Managing Product Innovation

A study of product innovation in project management

Projectmanagement

Group 16

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1. Introduction

In the midst of a high volatile and competitive global market, worldwide recognition of the importance of product innovation has become one of the most crucial developments. In this context, innovation can be considered as the search for and the realization of new ideas, pursuing a competitive edge over others. Since there are clear and specific objectives concerning time, costs and specifications, theoretically, new product development can be run as a project. However, as opposed to conventional projects, the characteristics of product innovation projects are rather different.

Figure 1 represents a possible classification of projects, in which a distinction is made between innovation and conventional ones. The latter includes those projects that are executed on a regular basis, for instance constructions and operations. Although the list of innovation projects is not an all-inclusive one, it gives us some insight in the relative position of New Product Development Projects.

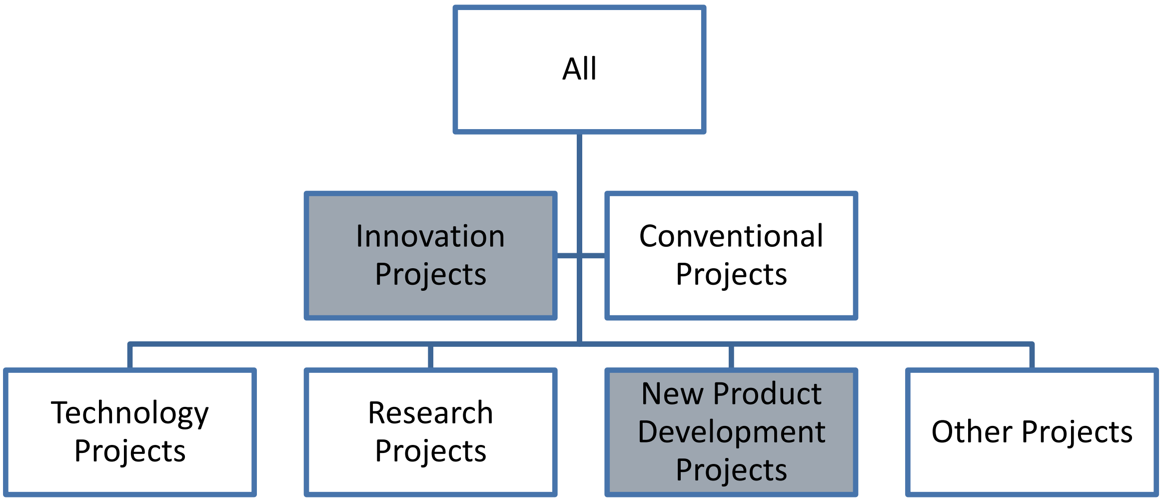


Figure 1. Project Classification

In light of the course project management, led by Prof. Dr. Vanhoucke, we focus on the main differences between project management and product innovation, namely complexity and high risk. Firstly, we want to put theory into practice by ignoring the non-linear nature of innovation and view this kind of project as a task-focused one without any feedback mechanisms. In this way, we create a project that proceeds in a continuous and analogous way from the start to moment of implementation. This enables us to address one out of three components of dynamic scheduling: to set up the baseline schedule of the project.

Secondly, based on the baseline schedule, we want to emphasize the complexity of this kind of projects. We will discuss Schedule Risk Analysis (SRA), performed by ProTrack. Furthermore, we used P2 Engine to run Monte-Carlo simulations. In brief, this entire section will examine the bottom-up approach and top-down approach.

We support the entire exercise with data gathered at Daikin Europe NV., creating a fictitious product innovation project.

2. Project Life Cycle (PLC)

Previous to the elaboration of the first pillar of dynamic scheduling and the analysis of complexity, we subdivide the process of a product innovation project into different phases to provide better insight in the whole project. As mentioned above, we support the following sections regarding dynamic scheduling with data gathered at Daikin Europe NV. These data include guidelines of all aspects of different activities of one particular product innovation. Since information concerning costs, durations, resources and relationships are rather hard to obtain, we had to make several assumptions, keeping in mind the provided directions (cfr. Exhibit 1). Given the nature of innovation projects and the fact that companies are the center of a high volatile global market in which sustainable competitive advantages are more important than ever before, we assume that time is the main objective.

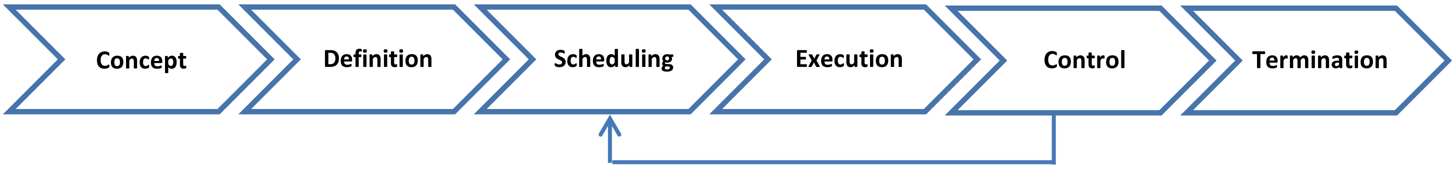


Figure 2. The Project Life Cycle (PLC)

Concept phase: To answer customer needs, managers, engineers and even customers come together to discuss different ideas. In the end, it is intended to develop a particular concept, which is actually the project itself. In this study, we create a fictitious project, using the limited information provided by Daikin Europe NV.

Definition phase: Once the concept is elaborated, it is our task to define a **'PLAN'**. **P**eople need to be allocated, **L**inks between different activities should be installed and **A**ctivities have to be defined. This finally leads to a project specific **N**etwork. As mentioned above, more information regarding data and assumptions can be found in Exhibit 1. Furthermore, a Work Breakdown Structure and an Activity-on-the-Node network are included in Exhibit 2 and Exhibit 3 respectively.

Scheduling phase: Using ProTrack, we entered all previous data and determined the start- and finishing times of all activities, which are represented by Gantt-charts. Furthermore, a cost overview and a work schedule for a team of resources are displayed (cfr. Section 3). It is important to mention that this scheduled information is rather a guiding tool, offering managers the opportunity to measure their performance. Therefore, managers need to be aware of the possible occurrence of different scenarios and risk analysis needs to be elaborated (cfr. Section 4).

Execution- and control phase: During the project execution, it is of high importance to monitor and control possible gaps between schedule and real progress. Aside from the information given by the Gantt-chart, performance concerning time, cost… can be measured using Earned Value Management techniques. By doing so, we will know whether our product will make it to the market in time and within a pre-defined budget range.

Termination phase: Once the project is successfully executed, the product innovation can be implemented in subsequent processes and consequently, can be launched in a pre-defined market.

Due to project scheduling, risk analysis and project control, this will be done in a cost- and time-effective way.

3. Baseline schedule

With respect to our fictitious data, personal assumptions and assumptions made by the ProTrack tool, the following baseline schedules can be constructed. To illustrate the impact of including resource limitations, which lead to resource conflicts, we provide both Gantt-charts: one in which resources are unlimited and one in which they are not.

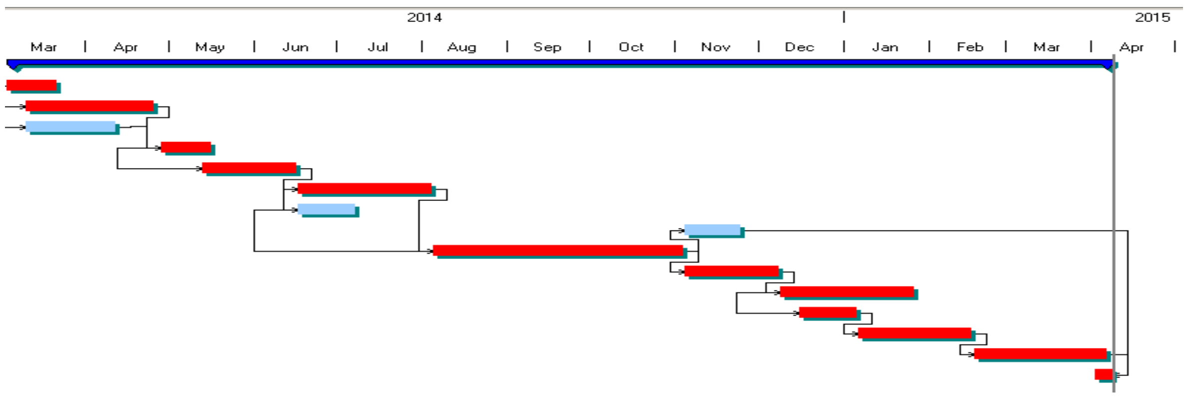


Figure 3. Baseline schedule – unlimited resources

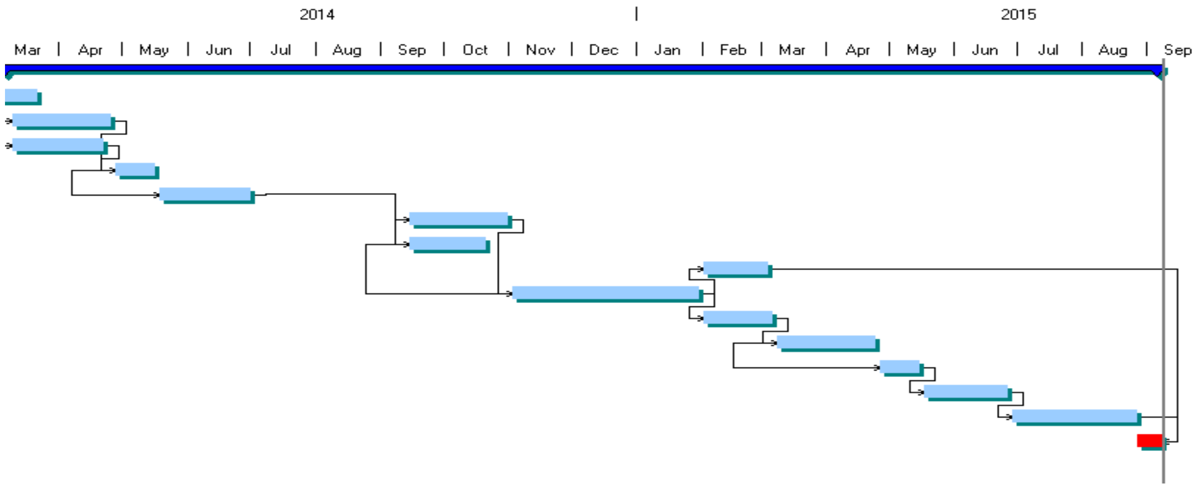


Figure 4. Baseline schedule – limited resources

When we take resource constraints into account, which is the most realistic scenario, following data result from the baseline schedule:

- Start date: March 3th, 2014
- Finishing time: September 8th, 2015
- Project duration: approximately one year and a half
- Budget At Completion: € 1.688.126

4. Risk analysis

4.1 ProTrack

By using ProTrack for SRA, we incorporated the risk information of the different project activities in the baseline schedule. As time is our main objective and cost is also of great importance within product innovation projects, we examined the potential impact of uncertainty on the final project duration and Budget at Completion (BAC). In order to perform a traditional SRA, we followed the four required steps in ProTrack (see figure 5).

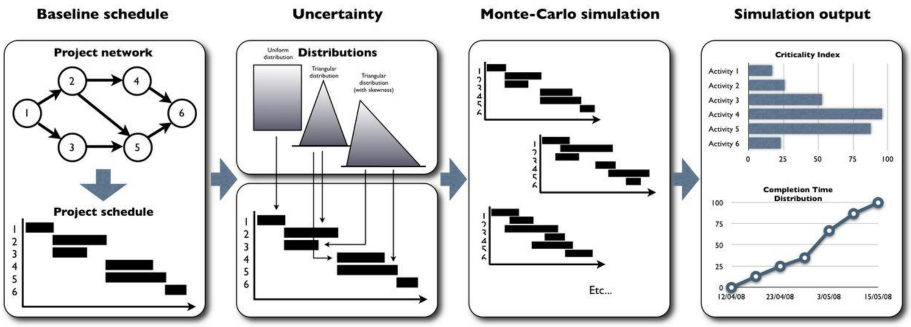


Figure 5. Schedule Risk Analysis

Since all activities within product innovation projects have different risk distributions, we used the advanced simulation engine to fully support the Schedule Risk Analysis of the Sensitivity Scan. Furthermore, as we do not want to focus on resources in this section, we assume that all resources have an unlimited availability. Consequently, the output of this analysis refines the critical path to a degree of sensitivity and provides us with optimal insight in the complexity and risk of our product innovation project (cfr. Exhibit 4).

To interpret these sensitivity measures, we first analyze the network structure of our project and its serial/parallel indicator. Since the SP-indicator reports a percentage of 78%, which means our network is more serial, most of the sensitivity measures in Exhibit 4 do not distinguish between sensitive and insensitive activities. Consequently, we choose to focus on the Schedule Sensitivity Index (SSI) to select a sensitive subset of activities as this is the only measure capable of doing so in serial networks. Furthermore, we used the Spearman's rank correlation coefficient and the Kendall's tau rank correlation coefficient as we assume that the relation between activity characteristics and the project as a whole are rather non-linear. In order to assess the potential impact of risk on the final project duration and the BAC, we calculate the average, taking these three relevant measures (SSI, CRIRho, CRITau) into account.

Final project duration

Looking at the averages, we can conclude that following activities tend to have higher risk (> 25%) and need to be closely monitored in order to get the innovation launched in time (cfr. Exhibit 4, highlighted in red):

- Concept creation
- Concept drawing
- Technical study
- Constructing prototypes
- Final prototypes

Referring to the method of Goldratt, we recommend **implementing time buffers** after these activities and at the end of the project to protect the due date against possible delays. Since time to market is crucial in product innovation projects, we can allocate **more aggressive estimates** and shorten the planned duration of the least sensitive activities in order to compensate for the use of time buffers.

Budget at Completion

Regarding the potential impact of risk on the budget at completion, following activities are considered as being sensitive and need a higher attention in order to keep the budget at completion within its limits (cfr. Exhibit 4, highlighted in red):

- Concept drawing
- Technical study
- Testing prototypes
- Final prototypes
- Final testing

This schedule risk analysis needs to be used as a tracking guidance for all highly sensitive activities mentioned above, with regard to both durations and costs. As figure 6 represents, to know on which activities the focus should lie, the union of all activities should be taken. This is consistent with the averages computed in Exhibit 4, since cost and time percentages run parallel to one another. If an activity is sensitive regarding its cost, the average percentage for the time measure will be high as well.

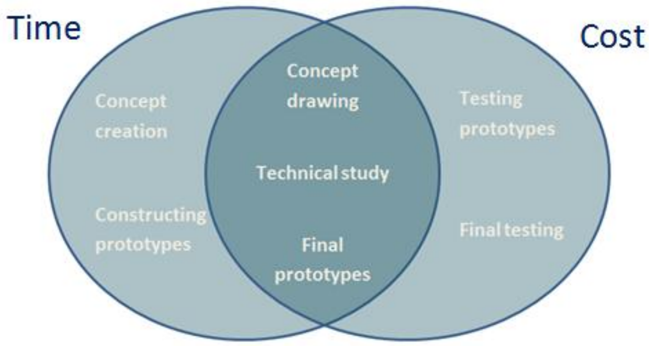


Figure 6. Sensitive activities

We want to mention that this approach is referred to as **'the bottom-up tracking approach'**, in which information prior to the execution, using schedule risk analysis, is gathered. Later on, this will be used as the basis for managerial interventions. However, since our network is more serial, it's rather interesting to consider 'the top-down approach', making use of EVM warning signals. This approach reveals a higher tracking efficiency within serial networks.

Figure 7. Bottom-up approach vs. Top-down approach

4.2 P2 Engine

In this section, we will elaborate on the **top-down approach** while using Earned Value Management (EVM) via P2 Engine. Figure 8 confirms the improvement in control efficiency for using this approach.

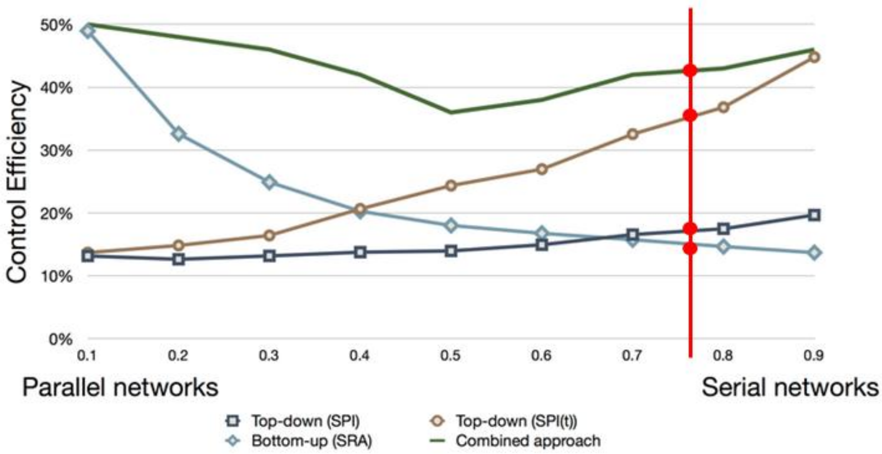


Figure 8. The control efficiency

We used P2 Engine to run one hundred Monte-Carlo simulations on the product innovation project for three scenarios based on time: low, medium and high risk. We chose to make these scenarios based on the time aspect because in an innovation project, the time to market is more important than the costs of the innovation. In order to define the beta distribution, which introduces different levels of risk, we had to attribute different values to the shape parameters denoted by α and β (see table 1). During the simulations, these distributions formed the basis for adding random values to the actual duration of each activity.

Risk	α	β
Low	0,5	1,5
Medium	0,8	1,9
High	0,9	10

Table 1. Shape parameters

Topological indicators

Aside from the SP indicator mentioned in the previous section, the following topological indicators give a more refined view on the product innovation project. As these indicators are project specific, the same results are generated by ProTrack.

The activity distribution (AD) indicator is equal to 81 percent and indicates that the distribution of our activities along the network carries an unequal distribution. The precedence indicator (LA) has a value of 66 percent, reflecting the fact that the distance between two activities are rather far. The last one is the topological float indicator (TF) which calculates the degrees of freedom for each activity as the amount of topological float an activity has in the project network. The TF indicator of our network is equal to 12 percent which means that we have a rather dense network.

Earned Value Forecasting Indicators

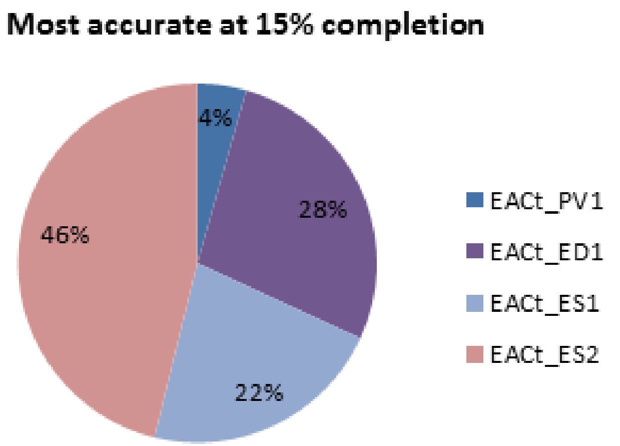
It is important for the project team to calculate the estimates at completion in terms of time (EAC(t)). As in schedule risk analysis, these data represent a tool for identifying and implementing corrective measures in a timely manner. In that way, the high level of uncertainty can be better managed. An overview of the time forecasting methods, explanations and formulas is provided in Exhibit 5.

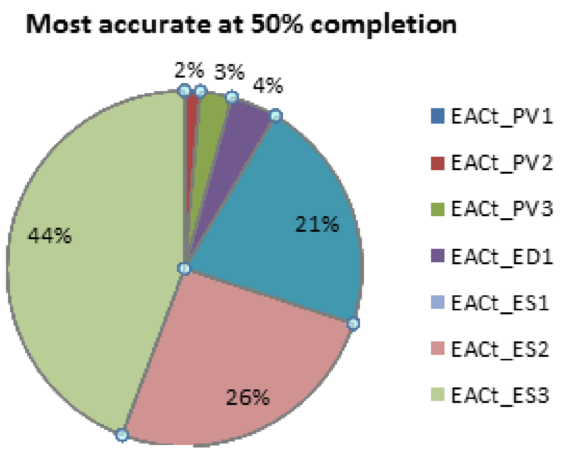
With regard to the need of forecasting indicators concerning time and cost, we investigated which of the measures is the most accurate one, considering different circumstances. These involve the combinations of three risk scenarios and three stages of completion (15%, 50%, and 82%). In order to assign the most accurate indicator we looked at the differences between the forecasted value and the actual simulated one at different percentages of completion. For each technique, we calculated the frequency of being the most accurate in all hundred simulations. This resulted in the percentages shown by the pie charts below.

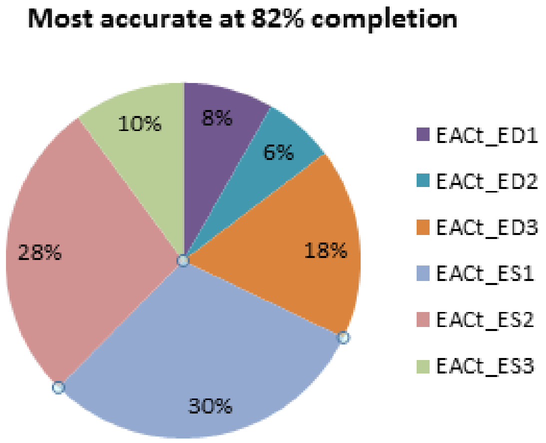
It is important to mention that the following results are specific to our project and that they should be interpreted as averages. Furthermore, we tried to select only one accurate forecasting technique. However, it is advised to consider alternative forecasting indicators as in some circumstances the differences in accuracy percentages are rather negligible.

Since medium and low risk scenarios can be investigated in a similar way, we will only provide the results of these two scenarios in the summary table, while excluding the pie charts. In the table below, you can find the most accurate methods for each combination of completion and scenario.

Time





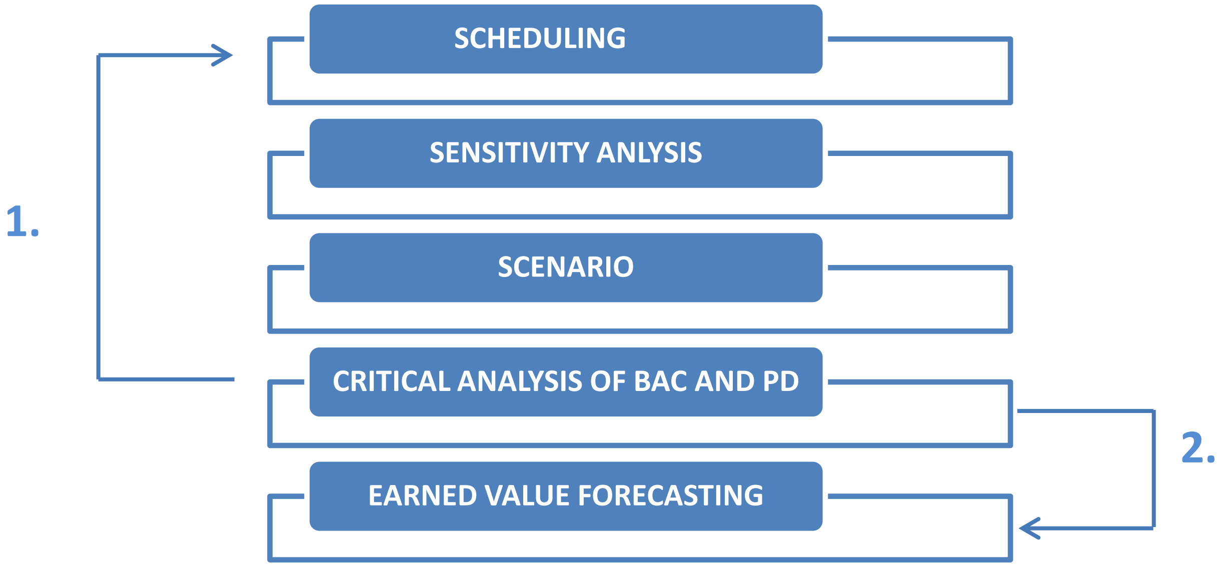


	High risk	Medium risk	Low risk
15%	EACt_ES2	EACt_ES1	EACt_ES1
50%	EACt_ES3	EACt_ES3	EACt_ES1
82%	EACt_ES1	EACt_ES1	EACt_ES1

Table 2. Summarized table accurate forecasting methods: Time

5. Combined approach and recommendations

Being consultants we analyzed a product innovation process at Daikin Europe N.V. After defining the project in the scheduling phase, we performed different techniques on the available data (cfr. Supra). We analyzed the results and came up with a **general framework for product innovation projects**, by which companies should be able to forecast and control the cost and time aspects (BAC and PD) of the project more efficiently.



In the future, we advise Daikin Europe N.V. to compare the actual data of their executed project with the most accurate forecasts, provided by us. In this way, it is possible to check the effectiveness our framework and optimize it.

Scheduling

When the company has an overall view on the cost and duration of each stage of the project, the baseline schedule can be set up and includes information concerning the **Budget at Completion and Planned Duration**. These are two crucial factors for a company to take into account when deciding to go ahead with the actual execution of a project.

In the Baseline schedule, the **critical path** also provides important information for the company. Those activities are critical and need to be focused on. Any delay occurred in one of these activities will have an impact on the total duration of the project. In our case mostly all activities were critical, indicating the high complexity of our project: any occurring delay will have implications for the further course of the project.

Since the time and cost aspects of our project are related, possible delays also have an impact on the budget at completion. However, a further analysis is required.

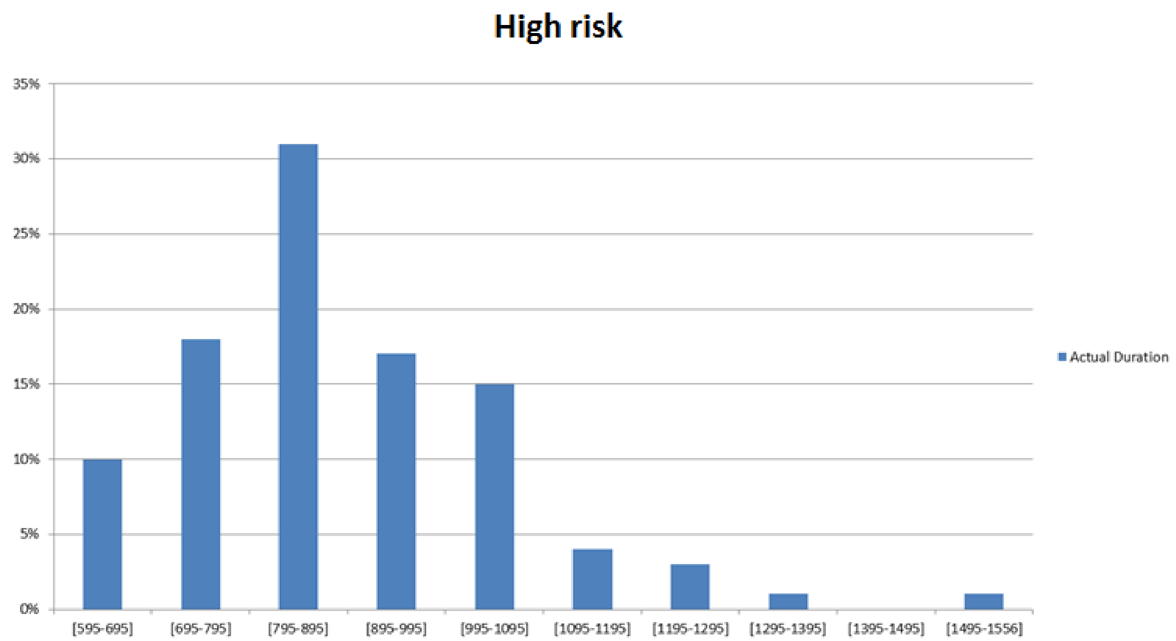
Sensitivity

After indicating the critical activities, these need to be refined in terms of sensitivity. Therefore a risk analysis is performed. This leads to an amount of **high sensitive activities** that need to be closely monitored and require high attention during the execution of the project. After the sensitivity analyses, insight is gained in which activities lie on the critical path and which activities have high probability at becoming critical.

Scenario

Based on experience and managerial insights, combined with the analysis of critical and sensitive activities, the most likely risk scenario needs to be assigned. Taking into account the Gantt-chart, the information provided by innovation experts at Daikin and the **complexity of product innovation projects**, it is logical to focus on a **high risk scenario**. This is also confirmed by the sensitivity analysis.

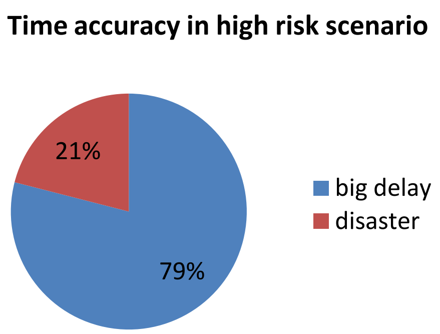
Critical analysis of BAC and PD

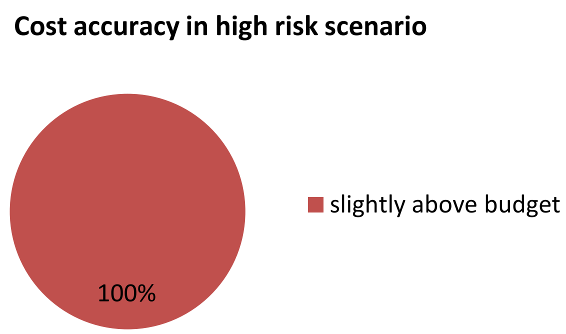


As mentioned above in the scheduling section, we know that the planned duration of the innovation project is estimated by ProTrack at 335 days. However, as the following graph shows, the minimal actual duration in the high risk scenario is much higher. We can state that in best case, the actual duration will be in a range between 595 and 695 days. Moreover, it is clear that in most of the cases this duration will even be higher than 795 days.

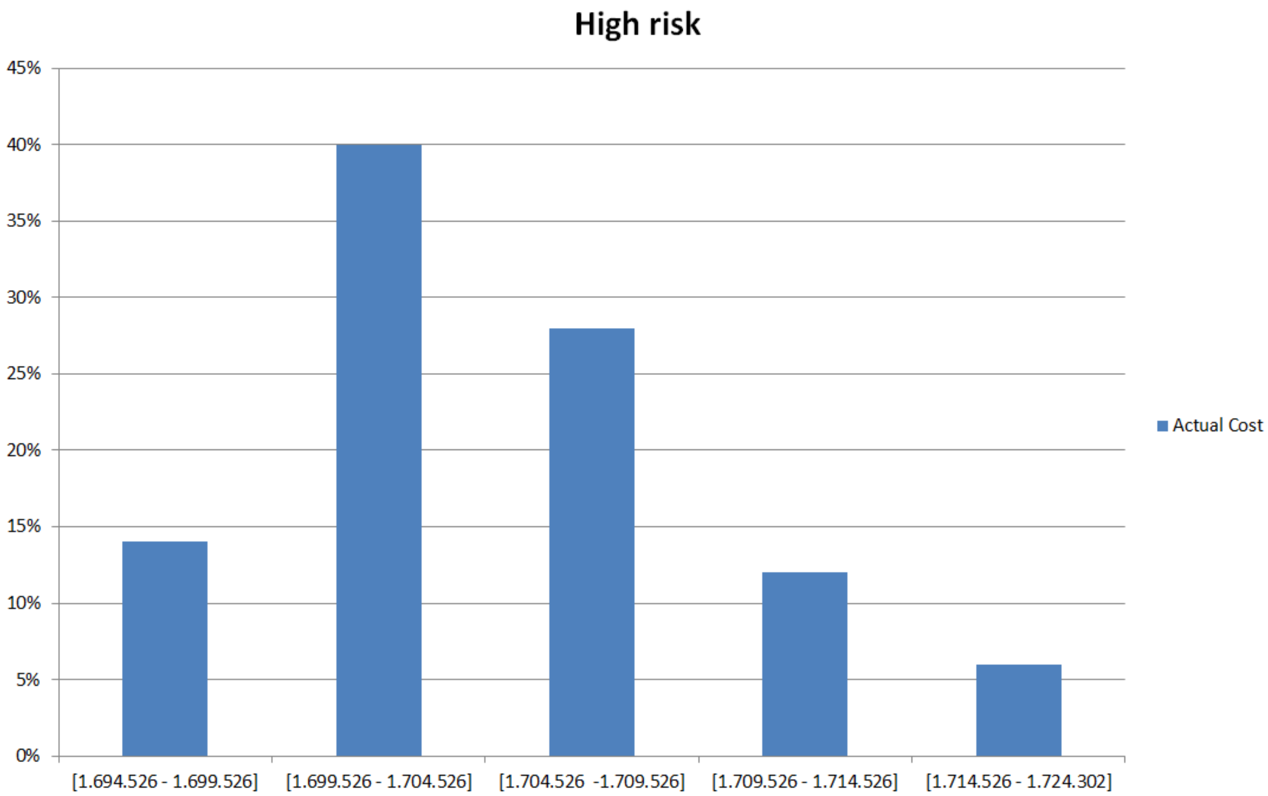
This analysis entails the recommendation towards Daikin Europe N.V. and all other innovative companies to **be more realistic about the planned duration and the impact of risk**. In order to fortify this statement, we compared the actual simulated duration with the planned duration to calculate the on average chance that the project will be on time for each risk scenario.

To catagorize the project in terms of time, we made four different classes: on time, small delay, big delay and disaster. These were constructed by dividing the planned duration by the actual duration. For the high risk scenario, we can conclude that there is an average chance of 79% that there will be a big delay and 21% chance that the project will result in a disaster concerning time.





Furthermore, we also compared the actual simulated **cost** with the budget at completion to calculate the on average chance that the project will be within budget for the high risk scenario. We made four different classes to categorize the total project cost as within budget, slightly above budget, seriously above budget and disastrous. We made these classes by dividing the budget at completion by the actual total cost. For the high risk scenario, we found out that all of our simulations were slightly above budget. So we can conclude that for our innovation project and its predefined budget at completion, the chance is on average 100% that the cost of the project will be slightly above the predicted budget at completion.



Looking at the graph, as showed above, we see that the maximum value for the actual cost is indeed relatively close to our BAC of € 1.688.126. The difference of € 36.176 is rather peanuts, compared to the bombastic amounts of money invested in a product innovation project.

In general, in this project that is charactarized by a high risk scenario, big problems concerning exceeding the planned duration are more likely to occur. This means that planning and controlling the time aspects of the project are more crucial in comparison with the cost aspects. After **adjustments in BAC and PD** are being made, the **scheduling phase needs to be reexecuted** such that the Gantt-chart is more in line with the chosen risk scenario. Because of our framework and these adjustments, **the BAC and PD will be closer to the actual cost and the actual time.**

Earned value forecasting

When the project is being executed, deviations from the planned duration and the budget at completion provide new information for predicting the actual duration and the actual budget. These can be forecasted using the most accurate techniques (cfr. Supra). **Since these techniques vary across the different stages of completion, they should be chosen with high attention.**

6. Conclusion

In this study we analyzed **product innovation** in project management. First of all we recognized that innovation projects need to be treated differently than conventional projects because of their complexity and high risk. We constructed the product life cycle and described the different phases of an innovation project.

Secondly, we constructed the **baseline schedule**. One in which resources are unlimited and one in which they are not. The baseline schedule provided us with interesting information like the critical path, the project duration (approximately one year and a half) and the budget at completion (€ 1.688.126).

Because of the high risk nature of the project it was extremely important to do further investigation. That is why we also used **ProTrack for schedule risk analysis**. Time was our main objective in this analysis but also cost was of great importance so we examined the potential impact of uncertainty on the final project duration (PD) and Budget at Completion (BAC). This analysis gave us some important information like the activities who tend to have more risk to be completed on time and/or within the budget. This info needs to be used as a tracking guidance as it shows on which activities the focus should lie. This was our '**bottom-up tracking approach'.**

Since we are dealing with a serial network it was interesting to do also a **'top-down approach'** using **Earned Value Management (EVM) via P2 Engine**. This gave us a range of valuable indicators which allows us to control the progress of the project. Important for this study was calculating the estimates at completion because they show us the need for corrective measures. Since there are multiple types, we investigated the most accurate ones.

Both the information from a Schedule Risk Analysis (SRA) and the performance measurement of an Earned Value Management (EVM) approach can be used to improve the **corrective actions** that need to be taken when projects are in trouble. When managing innovation projects, it is extremely important to analyze both approaches thoroughly. It shows you the necessary adjustments in BAC and PD, such that the Gantt-chart is more in line with reality.

We believe that with this study we provided Daikin Europe N.V. with an **interesting framework** to manage future innovation projects. Because of our framework and the necessary adjustments it reveals, the **BAC and PD will be closer to the actual cost and the actual time**.

7. Exhibits

Exhibit 1. Data and assumptions

Activity	Planned duration	Fixed cost	Resources
Market research affiliates	3 weeks	€ 3.600,00	AP
Market research enquêtes	7 weeks	€ 28.400,00	AP
Consulting legislation	5 weeks	€ 1.500,00	JA
Drafting specifications	3 weeks	€ 9.547,50	DES; DES MAN; PL
Concept creation	5 weeks	€ 26.262,50	DES; DES MAN; ENG; ENG MAN; PLAN; PLAN MAN; PL
Concept drawing	7 weeks	€ 36.722,50	DES; DES MAN; PLAN; PLAN MAN; PL
Chosing materials	3 weeks	€ 19.990,00	PUR; PUR MAN; ENG; ENG MAN; PL
Patent application	3 weeks	€ 14.003,13	PL; AP; JA
Technical study	13 weeks	€ 113.349,00	DES; DES MAN; ENG; ENG MAN; PLAN; PLAN MAN; PL
Constructing prototypes	5 weeks	€ 275.900,63	DES; DES MAN; ENG; ENG MAN; QUA; PL
Testing prototypes	7 weeks	€ 191.947,50	NPD; TEST; TEST MAN; PL
Adjusting design	3 weeks	€ 129.547,50	DES; DES MAN; PL
Final prototypes	6 weeks	€ 531.338,00	DES; DES MAN; ENG; ENG MAN; QUA; PL
Final testing	7 weeks	€ 295.836,00	DES; DES MAN; ENG; ENG MAN; QUA; TEST; TEST MAN; PL
Pre-production	1 week	€ 802.912,50	ENG; ENG MAN; PL

Abbreviations			
AP	Administrative Personnel	PLAN MAN	Planning Manager
JA	Juridical Advisor	PUR	Purchaser
DES	Designer	PUR MAN	Purchasing Manager
DES MAN	Design Manager	QUA	Quality Controller
PL	Project Leader	NDP	New Product Developer
ENG	Engineer	TEST	Tester
ENG MAN	Enginering Manager	TEST MAN	Testing Manager
PLAN	Planner		

Exhibit 2. Work Breakdown Structure (WBS)

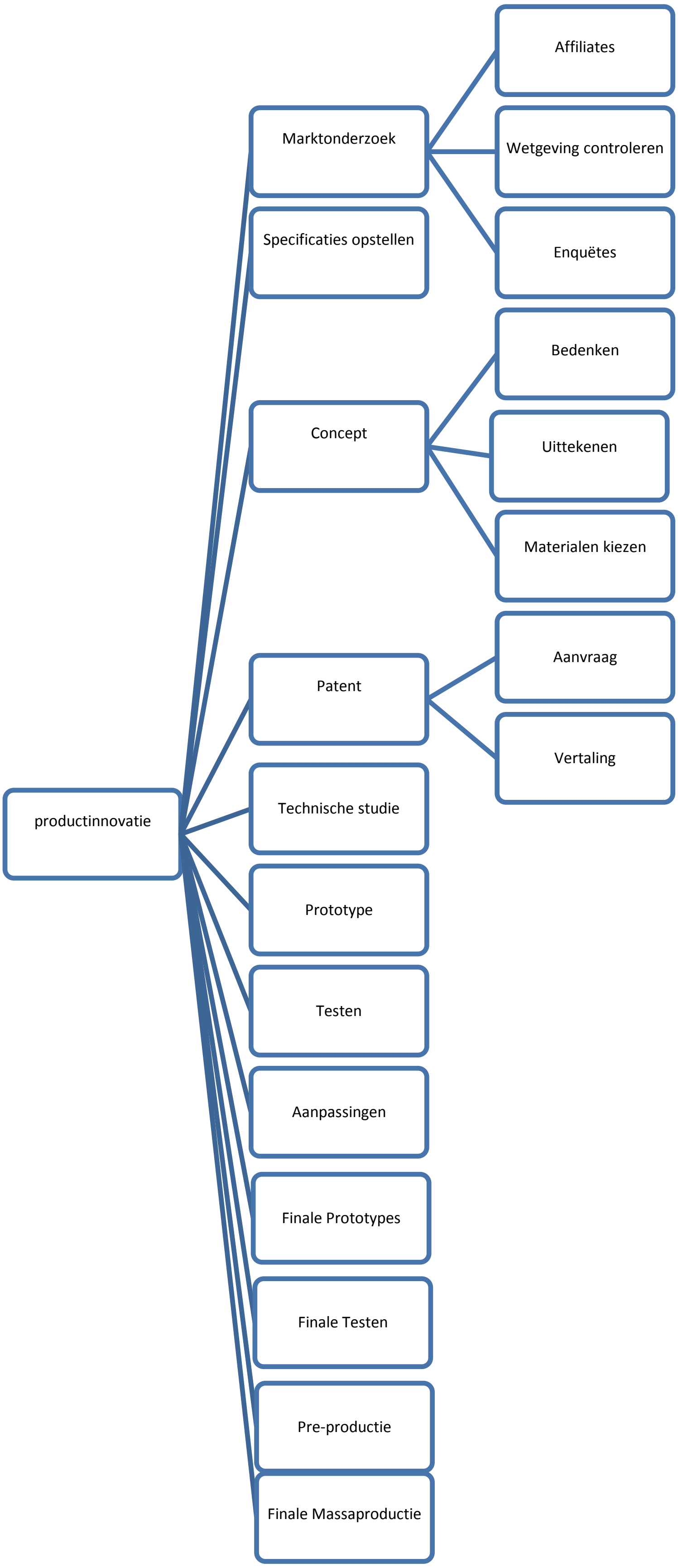


Exhibit 3. Activity-on-Node

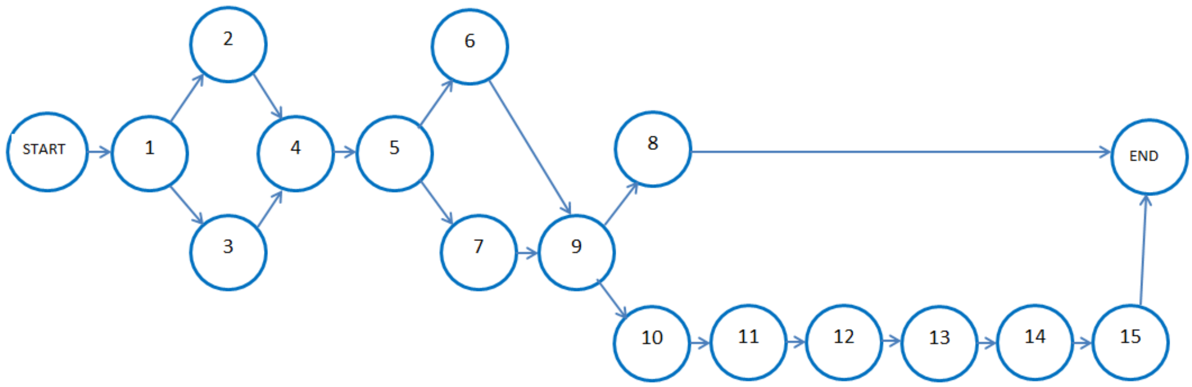


Exhibit 4. Sensitivity measures SRA

Activity	SSI	CRIRho_t	CRITau_t	CRIRho_c	CRITau_c	Average_t	Average_c
Market research affiliates	18%	8%	3%	9%	4%	10%	10%
Market research enquêtes	29%	15%	9%	2%	0%	18%	10%
Consulting legislation	5%	11%	8%	3%	3%	8%	4%
Drafting specifications	17%	6%	1%	3%	0%	8%	7%
Concept creation	38%	26%	17%	15%	9%	27%	21%
Concept drawing	41%	33%	21%	28%	18%	32%	29%
Chosing materials	0%	0%	1%	7%	4%	0%	4%
Patent application	0%	2%	3%	10%	5%	2%	5%
Technical study	72%	42%	28%	46%	31%	47%	50%
Constructing prototypes	30%	27%	17%	16%	10%	25%	19%
Testing prototypes	40%	5%	3%	44%	29%	16%	38%
Adjusting design	17%	4%	1%	8%	3%	7%	9%
Final prototypes	33%	32%	21%	26%	16%	29%	25%
Final testing	49%	38%	24%	41%	27%	37%	39%
Pre-production	9%	0%	5%	0%	5%	5%	5%

Abbreviations:

SSI: schedule sensitivity index

CRIRho_t: cruciality index, based on the spearman's rank correlation

CRITau_t: cruciality index, based on kendall's tau rank correlation index

CRIRho_c: cruciality index, based on the spearman's rank correlation and cost sensitive

CRITau_c: cruciality index, based on kendall's tau rank correlation index and cost sensitive

Average_t: sensitivity measure based on the average of SSI, CRIRho_t and CRITau_t

Average_c: sensitivity measure based on the average of SSI, CRIRho_c and CRITau_c

Exhibit 5. Forecasting methods

Time forecasting methods

PF = 1: Future performance is expected to follow the baseline schedule
PF = SPI or SPI(t): Future performance is expected to follow the current time performance
PF = SCI of SCI(t): Future performance is expected to follow the current time and cost performance

a. Planned Value Forecasting Method:

Version 1: $EAC(t)_{PV}$ = PD – TV with PV_{rate} = BAC / PD and Time Variance TV = SV / PV_{rate}

Version 2: $EAC(t)_{PV}$ = PD / SPI

Version 3: $EAC(t)_{PV}$ = PD / SCI

b. Earned Duration Forecasting Method

This forecasting method relies on the Earned Duration metric, which is equal to ED = AT * SPI. The final project duration using the earned duration method is calculated as

$$EAC(t)ED = AT + (\max(PD, AT) - ED) / PF$$

The three versions of this prediction technique only differ in their performance factor PF which can be equal to 1, SPI or SPI * CPI.

c. **Earned Scheduled Forecasting Method**

This forecasting method relies on the Earned Schedule metric and calculates the final duration prediction as:

$$EAC(t)ES = AT + (PD - ES) / PF$$

Consequently, the three versions of this prediction technique only differ in their performance factor PF which can be equal to 1, SPI(t) or SPI(t) * CPI.

Forecasting Method	Version 1: according to plan	Version 2: according to current time performance	Version 3: according to current time/cost performance
Planned Value Method (PVM)	EAC(t)PV (PF = 1)	EAC(t)PV (PF = SPI)	EAC(t)PV (PF = SCI)
Earned Duration Method (EDM)	EAC(t)ED (PF = 1)	EAC(t)ED (PF = SPI)	EAC(t)ED (PF = SCI)
Earned Schedule Method (ESM)	EAC(t)ES (PF = 1)	EAC(t)ES (PF = SPI(t))	EAC(t)ES (PF = SCI(t))