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Abstract

In this paper we investigate the causes of lateness of new product development projects. From literature, we have identified three possible causes of lateness: optimistic estimates of processing times, instability of project networks and the impact of due date nearness on engineer's performance. Over a time-span of 42 weeks, detailed empirical data were collected of two product development projects to verify the occurrence of these three causes in real-life product development projects. The data reveal that indeed engineers produce optimistic estimates, but only for large work packages, that the project networks were highly unstable, and that the engineer's performance was highly affected by due date nearness. The data suggest that project lateness is mainly due to the combined effect of project network instability and the engineer performance being dependent on due date nearness. From the interpretation of the data implications are derived for the management of new product development projects.

Keywords: New Product Development, Project Planning and Control, Project Lateness

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Introduction

Realizing the planned due date of a project is often difficult. Many examples can be found of projects that were delayed. Buehler, Griffin and Ross (1994), for example, described construction projects that had delays of 10 (the Sydney Opera House) or even 13 years (Olympic Stadium of Montreal). Icmeli Tukel and Rom (1998) performed a survey among project managers in various industries. 52% of the 90 respondents reported that projects were often delayed and 41% reported that projects were sometimes delayed. These project managers also reported that they used project planning techniques, but this did not prevent the projects from running late. What causes these delays?

On a high aggregate level a new product development project can be divided in two major phases: the 'fuzzy front end' or the project planning phase on the one hand and project execution on the other hand (Tatikonda and Rosenthal, 2000; Smith and Reinertsen, 1995; Ulrich and Eppinger, 1995; Wheelwright and Clark, 1995). The project planning phase includes identifying customers and competitive products, generating ideas, choosing the project to work on, setting product and project targets, and detailed network scheduling. The project execution phase involves actually carrying the project through completion. Tatikonda and Rosenthal (2000) note that substantial operations management literature exists on the topic of project planning. But the project execution phase of projects has received little attention in this literature. The current research is focused on the execution phase of projects, in particular of product development projects.

For many firms the execution phase of projects is a struggle (Repenning, 2000; Wheelwright and Clark, 1995). Realizing the project due date is extremely difficult in many projects. When the due date approaches, either long delays or an increase of allocated resources are reported. In this paper we examine the execution phase of product development projects in a longitudinal empirical study in order to identify the causes of project delays. We examine these possible causes in two real-life product development projects. First we will describe the hypotheses that guided our research.

Causes of project lateness

To prevent lateness it is important to examine the causes for project lateness. Generally projects are planned. Subtasks are defined resulting in a network of work packages. Due dates are assigned to each work package. Work packages are assigned to project engineers. It is the task of each project engineer to try to finish work packages on the due date. Three possible causes of project lateness will be investigated. The first possible cause is on the level of the initial project plan. As was said above, most product development projects consist of a network of work packages. The more radical and, thus, the more uncertain a product development project the more this network may change in the course of the project. New work packages may be added to the project network and other work packages may be deleted from the project network. The changes of the project network can be caused by a change of functional specifications of the product. When these specifications change, and consequently 'new' work packages must be performed that were not planned, the execution of 'old' work packages that were already planned may be postponed and their due dates may be exceeded. Eventually this may cause project lateness.

The next two possible causes of project lateness that we will investigate are on the level of the work package. Engineers working on a work package may be optimistic in estimating the workload of this single work package. During the execution of a development task, unexpected problems may emerge, which take more time to solve. Because more work has to be done that was not foreseen, it will be more difficult to realize the planned due date of this and other development tasks. This is the second possible cause of project lateness. Third, when the due date of a work package is not very near, an engineer may not feel enough pressure to work, or to work hard on the work package. As the planned due date approaches, an engineer may spend more time on a work package. As a consequence, when the due date is near, an engineer may have to work full time on the work package in order to finish it on time. Then, the discovery of a new development task will certainly disrupt the realization of the planned due date. No slack time remains to finish this new task too before the due date. This may cause project lateness. Below these possible causes are embedded in the literature and hypotheses will be formulated.

Changes in the network of work packages

New product development projects are often characterized by uncertainty. Galbraith (1973) defines

uncertainty as 'the difference between the amount of information required to perform a task and the amount of information already possessed by the organization' (pp. 5). If a task is not completely understood before it is started, then during the execution of this task more knowledge is acquired which leads to changes in resource allocations, schedules, and priorities. In product development projects, where uncertainty is high, it is possible that product specifications change when more knowledge is acquired, leading to a change of the development tasks that have to be performed. Early definition of product specifications or development tasks is not always possible. Bhattacharya, Krishnan and Mahajan (1998) explain why early product definition, recommended as a good practice in the literature, is not always a desirable approach. In such an approach one ignores the uncertainty surrounding product specifications, the firm's risk aversion, and the ability to benefit from customer input during the definition process. Recent literature shows that more and more researchers are examining the variability of product specifications. According to McDermott (1999), radical product development projects focus on what could be, rather than on what already exists. Tatikonda and Rosenthal (2000) describe that for many product development projects, particularly those with uncertainty in technology, the resulting capabilities of the product and the exact means to realize the product are not known with certainty at the start of the development project. When product specifications change, development tasks or work packages will change as a consequence. Furthermore, new work packages that were not foreseen at the start of the project may be discovered. McDermott (1999) discovered in seven case studies of radical innovation projects that "not all of the events leading to the development of the projects were planned" (pp. 639). Dawson and Dawson (1998) argue that uncertainty may also cause that planned work packages are not necessary anymore and are deleted from the project plan. Thus, even if processing times of individual work packages are predictable, unstable work package networks may cause a project to be delayed. This leads first of all to the hypothesis that the projects that we will be studying in the present paper will be late. Specifically, our first hypothesis is that the actual flow times of the projects under study will exceed planned flow times. Because we argued that this may, at least in part, be due to changes in the project network, our second hypothesis is that the network of work packages in the projects under study will be unstable.

Optimistic estimates of workload

Estimates of work package processing times (the net time required to execute a work package, thus excluding for example waiting times or holidays) are used to calculate the project completion time. These estimates are usually made by engineers having experience and knowledge about these work packages. These estimates are often subjective and not based on some objective method (see for example Lewis, 2001). Some researchers on project planning have reported that subjective estimates can lead to an over-confident prediction of the project completion time (Kidd, 1991). Webb (1994) agrees that optimism is common when it comes to predicting the future. These arguments are confirmed by cognitive psychology research, revealing that people tend to be optimistic about their productivity. Kahneman and Tversky (1979) use the term planning fallacy for the tendency to hold a confident belief that one's own project will proceed as planned, even while knowing that the vast majority of similar projects have run late. This implies that people do not use their previous (and negative) experiences when making estimates. Buehler et al (1994) analyzed this planning fallacy in a number of studies with students. Even if the students were instructed to make a pessimistic prediction, the accuracy of the prediction did not improve and fewer than half of the students finished by this pessimistic time. The students in these studies were performing academic tasks. Academic tasks can be defined as innovative, problem solving tasks, like development tasks, since they are often uncertain, ill-defined and unstable. Thus we may assume that engineers involved in product development projects also suffer from this planning fallacy and make optimistic estimates of their productivity or the processing time required for a work package. Uncertainty about the content of work packages makes it even more difficult to make accurate estimates. It is likely that for the more complex work packages, it is more difficult to estimate processing times correctly. We assume that more complex work packages will require more time. Therefore we will also examine the differences in optimistic behavior between small and large work packages (or less complex and more complex work packages). Two hypotheses are formulated: Hypothesis 3: processing times are underestimated by engineers, and Hypothesis 4: the longer the estimated processing time (the larger the work package), the larger the estimate error (the larger the optimism).

Due date nearness and performance

The estimated processing times of work packages may be used by the project leader to make a project plan

and to assign due dates to the work packages. The tightness of the due dates causes engineers to experience pressure. Buehler et al. (1994) examined the influence of an important deadline on the predicted and actual completion times of students performing academic tasks. They found that students with a two-week deadline predicted that they would finish later than those with a one-week deadline. But the deadline also influenced the actual completion times, since students finished their assignment later when their deadline was two weeks rather than one week. An explanation of these results is that a person experiences time pressure when the deadline is close. This time pressure affects the behavior of a person. Seers and Woodruff (1997) discovered this effect when they studied students working on academic tasks. At midpoint, instead of having 50% done, the results accomplished approximate 10% of the total work that needs to be done. The majority of the work is done in the second half of the project. The authors even found an exponential function across a relatively large number of people, indicating that early progress is relatively stable in contrast to late progress (pp. 184). These results correspond with the results of Gersick (1988) who discovered a *midpoint-transition.* At the midpoint of the allocated calendar time, groups undergo a transition in which the group makes a major jump in progress. Before this midpoint progress is small.

When pressure and performance are related, it may be expected that engineers will work harder on a work packages when the due date of this work package is near. To verify if this behavior is also encountered in the projects under study, we formulated hypothesis 5: nearness of the due date of a work package has a positive effect on the time an engineer will spend on the work package.

Data Collection

The company

The empirical study was performed at a large European optical equipment manufacturing firm that works under a time driven control system with a one year new product release clock speed. Historically accelerations in technology development and market demands transformed this firm in a very short time-span from a rather small one-product-one-project organization to a highly complex multi-product-multi-project organization, employing four thousand people. The product development projects at this firm can be characterized as highly complex and technologically uncertain. A concurrent engineering perspective is applied in the firm so that the development time can be shortened by performing processes that used to be

sequential, in a parallel manner (Clark and Wheelwright, 1993; Krishnan et al., 1997; Prasad, 1996; Smith and Reinertsen, 1995; Stalk and Hout, 1990).

Data collecting procedures

Two product development projects of this firm were chosen for the empirical study. The projects are part of a larger project for developing the first product of a new product family. The projects both consist of software development activities. The reason why these two projects is that software development is an environment in which engineers and project leaders are accustomed already to making detailed project plans, so collecting detailed project data for our empirical study would not disturb their normal activities. The two projects started in the Fall of 1997, the collection of data started in July 1999 and finished in May 2000. Since our study did not start before July 1999, we could not gather any project data in the period before July 1999.

During our empirical study we collected information on the two software projects at the beginning of each week for a period of 42 weeks. This information was provided by nineteen engineers and two project leaders. The engineers estimated the required processing time of each of their work packages as soon as the work package was known or planned. Every week engineers filled in an electronic time sheet to report how much time they worked on each work package and how much time they thought was required to finish the work package. The actual processing time is known when the work package is finished and the last time sheet is filled in. The time sheets of engineers are passed to the project leader. Based on the information of the time sheets the project leader can decide to change the project plan. For example, if an engineer estimates in week t that the remaining workload of a work package is even more than estimated in week t -1, the project leader can decide to postpone the planned finish date of that work package. The weekly updated project plan provided the information for our empirical study. With this information we performed measurements that were required for testing the hypotheses that were defined in the previous section. In the next subsection the measures required for testing the hypotheses are derived.

Measures

Flow times of work packages are planned by project leaders. The flow time of a work package is the time frame during which the work package is on hand. The flow time consists of the processing time (defined

below) plus a certain time slack that is reserved for unforeseen events, waiting for information from other engineers, illness of engineers, etc. It may be expected that the difference between actual and planned flow time is influenced by the difference between actual and planned processing time. Therefore, we define:

- Planned flow time: P_f: the planned flow time is the initial flow time (in number of days) of a work package, based on the processing time and a time slack of 1 day (that is a rule of thumb in the company).
- Actual flow time: A_f: the actual flow time is the time (in number of days) that elapses between the actual start date and the actual finish date of the work package. The actual start date of a work package is the date at which an engineer starts working on that work package for the first time. The actual finish date of a work package is the date at which an engineers works on that work package for the last time.

To test whether engineers are optimistic when they estimate processing times of work packages, the following measures are defined:

- Estimated processing time, E_p: initial estimate of the processing time of a work package, expressed in hours. The initial estimate is made by an engineer as soon as the work package is allocated to him.
- Actual processing time, A_p: actual number of hours the engineer spent to finish a certain work package, expressed in hours. The actual processing time can be measured only when the work package is finished.
- Estimate error, $E_p - A_p$: difference in hours between estimated and actual processing time. If the estimate error is negative, the work package needed more hours than initially estimated. This may be the result of an optimistic estimate of engineers. If the estimate error is positive, the work package was finished in less hours than initially estimated. This may be the result of a pessimistic estimate of engineers.

To examine whether a relationship exists between the nearness of the due date (or time to due date) of a work package and the time an engineer spends on that work package, the following measures are defined:

- Time to Due Date, TDD_t: the time, measured in days, between the first day of week t and the due date of a certain work package.
- Percentage of Time Spent, $\%TS_t$: the percentage of the possible time that an engineer spent in week t on a certain work package. For example, when at the beginning of week t the remaining workload of a certain work package is 30 hours and the engineer spent also 30 hours on that work package in week t, the $\%TS_t$ is 100%. When the remaining workload is 60 hours and the engineer spent 40 hours, the $\%TS_t$ is also 100% (because of the 40-hour-working week).

Descriptives of the measures are given in Table 1, in which *n* denotes the size of the data set.

[place Table 1 here]

Results

Work package lateness

To verify whether or not work package lateness occurs in the two software projects, we compared planned flow times with actual flow times of 108 work packages from both of the projects. In Figure 1 a scatter graph is shown of these 108 work packages.

[place Figure 1 here]

Figure 1 shows that most work packages finished (much) later than planned, but no simple relationship seems to exist between the planned and actual flow time. We have tried to fit a linear (this linear line is also shown in Figure 2), quadratic or cubic model to the data, but none of these models is significant. To test whether the actual flow time deviates significantly from the planned flow time, we measured the difference between planned and actual flow time, and the mean and standard deviation of this difference, and performed a large-sample, one-tailed test for a population mean based on the standard normal z statistic. This analysis shows support for hypothesis 1 that, on average, actual flow times are longer than planned flow times, $z = -9.22$, $p < .001$. The large variance in work package lateness suggests that external sources of variation exist which may or may not "hit" upon the work package or the resource available for this work package. Sources of variation could be new work packages competing for capacity or other work packages requiring more work then initially planned.

Changes in the network of work packages

We calculated weekly for both software projects the number of work packages that were added to or deleted from the network. We expressed this number as a percentage of the total number of work packages in the network in the previous week. The results are shown in Figure 2.

[place Figure 2 here]

Figure 2 shows that the changes of the project network of both projects are substantial. We have calculated the interarrival times of changes of the network and also the size of the change (number of work packages that were added to or removed from the network during each change). The results are shown in Table 2.

[place Table 2 here]

Table 2 shows that the project network of software project 1 and 2 changed respectively 19 and 12 times. The total number of work packages that were added to or removed from the network were 131 and 63 for software project 1 and 2. Furthermore, the table shows that the project networks of the two projects changed about every two or three weeks (the mean interarrival times are 2.21 weeks for software project 1 and 3.50 weeks for software project 2). The mean size of these changes is 6.89 and 5.25 work packages for software project 1 and 2. The instability of the project network seems to be very high. Work packages that were added to the project often had high priority, thus sometimes overtaking priority of other already planned work packages. In fact, the stream of new work packages can be considered as a high priority stream of work orders. As is known from production control research, emergency orders have a negative impact on the due date performance of planned orders, unless the occurrence of emergency orders is accounted for in the due date setting of the planned orders (Van Ooijen, 1991; Bertrand and Van Ooijen, 1991). However, in the planning of work package times and setting of due dates no provisions are made for the emergence of high priority new work packages. Thus the instability of the network of work packages may be one of the causes of project lateness.

Optimistic estimates of workload

To test whether the processing times can be estimated correctly by engineers we measured the estimation error (estimated minus actual processing time), its mean and standard deviation and performed a large-sample, one-tailed test for a population mean based on the standard normal z statistic. In Figure 3 we show both estimated and actual processing times for 108 work packages.

[place Figure 3 here]

The results of the statistical test of our hypothesis are given in the second column of Table 3. These results show support for our third hypothesis that processing times are underestimated by engineers, because actual processing times are longer than estimated processing times. How much longer (on average) can be shown by fitting a straight line to the data in Figure 4. We find: $A_p = 6.9048 + 1.1179\ E_p$, and the coefficient of determination, $R^2 = 0.637$. The intercept of this line is about 6.9 hours, which is almost equal to 1 working day. Thus it seems that actual processing times are at least 1 day longer than estimated processing times.

In the introduction we argued that it is likely that engineers will have more difficulty in making accurate estimates of processing times for larger (and probably more complex) work packages. The linear relationship we found between A_p and E_p suggests that the estimate error becomes larger when the estimated processing time is longer and thus when work packages are larger or more complex. To test whether this is correct, the data set was divided in three equal-sized groups of work packages according to their estimated size (small, medium, large). The *small* group consists of work packages with an estimated processing time between 8 and 40 hours. The *medium* group consists of work packages with an estimated processing time between 40 and 105 hours. The *large* group consists of work packages with an estimated processing time between 106 and 392 hours. The results of our statistical tests are given in the third, fourth and fifth column of Table 3.

[place Table 3 here]

The results in Table 3 show that for small work packages the estimate error does not differ significantly from zero ($Z = -0.3090$). Only for medium-sized and large work packages the estimate error can be considered as negative ($Z = -1.8050$ and $Z = -1.9438$ respectively). Thus when engineers estimate processing times for medium-sized or large work packages (longer than 40 hours), it seems that they are optimistic. There is not sufficient evidence that engineers make inaccurate estimates of processing times when work packages are small (shorter than or equal to 40 hours).

Due date nearness and performance

To examine the effect the nearness of the due date of a work package (or time to due date) has on the performance of the engineer responsible for this work package, we measured weekly for each work package the time to due date and the percentage of the possible time that an engineer spent on the work package. This resulted in a data set of 835 work packages (Note that when a work package has a flow time of 20 weeks, this work package is included in this data set 20 times, because in each week during the flow time, the time to due date and the percentage of time spent is different). In Figure 4 this data set is shown.

[place Figure 4 here]

Figure 4 shows that a strong relationship exists between time to due date (*TDD*) and percentage of time spent (*%TS*). An exponential relationship between *TDD* and *%TS* fits the data quite well. This relationship can be expressed by: $\%TS = 0.4665 * e^{-0.0133 TDD}$ (coefficient of determination, $R^2 = 0.461$). This suggests that hypothesis 5 is supported. The nearness of the due date of a work package (a short time to due date) positively influences the amount of time an engineer will spend on this work package. It seems that an engineer postpones working on a work package until the time pressure is high.

Discussion

Network of work packages

Hypothesis 1 was supported. Actual flow times are significantly longer than planned flow times. In the empirical study we examined possible explanations for lateness. The first explanation is the discovery of new, unplanned work packages during project execution. When suddenly more (higher priority) work packages have to be done by the same number of engineers, planned due dates of existing work packages may be difficult to realize and as a consequence, actual flow times may turn out to be longer than planned. Figure 2 and Table 2 showed that the project networks change very often (about every 2 or 3 weeks). It seems that unstable project networks (and in particular the discovery of new, unplanned work packages) are an important reason for lateness in the projects that we studied.

Optimistic estimates of workload

Hypothesis 3 (processing times are underestimated by engineers) was confirmed. However, examining the data in more detail (hypothesis 4) shows that for small work packages (i.e. smaller than or equal to 40 hours) hypothesis 3 is not supported. Thus, only for medium-sized and large work packages the actual processing times are significantly longer than the estimated processing times. The relationship between estimated and actual processing times can be expressed quite well by a linear regression line. This suggests that engineers are not as optimistic as we initially conjectured and processing times can be predicted by engineers, especially for smaller work packages. The larger the work package, the larger the estimate error will be (the slope of the regression line is 1.1179).

Due date nearness and performance

Strong evidence was found that the nearer the due date of a work package, the more time an engineer will spend on that work package. Engineers seem to postpone working on a work package when the time pressure is low. When the work package network of the project is fixed, and when the workload per work package can be estimated accurately, postponement of work does not need to result in lateness. However, the closer the due date of a work package, the smaller the time slack left for dealing with unexpected problems, rework, or new work packages. When the due date is near, each problem or work package that requires some time of the engineer, will have a negative effect on realizing the due date. Since we showed that project networks are unstable and often new work is discovered, postponement of work may lead to lateness.

Consequences for project management

The results that were found in the empirical study may have important consequences for managing projects. In this paragraph possible consequences are listed.

- Estimates of processing times of large work packages will probably turn out to be optimistic. If possible, the definition of work packages in a project must be done in such a way that work packages are not too large. For example, we showed in our study that for small work packages (with a processing time of 40 hours or less) the processing times could be estimated quite accurately by engineers.
- Project plans that are made at the beginning of the project, will be obsolete in a few weeks, because of the

discovery of new development tasks. Therefore it is advised that detailed project plans (with work packages and their due dates) are made only for the next two to four weeks, depending on the instability of the work package structure (mean interarrival times of work package structure changes). The overall project plan can be formulated in more aggregate or general terms for the period longer than this two to four weeks timeframe. This will prevent that many hours are spent on planning and replanning the whole project.

- Planned start and finish (or due) dates of work packages are an important characteristic in the projects that we studied. The planned start dates of work packages indicate when engineers are allowed to start working on the work packages. Thus, the planned start dates indicate when a work package can be considered as 'on hand'. The planned due dates may have three different functions. First, due dates direct engineers because due dates can be used as a 'priority rule'. Engineers can consider the work package with the earliest due date as the one with the highest priority and choose to work on the work package with the highest priority. Second, the pressure induced by the due dates can encourage engineers to work. The nearer the due dates of work packages, the more time engineers will spend on that work package (compared to other work packages of which the due dates are far). Third, due dates can protect engineers. When the pressure becomes too high, when the workload of engineers is too high, the project leader can delay the due date of one or more work packages. As a consequence, the engineer will perceive less pressure. Thus, due dates of work packages are managerial instruments that should be used for their effect on the performance of engineers.

Conclusions

In this paper we have reported on the results of a longitudinal empirical study of two product development projects, in particular of the causes of lateness. The two projects were performed in an optical equipment manufacturing firm that employs a time-paced release policy for new products. Empirical data were collected from nineteen engineers working on two projects. During a period of 42 weeks the engineers estimated on a weekly basis the progress they had made while working on work packages and the time required to finish work packages. We measured processing times and flow times of work packages to examine if lateness was caused by inaccurate estimates of processing times (optimism of engineers). The results of the study showed

that estimates of processing times were *not* very inaccurate, especially for small work packages. But the differences between planned and actual flow times were very large. Almost for all work packages actual flow times were much longer than planned. This is a surprising result because this difference is not the result of the optimistic estimates of processing times. This difference may be caused by the discovery of new work packages. It was shown that the project network of work packages changes very often. When suddenly new work packages are discovered, priorities may change and 'old' work packages may be delayed, resulting in a lateness of these old work packages. The empirical study also showed that engineers spend more time on work packages when the time to due date is short. It seems that engineers postpone working on a work package until its due date is very near. When the due date is not near, time pressure will be low and consequently the time spent on the work package will be low. The nearer the due date, the more pressure the engineer will perceive to finish the work package. If no additional unplanned work has to be done, the engineer may finish the work package just in time. But, when new work is discovered that also has to be done before the due date, hardly any slack time remains and the due date is endangered. Thus, based on the results of the empirical study, it is suggested that the unstable project network (caused by the discovery of unplanned work packages) in combination with the effect due dates of work packages have on the performance of engineers are the most important cause of lateness. Optimistic estimates of processing times of work packages do not seem to be an important cause of lateness.

The implications for project management of these results can be summarized as: 1) define small work packages because processing times can be estimated more accurately if work packages are small; 2) make a detailed project plan only for a short term (approximately four to six weeks) because very often new work packages are discovered, making the plan obsolete; 3) use due dates as a control mechanism to prioritize work packages, to encourage engineers to work more on work packages of which the due date is near, and to protect engineers from a high workload by postponing due dates of some work packages. It is suggested to examine these consequences in real-life product development projects in a future empirical study.

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Table 1 descriptives of the parameters				
parameter	**n**	**μ**	**σ^2**	**σ**
E_p	108 wp's	97.6019	7189.7185	84.7922
A_p	108 wp's	116.0093	14097.5420	118.7331
P_f	108 wp's	22.2032	412.2733	20.3045
A_f	108 wp's	70.1698	3283.9823	57.3060
TDD_t	835 wp's	55.1162	3127.6975	55.9258
$\%TS_t$	835 wp's	0.3628	0.1044	0.3231

Table 2 interarrival times and size of work package structure changes				
	software project 1		**software project 2**	
	n	**μ**	**n**	**μ**
interarrival time (in weeks)	19	42/19 = 2.21	12	42/12 = 3.50
size (in # work packages per change)	19	131/19 = 6.89	12	63/12 = 5.25

Table 3 estimated versus actual processing times of all work packages and of work packages divided in three groups (small, medium and large)				
	all	**small ($8 \leq$ wp ≤ 40)**	**medium ($40 <$ wp ≤ 105)**	**large ($106 \leq$ wp ≤ 392)**
n	108	36	36	36
μ	-18.4074	-0.9167	-23.8056	-30.5000
s	72.2023	17.8027	79.1313	94.1471
Z	-2.6494	-0.3090	-1.8050	-1.9438
μ = the mean of $E_p - A_p$; s = standard deviation of $E_p - A_p$; Z = test statistic, $z_\alpha = z_{0.05} = -1.645$				

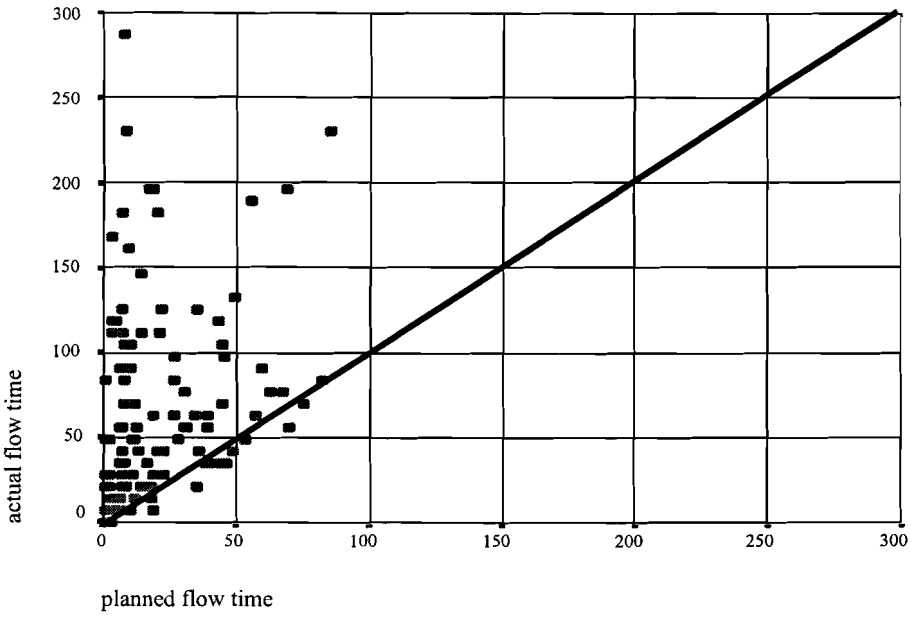

Figure 1 comparison of planned and actual flow time (in days)

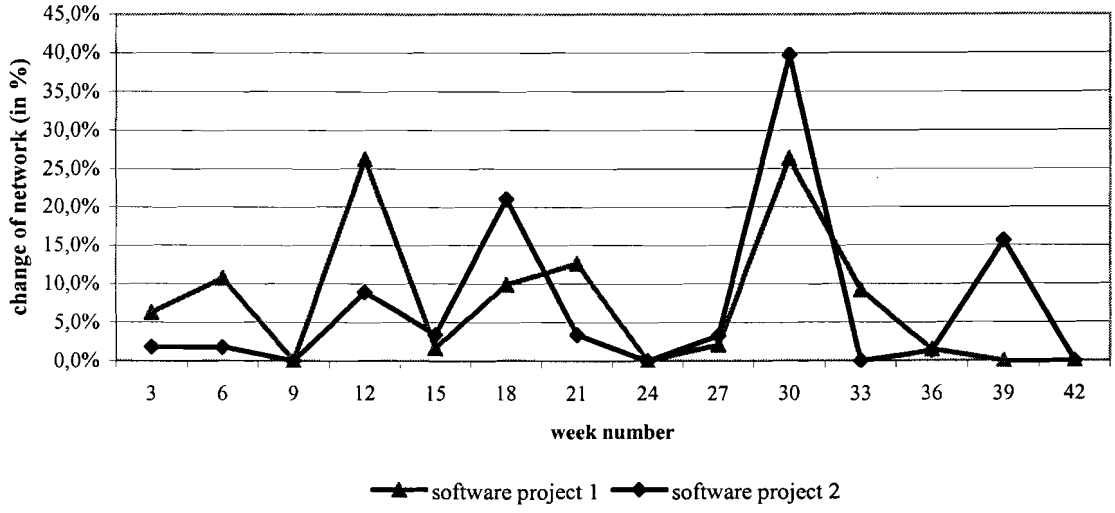

Figure 2 changes (in %) of project network of the two software projects

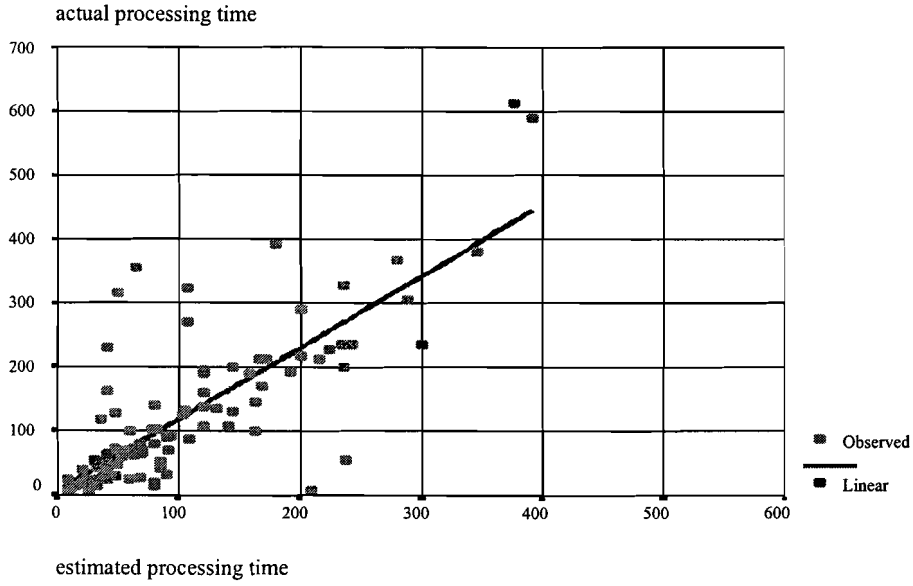

Figure 3 comparison of estimated and actual processing time (in hours)

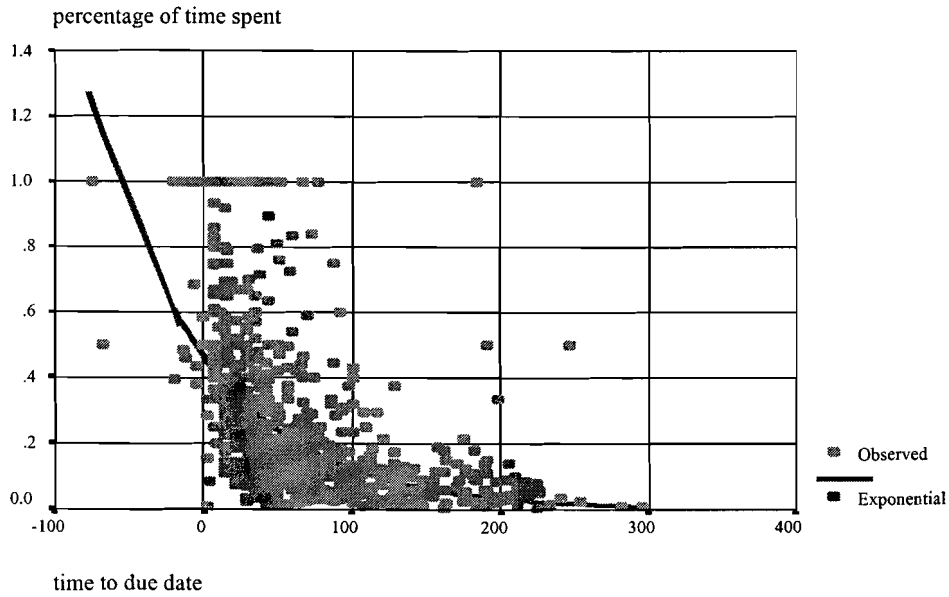

Figure 4 comparison of time to due date (in days) and percentage of time spent