

Severity of Variation Order Factors in affecting Construction Project Performance

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ABSTRACT

Construction industry continues to be a driving force in the growth of the nation's socio-economic development. Hence, construction industry is growing rapidly. Unfortunately, many of the construction projects fail in achieving desired performance specifically performance of time and cost as targeted. This is resulted due to various reasons. One of the reasons for this failure is variation order. Variation Order (VO) in the construction industry has become one of the common and serious issues. Undoubtedly, frequent occurrence of variations may decelerate the growth of the economy. Thus, it is very indispensable to discover and review the factors causing variation orders. Therefore, this study is focusing on identifying various causes of the variation order and assesses their effect on time and cost. This was done through comprehensive quantitative data collection method using questionnaire survey. The questionnaires were distributed to clients, consultants and contractors involved in the construction industry. The factors were categorized in groups by analyzing gathered data with multivariate statistical method of Factor Analysis. Factor analysis was run with SPSS software for Principal Component Analysis (PCA) test. Kaiser-Meyer-Olkin (KMO), the measure of sampling adequacy was found as 0.834 at significance level of 0.000, which showed that the data was adequate for further analysis. It resulted in categorizing data into 4 components which were used to calculate Average Index (AI) in evaluating the severity of various factors in affecting time and cost performance. Results showed that severe VO factors affecting time performance are; change in schedule, change of scope, change in design, financial problem and lack of strategic planning. Severe factors in affecting cost performance were change of schedule, financial problem, inadequate working drawing detail, change in specification, and financial difficulties. It is recommended that effective financial management and careful design can be very useful in reducing variation orders and hence project performance can be improved.

KEYWORDS: Variation order, factors of variations, time performance, cost performance, PCA

1. INTRODUCTION

Construction projects are continuously reported as experiencing poor performance. One of the reasons for this poor performance is occurrence of variation orders. It has become a common phenomenon in construction projects globally [1, 2, 3] and occurs even in the most well planned project [4] which may necessitate due to various factors. Variation is defined as any type of deviation from agreed upon; well defined scope or schedule of works [3]. Variation in any project can occur from various factors such as mistakes in the contract document, unknown ground conditions, modification in work scope or improper coordination and communication between the parties. Consequently, variation orders take place to put the variation together as part of signed contract [5]. Variation orders have a significant impact on the performance of the project. Variations may result in considerable amendment in the contract documents, project time and cost [6, 7]. In United State, Hanna and Gunduz [8] estimated that the United States construction industry spend 13-26 billion dollar in 1 year for construction variation order. Commonly, change order is issued to correct or modify the original design or scope of work [9]. Change order is an addendum to the contract conditions and is signed by all the parties involved in the contract. It becomes part of the contract and symbolizes an alterations required in the project, discover the change in time and cost of the project [10]. The occurrence of variations is a common issue in Malaysian construction industry. The variations in construction occur due to various reasons. The construction performance can be affected severely if the project team cannot analyze and overcome the problem effectively. Hence, it is very important to identify and assess the factors causing variation orders. This study focused on identifying common factors of variation orders and their effect o project performance.

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2. PROJECT PERFORMANCE

The term performance does not have any specific definition. It is used for several meaning depending on perspective for which it is defined [11]. In general, performance indicates the effectiveness (doing the right thing) and efficiency (doing the right thing right). Measurement of performance is defined as a structured method for appraising the inputs and outputs of construction activities, process [12, 13]. In construction projects, project performance is defined as the set of measures used for evaluating the success of the project. These measures may vary for project to project depending on the type of project, required input and expected output. Hence, it is very important to understand which criteria the clients employ in actual practice for assessing the performance of the project. In fact, there is no definite approach to measure performance; it follows the requirement of the client. Various researchers have suggested different norms of measuring project performance. For example, Thomas [14] highlighted that the success of the project can be measured in terms of rework, schedule performance, and budget performance, especially for keeping construction projects within estimated costs and schedules requires sound strategies, good practices, and careful judgment [15]. Odusami [16] observed that cost and time performance always fall into one of the top five of the main project objectives, as seen in the works of [17]. In addition, Sanvido [17] highlighted that compared to the consultant and contractors who are interested in profit making, clients of the project intend the completion of the project must be ensured within stipulated time and cost. Among the indicators of project performance, cost and time are the only criteria which can be measured directly. In addition, Odusami [16] remarked that some of the criteria are not compatible because those depend on the perception of respondents. Hence, this study adopted construction cost and construction time as measures of project performance as time and cost are the fundamental norms of measuring project success [18].

Project time is an important indicator for any construction project. It is defined as the time required or accomplishing the project activities [19]. According to Chan and Kumaraswamy [20], construction time is the total time required for achieving work completion (from stating activities on the site until the completion of the last activity) and is reflected in terms of days/weeks. Completion of any project within estimated time reflects the efficiency of the construction crew through the construction process. Unfortunately, due to unique and complex in nature, rarely construction project are completed within the specified time [21]. Thus, it leads to need of sufficient preparation or to make certainty of project compliance within the stipulated time.

Project cost is key indicators for measuring the performance of any project. It plays an important role in achieving the satisfaction of the project owner. It is the fundamental requirement of every owner that his project scope must be accomplished within the estimated cost. It depends on effective cost performance. Cost performance is the measure of the degree which indicates the probability of project completion within the budgets cost [22]. It reflects overall expenses occurred in any project from the initialization until the finishing of the project. It also includes the additional expenses incurred throughout the project span such as change orders, legal claims and others. Ali and Kamaruzzaman [23] also mentioned that the cost is an imperative indicator in any project and is of more interest for clients. Despite, owners of the project are always concerned with the monitoring project cost to avoid any overrun, construction projects often fail in achieving satisfactory cost performance [24].

3 VARIATION ORDER (VO) FACTORS

Variation orders in construction projects occur because of different reasons and factors. In order to control the issue of variation orders, it is very important to understand the factors causing variation orders. Review of previous studies highlighting causes of the variation order resulted in identifying 18 common factors as summarized in table 1.

Table 1. Factors of Variation Orders

Factors	Source
Change in scope of the project	[21, 25, 26, 27]
Change in Schedule	[2, 4, 21, 27, 32]
Owner's financial problems	[4, 17]
Impediment to prompt decision-making process	[17, 21, 27, 29, 32, 33]
Obstinate nature of owner	[21, 26, 27, 30, 32]
Change in specifications by the owner	[4, 26]
Changes in Design	[2, 21, 26, 27, 33]
Design complexity	[2, 26]
Inadequate working drawing details	[4, 26, 32, 33]
Inadequate design	[2, 25]
Conflicts among contract documents	[25]
Change in specifications by the consultant	[4]
Unavailability of equipments	[4, 32, 33]

Poor workmanship	[2, 4]
Lack of strategic planning	[4, 26, 28]
Contractor's financial difficulties	[21, 27, 31,32, 33]
Poor procurement process	[2, 26]
Shortage of Skilled Manpower	[21, 26, 27, 32]

➤ *Change in scope of the project:* Change of plan or scope of the project is a common issue faced by construction industry and is reported for affecting project time and cost performance [21, 27]. It is one of the extremely severe factors of variation in construction projects [25]. Insufficient planning during the conceptualization stage and lack of owner's participations during design activities are major reasons for causing change in scope [26].

➤ *Change in schedule:* Almost every construction project in the world is facing problem of change of schedule during the executions [2,4]. In the case of change in schedule, the contractors have either to endow with extra resources or also may cause keeping some of resources inactive. In both cases, additional cost is incurred. Thus, it affects severely the performance of the project [21, 27, 32].

➤ *Owner's financial problems:* Financial problems of the owner affect severely the quality and progress of the project [4, 28]. This problem can lead to change in work schedules and specifications, affecting the quality of the construction.

➤ *Impediment to prompt decision-making process:* For achieving successful project, it is very important that decisions must be made promptly [17, 29]. Due to fragmentations, it is very common that decisions are taken very slow especially when suddenly unexpected technical problems occur on site. This failure in making quick and prompt decision results in waiting time and loss of resources, which have adverse effects on project performance [21, 27, 33].

➤ *Obstinate nature of the owner:* Construction projects are resulted from the combined efforts of the various professionals working together at various interfaces of the project [26, 30] and many times approval of the owner is required. If the owner is obstinate, it can cause hindrances in working, and result in variations at the later stages of a project. It has significantly affected time and cost performance in construction projects [21, 27, 32]

➤ *Change in Specifications by the Owner:* Construction projects often experience the issue of changes in specification [4]. If the owner changes the specification of the design or requirement, then this may lead to variations in the construction phase [2].

➤ *Changes in Design:* Design changes by consultant are a common phenomenon in construction projects [26] which are frequently observed through the project lifespan [2]. These changes influence the project from a different aspect depending the time when changes are incurred [21, 27, 33].

➤ *Design complexity:* Design complexity highlights the need of exclusive expertise and special construction methods [26]. Complexity impinges on the flow of construction activities while simpler and linear construction activities easy to handle [2]. In other words, if the complexity of the design increases this will create more opportunities of variations in the project.

➤ *Inadequate Working Drawing Details:* In achieving efficient working on the site, it is very important to have complete project design, clear and concise working drawings. Incomplete details of working drawings can result in misinterpretation of the actual requirements for the project [26] causing variations in the project.

➤ *Inadequate design:* Inadequate design is a common reason of variation occurrences in construction projects globally [2, 25].

➤ *Conflicts among contract documents:* Conflict between contract documents often results in misinterpretation of the project requirements [25]. For successful projects, it is essential that the contract documents are clear and precise. Insufficient details in the contract documents may result in delays to the project completion or cause variations in cost.

➤ *Change in specifications by the consultant:* Changes in specification are observed frequently in construction projects [4]. Changes in specification may result in variations to the project, leading to delay and increased overall cost.

➤ *Unavailability of Equipments:* Construction project involves heavy works. In big projects, large amount of work is to be carried out, which can be executed with the help of various equipments in a faster and smooth way. Availability of adequate and sufficient number of equipments plays a major role in project success [32, 33]. Unavailability of equipment is a procurement problem that can affect the project completion [4].

➤ *Poor Workmanship:* Poor workmanship can cause the need of demolition or rework activities [2, 4]. This results in delay and increased cost.

➤ *Lack of strategic planning:* Proper strategic planning is a significant factor for ensuring the success of any project [28]. The lack of strategic planning is a universal issue which results with variations in construction projects. It imposes negative effects in the project where execution works are started before the design work is completely finished. This is a common case in projects awarded based on concurrent design and construction contracts [4, 26].

➤ *Contractor's Financial Difficulties*: Contractor is a key player in bringing the actual works done on site. He depends on labor availability which needs to pay proper wages paid on time, even though the contractor is not paid [31]. If the contractor experiences financial difficulties, it hinders in ensuring the availability of required skilled and unskilled labour. With this, the quality and progress of the project can be affected severely [21, 27, 32, 33].

➤ *Poor procurement process*: Poor procurement process reflects the delays in procuring the resources required for the project. It exerts various adverse effects on the construction cycle of activities [2]. It can also result in the entire change of plan or replacement for specified materials or equipments of any project [26].

➤ *Shortage of Skilled Manpower*: Construction projects highly depend on skilled manpower for performing technical activities [26]. Lack in skilled manpower can slow down the works and also make mistakes in working which will affect the project performance [21, 27, 32].

4. RESEARCH METHOD AND DATA COLLECTION

This research involved quantitative mode of research. It involved questionnaire survey for collecting data. Questionnaire was developed based on variation order factors identified through literature review as discussed in section 3. Among the client, consultant and contractor firms registered in Malaysia, a total of 200 personnel were contacted for participating in the survey. Out of these, 101 respondents completed and returned the questionnaire forms which were analyzed statistically.

Among these respondents, 39 respondents are representing clients while 37 and 25 respondents are engaged in contractors and consultant firms respectively. All the respondents have attained technical education where 50 respondents have completed their civil engineering degree, 32 respondents are diploma holders; 10 respondents have received professional certificates, and 9 respondents have completed master studies in civil engineering and project management. These respondents have minimum experience of 5 years and a maximum of 34 years in handling construction projects.

5. CHARACTERIZATION OF VO FACTORS

Characterization of the factors was carried out to sort the causes of variation based on similarity. It was done with Principal component analysis (PCA) test. PCA is the most popular multivariate statistical technique, and it is used by almost all scientific disciplines to extract the important information from observed data based on inter-correlation [34]. PCA test using varimax rotation technique is also used for data validation by calculating item-total score correlations [35]. Prior to PCA test, suitability of data was tested with Barlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was found as KMO=0.834 and significance= 0.000 which indicates that the data is adequate. PCA test showed that a total of 4 components are extracted with Eigen values of greater than 1 as shown in table 2.

Table 2. Total Variance Accounted

Component	Initial Eigen values			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.808	43.375	43.375	3.429	19.052	19.052
2	1.562	8.680	52.055	3.306	18.368	37.421
3	1.491	8.284	60.339	3.089	17.159	54.580
4	1.101	6.115	66.454	2.137	11.875	66.454

Table 1 demonstrates that with 66.45% of the variance is accounted for variations with four extracted components. PCA was conducted by using varimax orthogonal rotation criteria and the extracted components with loading value are illustrated in Table 3.

Table 3. Principle Component Analysis (PCA) Loading Results

	Component			
	1	2	3	4
Owner's financial problems	.726			
Impediment to prompt decision-making process	.665			
Poor procurement process	.658			
Contractor's financial difficulties	.651			
Change in Schedule	.632			
Lack of strategic planning	.601			
Inadequate working drawing details		.829		
Inadequate design		.771		
Design complexity		.703		

Changes in Design		.619		
Conflicts among contract documents		.519		
Shortage of Skilled Manpower			.802	
Poor workmanship			.753	
Unavailability of equipments			.609	
Change in specifications by the consultant				.773
Change in scope of the project				.668
Change in specifications by the owner				.520
Obstinate nature of owner				.501
Extraction Method: Principal Component Analysis.				
Rotation Method: Varimax with Kaiser Normalization.				
a. Rotation converged in 12 iterations.				

These four components are named:

- Financial and Decision Management which consists of 6 factors which are owner’s financial problems, impediment to prompt decision-making process, poor procurement process, contractor’s financial difficulties, change in schedule and lack of strategic planning.
- Design Issues consisting of 5 factors as inadequate working drawing details, inadequate design, design complexity, changes in design and conflicts among contract documents.
- Human and Equipment Resource contains 3 factors i.e. shortage of skilled manpower, poor workmanship and unavailability of equipments.
- Client Requirements consists of 4 factors which are change in specifications by the consultant, change in scope of the project, change in specifications by the owner and obstinate nature of owner

6. VO FACTORS’ SEVERITY LEVEL

Collected data was analyzed statistically for ranking the factors derived from the level of severity in affecting project performance. Ranking of factors was done based on Average Index (AI) value of each factors calculated according to equation 1:

$$AI = \frac{\sum(1X_1 + 2X_2 + 3X_3 + 4X_4 + 5X_5)}{N} \quad (1)$$

Where;

AI= Average Index

N= Total number of respondents

X = Number of Respondent or frequency of the response given of the total responses for each factor.

Likert scale used for data collection in this study was based on 5-points where, 1= Not Severe, 2= Slightly Severe, 3= Moderately Severe, 4= Very Severe, 5= Extremely Severe. The results are presented separately for assessing severity level of factors in affecting time performance and cost performance as discussed in following sections.

6.1 Time Performance

Table 4 shows the results for level of severity for VO factors in affecting time performance from the perspective of the client, consultant and contractor.

Table 4. Severity level of VO Factors affecting Time Performance

Factors	Client		Consultant		Contractor	
	AI	Rank	AI	Rank	AI	Rank
Financial and Decision Management						
Owner’s financial problems	3.13	1	3.05	2	2.78	4
Change in Schedule	3.10	2	3.11	1	3.08	1
Contractor’s financial difficulties	3.08	3	2.89	3	2.81	3
Lack of strategic planning	3.05	4	3.00	4	2.78	4
Impediment to prompt decision-making process	3.03	5	3.05	2	2.86	2
Poor procurement process	3.03	5	2.89	3	2.78	4
Design Issues						
Changes in Design	3.13	1	3.32	1	3.00	1
Design complexity	3.10	2	2.95	4	2.89	2
Inadequate design	3.08	3	3.05	3	2.73	3
Inadequate working drawing details	3.00	4	3.05	3	2.76	4
Conflicts among contract documents	2.97	5	3.11	2	2.54	5

Human and Equipment Resource						
Shortage of Skilled Manpower	3.00	1	2.84	3	2.54	2
Poor workmanship	2.90	2	2.95	1	2.84	1
Unavailability of equipments	2.72	3	2.89	2	2.43	3
Client Requirements						
Change in scope of the project	3.21	1	2.84	4	3.05	1
Obstinate nature of owner	2.97	2	3.00	1	2.73	3
Change in specifications by the owner	2.95	3	2.89	3	2.76	2
Change in specifications by the consultant	2.74	4	2.95	2	2.62	4

Table 4 shows that in category Financial and Decision Management, from client's perspective Owner's financial problems is the most severe factor in affecting project time performance, however, the consultant ranked this factors at 2nd place and from contractor's perspective, this factor is medium severe placed at 4th place within the category. 2nd most severe factor in this category from the client perspective is change in schedule while consultant and contractors believe that this is the most severe factor in this category in affecting time performance. On 3rd place, "contractor's financial difficulties" is ranked for severity in affecting time performance unanimously agreed by all respondents participating in the survey. In the category of design issue, changes in design is placed at first place and is agreed by all the parties of respondents that it is the most severe factor affecting time performance. Design complexity is ranked at 2nd place as agreed by client and contractors while consultant placed this factor at 2nd rank. All the respondents agreed that the inadequate design in 3rd ranked severe factor is affecting time performance. For Human and Equipment Resource related factors, client ranked shortage of skilled manpower as the most severe factor. There is disagreement between consultants and contractors for rank of this factor who placed at 3rd and 2nd place respectively. Client respondents placed poor workmanship at 2nd rank while consultant and contractors consider this factor as the most severe factors by placing it at 1st rank. Unavailability of equipments is placed at 3rd rank by client and contractor respondents while consultants have placed it at 2nd rank. In client requirement category of factors, client and contractors agreed that change in scope of the project is the most severe factors in affecting time performance while consultant considered this factor as the least severe within the group by placing it at 4th rank. For the factor obstinate nature of the owner, there is disagreement on rank among all parties where client ranked this factor at 2nd place, consultant placed at 1st rank and contractor ranked it as 3rd severe factor. Change in specifications by the owner is placed at 3rd rank and is agreed by client and consultant while contractors placed this factor at 2nd rank in affecting time performance.

6.2 Cost Performance

Severity level of factors for ranking in affecting the cost overrun is calculated based on the AI value and ranked accordingly based on the perspective of the client, consultant and contractor as summarized in table 5.

Table 5. Effectiveness level of VO Factors on Cost Performance

Factors	Client		Consultant		Contractor	
	AI	Rank	AI	Rank	AI	Rank
Financial and Decision Management						
Contractor's financial difficulties	3.08	1	2.79	4	2.76	3
Change in Schedule	3.03	2	2.58	6	3.27	1
Owner's financial problems	2.97	3	2.89	2	3.11	2
Lack of strategic planning	2.97	4	3.05	1	2.68	4
Impediment to prompt decision-making process	2.90	5	2.74	5	2.76	3
Poor procurement process	2.79	6	2.84	3	2.76	3
Design Issues						
Inadequate working drawing details	2.97	1	2.11	5	2.76	2
Changes in Design	2.95	2	2.95	3	2.86	1
Design complexity	2.87	3	2.79	4	2.76	2
Conflicts among contract documents	2.87	3	3.16	1	2.57	4
Inadequate design	2.85	4	3.05	2	2.59	3
Human and Equipment Resource						
Poor workmanship	3.00	1	2.95	2	2.57	2
Shortage of Skilled Manpower	2.87	2	2.79	3	2.49	3
Unavailability of equipments	2.79	3	3.05	1	2.62	1
Client Requirements						
Obstinate nature of owner	2.95	1	2.79	3	2.59	3
Change in scope of the project	2.92	2	2.58	4	2.92	2
Change in specifications by the consultant	2.85	3	3.00	1	2.51	4
Change in specifications by the owner	2.82	4	2.89	2	3.03	1

Table 5 shows that in category financial and decision management, owner’s financial problem is the most severe factor in affecting project cost performance from the perspective of the client representative, however, the consultant ranked this factor at 4th place and from contractor’s perspective; this factor is medium severe placed at 3rd place within the category. 2nd most severe factor in this category from the client perspective is change in schedule while consultants believe that this is the least severe factor within the category and have placed it at 6th rank and contractors believe that this is the most severe factor in this category in affecting cost performance. On 3rd place, “owner’s financial problems” is ranked for severity in affecting cost performance by client respondents. However, consultants and contractors have placed this factor at 2nd rank in affecting cost performance. In the category of design issue, inadequate working drawing details is placed at first place by client representative and is ranked at 2nd place by contractors while consultant respondents have placed this factor at 5th rank. The factor ‘changes in design’ is ranked at 2nd place by clients while consultants ranked it at 3rd place, and contractors believed that it is the most severe factor within the design category of factor. 3rd severe factor in this category for affecting cost performance is design complexity. However, there is disagreement on ranking of this factor among all parties. Clients ranked this factor at 3rd place; consultant placed at 4th rank and contractors ranked it at 2nd place. For human and equipment resource related factor, client ranked poor workmanship as the most severe factor while consultant and contractors ranked this factor at 2nd place. Client respondents placed shortage of skilled manpower at 2nd rank while consultant and contractors placed this factor at 3rd rank. Unavailability of equipments is placed at 3rd rank by client while consultants and contractors consider this factor as the most severe factor by placing it at 1st rank. In client requirement category of factor, client obstinate nature of the owner is ranked at 1st place by client respondents while consultant and contractors ranked this factor at 3rd place. From a client perspective, change in scope of the project is the 2nd severe factor in affecting cost performance and it is agreed by contractors also while consultants considered this factor as less severe and have ranked this factor at 4th place. Change in specifications by the consultant is placed at 3rd rank while consultants consider this factor as most severe factor within the category and contractors ranked this factor at 4th place.

7. DISCUSSION AND CONCLUSION

VO factors have a significant effect on project time and cost, however, the level of effect varies for each factor. This effect level is reflected in terms of severity level calculated with average index method for gathered data through survey. Severity index value and rank of each factor in affecting time and cost performance separately calculated based on overall respondents participating in the survey is presented in table 6.

Table 6Severity level of Factors in affecting Project Performance

Factors	Time		Cost	
	AI	Rank	AI	Rank
Change in Schedule	3.10	1	2.99	1
Change in scope of the project	3.09	2	2.85	8
Changes in Design	3.09	3	2.89	6
Owner’s financial problems	2.99	4	2.98	2
Lack of strategic planning	2.97	5	2.88	7
Design complexity	2.95	6	2.80	11
Impediment to prompt decision-making process	2.95	7	2.78	14
Inadequate design	2.94	8	2.79	12
Contractor’s financial difficulties	2.94	9	2.90	5
Inadequate working drawing details	2.93	10	2.93	3
Poor procurement process	2.92	11	2.78	15
Obstinate nature of owner	2.92	12	2.78	13
Change in specifications by the owner	2.88	13	2.91	4
Poor workmanship	2.87	14	2.82	9
Conflicts among contract documents	2.85	15	2.82	10
Shortage of Skilled Manpower	2.80	16	2.73	18
Change in specifications by the consultant	2.76	17	2.75	17
Unavailability of equipments	2.63	18	2.77	16

From table 6, it is seen that change in schedule, change in scope of the project, changes in design, owner’s financial problems and lack of strategic planning are the top 5 factors affecting project time performance. While, top 5 factors affecting cost performance include change in schedule, owner’s financial problems, inadequate working drawing details, change in specifications by the owner and contractor’s financial difficulties. Overall, change in

schedule is reported as the most severe and common factor is affecting time and cost performance. Hence, it is very important that all the parties be enforced to follow the schedule of activities. Besides that, financial and design related issues are found as severe factors in affecting project performance. Thus, for improving project performance, it is recommended that a clear and thorough project brief would be given to all participants involved in the project. It will assist in eliminating variations that may arise when the project had started. This may assist in developing a clear scope of work for the parties that involved on the project. Owners and contractors should have strong financial aspects and cash flow during the project must be regularly monitored wisely. Integrated project scheduling and management techniques should be adopted for planning and monitoring the progress of the project. Further, the owners should be involved in the design phase that would assist to give exact objective to the design specification which can reduce the changes of the design too frequently.

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