructive, has minimal waste and human error, and is clean, uncluttered, and organized.

What does it mean?	Why is it important?	What problems are avoided?
▪ Integrates Sort, Set in Order, and Shine into a unified whole.	▪ By ensuring conditions do not deteriorate to former state, facilitates implementation of the first three pillars.	▪ Conditions go back to their old undesirable levels. ▪ Work areas are dirty and cluttered. ▪ Tool storage sites become disorganized and time wasted searching for tools. ▪ Clutter starts to accumulate over time. ▪ Backsliding occurs.

Sustain /Shitsuke/

The basic translation of the final stage is Discipline. Monitor, expand & refine 5S results. Although both Seiketsu and Shitsuke are aimed at ongoing maintenance of 5S, the two approach the objective from completely angles. The fourth pillar is the introduction of a formal, rigorous review programme – the mechanical aspects of maintenance. The fifth is the set of approaches we use to win hearts and minds, to make people want to keep applying best practice in shop organisation and housekeeping. In this sense, 'discipline' is an unfortunate term as it implies people forced to do something, with consequent penalties if they do not.

Target Outcome - A workplace that automatically restores order, regulates activity, and continuously improves.

What does it mean?	Why is it important?	What problems are avoided?
▪ Making a habit of properly maintaining correct procedures. ▪ Instill discipline necessary to avoid backsliding.	▪ Consequences of not keeping to the course of action greater than consequences of keeping to it.	▪ Unneeded items begin piling up. ▪ Tools and jigs do not get returned to their designated places. ▪ No matter how dirty equipment becomes, nothing is done to clean it. ▪ Items are left in a hazardous orientation. ▪ Dark, dirty, disorganized workplace results in lower morale.

5S Cycle

5S is a cyclical methodology: sort, set in order, shine, standardize, sustain the cycle. This results in continuous improvement of a workplace and whole production. Sort, set in order and shine are main principles. Standardize and Sustain are more management of basic three pillars. Standardize is more technological method and Sustain is more human and/or organizational method. On the Figure 1 shown the 5S Cycle.

Figure 1. 5S Cycle. adapted from [10]

5S Implementation

There are few approaches for implementing the 5S methodology. It depend of type of production, industry, team and local unique preferences. Easiest way is 4-step implementation related to management cycle Plan-Do-Check-Act :

1. Establish a cross-functional and interdisciplinary team.
2. Review and systemize all areas of production process. (Value stream mapping)
3. Brainstorm ideas about improving process and reduce waste and operational time
4. Actions in continuous perspective with both human and technology feedback.

Further we will describe more specific questions for each pillar in terms of actions and resources. Information is mainly from “the 5S Handbook” [10] that is company standard example.

Table 2. 5S actions

Sort /Seiri/	
Action Steps 1. Identify a 5S-project area and take "before" pictures 2. Review sorting criteria 3. Create a local red tag area 4. Tag, record, and move red tagged items 5. Take "after" pictures 6. After target time, move unclaimed items to the central red tag area	Resources 1. Red Tags 2. Red Tag Record Forms 3. Camera for “before” and “after” pictures
Set in order /Seiton/	
Planning phase	
Action Steps 1. Create a current state workplace diagram. 2. Team shares insights gained during S1&S3 3. Evaluate current workplace 4. Create a future state workplace diagram 5. Get approval for change from stakeholders	Resources 1. Flip charts for creating current and future state diagrams 2. CAD system (optional) to draw workplace to scale 3. Camera 4. Stakeholders (i.e. production, maintenance, safety) to consider proposed changes
Implementation phase	
Action Steps 1. Take “before” pictures 2. Implement workplace changes 3. Mark locations by creating addresses and applying labeling, marking, and color-coding 4. Take “after” pictures	Resources 1. Existing plant standards for labeling, marking, and color-coding 2. Labeling supplies 3. Tape for creating borders on work surfaces and floors 4. Paint and painting supplies
Shine /Seiso/	
Action Steps 1. Define "clean" 2. Get cleaning supplies 3. Take "before" pictures 4. Clean the work area 5. Fix small imperfections 6. Identify contamination sources 7. Take "after" pictures	Resources 1. Cleaning supplies such as brooms, dust pans, rags, degreasers, and floor cleaner. 2. Personal protective equipment such as gloves and eye protection. Do not wear jewelry that can get caught in the equipment.

Standardize /Seiketsu/

Action Steps	Resources
1. Brainstorm ideas for making the 5S changes standard operating procedure 2. Update documentation to reflect changes 3. Make sure all stakeholders are aware of the new standards - inform and educate	1. Support from those who can create documentation, job aids, and visual aids 2. Information and approval from those responsible for maintaining company procedures 3. Poster-making supplies for posting new standards in work areas

Sustain /Shitsuke/

Action Steps	Resources
1. Monitor processes established during S4 - Standardize 2 .Expand 5S efforts to other work areas 3. Evaluate 5S effectiveness and continuously improve 4. Recognize and reward strong efforts	1. Management audit forms 2. Resources for communication and recognizing successes (newsletters, dis-plays, awards) 3. Presentation tools for sharing best practices with other work areas 4. Managment commitment and focus on maintaining the new standards

In practice management establish even competition between departments or area for the best 5S. Special team regularly makes an audit of working places with scores. Every month or 3 month organization has winners with prizes for motivation reasons.

5S in the DNV Fuel Fighter project.

Safety and Risk management concept

Safety is an essential consideration for the event organisers – Shell Eco Marathon.

The DNV Fuel Fighter team considers safety as a concern that cannot be ignored in any task during the design, production and competition. We know that unsafe behavior could result in damaged health of the involved, economical losses and bad press for the idea behind the project - the future of energy efficient mobility. Regulations from event organizers, NTNU, Norwegian government and common sense gives a reason for deep and serious risk and safety analysis.

For preliminary risk identification for Economical loses, social and emotional loses and health we use the Bowtie model:

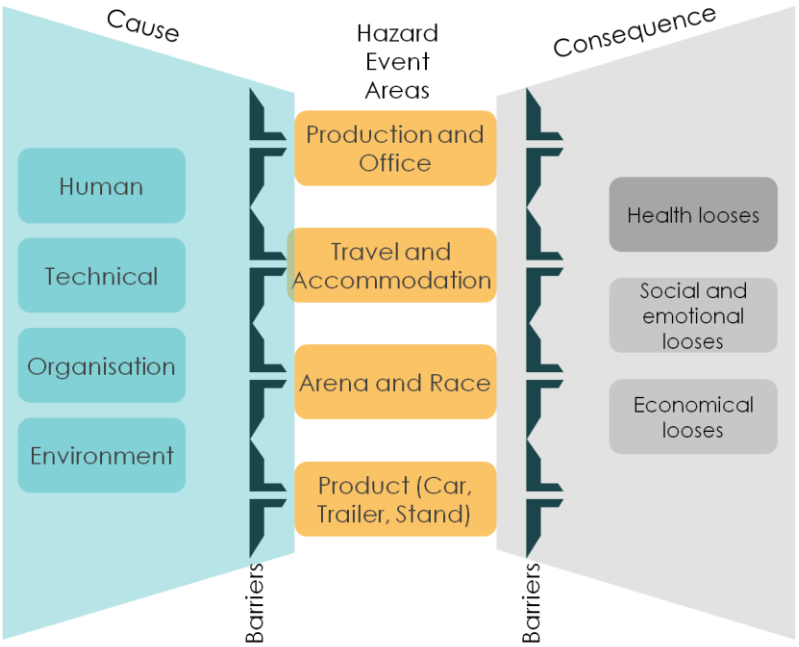


Figure 2. Bowtie model for project risk identification

We classify Hazard sources in four categories:

> Technical (car and support systems, resources for production, technology etc.),
> Human (personal errors, motivation, skills, experience, etc.),
> Organizational (teamwork, management, decisions, priority, etc.),
> Environmental (Organisers, Competitors, Public, Sponsors, Weather, etc.).

Hazard event areas are:

> Production and Office (working conditions for the team)
> Travel to/from Rotterdam, Ahoy Arena and accommodation.
> Arena and Race (whole Shell Eco Marathon event in Ahoy, Rotterdam)
> Product (Car, Trailer, Stand features – design, maintenance and operate the products with safety issues)

Production and Office and also Paddock in Rotterdam was chosen for implementation the 5S methodology. Sort, set in order, shine, standardize, sustain are pillars for the reducing the risks and way to efficient and safe project. Safety is really behind these principles and Secure in the limited access to workshop. We try to follow 5S principles in workshop and paddock as much as it possible, but of course as any new principal it's not happened immediately, this is continuous process.

The project has few phases for creating the car – Analysis, Design, Production, Assembling and Testing. The team uses the University facilities for that aim – Office, Workshop and also special labs and machines. The most difficult or dangerous task are on the outsourced to sponsors, partners or suppliers.

Workshop and office

- **Office**

Our office is on the University Campus with 8 desks and sofa area. As any other room in University safety regulations and actions are important. Access, electricity, ventilation, cleaning, fire protection etc. are on of a high standard. So University regulations, National regulations for the schools and other standards are the barriers to avoid the most of the risks.

To increase the comfort in working conditions we changed the position of desk, bought the modern powerful computers with big two screens each on the project beginning. We also improve our sofa area with big screen on the wall for the team rest.

Figure 3. Project office

- **Workshop**

Workshop is special room where the car and tools are located. This is locked room in University Camus on the ground floor. Access to the room is only for the team members that have key. Workshop is University room and all Norwegian national and University regulation helps to protect people and property. Workshop we use mainly for the assembling, testing and technical adjustments. We have own wide set of tools.

5S implementation process.

Step 1. Core project team has recognized high needs to improve workshop condition. One person from each area of the project was in special 5S team – Project management, PR and Media, Mechanical, Electrical and Safety.

Step 2 (Sort). All stuff in workshop was divided into categories: Project management, PR and Media, Mechanical, Electrical, Safety, Dangerous Chemical. After that special areas in workshop were established with responsible person. Name of area and contacts of responsible person was labeled in such area. Project has annual basis and stuff that not needed for

the team could not be throw out. Special area for this “red tag” stuff was established but without removing.

Step 3. (Set in Order). Each responsible person with own support team made decision how to organize stuff within own dedicated area and also procedures who and how to use it. Mechanical and electrical engineers that mainly work on the workshop made special rules and put it on the wall.

Step 4. (Shine). Every week on Monday was “cleaning day”. Core team used 1 hour for cleaning and setting in order chaotic stuff.

Step 5. (Standardize and Sustain). Practically, team didn’t finish those steps because of time. But team leaves instructions and documentation as well as suggestion for the next team.

Figure 4. Project workshop

► **Special labs and machining in University.**

The most dangerous tasks in production that we do at the University are chemical composite tasks and mechanical machining. The students that get access to work in the labs where the tools are have to pass special courses before they are allowed to operate any equipment. After that each student has to have proper clothes and other safety features. Labs have special certified facilities as ventilation, emergency signalization etc.

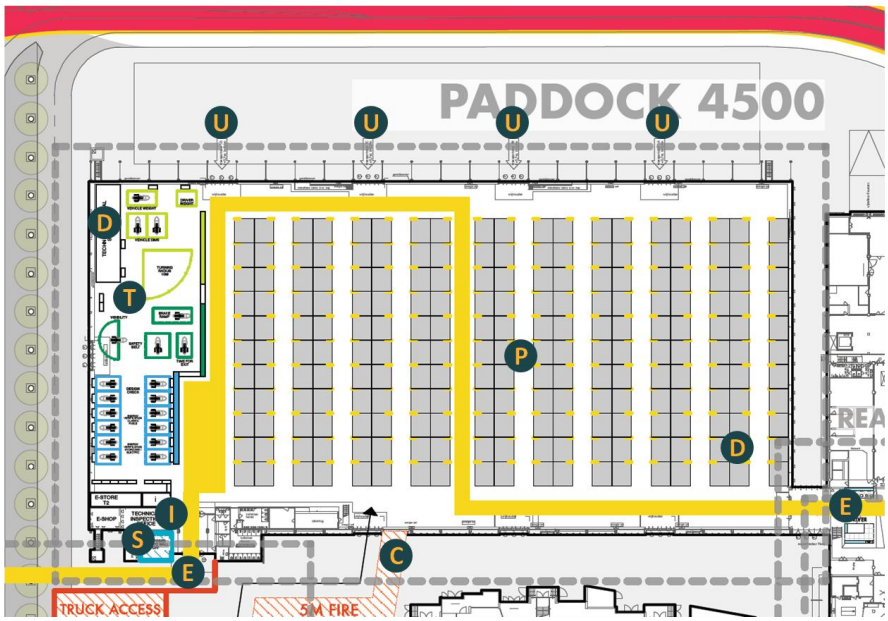
Figure 5. Project workplace

Paddock

Paddock is special area for the team to present the project, work on the car and just stay during the Event. Paddocks of almost 200 teams are in Hall1. On the same Hall 1 are situated also technical inspection area, informational desk with organizers, e-shop. So paddock is situated in crowded noise place and make few function on the same time – PR and media, Safety, workshop and just place to stay for a team.

Team paddocks are located according to the fuel type. Individual paddock for team is 4m x5m. Each paddock is equipped with:

2 x Chairs
1 x 2m x 0.8m Table
1 x Locked storage unit
1 x Waste paper bin
2 x 13a 240v socket
6 x Spotlights



D Main Display
T Technical Inspection
C Car's way Paddock-Track
I Information desk
E Entrances to Hall
S E-Shop
U Parking for unload trailers
P Team's paddocks
D DNV Fuel Fighter Paddock

Figure 6. Paddocks area map

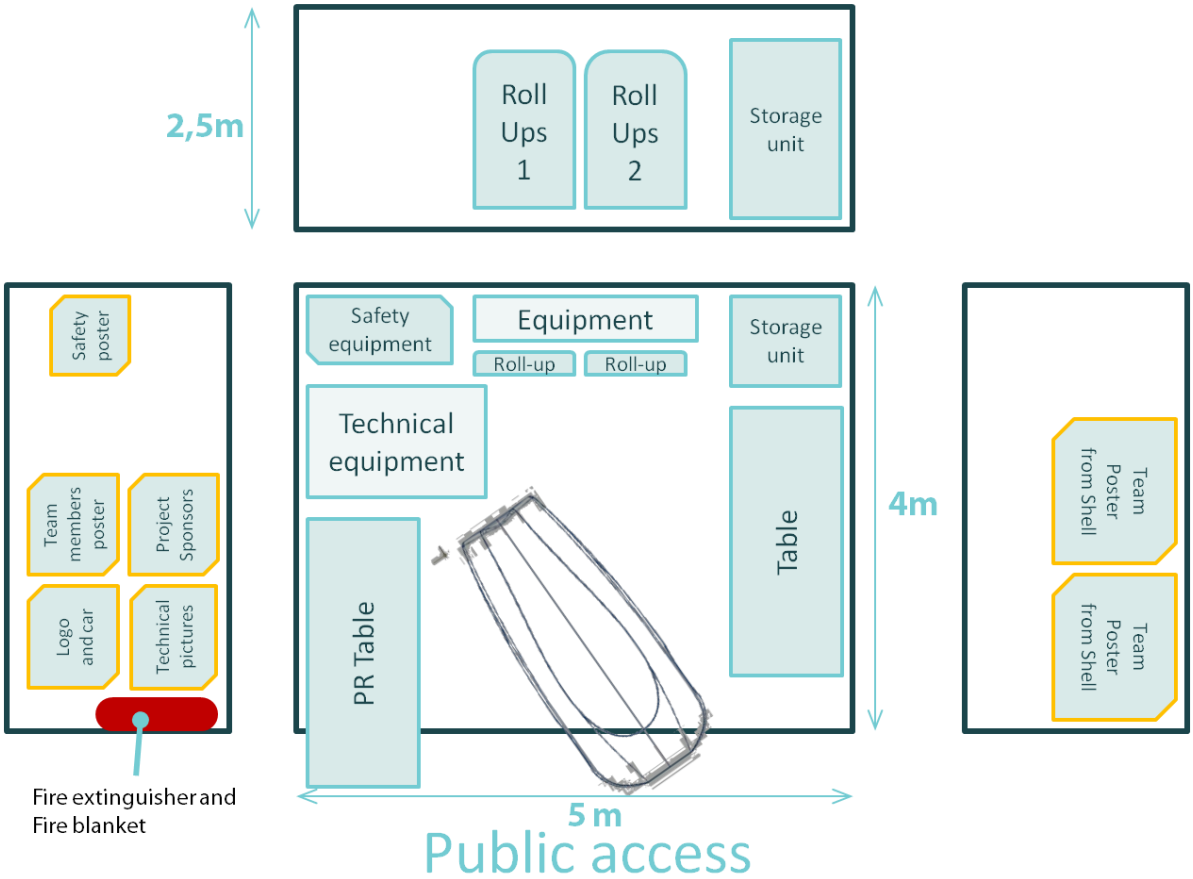


Figure 7. DNV Fuel Fighter Paddock plan

Because paddock is temporary but very important place for result of the whole project we started plan it 3-4 month before. On the same time in paddock are processes for PR and Media for public and the technical adjustments for the car. Behind this purpose safety is required by organizers and our project purpose. 5S team establish concept of paddock with detailed location of each type of equipment and procedures how to use it.

On practice team has to adjust plan to reality.

First, paddock was equipped PR and Safety stuff and after that technical stuff and car arrives. In paddock is forbidden to use usual tape and any damage of panels will cost penalty for the team. Special type of tape spots are provided by organizers. Electrical cables have to be taped to the floor as well as carpet from public access side for the safety reasons. Fire extinguisher and Fire blanket have to be visible and accessible in case of accidents. When team arrives to paddock one of the team posters from Shell was with wrong photo and after few days new correct poster was printed by Organisers. Spotlights position was adjusted to emphasize lights for the Roll-ups, Posters on the wall and the car.

Adjustments and plan gives excellent results in very busy and critical for the project and team days in Rotterdam.

In the Appendix 1 is picture gallery related to applying the 5S methodology.

Conclusion

DNV Fuel Fighter project was exciting student practical project in terms of “learning by doing” concept. Team got amazing result – car was 3rd on the race and additionally the best design and the best PR prizes were won. Project was safe and was no any damages for property, health of people or hits for budget. Multidisciplinary team has attempted to apply 5S methodology for the workshop and paddock. Something works well, something not. But general impact was highly positive as from safety, human health, environment and economical losses as from new knowledge and skills point of view.

This report shows the theoretical and practical aspects of implementing 5S Methodology and impact of that for general project aims in terms of safety, operating, maintenance and overall time reduction.

Further the general findings are listed.

Advantages of 5s

Order, easy to find, ready to use, safe working area, reducing time for operations etc.

Disadvantages of 5s

Additional time and human resources, “necessary evil”, additional management focus, sometimes more safety than necessary for easy operations.

Theory meet Reality

Method does not work in critical situations when result and time more important than procedures.

Difficult to apply for students and temporary project.

Difficult to control in self-organized team.

5S methodology doesn’t go further than first 3 steps. We give up with continuous impotents. We got first practical results and later did actions on demand not on schedule. Mainly because of nature for the project – short, student, result-oriented creative team.

Ready to change. Plans always have to be flexible and actions pro-active – financial buffers, redundancy, alternative solutions, good communications with team and organizers.

Lessons and suggestions

Actions work when it’s really necessary and gives immediate effect. For the long-term effect management attention is needed.

Good examples of the best organizing the working space in competition. More than 200 teams have the same task and team could easily see alternatives.

Simple and visible labels and rules are the most effective.

Safety manager role has to be for only one person. In our project because of lack human resources Project manager was also safety manager and administrator etc.

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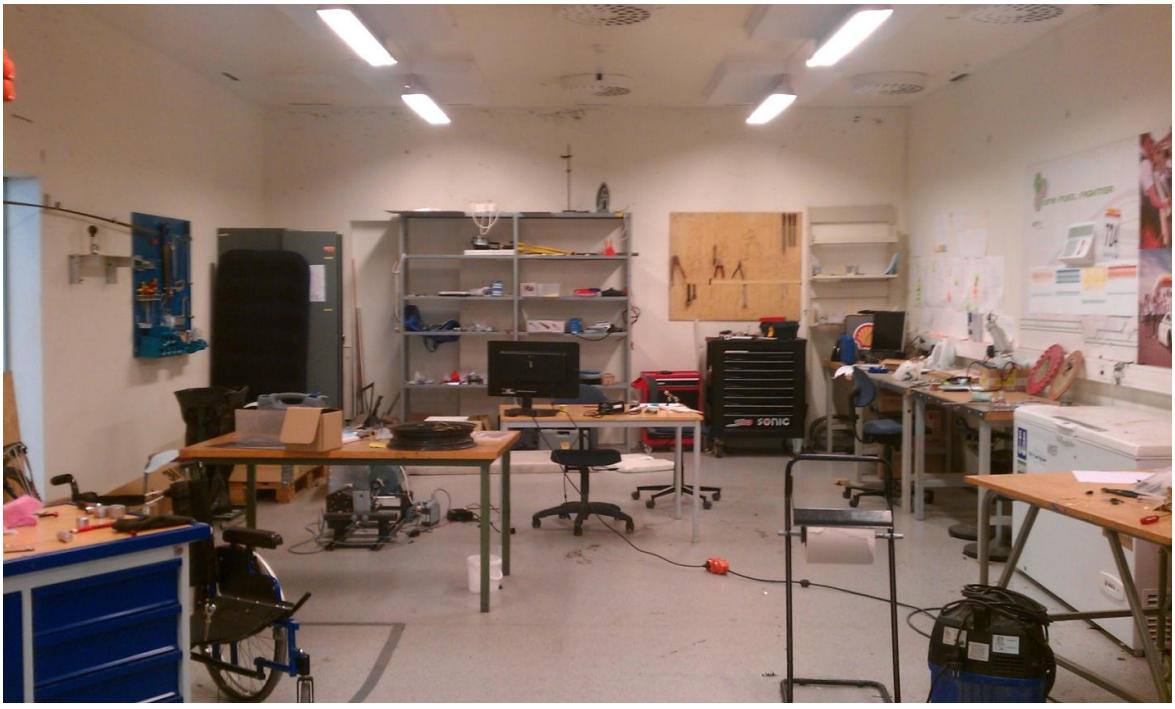
Appendix . Picture gallery.

Well organized set of tools

Good example of workshop organization



Bad example of workshop organization

Sorting process

Standardized work process – transportation of the car

Empty paddock

Paddock with PR and Safety equipment.

Paddock work condition

Marked areas separation and taped cables

Safety equipment

Organization of the stuff in order.

DNV
Fuel Fighter

Paddock check list
Protective equipment and materials

☐ Gloves for general work: leather or canvas;
☐ Gloves for handling fuel or motor oil: chemical resistant (nitrile gloves are recommended);
☐ Safety glasses for all team members (disposable types are permitted);
☐ Hearing protection for all team members (approved ear plugs or muffs);
☐ Duct tape to secure any cords or cables lying on the pit floor;
☐ Lift stands or appropriate raised platforms for vehicle tuning and repairs;
☐ Fire blanket to be visible in the paddock workshop when working there;
☐ Operational 6 kg dry-chemical (powder) extinguisher suitable for 'ABC' class fires (European norm DIN EN-3), of which the maintenance date is later than 31/5/2013 (to be placed in the garage);
☐ Dust masks when required for specific work involving composite material, e.g. for grinding; and
☐ Shell strongly advises participants to undertake work on Prototype and UrbanConcept vehicles with appropriate overalls and clothing and to ban synthetic underwear or clothing.

Equipment check list

Safety poster example