# Estimate faster, cheaper... and better!

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## Abstract

*Nowadays, Sogeti Nederland gets more and more questions from clients like: "What is your productivity rate for Java projects?", "What is your duration for building an application of 1000 function points?" and "What is your price per function point for a .Net project?" Literature shows us however, that there is no good answer to these kinds of questions. Putnam [1] is one of the people that show us that the amount of effort needed for a project highly depends on the duration chosen. Other factors that influence the answer to these questions might be: size, complexity and the amount of work that is being carried out on an offshore location (like India). It is therefore necessary to consider all the relevant factors when preparing a project estimation. However, if this has to be done on an ad hoc basis (whenever a client asks, or whenever a Request for Proposal comes in), it will take a lot of time to analyze the right projects. To make things faster and easier, Sogeti has developed a tool to estimate projects and to answer questions like the questions mentioned above. In the paper the tool and its underlying principles are introduced and the preliminary results are given.*

## 1. Introduction

Thousands and thousands of requests for proposal (RFPs) for fixed-price software development projects are sent out every day all over the globe. These RFPs serve the purpose to select the most appropriate supplier for the deal. However, a lot of these RFPs prove to be counterproductive. Little knowledge about software project estimation lead to RFPs with questions that are not easily answerable for more mature suppliers of software projects.

Sogeti Nederland BV is an ICT supplier in the Netherlands with more than 3.000 employees in the Netherlands and more than 20.000 employees worldwide. Sogeti wishes to contribute to the simplicity, reliability and availability through ICT craftsmanship in order to turn ICT into a commodity [2]. Sogeti believes that software will become a service that organizations can use at their will. The Sogeti vision statement is: Results through passionate ICT craftsmanship.

Sogeti develops, among others, fixed-price fixed-date projects for a large number of clients. These projects are developed in a number of onshore and offshore delivery centers. But before a project is even a project in the delivery centers, first Sogeti has to win the bidding competition from their competitors. The basis for the bidding process most often is an incoming RFP.

Unfortunately, almost every RFP is quite different in nature, which makes it necessary to do a great deal of analysis work to come up with a good estimation. Furthermore, the required RFP answering time is almost always very short, sometimes even shorter than two weeks. Next to this handicap, there is also the issue of the documentation. Many RFPs are based on either high level requirements or on (often incomplete) high level designs. It is usually quite hard to do a solid size estimation on this documentation. Often, the accuracy level in the cone of uncertainty [3] is not lower than 50%. The challenge for suppliers of software ICT projects, and therefore for Sogeti as well, is to come up with a good proposal, within a short time-limit, with enough accuracy to be able to judge the profitability.

In Sogeti the Netherlands, there is a separate entity that is responsible for the estimation of fixed-price projects and the metrics part in RFP's with the name of Sizing, Estimating & Control (SEC). SEC uses the QSM SLIM [10] tooling to estimate the projects but it turns out that the results are not well comparable to the Sogeti way of conducting business. For instance it was not possible to estimate the part of the work can be done in an offshore location (with a different cost and productivity level).

Within Sogeti the question was raised how to build an estimation instrument that would gain us some time and effort in the bidding process, while being accurate enough to rely on. Furthermore, the instrument should be flexible enough to be able to calculate offshore influences, test strategies and complexity. Another important requirement is that the tool also had to implement the Deming cycle, also known as the PDCA (Plan, Do, Check, Act) cycle, meaning that it should be easy to tune the tool with experience data from projects completed.

In the remainder of this paper it is described how the this tool (with the name Estimating Wizard) has been designed and build. Furthermore the results of estimates with the wizard are compared to expert estimates. This paper is an update of an earlier paper on this topic [12].

## 2. Requests for Proposal

Software ICT service suppliers, like Sogeti, face the same problem every time an RFP is received from a (potential) client. Based on the enclosed documentation, it has to come up with a proposal that:

- delivers the required functionality
- suits the clients quality and technical requirements
- at a lower price than competitors
- but with a price that guarantees some profit
- supported by proof that we can deliver what we say

Most of the times, RFPs consist of a large number of questions. A number of these questions are about the project organization, but nowadays the trend is to ask for metrics as well. Recurring questions are questions like:

- What is your duration to build a 1000 function points software system?
- What is your productivity to build an application of 500 function points in Java?
- What is your price per function point to build an application of 500 function points in Java?

These are questions that are not easy to answer if your organization is not mature enough to use functional size measurement or to collect experience data from projects completed. However, these less mature organizations can still guess their productivity, for instance based on benchmarking data derived from the ISBSG database [4]. For more mature organizations, the questions are sometimes even harder to answer. Users of the SLIM toolset [10] know that there is a strong, non-linear relationship between the chosen duration of the project and the amount of effort that has to be spent. However, the duration variable is almost never asked in RFPs, so one has to guess. For instance, the answer to the question: "What is your productivity to build an application of 500 function points in Java?" can be anything between 4 hours per function point and 13 hours per function points, depending on only the chosen duration of the project, all other variables remaining constant. The reason for this has been

made clear by Larry Putnam [1] a long time ago. According to him, the level of effort needed varies with duration in the following way:

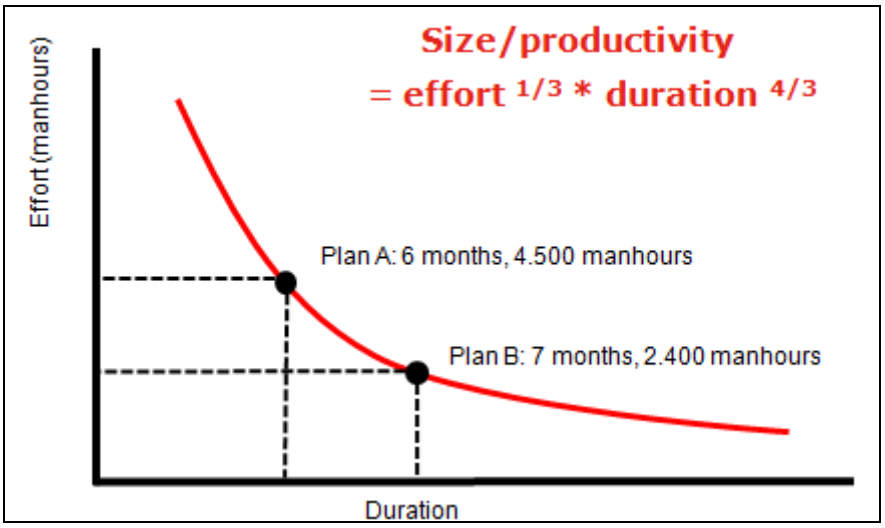


*Figure 1: PDR/Duration tradeoff according to Putnam [1].*

Although Plan A has a shorter duration compared to plan B, the extra amount of people needed to do the work in that timeframe leads to a lot of extra coordination and overhead, a less efficient process and an increase of project chaos, which all make the project extra expensive.

So, what are we going to answer to this RFP question? The easy choice is to go for the lowest possible PDR. Although this may lead to the winning of the contract, there might be a mismatch with the expectations of the client with regard to duration. This will lead to heavy negotiations and may lead to a disturbed relationship. Of course, answering the question with one of the highest PDRs is also not commendable, so what is it we have to do? Sogeti decided it would be best if we determine the optimal duration for a project and communicate the associated PDR.

In the meantime, we want to calculate the scenario's with a duration of x, y and z weeks shorter and x, y and z weeks longer. Although this may sometimes be outside of the RFP scope, this may be an extra service to the client, who then can choose the scenario that fits best for his needs.

## 3. The Estimating Wizard

The Estimating Wizard combines some of the well-known metrics models from literature with the experience data of Sogeti. The Estimating Wizard is used to estimate new development projects for software that resides in the business application software domain. Projects from this domain are used to calibrate the wizard. The Wizard is tuned periodically with new project data and it delivers a work breakdown structure that is very helpful for the project manager to plan his project into detail.

How does it work? The Estimating Wizard is built in MS-EXCEL and started out as a reference card with product size ranges and Project Delivery Rates (PDR = hours per function point) per product size range, like this:

| Hour/FP: Average Complexity<br>Duration in months | 3½ | 4 | 4½ | 5 | 5½ | 6 | 6½ | 7 | 7½ | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0-250 FP | 10,1 | 8,9 | 8,1 | 7,7 | 6,9 | | | | | |
| 250-500 FP | | 9,1 | 8,0 | 7,3 | 6,9 | 6,2 | | | | |
| 500-750 FP | | | 8,6 | 7,6 | 6,9 | 6,5 | 5,9 | | | |
| 750-1000 FP | | | | 8,3 | 7,3 | 6,6 | 6,3 | 5,6 | | |
| 1000 -1250 FP | | | | | 8,1 | 7,1 | 6,5 | 6,2 | 5,5 | |
| 1250 - 1500 FP | | | | | | 7,9 | 6,9 | 6,3 | 6,0 | 5,4 |

*Figure 2: First variant of the Estimating Wizard: reference card.*

For instance, to build a 300 FP application with a required duration of 5 months would have a PDR of 7,3 hours per function point. The same project with a required duration of 6 months would result in a productivity of 6,2 hours per function point.

Since its first version in 2006, the wizard has evolved into a sophisticated estimation tool. The latest version of the wizard works like this: First we have a selection screen on which the most relevant variables have to be entered.

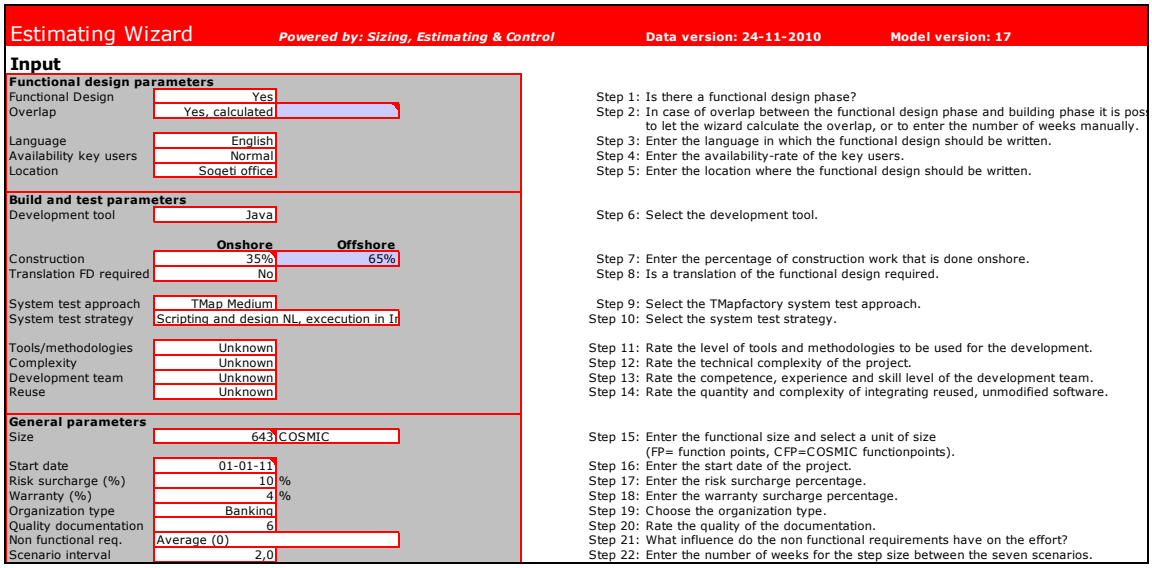


*Figure 3: Current input screen*

Sogeti experience shows that these are the input criteria that are considered to be of interest in the Sogeti bidding process and these factors will possibly also be applicable to other ICT suppliers. First of all it has to be clear whether the functional design phase is in scope of the estimate or not. Based on the input of a large number of Sogeti professionals in the functional design area, the estimation parameters were defined. The main parameters are size, language, location and the availability of the key users.

In the development tools list box, it is possible to choose from Java, MS.Net (web client or windows client) and a number of Oracle variants. These correspond with the Sogeti delivery centers, which are software factories specialized in the use of these development tools.

Next, we have to estimate the amount of work that is carried out in one of the offshore delivery centers. Most of the times a project is 100% onshore, or 100% offshore (which of course is not really 100% offshore, but only the technical realization activities are). However, there are occasions when it is considered to be wise to develop certain parts of the project onshore, while off shoring the remainder, for instance when requirements are not completely

clear yet and it takes a lot interaction with the client to make things clear. There are a number of different system testing variants, where all, or part of the intake, design and execution of the test scripts is carried out either onshore or offshore.

Then, the appropriate TMap [11] test strategy has to be chosen, which is dependent on the complexity of the system and the importance of the system to be bug-free after delivery. There are three test strategies available in the Estimating Wizard: TMap Light, TMap Medium and TMap Heavy. TMap is one of the world standards in testing methodologies, and is developed by Sogeti.

Then there are a number of parameters that are used to tune the project based on the actual characteristics, like the availability of tools and methodologies, the technical/functional complexity of the system (high, medium, low), the skills and experience of the development team and the amount of software reuse that is relevant. This is a rather subjective choice, but for experienced contract managers it is often not really a problem to make the right choice.

The size is about the most important factor of the wizard. Every RFP is sized within the department of Sizing, Estimating and Control of Sogeti in one of the methods NESMA FPA [4] or COSMIC [5], which are both an ISO standard. Because of the high level documentation, a lot of RFPs are sized with COSMIC. This is because often a data model is not present and FPA requires a data model to do an indicative FPA. In COSMIC this is not obligatory. Due to the recent studies on COSMIC to FPA conversion formulae [6][7][8], it is possible to convert a COSMIC size into an FPA size. This conversion formula derived from our own research [8] has been implemented in the tool.

The start date of the project is the moment the first team member is going to work on one of the project deliverables. After filling in the input variables, the Estimating Wizard calculates the solution and returns the following screen:

**Functional design phase**

| | |
|---|---|
| Duration in weeks | **17,6** |
| Design complete | **4-05-11** |
| Total effort | **1.975** |
| Effort per FP | **2,53** |
| Effort cost | **€ 208.531** |
| Additional cost | **€ 14.815** |
| Totaal cost | **€ 223.346** |
| Cost per FP | **€ 286** |
| Average team size | **2,80** |

**Build and test phase**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Duration in weeks | 20,0 | 22,0 | 24,0 | **26,0** | 28,0 | 30,0 | 32,0 |
| Start phase | 18-02-11 | 18-02-11 | 18-02-11 | **18-02-11** | 18-02-11 | 18-02-11 | 18-02-11 |
| Effort | 9.794 | 6.690 | 4.723 | **3.429** | 2.550 | 1.935 | 1.495 |
| Effort per FP | 28,06 | 19,17 | 13,53 | **9,83** | 7,31 | 5,54 | 4,28 |
| Effort cost | € 550.720 | € 376.152 | € 265.590 | **€ 192.826** | € 143.360 | € 108.787 | € 84.036 |
| Additional cost | € 56.446 | € 41.090 | € 31.364 | **€ 24.963** | € 20.611 | € 17.570 | € 15.393 |
| Totaal cost | € 607.167 | € 417.242 | € 296.954 | **€ 217.789** | € 163.972 | € 126.357 | € 99.428 |
| Cost per FP | € 1.740 | € 1.196 | € 851 | **€ 624** | € 470 | € 362 | € 285 |
| Average team size | 12,24 | 7,60 | 4,92 | **3,30** | 2,28 | 1,61 | 1,17 |

**Risk and warranty**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Risk hours | 834 | 586 | 429 | **325** | 255 | 205 | 170 |
| Risk cost | € 54.301 | € 39.107 | € 29.484 | **€ 23.150** | € 18.845 | € 15.836 | € 13.682 |
| Warranty hours | 209 | 146 | 107 | **81** | 64 | 51 | 43 |
| Warranty cost | € 13.575 | € 9.777 | € 7.371 | **€ 5.788** | € 4.711 | € 3.959 | € 3.420 |

**Total**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Duration in weeks | 27,0 | 29,0 | 31,0 | **33,0** | 35,0 | 37,0 | 39,0 |
| Delivery for acceptance | 8-07-11 | 22-07-11 | 5-08-11 | **19-08-11** | 2-09-11 | 16-09-11 | 30-09-11 |
| Total effort | 11.470 | 8.055 | 5.892 | **4.469** | 3.501 | 2.825 | 2.340 |
| Effort per FP | 32,87 | 23,08 | 16,88 | **12,80** | 10,03 | 8,09 | 6,71 |
| Totaal cost | € 746.634 | € 537.717 | € 405.400 | **€ 318.319** | € 259.120 | € 217.744 | € 188.122 |
| Cost per FP | € 2.139 | € 1.541 | € 1.162 | **€ 912** | € 742 | € 624 | € 539 |
| Average team size | 10,64 | 6,96 | 4,76 | **3,39** | 2,50 | 1,91 | 1,50 |
| Average hourly rate | € 65 | € 67 | € 69 | **€ 71** | € 74 | € 77 | € 80 |

*Figure 4: Current output scenario screen.*[1]

[1] The results displayed in this figure are not the result of the input parameters above and the data has been altered because of company security reasons.

The optimal duration is calculated and is in this case 33 weeks. The estimation of the delivery date (for customer acceptance test) is on August 19, 2011. The total number of effort hours estimated is 4.469 hours. The productivity rate, the total price and the price per function point is calculated. The total price is build up by multiplying all the effort hours with the appropriate hour rate (see figure 5) and add the total amount of costs to this (workstation use, translation costs and other costs).

Furthermore, these figures are also calculated for 6 scenarios: in this case 2, 4 and 6 weeks shorter duration and 2,4 and 6 weeks longer duration because the scenario interval in the input screen is set to a 2 weeks interval. The client can then decide if the project should be faster or slower than optimal and he can base his business case on this. It might be very reasonable for instance to go for the 6 weeks earlier scenario, when the time-to-market of the system is fixed by political decisions.

In addition to the figures above, the wizard also returns a detailed work breakdown structure (WBS). A small part of it is displayed below (also again on different input parameters and altered outcomes).

| Management Phase Construction (Onshore) | # hrs | # Hrs/FP | FL | Rate €/hr | Cost € | Cost €/FP |
|---|---|---|---|---|---|---|
| **Project management Construction** | | | | | | |
| Contract management | 88 | 0,82 | 10.2 | € 250,00 | € 22.000,00 | € 72,00 |
| Project management | 352 | 0,41 | 8.2 | € 200,00 | € 70.400,00 | € 224,00 |
| Quality management | 90 | 0,32 | 7.4 SC | € 230,00 | € 20.700,00 | € 134,00 |
| **Project preparation Construction** | | | | | | |
| Preparation workplace/infrastr/developenviron | 12 | 0,8 | 6.2 | € 200,00 | € 2.400,00 | € 12,00 |
| Preparation application framework | 112 | 0,4 | 6.2 | € 220,00 | € 24.640,00 | € 42,00 |
| Start up/reading | 33 | 0,7 | 6.2 | € 150,00 | € 4.950,00 | € 17,00 |
| Kick off | 8 | 0,1 | 6.2 | € 140,00 | € 1.120,00 | € 12,00 |

*Figure 5: Part of the WBS output screen.* [2]

This WBS makes it easy for the project manager to plan his project into detail after the bid is won. The same WBS is also the basis for the Sogeti effort registration tool. Employees in the delivery centers have to register their hours in the same format as the Estimating Wizard WBS. The effort is recorded per project in the effort registration tool and after the project has finished, the metrics department will derive the appropriate metrics from the tool in order to see whether the project has performed according to the wizard's estimate. This way, it is easier to tune the actual project performance to the Estimating Wizard and by doing this, to tune the wizard with new experience data.

Every quarter, a new version of the Estimating Wizard is released, so that estimations are always based on the most accurate version of the experience data This means that the Deming circle of Plan, Do, Check and Act is fully implemented.

From the start until the release of the present version of the wizard, about 800 effort hours were spent to design and to build the wizard. Every quarter it takes about 8 hours to update the wizard with the new experience data.

## 4. Underlying principles

The basis of the Estimating Wizard is a WBS template of the realization of a 500 FP application (new development), filled with average project actuals from the past. That is what we have called a typical 500 FP project and this project has been approved by Sogeti

[2] The results displayed in this figure are not the result of the input parameters above and the data has been altered because of company security reasons.

management to be the basis for the calculations and extrapolations. There is a baseline project like this for all the different delivery centers.

This WBS leads to a certain amount of hours per task. For each task the appropriate function level was determined. Within Sogeti, every function level has its own fixed hourly rate, which makes it possible to quantify the hours into costs. This can be seen in the figure above. A contract manager within Sogeti has on average a 10.2 function level. This means that he or she has a certain hourly rate. In the initial 500 FP baseline project, the number of hours a contract manager should make is a certain amount, so that the following figures can be derived:

- Hours per function point (PDR) per task
- Total cost per task
- Price per function point task

In addition, there are costs that have to be taken into account, like for instance workstation costs, software license costs and translation costs (in the case of offshore projects). Workstation costs are calculated by a fixed amount per effort hour, translation costs are dependable on the functional size of the project. The next task was to extrapolate our standard project WBS into a calculation model that takes into account all the other factors. The most important extrapolations are described in the remainder of this paper.

### 4.1 Size

First of all, we had to consider what would happen when the size of the project would be larger or smaller than the 500 function points of the baseline project. We know from experience that functional size measurement is often less useful when the functional size is lower than 100 function points. We decided therefore that the tool should only be used for sizes above 100 function points. We have used the SLIM toolset for exploring the effects of a larger or a smaller size with all other things being equal. This has lead to a size/PDR tradeoff curve which we have put in MS-EXCEL. However, we wanted to take into account our own experience data as well, so we tried to plot our own projects onto this curve and adjusted the curve with this data. This brought us the size/PDR tradeoff curve that we were looking for.

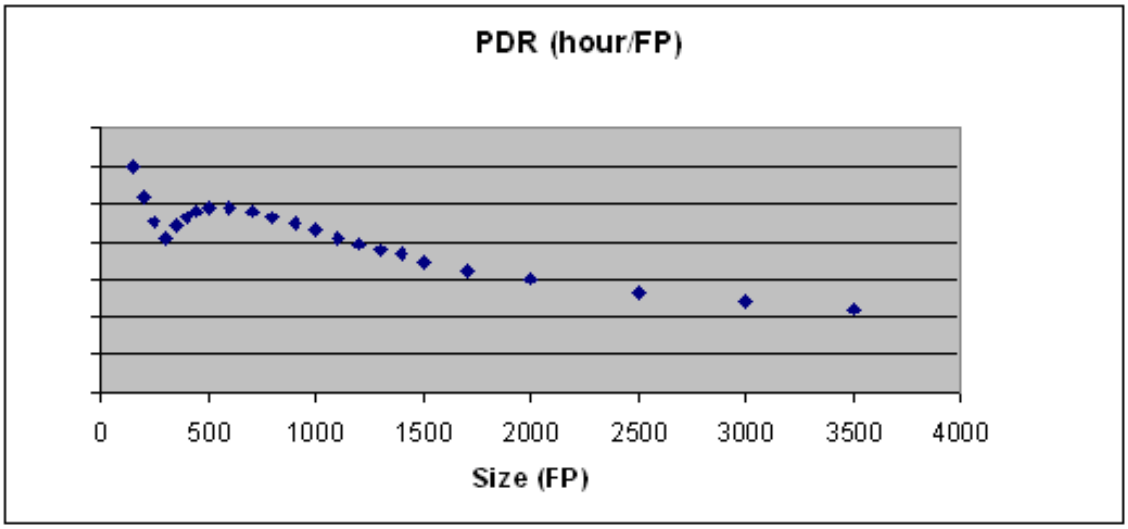


*Figure 6: Size/PDR tradeoff* [3]

[3] Y-axis labels are missing for company security reasons.

The figure shows that the productivity of a very small project is quite low (a high PDR), but PDR drops when the size is becoming somewhat larger. After a certain turning point (about 300 FP), PDR rises again, partly due to the fact that the team size has to become larger at this point and the need to apply more formal specifications and methods arises. This will need extra coordination and overhead. After a certain point (about 600 FP), PDR drops again due to efficiency and scalability reasons. The curve from figure 6 is implemented in the size extrapolation formulae of the Estimating Wizard in order to make it possible to estimate projects for building applications with different sizes than 500 FP.

## 4.2 Duration

After the effect of product size on the PDR of a project, we had to examine the effect of size on optimal duration on the total effort and the price of the project. Based on the outcomes of SLIM estimate and tuned with our own experience data, this lead to the following figure.

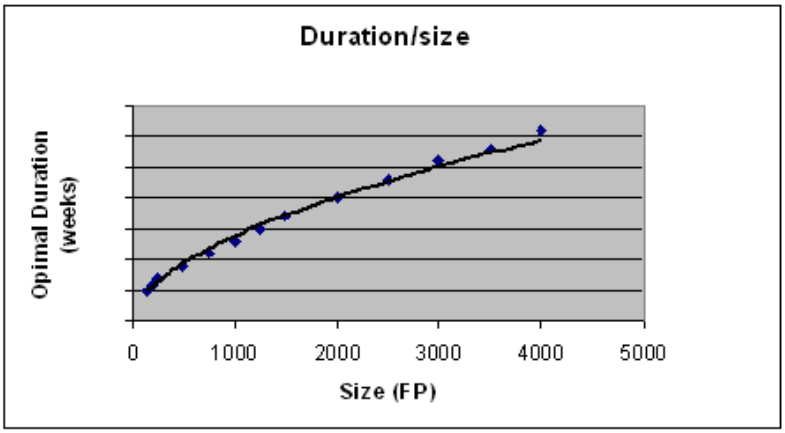


*Figure 7: Size/Duration tradeoff* [4]

When looking at small projects (< 500 FP), an increase in size leads to a relatively large increase in optimal duration. For large projects, an increase in size leads to a relative small increase of optimal duration. This relationship is an important factor in the Estimating Wizard, because it is the basis for the calculation of the six alternative scenario's. For each scenario, the effect of duration on effort, PDR and costs have been calculated based on experience data and on the figure above. This resulted in the following price model:

[4] Y-axis labels are missing for company security reasons.

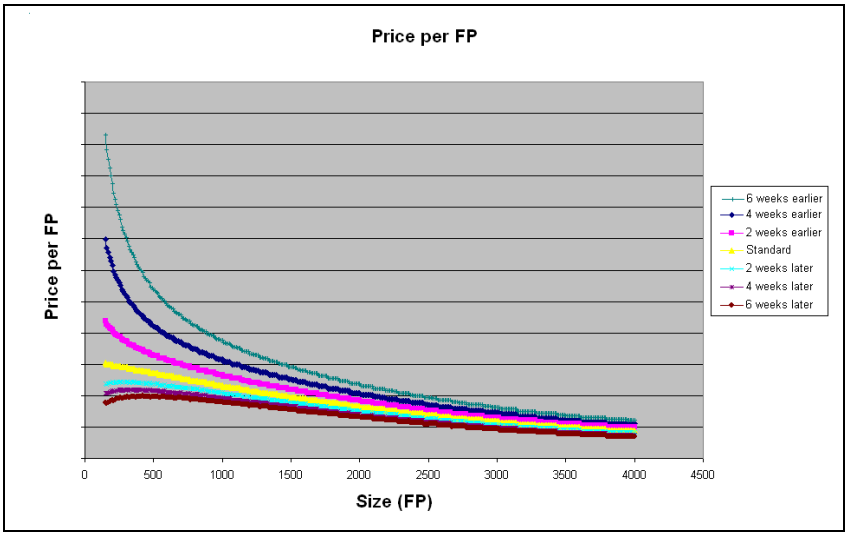


*Figure 8: Price per function point scenario model* [5]

## 4.3 Additional factors

The influence of the additional factors that we are using in the calculation model are all based on educated guesses by our experts. For instance the effect of complexity on the amount of effort needed and the effect on optimal duration was discussed by a number of experts and ultimately approved by the Sogeti management team. As for the TMap test strategy, we have the experience data that is involved with the three test strategies, so we know the difference in PDR and duration for the three different strategies. The hard part was to estimate the offshore component. For each Delivery center, a separate WBS template has been developed for a fully offshore project. The hours again being derived from experience data. After that, the outcomes with the different percentages could be calculated with MS-EXCEL.

# 5. Results

The last few years a large number of bids have been estimated with the Estimating Wizard. In this paragraph the results of ten representative estimates are compared to the results of the expert estimation (usually carried out by technical architects and engineers) in relation to the final results of the projects after realization. In order to analyze the results, three metrics have been used for both the Expert estimate and the Estimating Wizard estimate (including functional size measurement):

- Effort Accuracy (Effort Estimate / Actual Effort)
- Duration Accuracy (Duration Estimate / Actual Duration)
- Cost Accuracy (Cost Estimate / Actual Cost)

The results are given in table 1.

[5] Y-axis labels are missing for company security reasons.

*Table 1: Estimate accuracy results*

| Project | Size (FP) | Expert Effort Accuracy | Expert Duration Accuracy | Expert Cost Accuracy | Expert Time Spent | Est. Wizard Effort Accuracy | Est. Wizard Duration Accuracy | Est. Wizard Cost Accuracy | Est. Wizard Time spent |
|---|---|---|---|---|---|---|---|---|---|
| Project 1 | 277 | 0,675 | 1,545 | 0,467 | 30 | 0,477 | 1,204 | 0,501 | 17 |
| Project 2 | 359 | 0,579 | 0,951 | 1,139 | 35 | 0,707 | 0,775 | 1,170 | 26 |
| Project 3 | 347 | 0,589 | 0,142 | 0,615 | 40 | 1,067 | 0,996 | 1,283 | 14 |
| Project 4 | 1.178 | 0,414 | 0,557 | 0,312 | 60 | 0,774 | 0,590 | 0,862 | 55 |
| Project 5 | 951 | 1,430 | 0,997 | 0,946 | 34 | 1,067 | 0,877 | 1,718 | 24 |
| Project 6 | 295 | 0,763 | 0,857 | 0,619 | 26 | 0,881 | 1,200 | 0,845 | 6 |
| Project 7 | 790 | 0,717 | 0,850 | 0,976 | 34 | 0,926 | 0,865 | 1,132 | 27 |
| Project 8 | 350 | 1,258 | 0,800 | 1,309 | 28 | 1,203 | 1,096 | 1,318 | 20 |
| Project 9 | 746 | 0,586 | 0,296 | 0,545 | 34 | 0,826 | 0,385 | 1,953 | 22 |
| Project 10 | 2.293 | 0,766 | 0,421 | 0,797 | 40 | 0,931 | 0,632 | 1,058 | 14 |

The closer the accuracy value is to 1, the better the estimate was compared to the actual result. In table 2 the overall metrics are given.

*Table 2: Estimate accuracy results*

| | Expert Estimate | Est. Wizard Estimate |
|---|---|---|
| **Effort Accuracy** | | |
| Average | 0,778 | 0,886 |
| St.Dev. | 0,319 | 0,207 |
| Median | 0,696 | 0,904 |
| | | |
| **Duration Accuracy** | | |
| Average | 0,742 | 0,862 |
| St.Dev. | 0,405 | 0,272 |
| Median | 0,825 | 0,871 |
| | | |
| **Cost Accuracy** | | |
| Average | 0,772 | 1,184 |
| St.Dev. | 0,316 | 0,423 |
| Median | 0,708 | 1,151 |

It's clear to see that the average and median Accuracy results of the Estimating Wizard estimates are closer to 1 than the Expert Estimates. McConnell [13] states that expert estimates are usually up to 30% optimistic. This statement is clearly supported by the data in this sample, showing expert underestimation for effort, duration and cost. The Estimating Wizard also underestimates effort and duration in most cases, but overestimates costs. This could for instance be explained by a larger percentage of actual offshore work than estimated. Additional analysis is necessary to see whether this is really the case.

Another observation that can be made on the results in table 1 is that the Estimating wizard estimates are actually carried out in fewer hours spent than expert estimates. This contradicts one of the most heard arguments against using functional size measurement and methodical estimation, that is that it costs a lot of effort to do the analysis. Apparently expert estimates also take some time, at least within Sogeti this is the fact. The main reason is probably that the expert estimates are usually carried out by more than one person. The technical architect estimates part of the work, but also the lead engineer and the test manager may do their own estimates. Later these estimates are than aggregated by the contract manager. In fact, all these people have to read the documentation, analyze it and then estimate it. The contract manager

then has to puzzle and fit the different estimates into one quotation while being cautious that no activities are forgotten. Therefore, the more people involved, the higher the number of hours spent on the expert estimate.

## 6. Conclusions

The estimation process of new bids has become quicker and more accurate with the Estimating Wizard. Of course the wizard doesn't claim to *predict* the project from start to finish, because this is never possible for any project. However, by using metrics, experience data and literature models, an instrument has been built that helps to estimate quickly, estimate quite accurately and estimate different scenario's.

The results of the accuracy analysis of the estimates show that the tool is actually more accurate in most of the cases for effort, duration and costs. The results have to be analyzed into more detail to see why the duration and effort are underestimated and costs are overestimated by the tool.

The main objective, to build an estimation instrument that will gain us some time and effort in the bidding process, while being accurate enough to rely on, has obviously been met. The additional advantage is that now there is a standard WBS that is used in estimating and in effort administration, in order to make it possible to analyze the actual effort with regard to the estimated effort after project completion.

Furthermore the possibility to choose the price/duration combination for a project proves to be really valuable for most client organizations.

## 7. References


[1] Putnam, Lawrence H. and Myers, W., "Measures for Excellence: Reliable software on time, within budget", NJ: Yourdon Press, 1992.

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