Chapter 15

PRODUCT FAMILY REDESIGN USING A PLATFORM APPROACH

Assessing Cost and Time Savings

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1. SETTING: JUSTIFYING THE MOVE TOWARD A PLATFORM STRATEGY

Product strategy at the platform level simplifies the product development process and encourages a long-term view, because there are fewer platforms than products and major platform decisions are only made every few years. A move towards implementation of a platform strategy, which is significantly different from design and development of each product separately, can be a challenging undertaking. While the move is difficult, potential benefits from product family approach include decrease in development cost and time over a range of products. Consequently, key questions and issues that need to be addressed to justify a company's decision to allocate resources for refocusing their product strategy at the platform level are:

1. What will be the potential decrease in development cost for implementing a product platform strategy?
2. What will be the potential decrease in development time for implementing a product platform strategy?

Design and development cost and time are two of the parameters essential to quantify potential benefits for moving towards a platform strategy. In addition, cost and time associated with design and development of individual products, without a platform strategy, needs to be determined

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to estimate potential savings for a company. Activity Based Cost (ABC) and Activity Based Time (ABT) models can be developed and simulated to answer the two key questions. ABC is based on the idea: activities consume resources and products consume activities (Cooper, 1989). The cost of a product is then the sum of costs of activities associated with the product. An ABC system gives visibility to how effectively resources are being used and how all activities contribute to the cost of a product. These ABC related can also be utilized to estimate development time for a product.

One of the problems encountered, during development of ABC and ABT models, is that cost and time information related to product platform and family are not readily available. Available information includes cost and time data associated with development of individual product[24]. To complicate problems further, activities involved in design and development of individual products or families of products have inherent uncertainty associated with them, which needs to be included in the ABC and ABT models. Emblemsvag and Bras (1994) addressed this problem by using a combination of ABC and modeling of uncertainty as continuous and discrete probability distributions. In their method fuzzy numbers are used to model the uncertainty. The Monte Carlo simulation technique is then used to solve the model and to determine the effects of uncertainty on cost. In this chapter we employ a similar procedure to develop and solve Activity Based models with uncertainty to approximate financial effects and time savings related to implementing a product platform strategy.

2. MODEL DEVELOPMENT

Keywords and related activities associated with addressing the key questions are used to concisely present the overall problem formulation (see Table 15-1). The problem formulation starts with information that need to be *Given* to *Identify* design and development activities associated with moving towards a platform strategy. These identified activities and their associated uncertainty can then be utilized to *Formulate* and *Simulate* the ABC and ABT models. Statistical hypothesis testing can be used on the simulation statistics to decide if implementing a platform strategy will be beneficial for the company. A five-step approach (see Figure 15-1) is presented in this chapter to develop and solve ABC and ABT models for the problem formulation shown in Table 15-1. The outputs from the models, after simulation, are the cost and time estimate for implementing a product

[24] In this chapter, individual product denotes development of a variety of products with a platform approach, which requires each product variety to be designed and developed separately.

platform strategy for a family of products. It is assumed that (1) the company has knowledge about the current market, which includes market segmentation and requirements for each segment, and (2) the company is looking into employing a platform approach to satisfy multiple market segments. The five steps are detailed in the remainder of this section.

Table 15-1. Problem formulation to decide if cost and time savings justify moving towards a product platform approach for an existing family of products.

Keywords	Tasks
Given	Existing product family approach, activities involved in development and manufacturing of the product family, uncertainty involved with cost and time for each activity, new platform approach for the product family
Identify	Activities involved in development and manufacturing of the new product family approach, uncertainty involved with cost and time for each activity for the new platform approach
Formulate	Activity Based Cost and Time models for existing and new product family approach
Simulate	Activity Based Cost and Time models for statistical data related to existing and new product family approaches
Test	Hypothesis
Select	Approach with better financial and time savings

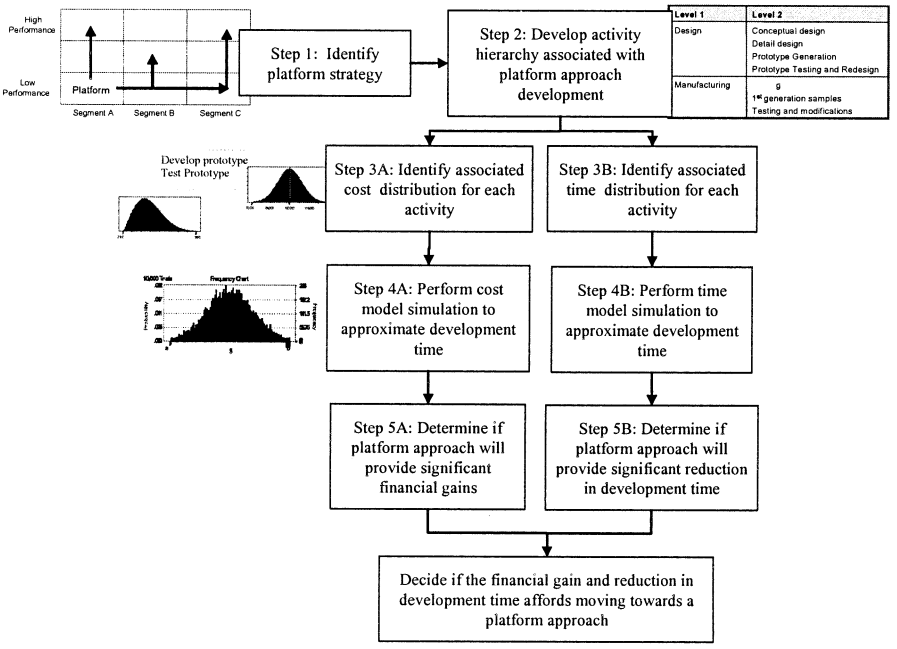


Figure 15-1. Steps for generating activity based cost and time model for product family.

2.1 Step 1: Identify platform strategy

The first step involves determining a platform leverging strategy for the product family. Market segmentation grid (Meyer, 1997) is one appraoch that can be utilized to specify the platform strategy. The market segmentation grid is setup by listing the major market segments serviced by a company's products in the horizontal axis, with different tiers of price and performance within each market segment listed in the vertical axis. Three types of platform leveraging strategies can be identified within the market segmentation grid as discussed in Chapter 5: horizontal leveraging, vertical leveraging, and the beachhead approach. In this chapter, the market segmentation grid is utilized to aggregate cost and development time for platform and family members. Step 1 corresponds to organizing some of the product family information provided in the *Give* of the problem formulation.

2.2 Step 2: Develop activity hierarchy associated with platform approach

Activity hierarchies are created to systematically identify tasks and steps related to design and development of product platform and family. A two stage approach is employed to create the activity hierarchy for the product platform and family members, from design and development activities for individual products. The activity hierarchy of individual product is created in the first stage, since companies usually have well-established procedures and/or are knowledgeable about activities involved in developing individual products. The second stage involves modifying/extending the single product activity hierarchy to separately and explicitly create new activity hierarchies for developing (1) the initial platform and (2) the family members from the platform (see Figure 15-2).

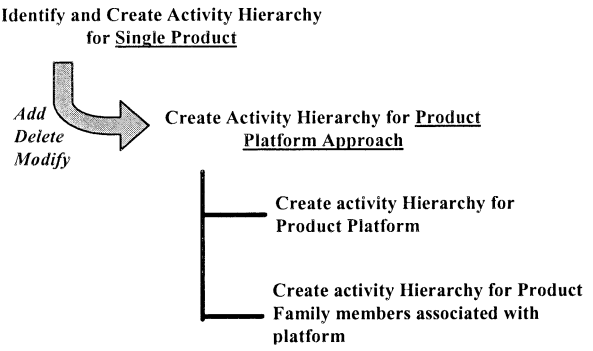


Figure 15-2. Development of activity hierarchy for platform approach.

As an example, consider the activity hierarchy shown in Table 15-2 for design and development of an individual product. This activity hierarchy can be modified for initial product platform and development of family members from the platform. In this example, some of the manufacturing activities (preliminary manufacturing, testing and process modifications) are not required for product family members that are supported by a platform. The reductions of these activities are a direct result of reuse of a platform that has already been tested.

Table 15-2. Design and manufacturing activity hierarchy for single product, product family platform and family members supported by the platform.

Level 1	Level 2 for single product	Level 2 for initial product platform	Level 2 for product family members
Design	Conceptual design	Conceptual design	Detail design
	Detail design	Detail design	Prototype Generation
	Prototype Generation	Prototype Generation	Prototype Testing
	Prototype Testing	Prototype Testing	Product Modification
	Product Modification & Redesign	Product Modification & Redesign	& Redesign
Manufacturing	Tooling	Tooling	Tooling
	Preliminary manufac.	Preliminary manufac.	Initial production
	Testing	Testing	Process modifications
	Process modifications	Process modifications	Ramp up
	Initial production	Initial production	
	Ramp up	Testing	
		Process modifications	
		Initial production	
		Ramp up	

2.3 Step 3: Identify associated cost and time distribution for each activity

Cost and time associated with each activity has variability associated with it, which needs to be included in the model. Cost and time for each activity in the hierarchy, developed in Step 2, are represented as probability distributions. Uncertainty in cost and time, associated with the activities, is modeled based on experience from engineering and finance, because cost and time data associated with activities related to development of individual product or product family are not available. The type of distribution to use, as well as the mean, the left deviation, and the right deviation, are modeled based on experience. Step 3 corresponds to utilizing information from *Identify* to perform the *Formulate* task of the problem formulation.

With the cost distribution information related to each activity specified, the ABC model can be developed (Step 3A of Figure 15-1). Development of the cost model for the platform approach follows the same overall procedure as the activity hierarchy development (described in Step 2)– (1) estimating

cost distribution for single product development activities and (2) modifying these estimations for the initial platform and subsequent products.

Development of the ABT model (Step 3B of Figure 15-1) requires identifying not only the time distribution associated with completing each activity, but also requires identifying the sequential and concurrency of these activities, which can be gathered from the development team. Development time for sequential activities can be estimated by direct addition of time for the activities. Development time for concurrent activities can be estimated in two ways, depending on the situation:

- Using percentage calculations, which can be utilized if for a set of concurrent activities, the later activities are started when a certain percentage of former activities have been performed.
- Using time gaps, which can be utilized in cases where later activities start after a certain amount of elapsed time for former activities.

2.4 Step 4: Perform simulation to approximate development cost

In this step, cost and development time is estimated by simulating the ABC and ABT models, with uncertainty, developed in Step 3. Design and development cost for entire product family (Step 4A of Figure 15-1), using a platform approach, is estimated as:

$$F_{cost} = P_{cost} + n*M_{cost}, \quad (1)$$

where:

F_{cost} = Cost for entire product family
P_{cost} = Development cost for initial product platform
M_{cost} = Development cost for product family members from platform
n = Number of family members

Development cost for product varieties (S_{cost}) without using a platform strategy is estimated by first simulating the cost models developed for individual products (Sp_{cost}), then multiplying the cost estimate with the number of family members (n).

$$S_{cost} = n*Sp_{cost} \quad (2)$$

The cost saving for utilizing a platform strategy can be estimated as:

$$\text{Cost Saving} = F_{cost} - S_{cost}. \quad (3)$$

If all activities involved in design and development are included in the model then the error related to the simple relationships shown in Eqs. (1)-(3) will be negligible. Otherwise, an additional term to address the error can be included in the model that can be determined from previous project data. A process is utilized to estimate development time for the entire product family, using a platform strategy:

$$F_{time} = P_{time} + n*M_{time}, \quad (4)$$

where:

F_{time} = Development time for entire product family
P_{time} = Development time for initial product platform
M_{time} = Development time for product family members from platform
n = Number of family members

The estimated time for developing the product family without using platform (S_{time}) strategy and the potential development time saving for utilizing a platform approach is estimated as (F_{time} - S_{time}), which is similar to Eqs. (2)-(3).

Monte Carlo simulation technique is used to determine the effects of the uncertainties in the final cost and time for the product family. To simulate the model using Monte Carlo technique, the Crystal Ball software is used, which adds on to Microsoft Excel. The Monte Carlo simulation provides random samples of numbers from the assumed probability distributions. These random numbers then propagate through relationships/equations in the model to estimate the desired final output, which includes development cost and time. This step corresponds to *Simulate* of the problem formulation.

2.5 Step 5: Determine approach with the better financial prospect

The Monte Carlo simulation output of the ABC and ABT models forms a new statistical distribution, when a considerable number of samples has been generated. Since the assumptions propagated through the model are random, the statistical distribution can be used in ordinary statistical analysis to make decision regarding moving towards a platform strategy. The decision maker is usually concerned if the potential cost and time savings will be more than a specified amount (δ), given a specified confidence level. The question is answered separately for cost and time utilizing hypothesis testing. The null hypothesis of interest is:

$$H_0: \mu_1-\mu_2=\delta$$
$$H_1: \mu_1-\mu_2>\delta \quad (5)$$

where:

μ_1 corresponds to the mean (cost or time) of the existing approach
μ_2 corresponds to the mean (cost or time) of platform approach

A large and same number of samples are used to simulate both platform strategy and non-platform strategy, hence the test statistic becomes:

$$z = \{(\bar{x}_1 - \bar{x}_2) - \delta\} / \sqrt{(\sigma_1^2 + \sigma_2^2)/N} \tag{6}$$

where N is the number of samples for the simulations.

The null hypothesis in this case will be rejected if $z > z_\alpha$, where α is the confidence level. Step 5 corresponds to *Test* of the problem formulation (see Table 15-1).

The results of hypothesis testing, for both cost and time, are used to select between platform strategy and individual product development approach. Although the hypothesis test results provide guidelines to reach a decision, the final selection should also include opinion of designers, manufacturing, and management.

3. COMPUTER DISK DRIVE SPINDLE MOTOR FAMILY CASE STUDY

The computer storage Industry has grown rapidly with increase in computer usage and storage demands. With the advent of personal computers and computer applications in various fields, new markets have opened up for data storage. With the constantly changing demands of computer industry and the existing competitions among different manufacturers, time cycle needed for hard disk development is decreasing and has become a never ending challenge for the disk drive manufacturers. In addition, the competition of bringing the products into market at an earlier time than the competitors is creating urgency in every new product release. These needs and challenges in the hard disk drive industry are forcing manufacturers to implement product platform concepts. Manufacturers are trying to implement platform strategy for components and modules of the hard disks. To make rational decisions on modules/components that should utilize a platform strategy, for a set of products, manufacturers need to identify potential investment outcome, which includes reduction in development cost and time.

3.1 Case scenario

One of the hard disk performance measures is the revolution speed of the spindle motor. The spindle motor of the hard disk drive is responsible for rotating the hard disk platters, allowing the hard disk drive to operate. Increasing performance and demand of storage capacity has increased the spinning speeds of the spindle, because with the increased speed the data can be read faster from the recorded media and thus quicken the operations of hard disk drive. Based on the spindle motor speed, the hard disk drive market can be segmented for both consumer (PC) and desktop drives (i.e., Unix-based desktops).

The spindle motors also need to meet certain specifications. First, the motor should be of high quality to run for thousands of hours with start and stop cycles without failures. Second, it must not generate particles, heat, or noise while operating over extended period of time. Third, it must be smooth with minimum vibration. This is needed as the tolerances between the media and head are very low, which if not maintained will affect the data. Finally it should able to run at constant speed. The spindle motor has a base with a vertical cylindrical hub (see Figure 15-3) that holds the platters and rotates it at constant speed, whenever computer is operating. The spindle motor is fixed to the base plate of the hard disk drive during assembly. Most disk drives have several disks that are separated by disk spacers and clamped to the rotating spindle by means of screws. The spindle, and consequently the disks, is rotated at a constant speed, usually disk drives speed range from 4200 RPM up 12000 RPM.

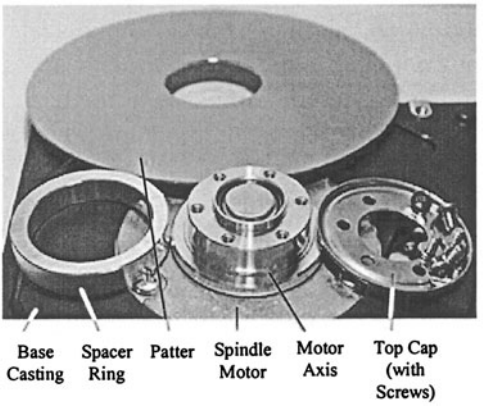


Figure 15-3. Components of computer hard disk spindle motor.

Based on the market needs and demand, three new hard disks will be introduced with varying speed. As shown in Figure 15-4, the speeds are:

(1) Consumer Drive with 4200 rpm (CD-1)
(2) Desktop Drive with 5400 rpm (DD-1)
(3) Desktop Drive with 7200 rpm (DD-2)

These disk drives will be introduced in the market over a period of time. The spindle motors used in these drives have the potential to be manufactured from the same motor platform, which is being considered by the developer. The consumer drive motor (CD-1) will be first developed, while DD-1 and DD-2 will leverage the spindle motor of CD-1. The manufacturer wants to identify the possible advantages over developing the products separately to make the decision of moving towards a platform strategy.

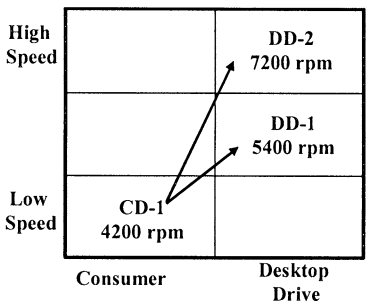


Figure 15- 4. Product platform approach for spindle motor product family.

Questions that need to be answered are: *What will be the financial gain from using one platform for the three spindle motors? What will be the potential decrease in development time from moving towards a platform strategy?* The decision to move toward the platform strategy for the spindle motor will be approved if there will be a cost savings of at least $2.25 Million and a decrease of 25 months in development time for launching the new program. These target values indicate minimum cost and time savings the company must achieve to change the current method and move towards a platform approach. If the cost saving or decrease in development time is less than the specified target then the motors for the three drives will be developed individually. It has been assumed that the technical problems associated with providing different speed for the motor can be solved.

3.2 Problem formulation and model development for spindle motor family

The problem formulation for the motor product family is shown in Table 15-3. The formulation summarizes tasks and required information to determine if implementation of the platform approach will be a beneficial undertaking and increase utilization of resources for the company.

3.2.1 Step 1: Platform strategy for spindle motor family

The platform strategy for the motor is shown in Figure 15-4. The initial platform for the motor family will be the motor used in CD-1 drive. The motor for the desktop drives, DD-1 and DD-2, will be developed from the initial platform.

Table 15-3. Problem formulation for motor product family.

Keywords	Tasks
Given	- Activities involved in development and manufacturing of motors individually. - Uncertainty involved with cost and time for each activity. - New platform approach (see Figure 15-4) for the CD-1, DD-1 and DD-2 motor product family, with CD-1 as the platform.
Identify	- Activities involved in development and manufacturing for the new product family approach (see Figure 15-4) - Uncertainty involved with cost and time with activities for the motor platform approach.
Formulate	Activity Based Cost and Time models for development of the 3 hard disk motors individually and using CD-1 as the platform.
Simulate	Activity Based Cost and Time models for statistical data related to design and development of individual motors and product platform approach.
Test	Hypothesis for cost savings with 90% and 99% confidence level: H_0: $\mu_1-\mu_2=2.25M$ H_1: $\mu_1-\mu_2>2.25M$ Hypothesis for decrease in development time with 90% and 99% confidence level: H_0: $\mu_1-\mu_2=25$ wks H_1: $\mu_1-\mu_2>25$ wks
Select	CD-1 as platform or development of the motors individually based on better financial and time savings.

3.2.2 Step 2: Develop activity hierarchy for individual, platform and product family motors

Activities associated with new motor development include both: (1) component level and (2) drive level activities. Drive level activities include engineering and testing to determine system level compatibility of the motor. Component level activities include cost and time associated with development of the motor excluding drive level activities.

Activity hierarchy for the current individual motor development process, which is gathered from designers and engineers, is shown in Figure 15-5. The individual spindle motor development process activities are then modified by engineers and designers to approximate development activities required for initial platform and subsequent spindle motor family members. The activity hierarchy for the initial motor development process and individual motor development process (without platform) were determined to be same. Activities involved in developing subsequent spindle motors from the platform are shown in Figure 15-6.

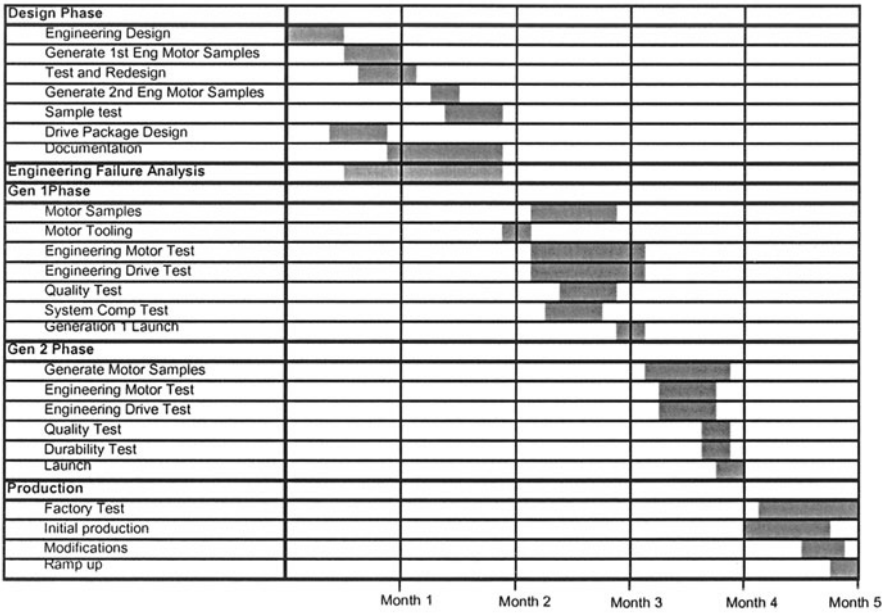


Figure 15-5. Gantt chart for single motor development.

Gantt charts that represent approximate development time for individual motor and family member, using a platform approach, are shown in Figure 15-5 and Figure 15-6, respectively. The Gantt charts will be utilized for summation of each activity time to approximate total time required for

development. As an example, for the product family member development, the three main phases are sequential, with most of the activities performed in each phase being concurrent. In the Production phase, Factory test of drives starts one week after Initial production, Modifications start half week after Factory test, as problems arise. Ramp up of production begins half week after Initial production ends.

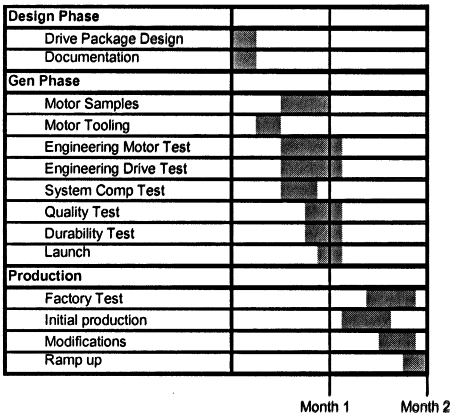


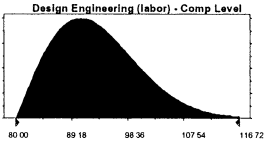
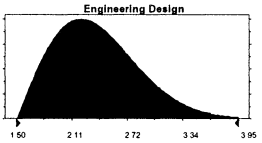
Figure 15-6. Gantt chart for motor product family member development.

3.2.3 Step 3: Identify associated cost distribution for each activity

Cost and development time associated with each activity is added to spindle motor development process for both individual and platform approach to complete the ABC and ABT models. The labor cost has been calculated with an approximate salary of $10,000 per month.

Uncertainty associated with each activity has been included in the activity hierarchy for single product development process. As an example, for the Engineering Design activity, the hours required to perform the activity can vary from 80-120 hours, with the possibility that on average the hours spent will be close to the minimum. The hours associated with Engineering Design activity are distributed among two designers, and the task is completed in approximately 1.5-4 weeks. A Weibull distribution was chosen, by the designers and engineers to reflect the uncertainty involved with the parameter. Scale and Shape parameters for the distribution for the Engineering Design activity are shown in Table 15-4. Distribution parameters associated with uncertainty for different activities for component level activities are shown in Table 15-5. The ranges are given in hours for labor, dollar for cost, number of items for other activities, and weeks to complete the task for completion time.

Table 15-4. Weibull distribution parameters associated with "Engineering Design" activity for labor hours and completion time in weeks.

	Weibull distribution with parameters	
	Labor hours	**Time in weeks**
Minimum	80.00 hrs	1.5 weeks
Scale	15.00	1
Shape	2	2
Distribution shape		
Selected range	80.00 to 120.00 hrs	1.5 to 4.0 weeks

Addition of the uncertainty to each activity completes the ABC and ABT models for single product development, and platform approach. The initial platform model is same as the single platform development approach. Distribution associated with activities involved in product family member development is estimated from single product development data. The probability distributions for activities involved at the component level for spindle motor family members are also presented in Table 15-5.

3.2.4 Step 4: Simulate model to approximate cost and time

The development cost and time for the entire spindle motor family is estimated by simulating ABC and ABT models for the initial motor platform, CD-1, and members of the product family, DD-1 and DD-2. In each case the simulation was performed by gathering data for 10,000 random samples. An approximation for the total development cost for the family of spindle motors, using a platform approach, is determined using Eq. (1) (i.e., estimated cost for developing the initial platform, CD-1, and the two motors of the family, DD-1 and DD-2). The estimated total cost for developing the spindle motors individually is obtained by running three cost models, representing each spindle motor simultaneously and then using Eq. (2).

Simulation is run on the entire model and results are obtained to demonstrate the applicability of the model. Statistical test data for total cost without platform, total cost with platform and total cost savings are shown in Table 15-6. The mean total cost saving for implementing the specific platform approach, instead of developing the spindle motors individually, is almost $2.3 Million. Frequency distribution for total cost savings is shown in Figure 15-7. The simulation data can be used to perform percentile calculations and other statistical analysis to help decide the financial gains in implementing a platform approach for the three spindle motors family.

Table 15-5. Range for motor development parameters at component level.

	Labor Hours and cost		Completion Time	
	Single product & initial platform	Subsequent Family members	Single product & initial platform [wks]	Subsequent Family members [wks]
Engineering Design	80 to 120 Hrs		1.5 to 4.0	
Generate 1st Eng Motor Samples	20 to 32 Samples		1.5 to 3.0	
Test and Redesign	160 to 240 Hrs		1.5 to 4.0	
Generate 2nd Eng Motor Samples	100 to 150 samples		1.0 to 2.0	
Sample test	80 to 120 Hrs		2.0 to 3.0	
Motor Samples	500 to 600 Samples	100 to 200 Samples	2.5 to 5.0	1.5 to 3.0
Motor Tooling	$250K to $300K	$20K to $80K	1.0 to 2.0	1.0 to 2.0
Engineering Motor Test	480 to 520 Hrs	200 to 225 Hrs	3.0 to 5.5	2.0 to 3.5
Engineering Drive Test	480 to 580 Hrs	240 to 340 Hrs	3.0 to 5.5	2.0 to 3.5
System Comp Test	80 to 120 Hrs	40 to 65 Hrs	1.5 to 3.0	1.0 to 2.0
Launch	7500 to 8000 Samples	3000 to 3500 Samples	0.75 to 2.0	0.5 to 2.0
Factory Test	10K to 12.5K Samples	5000 to 6250 Samples	3.0 to 5.0	1.0 to 3.0
Initial production	480 to 520 Hrs	200 to 225 Hrs	2.5 to 4.0	1.0 to 3.0

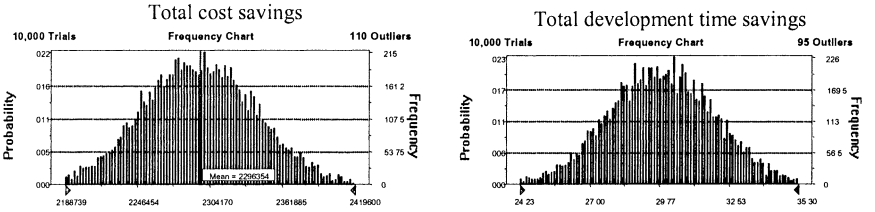


Figure 15-7. Frequency Chart for total cost savings and total time saving.

The development time for the entire family is estimated by simulating the ABT models to approximate the initial motor platform and members of the product family and then using Eq. (4) for total development time. In the case of the spindle motor, the estimated total time for the non-platform approach

is calculated by running three models, representing each motor, simultaneously and then adding each model approximation to estimate the total. In the case of the using the platform approach, the total time is approximated by estimating the time for developing the initial platform (CD-1) and the other two motors of the family (DD-1 and DD-2) supported by the platform. Statistical data obtained from simulating the ABT models for total development time without platform, total development time with platform and total development time savings are shown in Table 15-6.

Table 15-6. Simulation results for the cost and development time savings.

	Development Cost (dollars * 1000)			**Development Time (weeks)**		
	No Platform	With Platform	Total Cost Savings	No Platform	With Platform	Time Savings
Mean	4299	2002	2296	71.5	41.69	29.88
Median	4297	2001	2296	71.45	41.59	29.86
Standard Deviation	37	27	45	1.75	1.22	2.14

3.2.5 Step 5: Determine approach with better financial prospect

The management team of the company want to know if using a platform approach for the three spindle motors will save at least $2.25 Million and 25 weeks in development time for the company. Statistical hypotheses testing is used to determine the outcomes from the ABC and ABT models separately.

The hypothesis for cost saving, for the development of the three spindle motors, is formulated as:

$$H_0: \mu_1-\mu_2=2.25*10^6$$
$$H_1: \mu_1-\mu_2>2.25*10^6 \quad (7)$$

where: μ_1 corresponds to the mean of the existing approach and
μ_2 corresponds to the mean of platform approach

The hypothesis is tested for both 90 percent and 99 percent confidence level. Using statistical data obtained from ABC model simulation (see Table 15-6) the test statistics is z = 102.6. From statistical tables: $z_{0.10} = 1.282$ and $z_{0.01} = 2.326$. For both confidence level, the null hypothesis is rejected because $z>z_\alpha$. Hence it can be stated that with 99 percent confidence, for the cost model developed, the platform approach will yield at least $2.25 Million in savings.

In a similar way, the hypotheses associated with decrease in development time for the three spindle motors can be formulated as:

$$H_0: \mu_1-\mu_2=25$$
$$H_1: \mu_1-\mu_2>25 \quad (8)$$

where: μ_1 corresponds to the mean of the existing approach and
μ_2 corresponds to the mean of platform approach

The hypothesis is tested for both 90 percent and 99 percent confidence level. Using statistical data from Table 15-6 the test statistics is z = 223. From statistical tables: $z_{0.10}$ = 1.282 and $z_{0.01}$ = 2.326. For both confidence level, the null hypothesis is rejected because $z>z_\alpha$. Hence it can be stated that with 99 percent confidence, for the ABT model developed, the platform approach will yield at least a 25 weeks decrease in development time.

5. SUMMARY

In the present global market high quality, reduced cost, and development time are some of the challenges facing the manufacturers. Product platforms to support a family of product can reduce cost and development time for a family of products. Manufacturers need to estimate potential development cost and time savings to move toward a platform strategy. The Activity Based Cost and Time model were developed to assist designers/management in making decisions regarding implementation of product platform strategy. Using uncertainty in the model provides managers and designers to include the investment risks in the model. These cost and time estimates for the platform approach were compared with existing single product development approach to determine possible financial gains. The developed ABC and ABT models incorporated uncertainty associated with development cost and time of products. The addition of uncertainty is incorporated in the model using fuzzy numbers and then employing Monte Carlo simulation to simulate the models. The activity hierarchy, developed for the ABC and ABT models, provided information on the process of developing new products and platform approach.

The method of developing the ABC and ABT models for the platform approach was demonstrated using a family of hard disk drive spindle motors. Statistical results, which included frequency chart, quartile calculations and other data, associated with the models were calculated from the simulations. The statistical data, obtained from the simulation, were then used to determine if the platform approach meets a specified cost and time saving target. The statistical data can also be used to better understand the cost and time associated with platform development and be used to identify cost and time drivers associated with the specific product development to reduce cost and time. The current ABC and ABT models only address development cost

and time, other life cycle activities associated with developing product platforms need to be added to better estimate the effect of utilizing a platform approach.