NTNU – Trondheim
Norwegian University of
Science and Technology

Managing Execution Of Environmentally Friendly Vehicle

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Managing Execution of Environmentally Friendly Vehicle Shell Eco-marathon 2012

by

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MASTER THESIS
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MANAGING EXECUTION OF ENVIRONMENTALLY FRIENDLY VEHICLE
(Gjennomføring av et miljøvennlig bilprosjekt)

The master thesis will be based on the results obtained from specialization project conducted in the previous semester. In this assignment the candidate should perform the following tasks:

1. Monitoring and follow up of project execution, including; risk, communication, cost, time, performance and quality.
2. Review current literature on voluntary based projects, pitfalls, challenges and success factors.
3. Document and analyze project challenges during execution and document and analyze the lessons learned.
4. Description of the necessary organizational and operational adjustments that is necessary for successful completion of this type of voluntary based projects.

Within three weeks after the date of the task handout, a pre-study report shall be prepared. The report shall cover the following:

- An analysis of the work task's content with specific emphasis of the areas where new knowledge has to be gained.
- A description of the work packages that shall be performed. This description shall lead to a clear definition of the scope and extent of the total task to be performed.
- A time schedule for the project. The plan shall comprise a Gantt diagram with specification of the individual work packages, their scheduled start and end dates and a specification of project milestones.

The pre-study report is a part of the total task reporting. It shall be included in the final report. Progress reports made during the project period shall also be included in the final report.

The report should be edited as a research report with a summary, table of contents, conclusion, list of reference, list of literature etc. The text should be clear and concise, and include the necessary references to

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2012-01-09	BAH/LMS

figures, tables, and diagrams. It is also important that exact references are given to any external source used in the text.

Equipment and software developed during the project is a part of the fulfilment of the task. Unless outside parties have exclusive property rights or the equipment is physically non-moveable, it should be handed in along with the final report. Suitable documentation for the correct use of such material is also required as part of the final report.

The student must cover travel expenses, telecommunication, and copying unless otherwise agreed.

If the candidate encounters unforeseen difficulties in the work, and if these difficulties warrant a reformation of the task, these problems should immediately be addressed to the Department.

The assignment text shall be enclosed and be placed immediately after the title page.

Deadline: June 11th 2012.

Two bound copies of the final report and one electronic (pdf-format) version are required.

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Per Schjølberg
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Bassam Hussein
Responsible Supervisor

Abstract

Eco-marathon is an annual competition for student teams from high schools and universities around the world to design, build, test and race their energy efficient cars. Participating in this competition, teams have to deliver vehicles within either 'Urban Concept' or 'Prototype' categories. In the former, the vehicles must have ordinary four-wheel roadworthy design and in the latter cars should have futuristic design and maximum efficiency. Since 2008, Norwegian University of Science and Technology has taken part in Eco-marathon competition in urban concept category with a hydrogen fuel cell car (called DNV Fuel Fighter). After history of glory, the 2012 team decided to make a new vehicle from scratch for battery-electric class (DNV Fuel Fighter 2). Therefore, two objectives were defined for this project:

- Winning the first rank award in battery-electric class of urban concept category
- Winning communication and marketing award

This decision made the project to be categorized with NPD projects. Distinct characteristic of this type of projects is significant uncertainty associated with the effort. Based on experience gained from managing Shell Eco-marathon 2012 at NTNU, four types of uncertainties made this project challenging: technological, development, organizational and intra-organizational. This master thesis focuses on describing such challenges in the project's lifecycle and offers solutions to deal with them. Furthermore, a set of organizational and operational adjustments are proposed to promote the project at NTNU's environment.

NTNU's 2012 team finished the competition by achieving the 5th rank in battery-electric class. Although the objectives weren't met in this year, but project was accomplished successfully as almost all of the success criteria were met through this effort.

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Introduction

Eco-marathon is an annual competition originated in 1939 by a friendly bet between Shell research laboratory scientists. They wagered on their own made vehicles to see which one will get the most miles per gallon. Today, this notion has become a foundation for challenging student teams from high schools and universities around the world to design, build, test and race their energy efficient cars. Participating in this competition, teams have to deliver vehicles within either 'Urban Concept' or 'Prototype' categories. In the former, the vehicles must have ordinary four-wheel roadworthy design and in the latter cars should have futuristic design and maximum efficiency. Each one of two categories has 8 classes:

- Internal Combustion Engine (ICE)
- Fuel cells
- Battery-electric
- Petrol (gasoline) fuel
- Diesel fuel
- Alternative petrol fuel: ethanol vehicle
- Alternative diesel fuel: GTL (Gas-to Liquid) vehicle
- Solar.

In each category and class the winner will be the team which can drive own vehicle furthest on the energy equivalent to one liter of fuel. Today, Dutch Royal Shell holds this yearly competition in three continents, Asia, Europe and America. First race in Europe, in its current form was held in France in 1985 which drew engineering students and scientists from 20 European countries.

Since 2008, Norwegian University of Science and Technology (NTNU) has taken part in Shell Eco-Marathon (SEM) competition in urban concept category with a hydrogen fuel cell car (called DNV Fuel Fighter). During past 4 years, NTNU has won two fuel cell class awards, one road safety award, one CO_2 award and two communications and marketing awards which present a history full of success. In addition, a new world record in urban concept category (1246km/l) was set by NTNU's team in 2009.

Figure 1 - The 2011 team with DNV Fuel Fighter

Each year since 2007, NTNU has offered an opportunity to senior master students from different faculties to build multidisciplinary project team in order to write their master thesis based on experiences gained through working on project. Annually, in late August, students who have decided to join the project voluntarily, create a team and start the nine months project. At start of the project, participants may decide upon improving the existing vehicle received from last year or build completely new car. As NTNU doesn't finance SEM undertaking, it is up to team members to find sponsors with the purpose of providing financial resources to handle the project. After finishing the race, project will be terminated by delivering the vehicle and its related technical and non-technical documents to the university.

Shell Eco-marathon 2012-General Information

NTNU's 2012 team had two unique features:

- Internationality: team members were from four different countries, Norway, Spain, Germany and Iran.
- Multidisciplinary: thirteen project members were from seven various departments.

Although previous teams may had two above mentioned characteristics, but the diversity of culture and competency in the new team didn't have match comparing to previous groups. Names, education level and responsibility of the participants were as below:

- Aksel Qviller, ICT Engineering, Suspension

- Aslak Brage Espeland, Mechanical Engineering, Exterior

- Eivind Sæter, Industrial Design, Design

- Fariborz Ali Heidarloo, Project Management, Project Manager

- Fredrik Vihovde Endresen, Energy and Environmental Engineering, Engine

- Håkon Johan Seiness, Mechanical Engineering, Steering and Brakes

- Hans Gudvangen, Mechanical Engineering, Suspension and Rims

- Itxaso Yuguero Garmendia, Mechanical Engineering, System Engineering

- Mats Herding Solberg, Industrial Design, Design

- Oluf Tonning, ICT Engineering, System Engineering

- Petter Thorrud Larsen, Mechanical Engineering,

- Silje Kristine Skogrand, Media Communication and Information Technology, Public Relations (PR) and Media

Project team members put a lot of effort to find sponsors for the undertaking. Fourteen project sponsors can be classified into two groups: companies or entities which assisted the project with cash contribution and those that helped the project with offering their product or services for free. SEM 2012's sponsors and value of their contributions in the project were as followings:

- Det Norske Veritas (DNV), Safeguarding life, property, and the environment company, 600,000 NOK

- Transnova, Governmental body to promote eco-friendly solutions for transportation, 150,000 NOK

- High Performance Composite (HPC), Supplier and producer of composite products, 120,000 NOK

- Eker Design: Provider of turnkey mechanical and industrial design services, 100,000 NOK

- Smart Motor, Producer of compact, efficient, high torque electrical machines, 50,000 NOK

- ProNor, Retailer of 'Solidworks' software series, 30,000 NOK

- Altitec, Supplier of battery and related accessories, 15,000 NOK

- Gylling, Battery importer, 15,000 NOK

- SKF Norge, Bearings and seals supplier, 10,000

- Evonik Industries, Foam (core material) supplier, 10,000 NOK

- Re-Turn, Offering polymer solutions for plastic industry, 5,000 NOK

- Bilreklame, Customized foil producer, 5,000 NOK

- Jackon Isjolasion, Isolation supplier, 5,000 NOK

- Printing AS, foil printer, 5,000 NOK

Figure 2 - The 2012 team with DNV Fuel Fighter

Only DNV and Transnova had cash contribution and the rest, sponsored the project with their services and products.

Unlike past three years in which teams spent their time on improving DNV Fuel Fighter, the 2012 team decided to make a vehicle in urban concept category from scratch but in battery-electric class! Experiencing the adventures of trying new class of the competition and better efficiency gained from battery compared to hydrogen fuel cell were reasons for changing the class of the vehicle. According to mentioned facts, it can be concluded that SEM 2012 project at NTNU was a New Product Development (NPD) project.

Figure 3 - DNV Fuel Fighter 2

New Product Development Project

Accomplishing set of processes with systematic methods in order to bring a new product to market is called 'New Product Development' (NPD). Distinct characteristic of this type of project is significant uncertainty associated with the effort. Due to lack of clarity participants may face a lot of questions such as: 'How much money should be spent on new development?' 'Are there enough human resources with proper level of knowledge to handle the tasks?' 'How should be the design of the product and which materials shall be utilized in making it?'

Numbers of studies have been done to address uncertainties in developing new product. Tatikonda and Rosenthal (2000), in their study of task uncertainty in product innovation have indicated that technology novelty and project complexity are sources of uncertainty. Technology novelty has been defined as unfamiliarity with technologies that are going to be used in developing product, to the firm. This novelty can be in product or process. Project complexity has been defined in relation with number of organizational subtasks and their interdependencies. Kim and Wilemon (2003) have broadened the categorization and argued that five different types of uncertainties exist in NPD project. In their studies, they have used terms 'complexity' and 'uncertainty' interchangeably and stated that lack of certainty can be technological, in development, in marketing, organizational and intra-organizational. According to them, component integration and technology newness cause technological uncertainty. Challenges in making right decisions in time of dilemmas when an unexpected event happens, lead the project

team to development uncertainty. Deciding about budgeting NPD processes, doubts in pricing future product and having not clear understanding of new markets' behaviors are major uncertainties mentioned under marketing type. Difficulties in building a project teams with enough members, ambiguity in defining communication channels between functional teams, unclear status of knowledge of the team members and their capabilities in knowledge transfer process within organization are important issues under organizational category. Due to rapidly growing number of available methods and techniques for developing new product, companies don't have the capability to study and upgrade their own knowledge in all discipline. Therefore Kim and Wilemon (2003) has also mentioned that in time of bringing the knowledge from outside of the company, uncertainty about difference between level of knowledge of the source and the recipient, doubts in selecting methods of communications are noticeable challenges in intra-organizational level.

Mentioned ambiguities from literature review were faced during handling SEM 2012 project (except uncertainties related to marketing which are not applied). The rest of this report has been dedicated to highlight such challenges through project's lifecycle, initiating, planning, executing, monitoring and controlling and closing. In addition to this, based on project manager's experience, overcoming solutions are suggested.

Project Initiation

Project formally starts in this stage. Within initiating step, project will be officially authorized and information, essential to commence the undertaking must be provided.

Understanding Organizational Culture and Environment

Suggested by Engwall (2003), project manager has to find answers for following questions during initial steps of managing a project:

- Does project have support of middle or top authorities? Before starting with planning the project, manager should evaluate the status and position of the project in the organization. Concentration shall be placed on assessing the impact of executing the project on its surrounding e.g. university. If the undertaking has significant positive effect and its output is valued by environment, then it will be considered in top priority and thus be supported by dominant and key authorities. When a project with 'prestige' has such backup through future challenges, not only managers will dedicate their time to the project, but also low level employees will help participants when it is required as they might have found the project attractive. Assistance from willing staff at NTNU's transportation department with receiving permission for borrowing a van in order to facilities the moving of DNV Fuel Fighter 2 is a good example of this. The employees' interest in the project was the reason for helping the project team through overcoming transportation challenge. Therefore, if the project doesn't have prestige, with the purpose of having support from different level of the organization, it is up to project manager to think about a method to show how interesting and important the effort is.

- Have similar projects been executed before? What is the team's reaction toward the answer of this question? Team members may be pleased to carry out a project with repetitive framework. The reasons for this tendency can be high perceived risk in trying fundamentally new project and lack of technical knowledge. But participants may be dissatisfied with continuing similar project as they seek new challenge and clear uniqueness within an effort. Although project team's inclination is not the only factor for deciding upon whether the repetitive framework should be taken or not, but the answer to such question has huge effect on individual's performance. Thus, project manager shall take team's opinion about the project into his/her consideration before starting with

planning the project as s/he might need to make decision about preventive actions for avoiding negative feedback from team members. Not only the starting point has to be assessed versus participants' opinions, but also team leader should know how the team feels about the objective and outcome of the undertaking. Before executing SEM 2012, three years had been spent for developing and improving DNV Fuel Fighter, so upon a consensus, project team decided to build a new car from scratch as they had negative feedback on dedicating time to a three years old car. Besides, having a completely new vehicle as a result was another motivating factor to skip the available vehicle.

- How is the organization's environment and conditions for applying project management practices? Organizational culture, or Enterprise Environmental Factors (EEF) (PMI, 2008) are determinant elements for choosing management style. Project manager must clearly and thoroughly comprehend the conditions of the organization and evaluate them compared to his/her technique. It may be possible that following best practices in managing project is not suitable and consequently no one cares about how hard the leader is trying to apply those practices. Adapting own procedures with EEFs should be done before taking any managerial steps as this action makes firm foundation for future problem solving or decision making procedures. This key adjustment prevents further effort on defending management style against organization's norms.

- What is project manager's level of authority? Level of authority will be given by key persons in organization and its environment. Project manager must fully understand to what extend s/he can make decisions on own without including authorities. Clarifying the role's boundaries and limits is highly consequential as it has direct impact on team leader's performance. Most likely any confusion on this point causes severe ramifications which can affect project unfavorably.

Project Goal

Another important step in initiating stage is defining goal. Stated by Doran (1981), specified goal should be 'SMART', meaning that it has to be 'Specific', 'Measurable', 'Attainable', 'Realistic' and 'Time-bound'. In accord with five mentioned features, objectives of SEM 2012 were determined as followings:

- Winning the first rank award in battery-electric class of urban concept category

- Winning communication and marketing award

Success Criteria and Factors

On what basis project will be considered successful or failed? Project manager has to define criteria so that if accomplished, project is successful. Not only team leader has contribution in this but also stakeholders have key role in determining such criteria. SEM 2012 success criteria were:

- Finishing the project on time
- Finishing the project within budget
- Delivering a high quality, trustworthy vehicle
- Satisfying all internal and external stakeholders
- Strong presence in local (Norwegian) media and social network
- Having at least one accepted try in the competition

The project team shall also settle essential qualities for meeting success criteria. Below mentioned attributes were considered as success factors of SEM 2012:

- Supports from middle and high level managers
- Dedicated, motivated and flexible team
- Effective project manager
- Developing proper strategy for managing the project which fits with organizational culture and environment
- Initiate and maintain efficient internal and external communications
- Selecting appropriate communication channels

Management Strategy

Project manager should have a strategy for managing a project. First, s/he has to break the overall work into different steps (phases) and decide how to put them together by taking group efficiency and time limit into account. The strategy can be brief and not really detailed that shows the way for future steps through other stages (planning, executing…). By generating such high level plan, various phases will be prioritized, so that an overview for time and resource allocation will be prepared. Adopted from Nobelius and Trygg (2002) style for scheming front-end activities, following model presents the strategy chosen for SEM 2012:
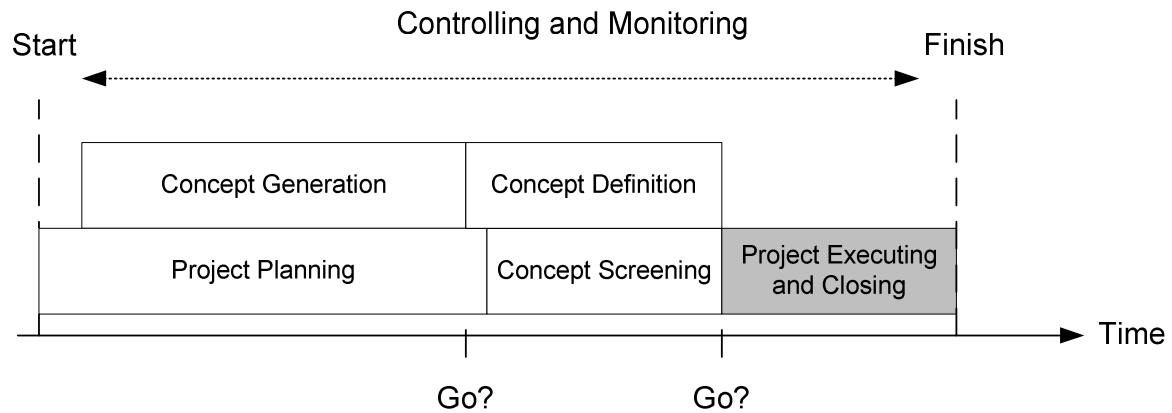
Figure 4 - SEM 2012, Management Strategy (Nobelius & Trygg, 2002)

Illustrated strategy shows how important the planning stage is as it takes more time compared to executing and closing. Besides, as it is shown, focus was put on following different phases in parallel not only for saving time, but also for increasing coordination among team members all along the way to avoid possible change requests in future. Two important gates are determined, one after concept generation and one before project executing and closing. These decision making points obliged participants to finalize their thoughts, opinions and drawing in order to freeze and not going back to them. Terms, 'Concept Generation, 'Concept Screening and 'Concept Definition' are used due to type of SEM project that is NPD. Executing of the project starts when all systems are completed and ready to be made. Presented strategy demonstrates that all of the steps through project lifecycle are monitored and controlled in purpose of directing them in specified way to achieve the goal.

Identifying and Analyzing Stakeholders

Freeman (1984) has defined stakeholders as any individual, group and organization that affect or can be affected by the accomplishment of the project and reaching the goal. This description was the basis for identifying stakeholders of SEM 2012. Recognizing and analyzing stakeholders is not a task that has to be done only in initiating stage. Through project lifecycle stakeholders may leave or join the project. Even according to Elias et al. (2002) their stakes might vary in each step. Therefore, it is project manager responsibility to continuously acknowledge stakeholders and consider their 'Dynamics' while managing the effort. Involved parties can have positive or negative influence on the undertaking. Those who gain benefits out of executing the project and goal achievement will provide help to successful end. But stakeholders with negative effect try to

disturb or hinder the project's progress. Crucial task of team leader is identifying stakeholders with negative impact because neglecting them increase the chance of failure. Those bodies that affected and were affected by SEM 2012 can be classified into two groups:

1. Internal Stakeholders: the internal stakeholders are involved parties that perform within university boundaries. This group consists of: project team, project manager, project supervisors, last years' teams, internal press entities, various departments of NTNU and their staff (e.g. workshop employees).
2. External Stakeholder: the external stakeholders are involved parties that operate outside of university boundaries: project sponsors, Royal Dutch Shell, external press and media entities and competitors.

Expectations of stakeholder shall be met and project manager is responsible to ensure that all involved individuals, groups or organizations are satisfied. Stakeholder's expectancies might be very different and incompatible with project's objective. Thus, with the aim of balancing internal and external participants' prospects and assuring proper communications between project team and stakeholders, a managerial strategy has to be developed. Before making a plan for approaching different stakeholders, their status in project must be analyzed. 'Power-Impact' matrix is a common tool for such analysis. The structure of this grid is varied but the principle is inspecting stakeholders influence by two factors, power and impact that can have descriptive (e.g. low, medium, high scale) or numerical (e.g. on scale of 1-5) measurement. The shortfall of using this tool with numerical measurement is team members' confusion on giving numbers to the factors for different stakeholders as numbers are lame to express the status of qualitative determinants. Also power-impact matrix with descriptive measurements is not completely capable of showing the picture. Using a term such as 'Low Power' can possibly bring up a question 'To What Extent Low?". Overcoming the difficulties with this type of grid, stakeholders' analysis of SEM 2012 was based on theoretical model of Mitchell et al. (1997). According to them stakeholders have one or combination of following three attributes:

1. Power: ability to force own will or preference
2. Legitimacy: behaving and making communications according to socially agreed believes and norms
3. Urgency: when a stakeholder has this attribute, its demands prompt attention.

Discussed typology results into figure below:
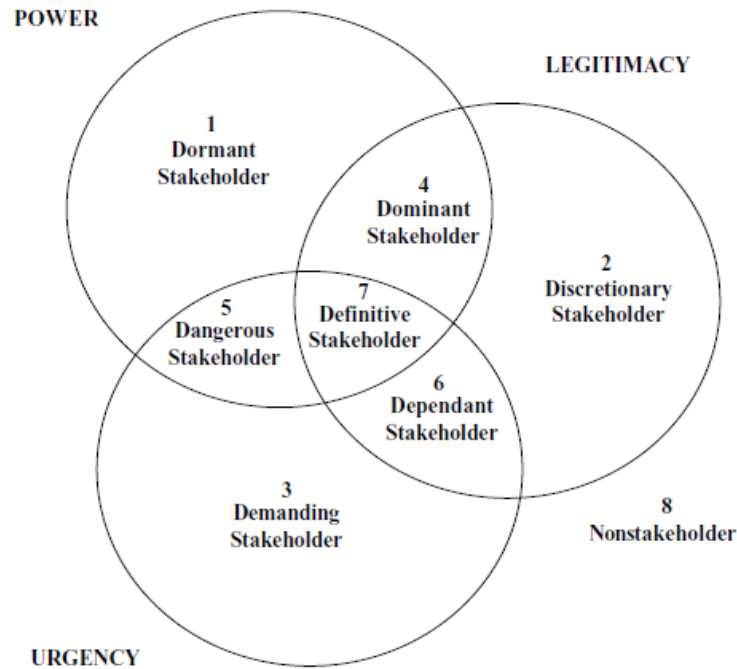
Figure 5 - Stakeholder Typology (Mitchell, Agle, & Wood, 1997)

It is important that project team understands that importance of stakeholders will be increased when they have or gain (considering dynamics of stakeholders) more attributes and so definitive stakeholders are the most influential entities on the project. The advantage of this method is using the factors that all have clear meaning, so less confusion is expected among team members. Table below shows stakeholders analysis of SEM 2012:

Name	Power	Urgency	Legitimacy	Type
Det Norske Veritas		■	■	Dependant
Transnova		■	■	Dependant
HPC	■		■	Dominant
Eker Design			■	Discretionary
Smart Motor	■		■	Dominant
SKF			■	Discretionary
Re-Turn			■	Discretionary
Evonik Industries			■	Discretionary
Bilreklame			■	Discretionary
Gylling			■	Discretionary
ProNor			■	Discretionary
Jackon Isolasjon			■	Discretionary
Altitec			■	Discretionary
Printing			■	Discretionary
Project Manager	■	■	■	Definitive
Project Team	■	■	■	Definitive
Last Years' Teams			■	Discretionary
Project Supervisors		■	■	Dependant
NTNU Departments			■	Discretionary
Internal Press Entities			■	Discretionary
Royal Dutch Shell	■		■	Dominant
External Press Entities			■	Discretionary
Competitors			■	Discretionary

Table 1 - Stakeholders Analysis

Competitors are the only stakeholders with negative impact on project. Taken strategies for different types of stakeholders were:

- Dependant: Keeping them informed frequently
- Dominant: Planning and executing project with their consultancy
- Discretionary: Keeping them informed via general communications
- Definitive: Manage project with their close involvement

Securing Sponsors

The biggest challenge in initiating stage is finding sponsors. SEM project at NTNU has not been executed with sponsorship of same company each year. Even if some companies remain by project from previous years, they won't have same expectation out of it. Each year, sponsors contract to fund the project for one year and after that the compact will be expired. Therefore, new team starts the project without knowing whether they can find a main sponsor for the project or not or whether the previous main sponsor is still eager to fund the project. If team members cannot convince a corporation to finance the majority of expenses, project will be failed.

Tighe (1998) has introduced three steps for securing sponsors in order to finance the NPD project: identifying and securing a sponsor, selling the project and maintain sponsor support. For decreasing related uncertainty, few logical steps were taken. First, after defining objectives, potential sponsors not only for funding the project but also for getting assistance in regard to making different systems were identified and sorted. Then communications were initiated with selected companies by team members. For having effective communications some ground rules were defined e.g. using proper words and following up the results in predefined time interval. Companies interested in knowing the project more, were asked to have meeting in order to give presentation and sell the project to them. At last, agreements were signed between project team and joined sponsors.

Knowledge Transfer

When a new team holds the responsibility of the project at NTNU, they have to decide upon their approach, either considering the available car and apply improvements or building a new vehicle from scratch. In both cases, the new team needs the knowledge of previous groups in order to comprehend the project context and make right decision. Project manager is responsible person to ensure required knowledge is successfully transferred from the sources. "Regardless of the setting, the objective of any knowledge transfer project is to transfer source knowledge successfully to a recipient" (Cummings & Teng, 2003). Handling efficient knowledge transfer is challenging and project manager may face following issues during process advancement:

- The knowledge can be tacit as it is part of the source that makes it hard to communicate.

- The source might not be capable of transferring the knowledge in clear and distinct manner (orally, written or schematically). Therefore, the process depends on how the source articulates what the recipient requires.

- Physical distance between the source and recipient can be large which makes the knowledge transfer less effective. Galbraith (1990) has indicated that the physical distance and the speed of knowledge transfer process have inverse relation.

- Difference between knowledge and skill level of the source and the recipient can be prolematic. One of the purposes of knowledege transfer is learning. If the recipient cannot understand communicated knowledge or in other case if the source doesn't have enough technical skill to express the knowledge clearly, the process is failed.

- Discussed by O'Reilly and Chatman (1996), if the source and recipient have different organizational norms and culture, knowledge tarnsfer process won't be smooth because both parties have dissimilar defined acceptable and unacceptable factors for making communications which leads to conflict and confusion.

Two days knowledge transfer sessions were hold during initiating step of SEM 2012. 2011 team was invited to come to Trondheim in order to decrease the physical distance. Source was newly graduated master students and recipient was 5th year scholars, so the difference between level of knowledge was minimum. Most of the participants in sessions were Norwegians, therefore by considering that the majority of individuals had common norms and background efficient communications were experienced, stated by 2012 team. Considering above mentioned facts, knowledge transfer for SEM 2012 was done successfully.

Project Planning

The planning stage comprises those course of actions executed to found the scope of the project, clarify the goals, and develop the processes needed to achieve those goals.

According to Verganti (1997) two planning styles may be utilized for new product development projects, feedback planning or reactive approach and feed-forward planning or proactive approach. Choosing how the project is going to be planned in early phase in order to save time and money is another challenge. By using reactive approach, project team does not spend significant time on solving uncertainties and gathering information for accomplishing tasks. This method which is based on the notion of uncertainty reduction during project advancement, doesn't need substantial financial resource and it is not time consuming but it increases the risk of facing late changes during execution phase that puts sizeable financial burden on project. Unlike this, by following proactive approach, project team shall allocate considerable time to think about what may go wrong during project development and come up with solution for each opportunities or constraints. Performing this method is expensive as processing data and having experts for anticipating uncertain information needs substantial financial support and the danger of losing track of time due to drowning into analyzing details is high. Project manager shall choose suitable technique for planning based on project characteristics. In SEM 2012 project both feedback and feed forward approaches were used. During initiating phase, following table (partly shown) was prepared which illustrates the improvement points in developing new vehicle based on study performed on status of various systems of precedent car, DNV Fuel Fighter.

Name of Part	Major Improvement Points	Scope of Change	Impact on Making New Car
Chassis	More complete shape and better aerodynamics, Use of lighter materials, increase aerodynamics	Complete change	High
Control System	Software: Two-way communication with the SMC, possibly using CAN-bus!	Complete change	Mid
Engine Plates	Weight reduction	Slight change	Low

Table 2 - Improvement Points of DNv Fuel Fighter

This table helped project manager to know which type of planning approach is suitable for various parts or systems of the future vehicle. If the scope of change is not huge, then feedback planning but if complete change is expected feed-forward planning was used.

For accomplishing this stage through SEM 2012 project, following processes were carried out: developing individual management plans, creating work break down structure, scheduling project, budgeting and risk identification and management.

Individual Management Plans

Why previous leaders of NTNU's SEM team weren't totally successful for handling all project management knowledge areas? Why same level of management wasn't applied on various knowledge areas? The answer for these questions can be inferred from project reports of prior teams as following:

- Absence of management plans
- Unsuccessful efforts to properly implement management plans during project lifecycle due to lack of experience

Lack of experience is not avoidable factor since team members including project manager are chosen among master students who are not experts. According to available project reports, preceding team leaders preferred to decide upon the way of managing different processes right before their executing time. This approach caused various troubles for team leaders such as losing track of time, inefficient data distribution and communication. Avoiding similar difficulties, project manager needs to think about strategies to manage and control different knowledge areas (scope, time, cost, communication…) before starting with any course of actions. Not only experience is an important factor to develop strategies (individual management plans), also stakeholders' opinion and comments, lessoned learned from preceding projects and university's policies are key factor to build a basis. Project manager shall not consider planning processes as one time tasks while request changes from stakeholders or project team, unexpected events and feedbacks from executing and monitoring stages make reviewing and revising plans repetitively critical. Precluding lack of enough time to proceed with other project's stages, it is important to spend sufficient time on planning processes. Therefore, based on importance of project and required level of management, project manager needs to think how detailed the initial plans should be. By taking progressive elaboration into account, making a comprehensive and

perfect plan on inceptive steps which demands a lot of information is misleading point of view about planning project. Following individual plans were generated for SEM 2012 project, after few modifications:

Time Management Plan

Team members have to read previous project reports and choose their role in project within two weeks after introductory session. Next two weeks should be assigned to think about master plan of different systems of vehicle and project's goal needs to be defined during this time. A week after by taking team members' individual plans into account, team leader has to propose an initial schedule. Project schedule should be realistic; meaning using large leads, lags or slack is not approvable. Proposal may be reviewed and modified by team during group sessions and be finalized (baseline) in one week. SEM 2012 will have deterministic weighted schedule. The schedule shall contain work breakdown structure in two levels (excluding level 0), estimated duration of each work package, relations among them, their weight factor and list of important milestones. Preventing complexity and delivering easy to understand schedule, resource allocation will not be considered in schedule's network calculations. For accurate and realistic result out of project schedule updating work packages have to be weighted. Project manager is responsible for breaking the weight factors and assigning them to project schedule elements. Microsoft Project 2012 is going to be used as time management tool. For tracking time, each week team members have to send a summary to project manager that includes 'what they have done' and 'what they will do'. Project schedule will be updated and be compared with baseline based on received summaries. Among different updating approaches available in Microsoft Project 2012 software, recording elapsed actual duration will be used. Results of weekly evaluation have to be communicated with authorized stakeholders. These weekly reports shall cover the status of project, roots of variance and forecasts to be illustrated with tables, charts and especially S-curves. This plan can be altered by any change request confirmed by project manager.

Cost Management Plan

Project team is responsible for developing list of activities in order to estimate demanded financial resources. Proposed budget for securing sponsors shall be calculated by bottom-up approach. Rough estimations from team members have to be aggregated to calculate required funds for higher work packages. Contingency reserve has to be considered in final approximation

of proposed budget. This reserved will be evaluated for each level 1 work package. If project team is not successful to gather funds as enough as proposed budget, project manager is responsible to do top-down budgeting based on available money after securing sponsors. Project manager has to have a categorization for different cots within project to have better control over them. Spent amount of money on each system of vehicle needs to be communicated with project manager by weekly summary. Project manager is in charge of generating clear report of financial status of project that includes comparison of actual expenses and baseline (budget) for each work package. Any purchase that values less than 1500 NOK can be carried on without project manager confirmation. Project manager has authority to block further procurement and money transaction of work package if associated budget is reached its limit. As reviewing money transactions and tracking expenses is essential, project team members must preserve procurement documents appropriately.

Communication Management Plan

Apart from any communication which includes technical data, team leader shall be the hub for any external communication and responsible to distribute information to right person in team. Due to the fact that reviewing history of communications may be necessary any time in future, project team has to avoid relying on exchanging information via telephone or any other methods that they are not traceable. Using same email address (e.g. NTNU's) for any communication is imperative. In case of sharing information with whole team, individuals can use either shared project calendar on Google or using project mailing list. Precluding misunderstanding, interchangeable information must be clear and easy to understand. Language of all different types of communication (verbal and non-verbal) should be English. This plan can be altered by any change request confirmed by project manager.

Risk Management Plan

Project manager and system engineer are responsible persons to handle project risks. System engineer may define risks in different systems of the vehicle by involvement of other team members to prepare risk register. Project manager has responsibility to assure that not only technical risks but also organizational risks are considered. Preventing confusion, only qualitative risk analysis will be performed to determine the likelihood and impact of each risk. With help of other members, system engineer is in charge of preparing preventive or mitigation actions. Reviewing risk register has to be done each two weeks to ensure proper monitoring. All

team members are in charge of reporting emergence of new risk by weekly summary. If required, both project manager and system engineer have to make sure risk response is applied completely. Risk register may be updated anytime during project planning and executing by anyone in the team. In order to communicate status of project risk, online shared spreadsheet on Google Document platform will be made to simplify data gathering and distribution. This plan can be altered by any change request confirmed by project manager.

Although these plans were improved and detailed by passing time but due to lack of enough information at start-up to create comprehensive framework, above mentioned plans sufficed to make a foundations for managing different knowledge areas. Collecting individual plans result in cohesive structure that is called 'project management plan'. Project management plan is endorsed, confirmed, live document that defines project requirements, determine expected outcome, and lead project execution and control. This document is integral point of team leader's responsibility and s/he needs to receive the approval from key stakeholders and the commitment of team members on its content to solve further conflicts as it becomes project control reference.

Individual Plans Challenges

By defining individual management plans, team leader determines what have to be done during project life cycle. By this mean, s/he specifies a framework which team members are expected to perform in. Apart from feature of the plans, strict or easy to deal, detailed or abridged, project manager shall not assume all of team members will accept management style right away. The point about SEM project that shouldn't be neglected is how individuals form the team, voluntarily. Therefore project manager cannot impose own preferred style of management plans to team members because it might have negative impact on team performance or in the worst case may result in disbanding of one or more members which put the project in huge danger. Confusion, rejection or not having same comprehension of project management plans, from team members was one of the challenges during planning stage of SEM 2012 project. Due to facing rigid deadlines, responsibilities and clear expectation from project manager, team felt limited and tried to bring comments in order to alter the content of plans and make them easy to deal which mostly result into less structured arrangement. Although some opinions were considered but project manager put endeavor to give the understanding of why individual plans are required and essential to handle project in integrate manner. If it is required, one-on-one meeting with each team member should be held to ensure same level of comprehension is shared among them. Not

following same path for reaching goal or working out of project scope are possible outcomes if team doesn't not work in predefined framework. Important rules and deadlines shall be printed and put on the wall or a place where everyone can easily see them as oral communication is not reliable method for conveying important information that need to be last till end of project.

Creating Work Breakdown Structure (WBS)

Work breakdown structure is a hierarchical arrangement which shows how the project work is decomposed to manageable and understandable pieces. This structure visualizes the project scope; meaning it defines what is and is not going to be done and delivered during with project life cycle. As all of required steps to accomplish project has to be determined in WBS, missing a work package may cause unfavorable consequences. Depending on project manager's preference and the purpose of executing project, WBS may be created in several ways. Garcı´a-Fornieles et al. (2003) have introduced following approaches (classifications) for making WBS: product oriented, process or functional, organizational, project life cycle, geographic location of people. Suitable WBS is not only a tool for understanding scope; also it is useful to estimate time and budget. Furthermore, work breakdown structure provides holistic view of project to stakeholders which help them to comprehend what project team is going to do. Jung and Woo (2004) stated that the WBS provides a common view toward project for involved parties and it provides shared project language. Based on importance of the project, manager has to decide upon proper level of detailing in WBS. Level of detail has influence on how project cost, duration and technical complications will be taken care of. In another word, it deals with the manageability of WBS segments. Reaching the smallest (lowest) elements of WBS makes more information available but it is also has to be considered that it requires more data processing and calculation. Besides, sticking to high level work packages makes the road of achieving goal vague and less comprehensible.

Based on the project goal, functional work breakdown structure was chosen for SEM 2012 project. Different systems of final deliverable (vehicle) were assumed as high level work packages and almost same logic was considered for decomposing them: specifying reusable parts from previous vehicle if it is possible, making a list of general requirement for the system, conceptual designing, finalizing design of system, producing and/or purchasing of parts. Avoiding confusion, WBS was detailed down to two levels (excluding level 0) and supporting efforts such as PR and media activities or team building sessions cannot be found in WBS

because this type of efforts didn't have influence on scope of final deliverable but they are considered in the project schedule as milestones. Although more levels were prepared by team members to not miss any single task for delivering a system, but including them in work break down structure was totally unnecessary as they could make time tracking, budgeting and resource planning complicated. In presence of other team members bottom-up assessment was done to assure all deliverables and tasks are involved. Tasks related to work breakdown structure of SEM 2012 project was created as following. Due to lack of information regarding time and place of testing the vehicle as integrated whole, this task is not mentioned in WBS and considered as milestone in the project schedule.
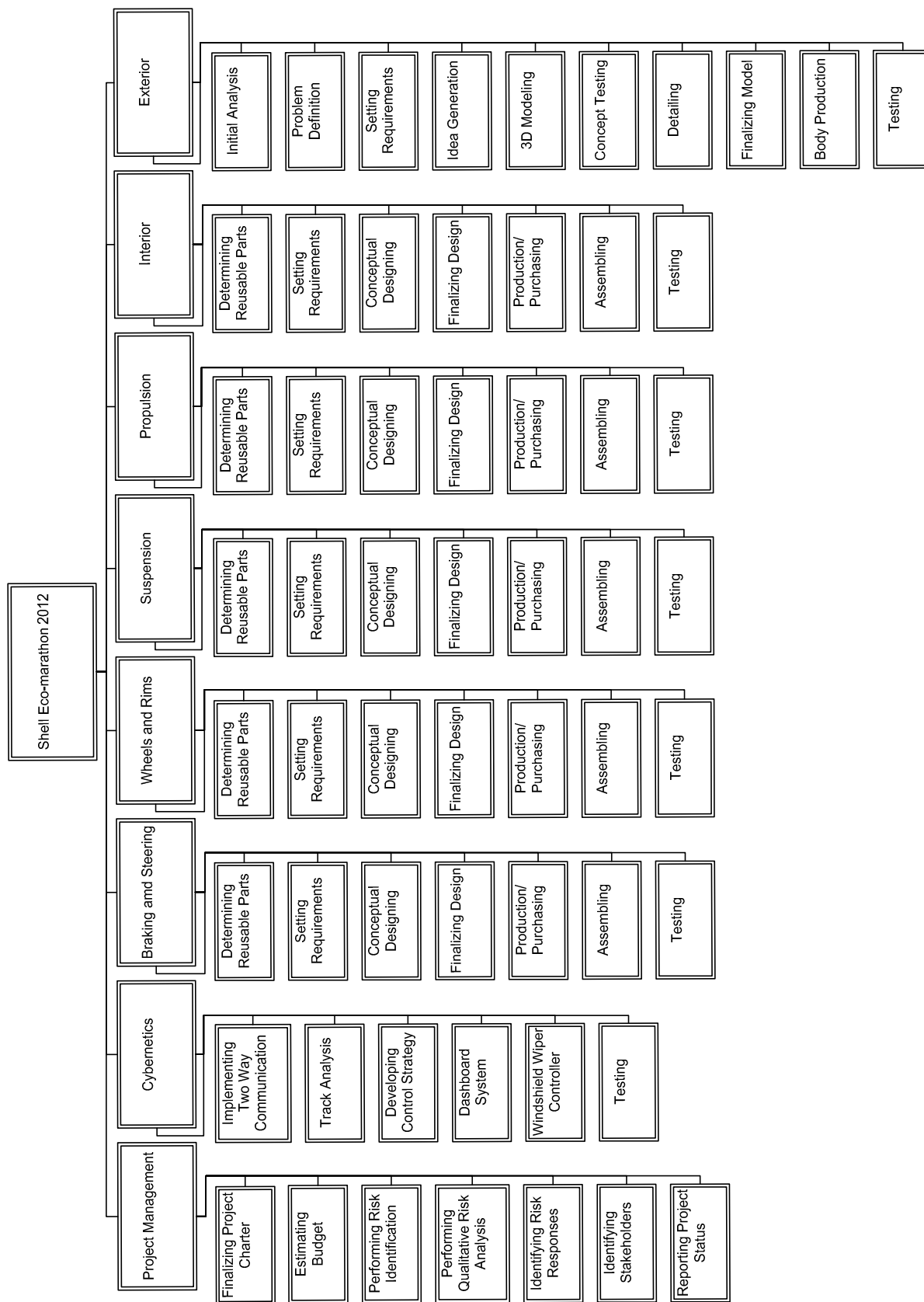
Figure 6 - SEM 2012, Work Breakdown Structure

Scheduling Project

"Develop schedule is the process of analyzing activity sequences, durations, resource requirements and schedule constraints to create project schedule" (PMI, 2008). Project schedule has different types of elements which may be used based on scheduler's choice, but following components are essential:

- Activities: Lowest level of work breakdown structure also known as operation or tasks which are steps to accomplish work packages. Time, budget and resource can be allocated to this element.

- Milestones: A milestone is a principal event that mostly indicates completion of a deliverable or a major step during project execution.

- Precedence relations: This element shows in what sequence activities or milestones shall to reach the goal. Four precedence relations in scheduling are: Finish to Start (FS), Finish to Finish (FF), Start to start (SS) and Start to Finish (SF).

Before start with scheduling, the project manager needs to decide upon the approach for generating the framework. Generally, two approaches exist:

- Deterministic: Assuming fixed duration for project schedule's elements is fundamental of this approach. Two methods are widely use in this class: Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT). By using CPM, duration of task or work package will be a single number which is derived from past similar projects or technical opinion of experts. In PERT, three numbers, optimistic (minimum) time, most likely time and pessimistic (maximum) time, are generated for estimating duration. As this method uses predefined probability distribution (beta) that results into definite value, it is classified in deterministic approach.

- Probabilistic (stochastic): in this approach, a unique statistical distribution curve is assigned to each activity or work package which determines the duration by generating a random number from defined curve.

Each approach has its own advantages and disadvantages. Deterministic approach is easy to do and understand. It needs less time and knowledge compared to probabilistic approach. But according to Pohl and Chapman (1987) deterministic scheduling is unable to take uncertainty into account and it leaves no opportunity for project manager to handle it. Although stochastic scheduling aims at considering uncertainty of activity or work package, but this approach needs

considerable experience and knowledge and it takes more time to make a framework compared to deterministic one.

Project manager has to put enough time to prepare a flexible schedule that covers entire scope of project, nothing more or less. Project schedule is a framework to include essential elements that without them the objective is not attainable. This framework shall contain tasks or work packages which estimating time, cost and required resources for them is feasible. Supporting tasks such as public relation and media activities is recommended to not be taken into account during scheduling because they are not dependant on specific duration, and mostly not schedulable. Activities with this attribute are called 'Level of Effort' (LOE). Project schedule components have to have unique and clear name. This makes it more understandable for anyone and also it helps the project manager in time of filtering or grouping segments.

According to PMI (2008) three types of dependencies may be used during scheduling. Dependencies determine precedence relations.

- Mandatory: mandatory dependencies are constraints which are forced by nature of the work

- Discretionary: Discretionary dependency, also called soft logic, is restriction applied based on scheduler's logic in order to handle elements better.

- External: external dependency is limitation from outside of project team such as stakeholders that might influence the schedule.

In time of defining precedence relations, all activities and milestones have to have successor and predecessor expect first one which doesn't need predecessor and last one which doesn't need successor. So, it is logical to say that all activities and milestones should have at least on FS or SS relation with predecessor(s) and at least one FS or FF relation with its successor(s). It is project manager responsibility to review all relations in order to ensure that none of the elements is dangled. Independent elements cause inaccurate tracking over schedule in time of updating it. Misusing leads and lags for compressing or giving float without any strategy will decrease the authenticity of the schedule as it won't show the real condition.

Although assigning resources makes schedule more professional but it should not be always an option as also it makes the schedule more complicated and hard to comprehend. Therefore, for preventing bafflement, if resource management is not important, resource allocation is better not to be done in project schedule. Kolisch and Padman (2001) have defined two categories for project resources: renewable and nonrenewable. Renewable resources are available within

specific period e.g. manpower. Nonrenewable resources without time restriction are accessible as long as project runs e.g. project budget.

SEM 2012 had deterministic schedule. CPM method was used to determine work packages duration. This option was chosen due to short available time for making schedule and build easy to understand framework for involved parties. Estimating time was done for level two work packages. Based on detailed breakdown that each team member possessed for related system, approximate duration for each work package was appraised. Summation of rough numbers from team members and reserved slack time for each work package was considered as project duration. Project manager should be aware that team members mostly try to assume the best condition in time of generating values. So, it is up to him/her to think about time safety margin for each component or whole project to avoid lack of time and having buffer in order to respond risks or deal with uncertainties. Milestones were used in two situations: For significant steps through project such as 'body mold is available' and when team had no control over task's duration in which it was totally depended on external entity such as sponsor. Following picture shows how milestones were arranged in schedule. Based on experience and information from interviews with team members that provided more technical insight, project manager defined the relations among work packages. All three types of dependencies were considered during scheduling. The most influential dependency was external one from DNV (main sponsor) and

98			⊟ **Important Milestones**	**155 days**	**Wed 28/09/11**	**Tue 22/05/12**	
99			Initial contacting-old sponsors	0 days	Wed 28/09/11	Wed 28/09/11	1
100			Meeting with old sponsors / Finding new sponsors	0 days	Mon 31/10/11	Mon 31/10/11	99
101			Finalizing contarct with sponsors	0 days	Wed 30/11/11	Wed 30/11/11	100
102			Finalizing Recruitment	0 days	Tue 15/11/11	Tue 15/11/11	1
103			Finalizing contract with main sponsor	0 days	Tue 01/11/11	Tue 01/11/11	1
104			Ordering Carbon Fiber	0 days	Mon 23/01/12	Mon 23/01/12	9
105			Carbon fiber available	0 days	Mon 06/02/12	Mon 06/02/12	104FS+2 wks
106			Order mold material	0 days	Mon 23/01/12	Mon 23/01/12	9
107			Mold material available	0 days	Mon 06/02/12	Mon 06/02/12	106FS+2 wks
108			Odering body mold	0 days	Mon 06/02/12	Mon 06/02/12	107
109			Body mold available	0 days	Mon 06/02/12	Mon 06/02/12	108
110			Car Testing Starts	0 days	Mon 16/04/12	Mon 16/04/12	14,22,30,46,54,6
111			Car Testing Finished	0 days	Mon 07/05/12	Mon 07/05/12	110FS+3 wks
112			Preparing For Rotterdam Trip Finished	0 days	Fri 11/05/12	Fri 11/05/12	1
113			Having Trip To Rotterdam	0 days	Mon 14/05/12	Mon 14/05/12	112FS+2 days
114			Coming Back From Rotterdam	0 days	Tue 22/05/12	Tue 22/05/12	113FS+8 edays

Shell (competition holder) that imposed strict deadlines on project. SF relation wasn't use at all and maximum duration for leads or lags was 4 days. Before proposing the schedule, all work packages and milestones were checked to be not dangled. To have accurate and realistic result from upgrading the schedule, SEM 2012 had weighted timing framework in which, each work package was given a value, according to its importance and duration. The total of weight factors shall be 1 or 100. Following table shows how weight was distributed among different elements of schedule. Important milestones item has the most weight, as very important elements such as testing the vehicle is included in it.

Name of Work Package	Weight
Exterior	14
Interior	9
Propulsion	11
Suspension	12
Wheels and Rims	9
Braking and Steering	9
Cybernetics	11
Project Management	8
Important Milestones	27
Total	**100**

Table 3 - Weighting Work Packages

Group session was held with entire team to review project schedule and ensure all relations within a system and among systems of the vehicle have correctly set. The outcome of this meeting was the baseline. S-curve related to the baseline was sketched afterwards in order to be a tool to compare actual performance with planned one. According to time management plan, Microsoft Project (MSP) 2012 software was chosen to implement the framework. For sketching planned S-curve which showing expected cumulative progress, two new columns were defined in MSP file, 'Weight Factor' and 'Weighted %Complete'. Following formula was set for Weighted %Complete column:

[% Complete]*[Weight Factor]/100

By updating the project schedule weekly in the software (moving status date), MSP calculates %Complete column (cumulative progress) based on proportion of elapsed duration to total duration. But this doesn't count the importance of the element into account. That is why Weighted %Complete is more realistic value to rely on. Planned S-curve of SEM 2012 project including weight factors was sketched as below:
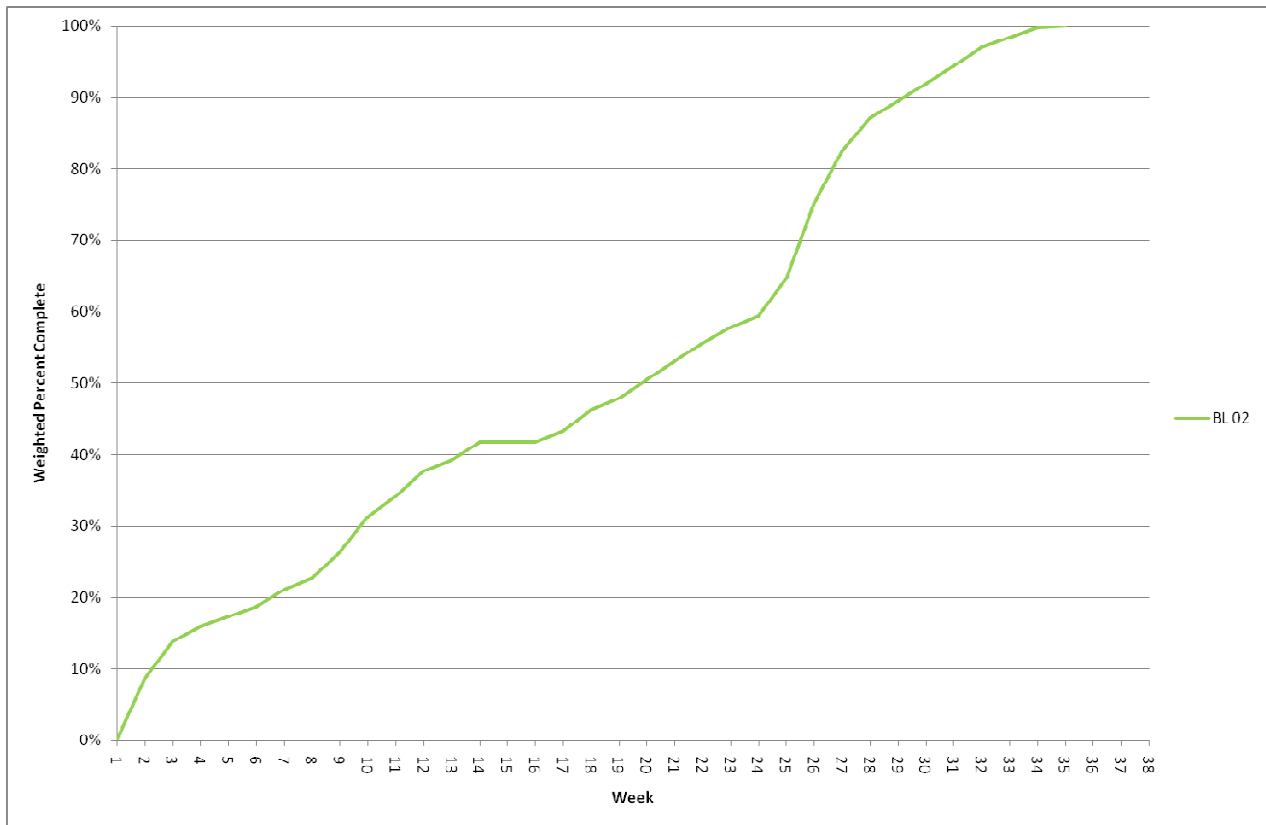
Figure 7 - SEM 2012, S-Curve

As it is shown, no progress is expected between weeks 14 to 17 due to the Christmas break. The slope of S-curve is considerably increased between weeks 24 to 30 because the work packages with huge weight factor had to be accomplished in this period.

Scheduling Challenges

How the best fitted schedule for project can be developed? Answering this question is a challenge for project manager during scheduling. Scheduling a project should be done by considering its resource, activities and performance measure characteristics. If project manager doesn't put enough thought on identifying what is the status of three mentioned factors, s/he might have a result that is not realistic. Herroelen et al. (1997) have mentioned that for dealing

with complexities during scheduling, knowing its three features is essential. According to them, three elements shall be assumed for resources to analyze them properly:

1. number of resource types which can be zero, one or more than one
2. whether the resources are renewable or non renewable and their accessibility time period, if it is for whole duration of project or specific one.
3. Availablity of renewable resources if it is in constant amounts or in variable amounts.

Six elements are recommended for understnding the activties' attributes:

1. If activities can be resumed in time of interruption or not
2. Constraints between activities that can be mandatory, external or discretionary
3. The network of activities is probabilistic or deterministic
4. Activities duration that can be random integer number, or random continuous duration or all tasks have same duration equal to T_d
5. Project deadline, which means if there is no deadline, there is deadline imposed on activities and there is deadline on the whole project
6. If cash flows are considered with activities or not. Both amount and timing of cash flows can be arbitrary or predetermined numbers.

Regarding performance measures, project manager shall know if penalty functions for delivering the final product, result or service in due time exist or not. Former condition is called regular and latter is named non-regular measure. Minimizing the project delay is an example for regular measures and maximizing quality of the project is an instance for non-regular measure.

Analysis of SEM 2012 project schedule by considering resources, activities and performance measure characteristics are as below:

*   Resources: project had two types of resources, work and material. Both renewable and nonrenewable (with variable amount of availability) resources were accessible for limited and specific period of time.
*   Activities: SEM 2012 project had deterministic schedule. Both resumable (testing a system) and non-resumable (producing monocoque) activities were taken into account. Also project manager thought over three types of contraints in time of defining relations among tasks. All of activities had integer number as duration which weren't random as

they were calculated based on members' judgement and historical data. Non of tasks had specified deadline but project had strict deadline of May 17, 2012 for competing in the race.

- Performance measure: Schedule of project were developed based regular measure, minimizing the project tardiness.

Budgeting

According to Huang and Xu (1998) best solution for financing projects with high uncertainty is external subsidization. This is exactly how SEM project is financed every year. It is up to project team to find sponsors for project and university plays no role in supporting project financially. Kamien and Schwartz (1978) indicated two main difficulties with external financing compared to self-financing for project associated with high uncertainty:

1. Finding external sponsor may be hard in such endeavors because if the project fails, few tangible assets will be left which lender can make claim on them.
2. Receiver of the fund may reveal some information about project which might be valuable for existing or new rivals within lender's business.

For attracting external sponsor(s), project team has to calculate proposed budget which will be the basis of financial negotiations in further steps.

An estimate should be calculated for all project works or any element of project schedule that needs financial resource to be taken care of. This estimation that has to be approved by key stakeholders is the budget. Taking all project costs into account is essential for budgeting. Project manager has to classify costs in order to not miss any and have better control over them. There is no single categorization logic for grouping them and suitable approach may be chosen depending on project condition. As unexpected events which burden extra costs on project happen during execution, contingency reserve shall also included in budgeting process. Contingency reserve is critical financial resources to reduce the risk of cost overrun. For estimate the reserve, project manager needs to go through the result of qualitative or quantitative analysis of risks. By considering the risks that have significant financial impact on budget, required fund can be estimated. There are two approaches for calculating demanded money to finish project work: 'Bottom-Up' and 'Top-Down'. In bottom-up approach, cost estimation has to be done for the lowest level components of work breakdown structure. Then estimation of activities which are

related to same work package shall be summed. By continuing this, essential fund for the highest level of WBS can be calculated. This approach has following advantages:

- The most important advantage of this method according to Venkataraman and Pinto (2008), is forcing project team to make detailed breakdown structure at planning stage
- Within this approach, as the knowledge of all involved persons in project, even those who are responsible for the lowest level activities will be used for such important process; motivation of team members will be increased due to feeling of involvement with project.

But this method has also down side:

- By applying this method, the role of project manager (or top management) in such critical task will be reduced at first steps as team members in lower level of hierarchy who has the responsibility of activities shall estimate the costs and project manager has no control over the process till analysis are presented.
- The chance of overestimating within bottom-up approach is higher compared to top-down because project team members might tend to exaggerate the cost in order to increase the flexibility.
- By considering before mentioned characteristics, repetitive adjustments to have best estimation is expected and this makes bottom-up approach is time consuming

In bottom-up approach, demanded financial resources is calculated and then provided but in top-down approach, project team has to deal with predefined amount of money that has been allocated to project by upper managers and try to proportion it appropriately among high level work packages and this process continues to the lowest level of WBS. Top-down method has following advantages:

- "The advantage of top-down budgeting is that top management's estimate of project costs, in aggregate terms, often tend to be quite accurate" (Venkataraman & Pinto, 2008).
- On contrary to bottom-up approach, project manager has full control over disaggregating the budget to work packages, which results in more accurate estimations and cost control.

Disadvantages of this method are as mentioned below:

- Project costs might be underestimated due to cost saving.
- Experience is essential to perform this method. If project manager doesn't have enough knowledge or understanding about work packages and related activities, improper fund allocation is largely possible.

SEM 2012 project costs were classified into followings:

- Direct costs that are particularly related to activities on project. Following items are included in this category:
    - Human resource costs: this includes salary of two team members that had to be paid because of their student assistant contract with department.
    - Material Costs
    - Operational Costs
- Indirect costs which do not have direct impact on the work of project. Mostly, administrative expenses are put in this category.

Budgeting this project requires both bottom-up and top-down budgeting approaches. First for negotiating with sponsors, project team needed to come up with proposed budget. In this order based on historical data from previous project reports and team members' judgments, rough calculations were done for WBS work packages. Using bottom-up approach, the proposed budget was estimated at 1,095,000 NOK including contingency reserve. Following table shows more detail about it:

Budget item	Planned Cost (NOK)	Contingency Reserve (NOK)
Propulsion	150,000	20,000
Exterior	300,000	50,000
Wheels and Rims	55,000	5,000
Suspensions	110,000	20,000
Braking and Steering	15,000	5,000
Interior	10,000	5,000
Cybernetic	50,000	10,000
Shipments	40,000	10,000
Trip to Rotterdam	142,000	8,000
Misc.	40,000	0
Safety Margin		50,000
Total	912,000	183,000

Table 4 - Bottom-Up Budgeting
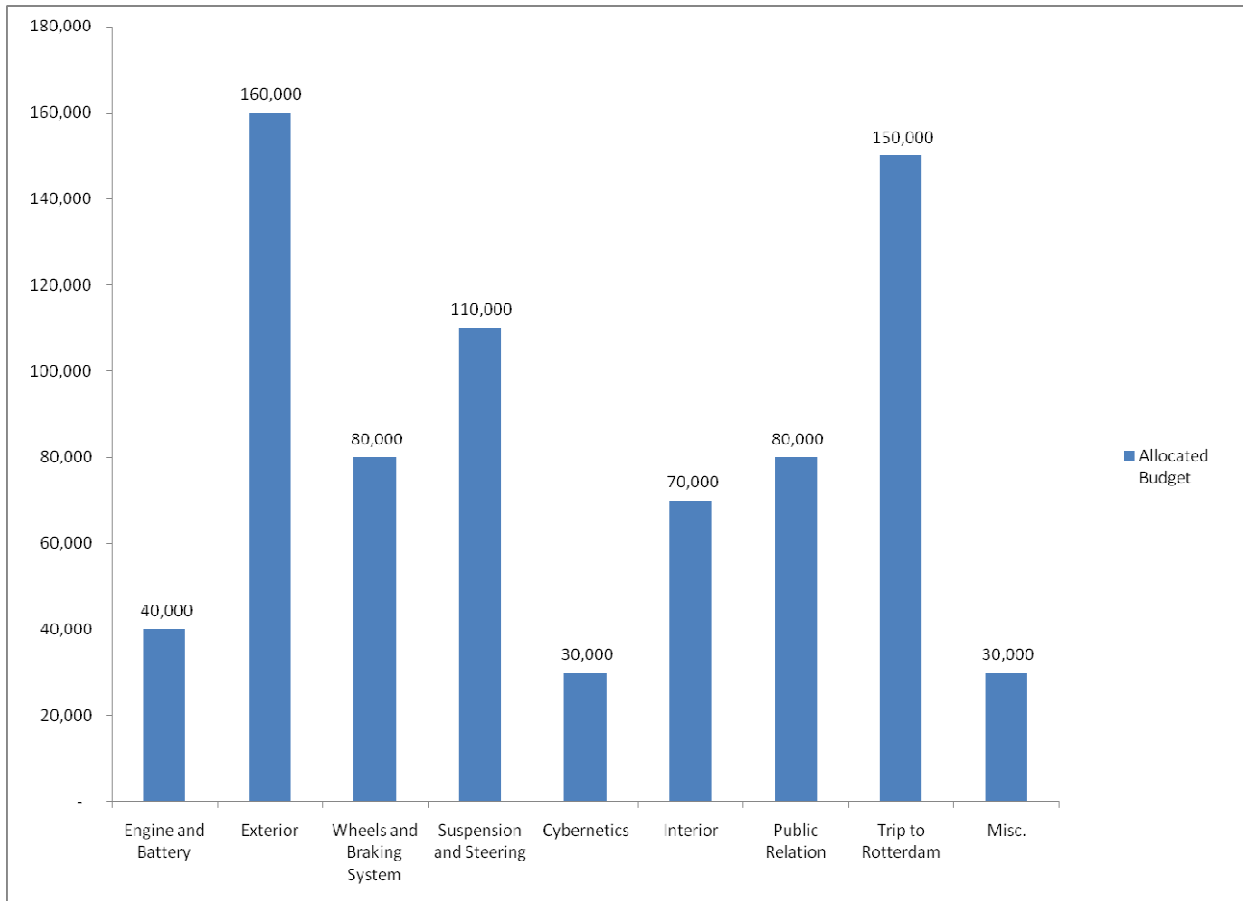
Figure 8 - Top Down Budgeting

Lots of efforts were put by project team and manager to secure sponsors in order to decrease the amount of demanded money in different items of the budget. Beside, by gaining more information about structure and design of various systems, team found overestimating in some items which was expected after utilizing bottom-up approach because for not facing any trouble individual's assessments were associated with high uncertainty. At last, NTNU's team could receive financial contribution from Det Norske Veritas (DNV) at 600,000 NOK (main sponsor) and Transnova at 150,000 NOK. As taken funds were less than what team planned for, budget was revised by top-down approach by project manager. Practicing this method, available fund was distributed among high level work packages which resulted in following figure (cost baseline).

Risk Identification and Assessment

An undetermined event with either positive or negative impact on project is called risk. One of the critical responsibilities of project manager is ensuring that project's risk are identified and assessed. Registering risks and their characteristics should be performed as first step. Involving

project manager, project team and stakeholders in this step is crucial. Team members' participation is important as they have to take responsibility of determined risks and their responses. Involvement of stakeholders is critical that they provide supplemental goal information. Identifying risks and making associated plans to respond them for whole project life cycle at planning stage is not possible as new risks emerge during project advancement. Because of this, project management team should analyze the status of project iteratively in order to be sure that all kinds of risks are considered. Project feature (low/high uncertainty) defines how often such analysis shall be done. According to PMBOK (2008) five processes can be accomplished in planning stage to follow best practices in risk management area:

- Plan risk management: within this process, project manager define how risks are going to be handled through project life cycle. Importance of making this plan is having an accepted basis among team members to evaluate undetermined events. Risk management plan is explained in *section*

- Identify risks: result of finishing this process is a list of categorized risks. Chapman (2002) has stated that although present models and methods in project management make valuable tools available but still experts' judgments are the key input for identifying project risks. This process is fundamental for all of risk management efforts; therefore is accuracy is very important. Various methods are available for gathering such inputs. Chapman R. J. (1998) has classified all methods into three groups:
    - Identification managed by one risks analyst e.g. reconsidering historical data
    - Identification performed by analyst interviewing project's key players
    - Identification conducted by presence of all key players in form of group sessions that is leaded by analyst e.g. brainstorming

From above mentioned classes, first and third were used in SEM 2012 project. First, different engineers based on historical data from previous years' reports and their experience, tried to list risks associated to systems that they are responsible for. Afterwards, by using scenario building (analysis) technique in group sessions leaded by project engineer and supervised by project manager, risks related to system interfaces were determined. By using this technique various possible events and their outcomes were identified. While scenario building, doesn't count historical data and it doesn't include them into assessment; but it provides a picture of future which is linked to past.

Beside technical (low level) risks, team members and project manager identified managerial and organizational (high level) risks which are mostly connected to team, its performance and managing project.

- Perform qualitative risk analysis: The purpose of following this process is organizing of identified risks in order to enhance execution of project by concentrating on high-priority risks. High-priority risks are those which have significant impact on time, cost and quality of project. For deciding how critical each risk is, two criterions are used: probability and impact. For assessing subjectively, a scale shall be defined for each parameter in order to have common understanding of rating system. Depending on project manager and project feature defined structure for scales varies. Often, 'High, Medium, Low' or numeric '1-10' scale is used for measuring both probability and impact of risk, if occurred. Project manager needs to be aware that in qualitative assessment "risk is relative to the observer" (Kaplan & Garrick, 1981). Specified risk characteristics may differ from one team member to another as the knowledge and experience of the observer are important factors in organizing risks. Probability and impact matrix was used in order to accomplish qualitative risk analysis in SEM 2012 project. Numeric '1-5' rating system was fixed for assessing two parameters of each risk. Numbers have following definition:

Scale	Probability of occurrence/Impact	Related Color
1	Very Low	
2	Low	
3	Medium	
4	High	
5	Very High	

Figure 9 - Risk Scaling

This tool helps project team to know which risks need immediate response and which ones needs to be reviewed later as they are not critical. Qualitative risk analysis has some advantages and disadvantages. Startienė and Remeikienė (2007) have indicated followings as its advantages:

- It is useful when enough experience is not avaliable

- It is flexible as scales can be altered easily because no complicated calculations exist behind them
- It is less time consuming and cheaper compared to quantitative risk assessment

But this approach has following downsides as well:

- Less precise compared to quantitative approach because results are shown in subjectvely manner.
- Cost-benefit analysis cannot be done with outputs from this method

- Perform quantitative risk analysis: for accomplishing this process, team tries to quantify the likelihood of risk occurrence and its impact that mostly measured in terms of currency. According to Apostolakis (2004) this approach has following benefits:

  - Delivering thorough comprehension of system failure manners by considering significant number of scenarios include different style of failures.
  - It is unified method, so determining the requirements from various disciplines involved in project.
  - By using this approach, the chance of taking intricate interactions between systems and operators into account will be increased.
  - Unlike qualitative risk assessment approach, output of quantitative method can be used in cost-benefit analysis.

  But this technique has following limitations:

  - Not modeling human errors in time of facing risk
  - Not considering the culture of people who have the responsibility of handling the risk, as it is influential factor in how individuals will react when accidents happen
  - Not taking design and production errors into account.

  This approach wasn't used in SEM 2012 project because: it is time consuming and team members didn't have the experience and knowledge about following quantitative risk analysis.

- Plan risk responses: Considering the outputs of identify risks process and all possible upcoming and expected events, team members developed mitigation actions individually (for responsible system) or in group (for interfaces of systems). Also, project manager build a list of responses for managerial and organizational (high level) risks.

Risk Identification and Assessment Challenges

There is no guarantee for reaching expected outcome out of group sessions that are dedicated to risk identification and assessment. What makes it uncertain is the group effectiveness during meetings. This is a challenge for project manager to comprehend the status of team's effectiveness and make proper decision if it is low. This evaluation is very critical because in time of low efficiency, not only time is wasted but also the results are not reliable and the chance of facing troubles during project advancement will be increased if risk management processes are based on untrustworthy judgments. Chapman (1998) has developed a model for evaluating group efficiency. According to model three factors can be assessed related to group sessions: 'The Givens' and 'Intervening Factors'. In his paper each factor is detailed into few determinants but in this report only those that are connected to the project are discussed.

- Givens: this feature describes the status of the group, the tasks and the environment that are inputs for risk identification and assessment.
    - The group: size of the group matters. Although increasing the number of the group for each session guarantees the involvement of various disciplines and knowledge but project manager should be aware that this might result in decreasing the individual contribution. Compatible members shall be present in meetings. Discordant members will decrease the effectiveness of group work. While productivity of sessions is the common goal for all participants, project manager shall have this awareness that members may try to include their personal objectives as well e.g. imposing own interest or trying to grab the lead. Therefore, an unbiased person who has enough knowledge to guide the meeting should be present.
    - The tasks: team leader must be sure that team members take their responsibilities seriously and handling various tasks is important for them. Individuals show more commitment if they consider the task prominent. Lucidity of the tasks is important factor on group effectiveness as well. When the expected performance and outcome is less ambiguous for participants in a meeting who have same level of comprehension about what they have to do, effectiveness will be increased.
    - The environment: it is important that participants in risk identification and assessment meeting feel that the location of session is proper. Quiet room that has

enough facilities where people can find a comfortable seat gives good sense to team member and they can carry on the tasks in effective way. Members don't want to spend their time in assemblies in which the outcome of it is not communicated or put into effect. Therefore, team leader or director of meeting should provide an environment in that participants feel its significance for project e.g. to hold the meeting in structured or organized manner.

- Intervening Factors: the most important item in intervening factor is motivation. Risk identification and assessment sessions should be presented by team leader in way that team members wish to be part of them and approve the objective of meetings.

For SEM 2012 project, risk identification was done by individuals and in group for ensuring, each team member benefits of own contribution and team work. Meetings weren't held for more than five members including system engineer as director. Director had the knowledge about technical group gathering to not let the members distract the flow of proceedings by their personal interest. All of team assemblies were carried on in presentation room in order to provide appropriate physical location. Before each meeting, participants were informed about agenda and topic, so they could make their opinions ready. Minute of each meeting was prepared of system engineer to communicate the result with all team members with purpose of showing the importance of assemblies to them. Not only project manager explained the significance of this step to team members, but also director of meetings, clarify why project needs it and what the goal is. Therefore, everyone had clear and common understanding of process and its objective.

Project Executing

The executing stage comprises those course of actions executed to finish the work determined in the project management plan to fulfill the project requirements. For accomplishing this stage through SEM 2012 project, following processes were carried out: direct execution,

Directing Project Execution

Depending on type of project, management style varies for handling executing step. Project manager who has experience in leading construction projects cannot apply his/her experience on managing information technology project. Therefore, it is important that manager understands the context of project and try to choose the leadership manner based on it. SEM 2012 project is a new product development project. Tritle et al. (2000) have defined six steps for accomplishing new product development project: idea, concept, prototype, development, commercialization and termination. According to this, following steps were defined for executing SEM 2012 project:

Regular New Product Development Stages	Executing SEM 2012 Stages
Idea	Generating Product Master Plan
Concept	
Prototype	
Development	Product Development
Commercialization	
Termination	

Table 5 - SEM 2012, Executing Stages

Commercialization stage is not applicable to SEM 2012 project and discussion related to termination is not in the scope of executing project.

Generating master plan for new product is process of defining product strategy. Basically, through this stage, two questions should be answered, to what extent new product shall be changed compared to its precedent? Is new product going to have fewer systems and parts or not?

- Incremental vs. radical change: given time and available resources to accomplish a project are determent factors for making decision about the extent of change. Project manager shouldn't put the effort in danger of going with radical change if available time

is short; this increases the chance of failure. Zirger and Hartley (1996) have mentioned that proceeding with incremental change is faster in long term because of low technical uncertainty (less technical feasibility study) and safer because the project expectedly can be handled within schedule. As incremental change needs less necessary time, it provides a basis for learning to project team, so the leverage their technical skill and ability. On contrary, the probability of managing radical change with schedule is difficult because high technical uncertainty and long lead times. This flow requires significant time for feasibility study. Implementing radical change needs skilled experts from beginning, therefore less educational perspective can be found with it because team members cannot perfectly learn when substantial amount of data needs to be processed. Reaching to stakeholders' satisfaction is harder a long with dramatic change compared because if any external party to project ask for any modification, financial impact and amount of rework during putting considerable changes into place is high but when minor changes are performed gradually, stakeholders can follow the progress and any alteration can be executed with smaller effects. Project manager of new product development effort should be perceptive that incremental change is effective until it provides value in project outcome and satisfies stakeholders. If it is not the case, radical change must be considered as the only option.

- Number of parts: Another important point about product master plan is number of systems and parts. Project manager with team member's assistance should come up with proper decision regarding number of features of product by considering available resources and time. Engineers tend to build their desired product without thinking about deadline. So, it is up to project manager to direct this passion within schedule frame. Clearly, considering more parts means longer production time and according to Zirger and Hartley (1996), complex interaction among systems. In contrast, Clrak (1989) has mentioned, reduction the number of part doesn't always result in less complex and fabrication time. As engineers try to build a product with same (more) performance and with fewer parts.

After managing the processes related to generating master plan for product, project manager has to carefully and properly handle the product development process. Following points shall be considered in this regard:

- Overlapping vs. Sequential: After choosing proper planning method, feedback vs. feed-forward, team leader has to think whether in preferred frame, development must be accomplished sequentially or in overlapping manner. Following sequential method means, each stage of effort should be finished completely and handed off to next stage after in depth analysis to check whether the product of precedent stage meets the requirements or not. But, in overlapping manner, various tasks in project are carried out simultaneously. Overlapping activities in executing step will reduce necessary time for producing parts. Different systems will be built in parallel fashion and engineers will be able to communicate requirements through the process, therefore less time is going to be spent for compatibility analysis of various parts after their production. Also, this technique helps project team to determine possible problems early in the process which results in less redesign. Demanding significant capability in processing information is the downside of following development with overlapping style. Smooth and efficient communication channels should be provided for members to speed up processing. If appropriate basis is not available, team cannot deal with uncertainties during product development that result in low quality final product.

- Early freezing of design: Based on engineers' inclination to make the best outcome, they might stick with design of a system for long time or new features may be added by them through development process. Project manager should avoid engineers to fall into such cycle that increases the possibility of not meeting deadlines. Therefore, a time limit has to be defined for team members to finalize their systems until that time. Team leader has to ask them to freeze their ideas and opinion after the time limit and start with analysis of their system. Pushing the deadline for freezing of design to early stages of development, save time for technical evaluation of parts and systems to prevent late changes.

- Suppliers: Engineers may try to procure parts from various suppliers that offer the best quality of product. Although considering the best supplier ensures high quality in final outcome of project, but project manager should avoid team members to increase the number of suppliers without limit. This, results in facing different lead times from companies that makes the managing project difficult. Project team has to find supplier that offer as many as product required by project. Dealing with fewer companies makes managing the project easier especially when it comes to thinking over the lead times. Assigning any process from generating master plan to final steps of development to

suppliers, in economic manner, has been advised by Zirger and Hartley (1996) to decrease the number of purchases and better management of in contact companies. Another important point is supplier's location. Engineers may make orders to companies around the world. Project manager should carefully evaluate international procurements and check whether an alternative exists or not. Delay in delivering orders from suppliers that are located abroad is highly possible due to any problem with packing, posting and delivering.

Apart from managing processes, team leader has crucial responsibility which is directing human resources. Managing individuals through executing stage has significant impact on how efficient activities are accomplished. Therefore, by understanding the context of project and available competencies, project manager has to use different technique to lead project team. Followings are utilized in SEM 2012 project:

- Centralization: it is highly recommended to team leader to gather all of team members in one location (office or building). This makes communication and decision making easier. Centralization helps team members to increase the frequency and quality of communication as the possibility of face-to-face communication will be higher. Centralization will decrease written communication in which distributing information may counter difficulties such as misunderstanding.

- Delegation of authority: to appropriate extent, project manager may delegate authority in decision making to team members. One of the advantages of this technique is that team members will decide based on real or the most up to date information instead of waiting for approval. Sometimes crucial action must be performed instantly and lack of authority in member might put project in great danger. Project manager has to delegate the authority carefully, to not letting project team think that the method is for reducing own responsibilities.

- Stress and motivation: Regularly, projects are prompting because of group work and definite objectives. On the other hand, strict deadlines involve in project put its team under high pressure. Therefore, team's impression of a condition will be changed when events happen which might affect the project execution. Presumably, the project team experience stress and motivation during accomplishing tasks. Gallstedt (2003) has defined motivation as "a set of energetic forces that originate both within as well as

beyond an individual's being to initiate work-related behaviors, and to determine its form, direction, intensity, and duration". Mentioned pressure can have positive role in achieving project goal when the condition is challenging, but as soon as individuals feel that the burden is harmful and not joyful, negative impact will emerge. So, strict condition can be effective or obstructive. Happenings such as losing important resource, stuck with design loops, being dependant on assistance of one person and reasonable or illogical absence of team members that disturb steadiness may be noticed as stressors which might give rise to feelings of insufficiency and less self confidence that result into negative effect. Project manager must know that before starting with project execution, the stress is so high due to uncertainty. Proceeding activities, stress level will be decreased but in time of closing the project it will be intensified again. Overall, project manager has critical role in managing project team's behavior in order to keep the level of stress low and motivation high. S/he has to detect changes in individual's mood in order to cope with situation as soon as possible.

Challenges of Directing Project Execution

One of the challenges in executing SEM 2012 project was the centralizing team members. Three of students (two industrial design and one public and media) were had their desk outside of the project office. This resulted in poor communication among those and rest of team members. A lot of 'come and go' was necessary between departments in time of finalizing the design of monocoque and check whether it is compatible with other systems or not. Engineers weren't involved in conceptualization process along with developing other systems and they couldn't see it closely in order to make their opinion from beginning. Only one session was spent for brainstorming and selecting a desirable design out of three options. The reason from industrial design team members for staying in another place was lack of PC with proper specification at office. This problem wasn't solved as the responsible person for IT services couldn't provide demanded facility. Therefore, communications mostly were conducted by emails, shared spreadsheets and documents on server and Google platform. It is highly recommended to next project manager to try to provide all require facilities in order to gather all of team members.

How project manager can cope with perception of team members after an incident happens? Team members' contribution in defining and comprehending of project goal and their understanding of the time constraint to have realistic perspective are prominent. These two points

are related to individual's feeling about the project, whether they find the project inspiring or stressful. Dealing with incidents and their behavioral consequences can be handled in two levels by project manager, project (group) level and individual level. In project level, applying risk management practices to follow proactive procedure in order to deal with unfavorable events has important role in dealing with such adversity. Concentrating upon objective(s) causes motivation but altering any feature of the goal may give rise to stress. In addition, members' devotion and liability is in danger if the steadiness and well balanced environment of the project is jeopardized. It is also possible that individuals try to share their perception with other team members. This can either have negative or positive result. The situation might get worse if members cause more stress through sharing or it might get better when other peers try to deal without project manager intervention. Holding one-to-one discussion in stressful situation can be helpful method for project manager to handle these kinds of issues. Routine conversations between project manager and members could be used for this intention. Team leader should take the organization's context and personal characteristics of team members into account while trying to proceed with coping methods.

Recruiting Team Members

Staffing new product development projects such as SEM 2012 with dedicated and motivated members can be hard due to the characteristic of this type of projects which is significant uncertainty. Therefore, project manager shall have recruiting procedure in order to ensure that systematic method for developing project team exists. The case about SEM 2012 project is even complicated than normal situation. Individuals join the project voluntarily. Under this condition, project is highly dependent on response of university's students to get involve. Thus, the process is different compared to normal procedure as the authority for making decision will be switched from project manager to potential individuals. More involvement and commitment is expected from members who are joined voluntarily as they find the project interesting. "A person is more likely to take action (e.g., take an active part in a project), when that person feels that his/her behavior is self-determined rather than controlled and imposed by others" (Eskerod & Jepsen, 2005). Finding relevant competencies to project context is easier in this way. Thus, project manager doesn't have to take of time consuming task of searching and finding peers with related skills. But, this method has also downsides. Selecting team members based on their interest doesn't ensure that volunteers have proper skill or enough knowledge. Moreover, recruiting

voluntarily does not take project manager's power of choosing who can be part of the team. Besides, there is no guarantee that enough number of individuals will join and therefore there is always a possibility to not start with project.

Voluntarily Recruitment Challenges

How project manager can have a systematic way to attract peers to project and have them involved?

Recruiting a cybernetic engineer for SEM 2012 project was a challenge that took about 4 months to overcome it. At NTNU various departments that want to involve in project, introduce representative(s) as future team member. This didn't happen from cybernetic department at NTNU and team strictly demanded an engineer who can take responsibility of the vehicle's control system. After talking to number of professors in the department, team found out that the level of interest in students is low to join the team because of following reasons:

- Too much responsibility which is hard to handle as according to requirements, the vehicle needed new control system that should be developed from scratch.
- Students prefer to take options that increase their chance and opportunity to contact with companies in order to secure their career path
- Car control system was not attractive case

To cope with this problem, the sequential appraisal model of Shalit (1998) was used. His model describes three stages that enroller may pass before taking the chance to join the team. These three stages are: appraisal, mobilization and realization.

	Process phases		
	Appraisal	Mobilisation	Realisation
Cognitive	1. Is it?	4. Do I understand?	7. What do I do?
Affective	2. Does it concern me?	5. Do I want?	8. Will I commit myself?
Instrumental	3. Can I affect it?	6. Am I ready?	9. Do!

Figure 10 - The Sequential Appraisal Model (Shalit, 1988)

In the first phase, person tries to understand the project and its context. In the second phase, potential enroller tries to match the gained understanding to his/her knowledge and preferences.

Last phase will be for checking whether the responsibility can be taken or not. The first step for getting cybernetic students' was locating where they go, eat or study. Then posters(s) were pasted on information boards near to spotted locations which contain clear fact and information about project and what the team is going to do. So, after this, team was sure that information has been transferred to some students. The next step was contacting all of students in department by using mailing list. Assuming that some students already know about the project, this time by an email, the team explained how this project is connected to their knowledge area and how they can have an important role in it. For the last step, various team members went to find students in cybernetic department and talked to them one by one in order to give them a drive to join the project and answer their question to handle any ambiguities. Overall, the process is too time consuming and it was not efficient because at last an exchange students from Germany who was highly interested in car control systems joined the team via head of the department. Eskerod and Jepsen (2005) has mentioned factors that may affect on these stage. According to their paper, mobilization stage is the most criticalone when an individual try to bridge his knowledge and skill to what is expected from his/her out of project. Therefore, personal background is determent factor to pass through the process and accept the offer. Moreoever, their analysis shows that if person finds project time consuming, negative impact is anticipated. Basically, another explanation for not getting positive outcome from team members' try to attract a cybernetic student can be the project characteristics. SEM project has been defined for five years at NTNU and they might think working on such project is boring. Therefore, project team has important responsibility to present the effort in a way to overcome with false perception.

Developing Project Team

Before discussing about developing a team, project manager must know about different types of teams. Four common types of teams have been indicated by Hellriegel et al. (1997):

- Functional team: in this type, individuals with similar background form a team to accomplish daily mutually dependent tasks.
- Problem-solving team: Individuals with same competency (mostly) get together to find a solution for an issue. After solving problem, team will be disbanded (non-permanent).
- Cross functional team: employees from various departments with different skills, gather to take of activities in a project to achieve a common goal.

- Self-managed team: when number of employees work together and handle both managerial and technical perspectives of tasks by their own, they are called self-managed teams.

Common team development techniques may be applied to varying types of project teams, but still project manager has to consider distinct feature and environment of each one into account. A lot of methods are available for developing project team but they all are not compatible with every status that the team is in. therefore, team leader must recognize development phase of the team to use proper methods. The Tuckman Model is effective, easy to use examining tool that determines 5 steps in which individuals initiate the bounding, reaching maturity level and at last disbanding. These steps are explained below:

1. Forming: The first stage is critical. When team members try to form a team in beginning steps, project manager should analyze their behaviors to overcome with any conflict and difficulty. Individuals may show following behaviors: shallow talking with indecision in disclosing some insights and information about themselves, uncertainty about the logic behind joining the team and project's goal, ambiguity about the norms and limits of different members. Incorporation is the term that members try to clarify it for themselves in forming stage.

2. Storming: Proceeding to this stage, means all of doubts in members about being part of the team is gone. During this step, individuals try to increase their interactions in order to define rules in practice. Team members try to show themselves out of the group. Project manager can easily sense that members try to take part in meeting's conversations more, compared to forming stage. Storming step is a period when individuals look for power in group to distinguish their position and status. Thus, project manager may apply controlling procedures to not losing the gained integrity from previous step.

3. Norming: After deciding on joining the team and finding own position, team members try to focus on their interpersonal skills during norming stage. Expressions are more open compared to previous steps. Individuals start criticizing ideas and offering alternatives. Greater unity emerges as participants find common norms, views and values among each other. Those techniques that are specifically for maintaining such condition and strength shall be applied by manager throughout this step.

4. Performing: supports from team leader must be increased and continuous because performing is the most fruitful step. During previous phases, members have found their way and they don't need project manager to show them the line toward goal. Supervising and keeping the spirit, speed and cohesiveness is important task of leader in this stage. The highest degree of cooperation, almost completely open communications, less focus on 'me' and more focus on 'we' and clear image of boundaries and authorities are the signs of performing phase.

5. Adjourning: when the team reaches its goal, it moves to termination step. Individuals may try to finalize the outcome of working together that can be a report, decision…. West (1998) has indicated that this step might also be used to determine whether another objective exists to reform the team again or not.

According to Hellriegel et al. (1997) below mentioned factors affect project team's performance to reach its maturity:

- Size of the team
- Number of roles and their variety
- Norms
- Integrity of team members
- Management style

Following figure shows how maturity or efficiency will be increased through the steps. As it is shown, failure is possible along the way to reach productivity and high performing team.
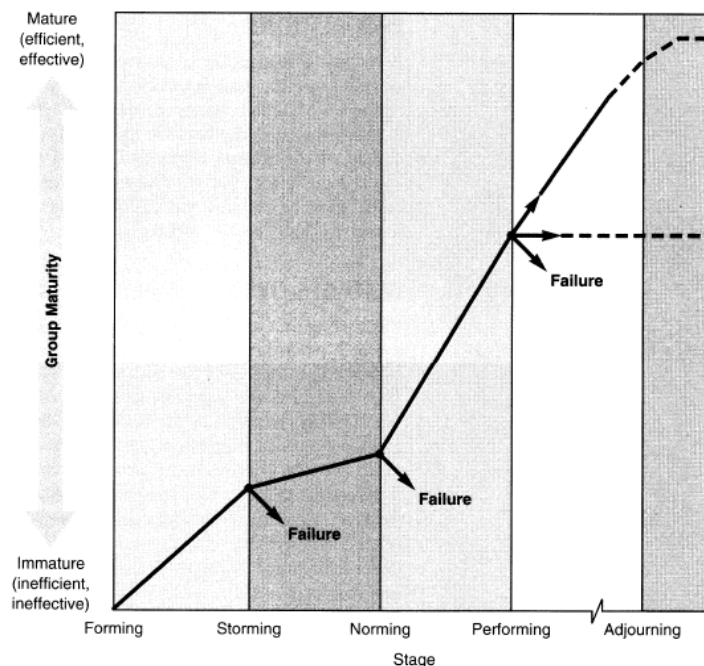
Figure 11 - Stages of Team Development (Hellriegel, Woodman, & Slocum, 1997)

Analyzing SEM 2012 project reveals that basically individuals form cross-functional team. On this basis, characteristics of functional and problem solving teams observed by project manager that shows team members tend to rearrange the formation depending on condition. Therefore, flexibility of the team is important in carrying out the effort as keeping same arrangement through project lifecycle may not result in expected efficiency. Besides, project manager has to take short project life of SEM 2012 into his/her consideration and shouldn't let the initial steps to reach performing phase take long.

Team Development Challenges

Developing team is challenging task as project manager faces different kinds of issues in above mentioned stages. Experienced difficulties and utilized methods to solve them while SEM 2012 team was developing are discussed below:

- Forming: As everything is unclear in forming stage, project manager has to deal with individuals' confusion and hesitancy. Potential members are not sure how to communicate with others, therefore courteous ambivalence can be easily sensed among participants. For giving members a drive and clarifying the condition, team leader may use these solutions: setting fundamental rules to describe required behaviors e.g. showing respect in any interaction and communication, being punctual, precise and responsible,

having goal-oriented insight and keep the communications open and clear. Also giving a name to the team will give a sense of unity and uniqueness to the team which is effective for speeding up the development. Holding a kick-off meeting by presence of all participants is very important step in dealing with issues as members can introduce themselves to the others and give reasons why they have joined the group. Following this helps individuals to define their boundaries easier as they gain initial grasp about how the others are.

- Storming: team members in this phase try to show themselves clearly out of the team as they look for any way to let the others know how s/he can be so influential. Unavoidable and expected conflicts emerge among participants while they search for distinguished status. Project manager has critical responsibility in this phase to maintain morality, obtained from previous step. Experiencing explained conditions among individuals of SEM 2012 team, led project manager to apply conflict management techniques in this phase to avoid severe tensions. According to Thomas (1992) five conflict-handling modes can be used:

  1. Avoidance: this technique should be used when arguments don't have logical basis and not practical consequence is expected out of them.

  2. Accommodation: when the source of conflict is slight dissimilarity between members' ideas or point of views towards a point, accommodation can be helpful to reach mutual taking based on temporary resolution.

  3. Compromise: For coming up with the best solution that benefits both parties, compromising approach is suggested. Going beyond mutual advantageous limit determined by this approach bring conflict and damaging interactions back.

  4. Competition: this technique shall be applied when a decision has to be made upon not favored topic in short period while it is very important from project manager's view.

  5. Collaboration: this approach may be used when a long-term solution is required for critical issue. The consequence of this technique might not be only for two persons but the whole team will be affected. Project manager shall utilize this when enough time is available for decision making because collaboration can be time consuming.

Thomas (1992) has shown how mentioned techniques vary in scale of assertiveness and cooperativeness. There is no the most advised technique as depending on situation, team leader is responsible to choose between self satisfaction methods or those consider others contentment.
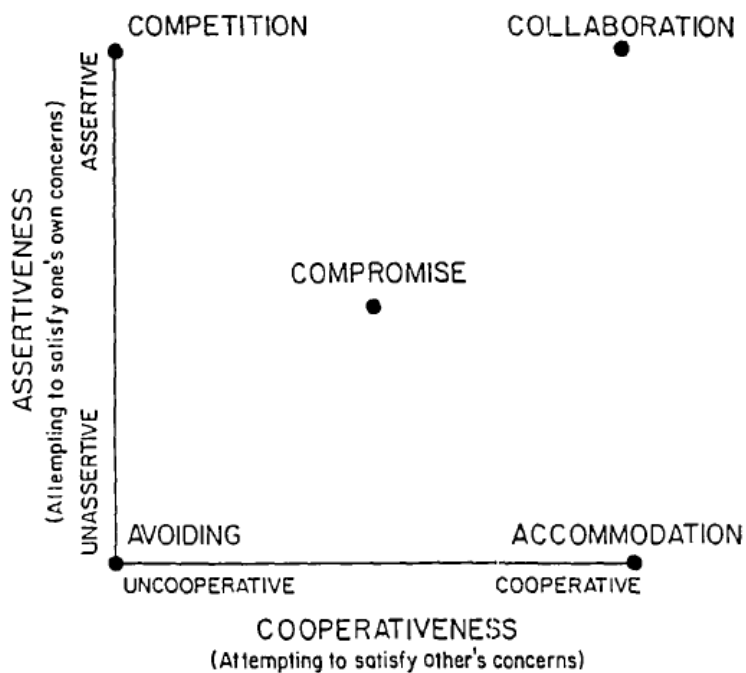
Figure 12-Two Dimensional Taxonomy of Conflict Management Modes (Thomas, 1992)

- Norming: for overcoming the challenges of keeping the integrity and cohesiveness project manager can focus on: showing his/her full support in internal communication and external communication e.g. while interacting with stakeholders or supervisors, bring forth the objective of project and concentrating on team's spirit and providing opportunities for members to show their contribution to stakeholders especially supervisors such as holding presentation sessions.

- Performing: supporting continuously is a challenge for project manager in this stage. S/he may follow approaches such as: keeping the team mood high with setting rewarding system, encouraging members to think of solutions by themselves and delegating appropriate level of authorities in case of decision making, focusing on more challenging perspectives of the objective and require more cooperation from individuals when a intricate problem shall be taken care of.

Developing the team shouldn't be limited to a location e.g. office. Leaving workplace and trying to have fun with the team such as eating outside, going on short trip…can boost the process of development and tide the bounds among team members.

Manage Project Team

"Manage project team is the process of tracking team member performance, providing feedback, resolving issues, and managing changes to optimize project performance" (PMI, 2008). On the basis of experience gained from managing SEM 2012 project two key factors for managing the project team are: national diversity in team and perceived benefits from executing challenging project.

National Diversity in Team

Despite all possible differences exist in way of team members from same country think, still unique homogeneity and specific norms are anticipated in their attitudes and behaviors because those individuals have been grown up in an environment which people share alike view toward particular things, so it is logical to conclude that basically they most likely have similar notion in shared circumstance. This fact can be disadvantageous as individuals may suppose that common believe and view is a firm basis to consider collective ideas as proper options. Miller et al. (2000) have called this 'group think'. Consequently, creativity and innovation is less awaited from homogeneous team. Contrarily, when shared believes don't exist, various views from team members who have completely different opinions about same issue can be advantageous for project team in time of decision making and solving problems. Diversity in visions means an issue won't be analyzed from similar perspective which could lead to creativity and innovation. Also non homogenous team carries dissimilar sources of skill and experiences that result in more extensive and varied alternatives for problem solving. This feature increases team's adaptability in changeable environment of a project. But is it correct to deduce that joining a member from other country or culture to a uniform team to avoid group think? The answer is it depends. If the majority accepts the diversity in viewpoints, cultures and norms, 'group think' is avoidable otherwise opinions from minority won't be distinct and considered.

Perceived Benefits

Although reaching project's objective is a driving force and has benefit for team members, but this is not the only reason that individuals try to overcome with challenging activities. Gaining

different type of skills (learning) through the project; makes it more valuable and interesting for team members. This is another drive to have more contribution and better performance of individuals. This is very prominent especially for SEM project in which team members are students (with nothing or low practical experience) who want to learn out of executing a challenging NPD project. Managing participants should be in way that they can obtain following benefits or skills:

- Executing project doesn't have benefit only for project management when it comes to having managerial skills. Individuals practice how to handle the activities and deliver the outcomes on time. They learn how to generate personal plans and allocated their time to different tasks appropriately. Participants shall learn the way of dealing with complexity and finding proper time to combine their efforts and their outcomes with others in different situations. Changeable conditions may teach them to have flexible plans and be ready to alter them with new conditions without taking too much effect.

- If project manager is successful with managing a project team that has members with various backgrounds, individuals will acquire knowledge about other disciplines in basic level. Not only this is important for members in terms of coordination when they try to fit their competencies to accomplish a task but also new knowledge benefits them to perform efficiently in future when they are in similar projects.

- Referring to experience in developing project team, changing the form of the team is possible. Therefore, individuals will be banded and disbanded for few times at least through project life cycle. This gives them chances to know each other better, to technically and socially evaluate others and to quickly find out how they can reach to desired integrity. According to Edmondson and Nembhard (2009) being a member of varied types of group or teams, increase individuals' 'teamimg capability'.

- One of the lasting advantage of working in team, if it is managed appropriately, is having precious and useful network of pepople who have been contacted during carrying on the project. Well managed team will cross boundaries to find new sources and gain knowledge via them. Therefore, individuals try to find a source to exchange their capability for what they are weak in. This communications will result in network of key persons who help each other when it is required.

Project manager has critical responsibility in managing team through various challenges which they face in executing stage. S/he shall be cautious that team's performance and productivity will be in danger if individuals believe no benefit exists in accomplishing tasks. Challenges in managing SEM 2012 team regarding multicultural perspectives and perceived benefits with related solutions are discussed below.

Challenges of Managing Project Team

National diversity in team has downsides as well. SEM 2012 team included participants from Norway, Spain, Germany and Iran who all uses English as their second language. They were taught English in different environments with dissimilar methods; therefore it is not surprising if international members describe same event or issue not in the same way. This subject may cause misunderstanding and poor communication as team members uses distinctive words, idioms and meanings which can result in unwanted comprehension. The worst case about this issue is not having same understanding of project objective(s). In addition, building and maintaining cohesiveness among members from varied country is another challenge of managing this type of team. People tend to share company with those who have same norms, views, language and cultural background. It takes long for minority group to be accepted by majority one. Although creativity in problem solving and decision making is an advantage of diversity but things might get out of control if the size of international group is large. It can be difficult to reach a generally agreed opinion or alternative when wide range of solutions is available. In this case, project manager would put a lot of effort on directing the team to reach a consensus.

Concentrating on common values and techniques that people with same background may share, can be a solution to give the members a drive for more integrity and less focus on diversity. Successfully managing an international group is tightly depends on project manager approach and behavior with team members. S/he should consider individuals more than colleague and try to spend time with them to have clear understanding of their background, culture and view. It is highly important that participants got recognized by their ethnic criterions. This can be done through one-to-one discussions or in casual group meeting to converse about cultural differences and their suppositions. Not only such technique benefits team members to learn about other societies and lifestyle but also common views will be identified to put the focus on to reach favored unity. Besides, team leader shall foster the thought of esteeming such dissimilarities in order to have the spirit of coordination among members.

What types of challenges might be encountered during executing and how overcoming techniques shall be applied to take benefits? According to Edmondson and Nembhard (2009), ambiguity and uncertainty are distinct characteristics of new product development projects such as SEM 2012. Handling project teams under such conditions, adding deadline's pressure and prominence of project will put project manager and the rest of the team in tough situation that may result into withdraw of the team. Project manager should evaluate the rate of involvement of the members through executing stage to find out whether an issue exists or not. Less involved in activities might have roots in low individual's effectiveness, not thinking highly of the team or having less valued status among the others. Less engagement in project means minimum participation of member(s) which leads to losing important information that could be vital or determinant for project. Disagreement easily emerge when a cross-functional team works on developing new product because each discipline tries to make an ideal system related to its expertise which may not be match with other developed systems. Not only idealism of competencies can be source of dispute, also dissimilar nomenclature, language and approaches can bring conflict that decrease team's efficacy. Pelled et al. (1999) have indicated that there is no guarantee for collaborative communication within cross-functional team. Challnege for team leader is confronting with a notion, called 'mental model' by Klimoski & Mohammed (1994). Fundamentals of members' professions make such models which gives the sense of preferring own views over others' opinions. Focusing on solving this issue causes another problem. Team members, by mistake can fully concentrate on buidling cohesive team despite all challenges to rach enhance internal dynamic and pay no attention to environement and external entities. Stated by Allen (1984), external communications are more effective on team's performance compared to intrateam ones.

One of the managerial techniques to overcome various types of challenges in order to offer benefits to team members is creating an inspired environement for participants to learn and be innovative. Although project manager always has to consider fallibility but still trying to make and keep a climate for participants to let them take the risks can be a driven force to overcome challenges. In terms of Edmondson (1999), leaders should provide pyschological safety for individuals to present an opportunity to learn by taking risks and gain related benefits. The leader shall support the team from any external force that may affect its performance. Mentioned by Edmondson and Nembhard (2009), leadr can be a proponent to protect the team and its

independency, so members allow to try new thoughts, methods and procedures. Besides, group sessions shall be hold by presence of team members to solve conflicts and disagreements emerged from mental models to increase collaboration and members' engagement. It is highly recommended to project manager to analyze issues carefully and attempt to find a solution for a problem that is related to majority of the team.

Project Monitoring and Controlling

Project manager has to set a reliable and logical control mechanism to direct the project team and avoid any misleading variances. The manager has to design a system which gives sufficient degree of control and keeps the adequate degree of flexibility and creativity within the team. Maintaining these two characteristic balanced is challenging. On one hand strict controlling techniques may decrease the perceived freedom among individuals which results in less team efficiency and advancement speed. On the other hand, loose procedures might lead the project to over budget or behind schedule status as it is extremely possible that the project team loses the track of time and allocated financial resources caused by too much freedom. According to Bonner et al. (2002) five types of management control system are common to be deployed for handling new product development project:

1. Process-oriented mechanism: in this type, project manager defines certain controlling procedures and asks the team to follow them. Therefore, monitoring efforts will be focus on individual's reaction, behavior and commitment towards specified sequence of instructions. So, basically, team leader wants to know to what extend accomplished processes by team members are matched with controlling guidelines.

2. Output-oriented mechanism: by following this, project manager determines various performance goals and asks individuals to meet them during project execution e.g. deadlines, budget limits or performance criteria. In this type of mechanism, project manager gives individuals freedom to choose their own way of accomplishing tasks and monitoring processes focus on the extent to which participants have met the goals.

3. Rewarding-oriented mechanism: team leaders may control team's performance by setting a rewarding system in order to motivate individuals to follow controlling norms. Various procedures may be taken in this type of mechanism. Manager may prefer to keep rewards extrinsic e.g. giving bonuses or deploy a system based on intrinsic rewards such as giving participants the sense of capability and expertise when they handle own tasks well. Also it depends on project manager to define a basis for rewarding. Praising (financially or non-financially) can be based on the outcome when individuals deliver desired result or it might be dependent on their performance, progress and accomplishment.

4. Engagement-oriented mechanism: another method for setting an effective control mechanism of involving key team members or if the team is small, all of them in time of

designing the system. In this case, participants can share their opinion on how technically the project can be supervised and monitor properly. Advantage of this method is a framework which is compatible for all and it may result in productive performance.

5. Intervention-oriented mechanism: Project manager can also try to control and direct team's performance by involving his/herself directly with individuals' decisions in order to impose own opinion. This method might be effective when participants' performance reaches the breaking point but based on practical evidence found by Olson et al. (1995), intervening increases power concentration that leads to less inspiration and inventiveness.

Monitoring and controlling mechanism of SEM 2012 was combination of output-oriented, rewarding oriented and engagement-oriented systems. During initiating stage, project manager offered a monitoring and controlling system to the team. The system was improved along with project advancement as individual's made change request in order to have better mechanism. This shows the framework had engagement-oriented feature. Before start with project executing, participants were well informed about deadlines, budget limits and short-term goals (milestones); so they could prioritize their tasks and choose own way to finish them. Therefore, the framework had outcome-oriented dimension as well. Time was controlled and monitored by comparing the actual duration of each task to planned duration, weekly during group sessions. For communicating the status of time to the team and authorized stakeholders, first the project schedule was updated. The result was put in weekly project report as a bullet chart and actual S-curve to compare with planned one. Following figure shows an example of bullet chart. As it is shown the time were controlled and monitored both periodically and cumulatively. After presenting this by project manager in weekly sessions based of gathered data from individuals about their performance, project team spent time to find the roots of variance between the actual work and schedule baseline. Such chart was used to control and monitor the status of each budget item. Similarly, information regarding weekly expenses was gathered through individual's report on actual costs. In addition to mentioned mechanism, rewarding system was used in management control system. Usually, project manager used nonfinancial intrinsic rewards such as praising and appreciating an individual's effort in front of the others. Only one time, the manager rewarded the whole team financially with equal amount for all as the team accomplished one of the most critical tasks (assembling vehicle's systems) within allocated time and least trouble.
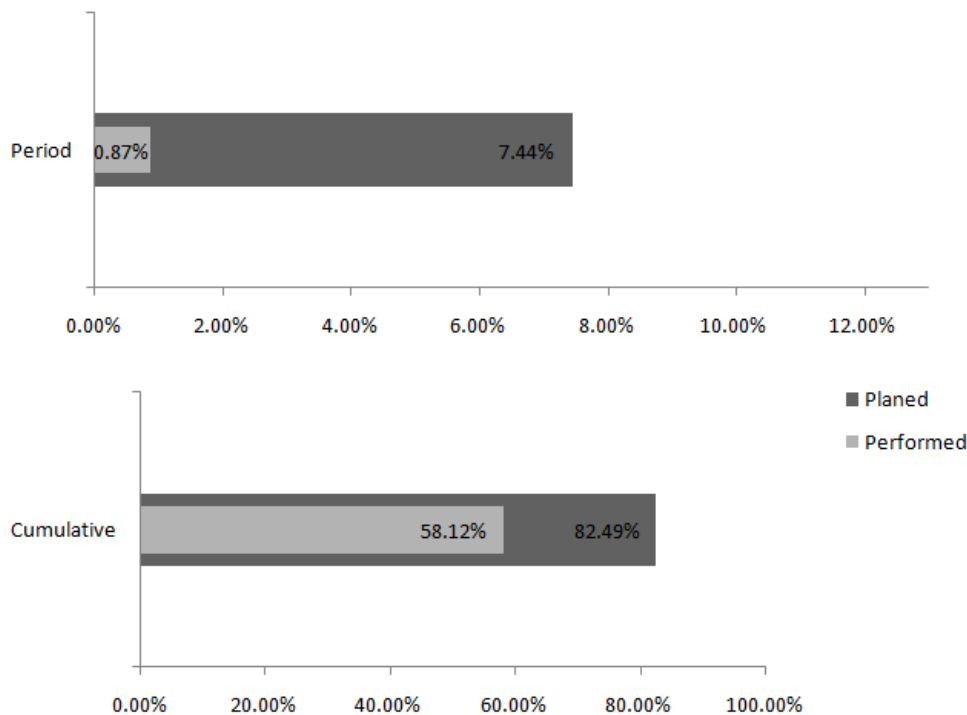
Figure 13 - Bullet Chart, Project Progress

Bonner et al. (2002) has named the first three mechanisms, formal controls and the rest two, interactive controls. Formal controls are fixed as they follow a routine continuously in same level during project lifecycle but interactive control are dynamic because they are formed on basis of communication between project manager and team members which most likely have rise and fall. Combination of both static and dynamic mechanism resulted in compatible management control system which could direct participants efficiently on specified track with least negative feedback.

Project Closure

Completing project's scope doesn't mean that project is finished. The undertaking reaches its end when processes in closing step are accomplished. Mainly, processes include managerial tasks such collecting form, records and replying letters. During this step project manager has to contact stakeholders in order to receive confirmation on acceptability of deliverable. Project team has to prepare evidences that either project has met success criteria and the final outcome is ready to be handed over or due to reasons project is failed and terminated. Project manager must ensure that all required payments are done and final calculations and transactions regarding budget are finished. From two perspectives the effort should evaluated, whether the project has been successful or not and whether customers and stakeholders are satisfied. Final report as an outcome of this step shall carefully be prepared. Participants have to consider this document as a knowledge transfer mean, so, it has to be informative, clear and credible. The most important section of the report is lesson learned. Project team should collect all lessons learned and properly document it in final report in order to share what they have acquired through project lifecycle with future teams. When, all administrative activities are finished, team leader may release human resources. Meaning that no one has no more responsibility about the project. For closing SEM 2012 following tasks were accomplished:

- Sending email to key stakeholders especially key sponsors in order to report the result of the competition and express gratitude for their involvement. Also this message included a question about the extent to which they are satisfied. Furthermore, a photo album that contains pictures from begging of the project to the end, was provided by team and sent to key sponsors as appreciation gift.

- All remained invoices and payments were taken care of by project managers with the purpose of clarifying the final financial status of the project and remained money for succeeding team.

- All lessons learned were gathered and organized. Based on this, a group report as project document which consists of knowledge and experience of all competencies was prepared. In addition to this, participants with system engineering, electrical engineering, cybernetic engineering, industrial design and project management backgrounds wrote a master thesis separately to transfer an in-depth image of the project from mentioned perspective

- All project files were organized on the server to facilitate finding required information for future teams.
- DNV Fuel Fighter 2 was taken to Høvik and presented to DNV's staff and middle managers in order to get the formal approval on acceptability and to make certain they are satisfied with the vehicle.

Lessons Learned for Project Managers

SEM 2012 was full of managerial challenges. Numbers of these were never solved due to lack of proper foundation to apply desired solutions. Therefore, this section focuses on management mistakes, their impact and suggested solutions (basically what was learned) for issues that require appropriate basis from very beginning.

Defining team members' responsibilities was done orally through few group sessions. Although, participants mentioned that boundaries are clear, but project manager spent significant time on solving problems related to scope of work of team members. Confusion on who has to take responsibility of handling tasks increased to such level that caused harmful conflicts among members and efficiency reduction. What project manager did wrong was relying on oral conversation in initial step. Individuals tried to make an image of their limits and this faded by time passing as they made effort to memorize what project manager told them. Avoiding facing such issue, it is recommended to create job description in both hard-copy and electronic format. This document shall be comprehensive and clear which should be prepared for each team member separately. Team leader has to require participants to read them carefully and keep them as reference for any case of confusion.

For managing SEM 2012 project, the leader mistakenly assume when team members want to make an order to purchase a part or necessary tool, they already know the qualities of it e.g. physical or mechanical features. In action, participants spent not enough time to think about what exactly they want and this resulted in reorders that put extra financial burden on the project. Another issue with procurements was quantity of the orders. Requesting more than enough or less than what project needed, made all process inefficient. This problem led the project to face the risk of extra lead times that caused delay in accomplishing activities compared to schedule baseline. Lack of experience in this knowledge area within project manager gave rise to not having procurement management plan that brought about dealing with indicated troubles. It is

highly advised to the team leaders to generate a plan for managing purchasing processes, in both terms of quality and quantity. Also another filter for controlling procurements can be purchase request form. By using this document project manager has better control and monitor over acquisitions and can prevent false orders.

Team leader was not quite successful in applying communication management plan generated in initiating stage as mishmash and chaos in distributing and exchanging information were experienced throughout managing the effort that caused team's productivity reduction. Ad-hoc requests from PR and Media contact person is good example of situation. Sending such requests directly to the team members not only violated this fact that project manager asked to be hub for distributing information among the team members but also distracted individuals from prioritized tasks. What the project manager neglected was importance of communication matrix. Similar to confusion related to scope of work, relying on oral explanation at project start-up and lack of determined pattern for exchanging information and clarifying communication channels caused a mess that significantly affect project team's efficiency. Based on this experience, preparing communication matrix that defines authorized communication means and channels is critical task. This management tool shall determined permitted recipients for various types of data and information.

Proposed Organizational and Operational Adjustments

Suggested managerial adjustments to enhance the project's status and condition within environment (the university) are as followings:

1. Focus public relation and media activities on university: it is really strange that people who live in Trondheim (excluding students) know much more about project and competition compared to NTNU's students. All of team members experienced it during last nine months which shows the extent to which the project is unknown. Clearly, this has strong relation with the voluntarily process of staffing the project. Therefore well-designed strategies shall be followed within the university's environment to increase the knowledge of students about NTNU's reasons for following such competition, the structure of the competition, the advantages of participating in the project and numerous career opportunities that students may face by involving in the project. Such efforts should not be limited to students as they can go to higher level and target different

department's or university's higher-ups. If successfully performed, marketing plans will increase the support from different level of the university that has significant positive impact on managing the project especially recruiting students. For instance, due to lack of information about the project, department of cybernetic didn't name SEM project as an opportunity for 2013 team which forces next year team to make a great effort on finding a team member.

2. Enhancing inter-communications among departments: current communications among involved NTNU's departments seem inefficient. Supervisors from various departments don't have close corporation on exchanging information about status of the project. More engagement of departments' representatives is crucial as they can make effective decision on different issues of the project. Result of such communications can be agreed set of processes to be followed by involved parties in order to attract students to join the project. NTNU's departments could communicate their problems on the project with others so that finding solution can be easier.

3. Bringing new challenge up: participating in same category (urban concept) for five years gives the impression of repetitive try. It might be attractive for students to go with brand new challenge of prototype category that has never been considered before. This idea can reach to level of having two team preparing both urban concept and prototype vehicle for SEM competition. Although this thought seems interesting but it is challenging from recruiting and team building perspectives.

4. Full dedicated students as a requirement: as individuals who are not completely assigned to the project cannot focus all of their efforts, they are not efficient enough that cause productivity reduction with the team. Also, non-dedicated members may fail to be integrated with the rest of the team perfectly due to less interactions between those and full time members.

5. Evaluating candidates: during past 5 years, team members have been chosen without passing technical evaluation given by departments. Lack of volunteers makes project supervisors to choose whoever announces his/her readiness to involve in project. There is no way to ensure that the selected student has proper competency to be part of the project. Therefore, varied associated departments, after successfully executing motivational activities, shall conduct technical assessment to know if potential team members have proper background to fulfill his/her role and responsibility. Since 2008, only department

of production and quality management has had specialized interview to filter nominates and pick out right person.

6. Early involvement of the future team: It is ideal if project supervisors choose right persons soon and encourage them to join responsible team while the project is in progress. Early involvement facilitates transferring knowledge between teams that helps the next team to have clearer image of future project as they might start developing plans based on analyzing current condition of project and information gained directly from responsible team via open communications channels.

Integrating above mentioned recommendations, offers 3 steps procedure of enhancing organizational and operational adjustments:
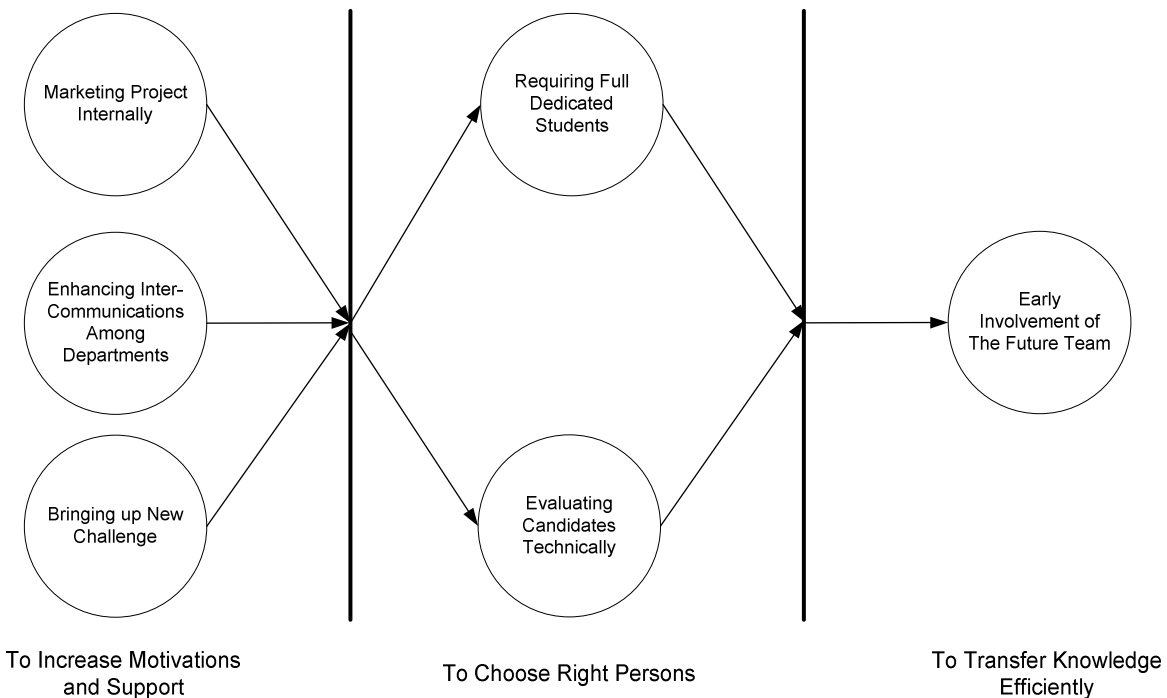
Figure 14 - Suggested Activities to Promote The Project

Purpose of first three purposed adjustments is to increase motivation in targets (students, supervisors…) that results in higher number of interested people in the project. Next two steps help supervisors to find students who have related and required competency and last steps prepares appropriate condition for effective information exchange between teams.

Was Shell Eco-marathon 2012 Project Successful?

This question can be answered from following two perspectives:

1. Success Criteria: Before closing the project, team had meeting to analyze the outcome and check whether all success criteria have been met or not. The vehicle was completely prepared for the competition before shipping it to Rotterdam, so team finishes the project on time. Project never ran over the budget as extra money (around 50 000 NOK) was saved for next year team, therefore project was accomplished within the budget limit. Before competition, DNV Fuel Fighter 2 was tested for numerous times in both system level and integrated whole to ensure the vehicle is reliable. The car successfully passed all of the tests and based on this team concluded that a trustworthy car is delivered. Having no negative feedback from internal and external stakeholders implied high satisfaction from involved parties which gave the team sense of meeting related success criteria. DNV Fuel Fighter 2 had two accepted tries, thus participants' endeavor met the success criteria that required at least one approved try. The only criteria that team couldn't reach to it was strong presence in Norwegian media and press as only 15 articles covered news about the project. Overall, five out of six measures were met which means SEM 2012 was successful project.

2. Project objectives: none of the goals were obtained by project team (failed effort!). The reason for not achieving communication and marketing award was lack of experience of responsible team member. She wasn't successful in showing great picture of the project to Norwegian media and press. Explanation for not winning the first rank award can be inferred from significant uncertainty associated with SEM 2012. The team not only built a new car from scratch but also change the class of the car from hydrogen fuel cell to battery electric. Lack of team experience in new category (technological uncertainty) led the members to make an engine which consumes more energy compared to other competitors and this is the single point of failure. The vehicle has great potential to be in higher ranks if the next year team specifies the improvement points properly and give special attention to the engine in order to produce lighter and more efficient one.

Appendix-Pre-Study Report

Background

Previous (specialization) report was dedicated to address difficulties in initiating and planning phases of an innovative project at Norwegian University Science and Technology, called Shell Eco-marathon 2012. After completing these phases during fall 2011; tasks related to executing, monitoring and controlling and closing phases should be followed up by project team during winter and spring 2012. The analysis of what project manager should do in three mentioned stages is briefed below.

Executing: within this stage project manager has the responsibility of accomplishing followings:

- Managing the activities related to producing deliverables in coordinated way by focusing on project goal.

- Being aware of change requests generated during this phase and managing them.

- Holding enough knowledge about different technical standards which deliverables shall be released according to them. Based on this, project manager is responsible to assure that planned quality auditing processes are being performed entirely and properly by project team.

- Holding enough information about status of the processes related to conducting procurements.

- Providing information that has been desired by stakeholders.

- Keeping communication channels open and clear with stakeholders in order to meet their expectations thoroughly.

- Enhancing the competencies, team communication and team environment to increase project performance.

- Engaging in team members' activities to follow them up, providing feedback to how project team performs tasks and resolving any issue that makes project team less efficient and slow in completing activities related to produce deliverables.

Monitoring and Controlling: during this phase, project manager shall perform following activities properly:

- Checking deliverables with sponsors to make certain that their expectation has been met and getting their formal acceptance on deliverables

- Evaluating project scope performance and handling scope baseline changes

- Directing and supervising procurement activities, administer contract performance, and applying changes and corrections as needed

- Being sure that project team pays attention to recognized risks and plans for responding them. Beside project manager has to track residual risks and the process of identifying new risks during execution phase.

- Tracking the status of the project to update project schedule and generating progress reports. In addition, project manager has the responsibility of applying changes to schedule baseline, if necessary.

- Tracking cost, updating project budget and managing changes to cost baseline.

- Supervising on execution of quality activities and keeping the record of their outcome in order to evaluate the performance and suggest required changes.

- Gathering and handing out information regarding project execution according to communication plan. Distributed information may include status reports and evaluation of future steps.

Closing: Executing below mentioned tasks is in area of responsibility of project manager:

- Tracking and supervising the process of taking final steps to complete all activities in project in order to terminate the project formally. At project closure, it is up to project manager to ensure that all steps in project has been taken appropriately and planned goals have been met. This can be done by reviewing information of process from all over lifecycle.

- Project manager in this stage has to be sure that all procurements are closed and completed. This means no claims related to contracts shall be remained after this phase.

Objective and Tasks

Performing before mentioned tasks during winter and spring 2012 is determined objective for this project assignment in order to assuring the final deliverable-DNV Fuel Fighter 2-meets the common expectation of project stakeholders which is winning the competition in battery electricity class. During this time project properties in field of managing risks, communication, cost, time, quality and human resource will be documented and analyzed in order to provide proper knowledge transfer mean to next project leader(s) of Shell Eco-marathon project at NTNU. Afterwards, recommendations will be maid based on experience by purpose of enhancing management of this type of voluntary based projects.

Due to time limitation, selected research method for this project assignment is going to be literature review which is recognition, reading, abridgement, and assessment of earlier published articles, books… on specified objectives. This method is going to be carried on through following steps:

- Organizing and reviewing: this includes identifying topics and keywords in literature to see if they were relevant to our topic.
- Identifying and finding resources: this includes using keywords in available databases to find appropriate documents.
- Reading and summarizing resources: taking notes and abridging chosen resources.
- Writing final text: combining and integrating the summarized data with each other.

According to the scope of this assignment which is explained before, following Work Breakdown Structure (WBS) will be basis for completing tasks related to master thesis. As technical perspective o the project consists of numerous subtasks only high level structure is shown.

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                          ┌─────────────────────┐
                          │  Project Assignment │
                          └─────────────────────┘
                    ┌──────────────┴──────────────┐
           ┌─────────────────┐          ┌─────────────────────┐
           │    Technical    │          │ Delivering Master   │
           │                 │          │ Thesis              │
           └─────────────────┘          └─────────────────────┘
```

Technical	Delivering Master Thesis
Quality Management	Writing Pre-study Report
Procurement Management	Performing Literature Review
Communication Management	Documenting Project Properties
HR Management	Preparing First Draft
Time Management	Asking For Feedback From Supervisor
Cost Management	Preparing Second Draft
Risk Management	Submitting Master Thesis

ID	i	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		⇨	**Delivering Master Thesis**	**100 days**	**Fri 20/01/12**	**Thu 07/06/12**	
2		⇨	**Performing Literature Review**	**50 days**	**Fri 20/01/12**	**Thu 29/03/12**	
3		⇨	Budgeting	1 wk	Fri 20/01/12	Thu 26/01/12	
4		⇨	Complexity	1 wk	Fri 27/01/12	Thu 02/02/12	3
5		⇨	Communication	1 wk	Fri 03/02/12	Thu 09/02/12	4
6		⇨	Early Phase Management	1 wk	Fri 10/02/12	Thu 16/02/12	5
7		⇨	Planning	1 wk	Fri 17/02/12	Thu 23/02/12	6
8		⇨	Project Performance	1 wk	Fri 24/02/12	Thu 01/03/12	7
9		⇨	Schduling	1 wk	Fri 02/03/12	Thu 08/03/12	8
10		⇨	Scope	1 wk	Fri 09/03/12	Thu 15/03/12	9
11		⇨	Success Factors and Criteria	1 wk	Fri 16/03/12	Thu 22/03/12	10
12		⇨	Project Team Management	1 wk	Fri 23/03/12	Thu 29/03/12	11
13		⇨	Writing Pre-Study Report	1 wk	Fri 03/02/12	Thu 09/02/12	2SS+2 wks
14		⇨	Documenting Project Properties	17 wks	Fri 20/01/12	Thu 17/05/12	2SS
15		⇨	Preparing First Draft	1 mon	Fri 30/03/12	Thu 26/04/12	2
16		⇨	Sending First Draft to Supervisor	0 days	Thu 26/04/12	Thu 26/04/12	15
17		⇨	Asking For Feedback From Supervisor	1 wk	Fri 27/04/12	Thu 03/05/12	16
18		⇨	Preparing Second Draft	2 wks	Fri 04/05/12	Thu 17/05/12	17,14FF
19		⇨	Sending First Draft to Supervisor	0 days	Thu 17/05/12	Thu 17/05/12	18
20		⇨	Asking For Feedback From Supervisor	1 wk	Fri 18/05/12	Thu 24/05/12	19
21		⇨	Finalizing Master Thesis	2 wks	Fri 25/05/12	Thu 07/06/12	20
22		⇨	Submitting Master Thesis	0 days	Thu 07/06/12	Thu 07/06/12	21

Project: Pre-Study
Date: Mon 02/04/12

Task		External Tasks	
Split		External Milestone ◆	
Milestone ◆		Inactive Task	
Summary		Inactive Milestone ◇	
Project Summary		Inactive Summary	
		Manual Task	
		Duration-only	
		Manual Summary Rollup	
		Manual Summary	
		Start-only ⊏	
		Finish-only ⊐	
		Deadline	
		Progress	

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