

**VALUE ENGINEERING**

**WORKBOOK INSTRUCTIONS**

**General Instructions:**

Complete each page clearly, legibly, and neatly with a dark pencil or black pen. In most cases this workbook will be reproduced as is and not retyped.

Instructions for Completing VE Study Identification

This is one of two pages used to identify the project and serve as an introduction to it. By reading this page, an interested party should be able to understand the general nature and scope of the project.

1. VE TEAM MEMBERS
	1. This area is used to record the name, title, agency, and telephone number of each team member.
2. PROJECT DESCRIPTION
3. Length - In feet or miles

1. Cost - Estimated total project cost
2. Type of Funds - Are there Federal, State, and/or Local funds in the project? List their classification: construction, maintenance, local, etc.
3. Design Speed - Miles per hour
4. Projected Traffic - Average daily traffic {ADT} and design hourly volume {DHV}
5. Projected Award Date - Anticipated letting date
6. Major Project Elements - Describe what the project enta.ils. What is involved? Give a verbal, non-technical description of what is included in this project. This description, followed by a listing of major components may be useful to individuals reviewing this workbook. For example: Grading, Drainage, Paving, Structures, Utility relocation, etc.
7. ROUTE CONDITION I GEOMETRY
	1. It is often useful to know the condition of the adjacent segments, and the total route. For example: sufficiency rating, tangent section, rolling terrain, roadway cross-section, lack of shoulders, etc.

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**Value Engineering - Study Identification**

Des & Contract Number: Route Number:

Location: Date:

**VE TEAM MEMBERS**

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| Name: | Title: | Organization: | Telephone: |
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**PROJECT DESCRIPTION**

Length: Cost:

Design Speed: Projected Traffic:

Projected Award Date: Type of Funds:

Major Project Elements:

**ROUTE CONDITION / GEOMETRY**

|  |  |
| --- | --- |
| Adjacent Segments: | Overall Route: |
|  |  |

**Instructions for Completing Investigation Phase – Sources:**

1. AUTHORIZING PERSONS

List here the persons who will have to approve the VE recommendations. This information will be useful in ensuring that the recommendations are presented in a manner tailored to the unique habits and attitudes that may govern final acceptance.

1. PERSONAL CONTACTS

List here fill the people from whom you seek advice and information regarding the study. Maintain and add to this list as the study progresses. Under "Notes," summarize the information obtained.

1. DOCUMENTS / ABSTRACTS

List all the reference material used in the study, i.e., standard specifications, AASHTO Guides, State standards, Means construction costs, AASHTO Green Book, etc. Briefly note the kind of information contained in them.

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**Investigation Phase - Sources**

Des & Contract Number: Route Number:

Location: Date:

**APPROVING / AUTHORIZING PERSONS**

|  |  |  |
| --- | --- | --- |
| Name: | Position: | Telephone: |
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**PERSONAL CONTACTS**

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**DOCUMENTS / ABSTRACTS**

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| Reference: | Notes: |
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**Instructions for Completing Investigation Phase - Cost Model:**

1. Prepare a COST MODEL for your project.
2. COST OF SIGNIFICANT BID ITEMS
	1. It is often true that 20 percent of a project's elements constitute 80 percent of its cost.
	2. Prepare a COST MODEL of all of the major items in you project. Using a Bar Chart format, show the cost of each item starting with the highest cost item first. Ten to twenty project cost elements are desired. Combine and/or breakdown cost elements to achieve this number of elements.
	3. Draw a horizontal line to show the 80 percent cost split of the project items. This will indicate to the team those project elements deserving the most attention.
	4. If some low cost project elements are used repeatedly throughout your organization, they may produce positive, organization-wide savings. List them on the cost graph, otherwise they will be ignored in the study.

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**Investigation Phase - Cost Model**

 Des & Contract Number: Route Number:

 Location: Date:

**Instructions for Completing Information Phase – Function Analysis:**

This is where the conventional listing of project items and costs is transformed into a listing of project FUNCTIONS and their relative costs. Keep in mind that the objective of the investigation phase is to identify those functional areas that have the greatest opportunity for value improvement. The listing on this page is another step to ensure that the functions with the "best" potential for savings are examined first. In the title block, identify the FUNCTION of your total project using one verb and a noun.

Assign a LETTER to each project cost item. Next, enter a "Two-Word" definition (Action Verb & Descriptive Noun) that expresses the function of each item listed. Enter the item's cost as shown in the Cost Model. In making out this list, items satisfying the same function should be grouped together.

1. OTHER ITEMS
	1. List any additional items that might have a potential for substantial savings. if considered on a program-wide basis. Enter the ''Two-Word" definition that expresses the function of each item listed. Enter the item's cost.
2. WORTH
	1. Worth is the least cost that the VE team believes can accomplish the same function. Consider a functional comparative for each item listed. This should be a less costly way of performing the same function, irrespective of its project application. Use the "comment" column to identify the functional comparative or other means taken to achieve worth. This will show you if there is any substantial cost difference between the design cost and its worth. Some examples are:

ITEM FUNCTION COST WORTH COMMENT

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| A. | Bridge | Cross Obstacle | $215,000 | $115,000 | Use Culvf3rt |
| B. | Culvert Pipe | Convey Fluids | $100,000 | $ 20,000 | Use open ditch |
| C. | Slope widening | Enhance Safety | $125,000 | $ 55,000 | Guide Rail |
| D. | Traffic Light | Control Vehicles | $ 75,000 | $ 10,000 | Stop Signs |

The size difference between· the design cost and the worth of the functional comparative is an indication of value opportunity.

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**Investigation Phase - Function Analysis**

Des & Contract Number: Route Number:

Location: Date:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Item |  | Basic | Function: |  |  |  |
| No. | Description: | Verb: | Noun: | Cost: | Worth: | Comments: |
| 1 |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |
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| 12 |  |  |  |  |  |  |
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**Instructions for Completing Investigation Phase – FAST Diagram:**

The FAST diagram is a graphic representation of the functional logic applied to the original design. To develop a FAST diagram, one has to ask the questions, HOW is the basic function (verb) (noun) actually accomplished, or HOW is it proposed to be accomplished? The answer, expressed as a verb and a noun is written in the next block to the right of the scope line.

The process is continued to the right by asking HOW. for each new function on the diagram. The process is repeated until the answer falls outside the scope of the study. To check the answers to the HOW questions, ask the question WHY as you proceed backward through the FAST diagram, starting on the right side and proceeding to the left until you have exceeded the scope of the study (reached a function with a higher order than the basic function).

The line of functions you have developed is called the critical path. If one of the Required Secondary functions is taken away, the Basic Function of the system cannot be satisfied. If a function can be taken away without affecting the performance of the Basic Function, then the function removed is not critical, but may be a supporting function.

1. SUPPORTING FUNCTIONS
2. Functions that happen all the time, at the same time, or are caused by the critical functions are supporting functions. They result from the particular method chosen by the designer for accomplishing the Basic Function. All the time functions are shown above the critical path line and same time and caused by functions are shown below the line.
3. The FAST diagram can be used to identify and visualize high-cost functions by including the functional cost in each of the critical and supporting function blocks.



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**Investigation Phase - FAST Diagram**

Des & Contract Number: Route Number:

Location: Date:

**Instructions for Completing Speculation – Brainstorming:**

This sheet is used for the SPECULATION & CREATIVE Phase of the VE Job Plan.

BRAINSTORM on each of the functions from the Function Analysis sheet. Put down as many ideas as possible. Use as many sheets as necessary. Do not limit your ideas.

Write down all ideas. Remember the number one rule of brainstorming, DO NOT JUDGE!

Speculation Phase

Objective: Task:

* Generate large numbers of ideas - Speculate on functions

 - Don't discuss

Key Questions: Techniques·

* What else will perform the function? - List everything

Where else may the function be done? - Be imaginative

* How else may the function be done? - Use creative techniques

- Defer judgment

- Do not criticize

- Be courageous

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**SPECULATION PHASE - BRAINSTORMING**

Des & Contract Number: Route Number:

Location: Date:

Item: Function:

**Instructions for Completing Evaluation Phase:**

This sheet is used for the EVALUATION Phase of the VE Job Plan. Consider first those functions that have the greatest potential savings. Two Evaluation methods will be used.

1. FEASIBILITY EVALUATI ON
	1. Review the creative ideas you have developed in your Brainstorming session and cross out those alternatives that the team believes are unrealistic and, therefore, unacceptable. CAUTION - Be absolutely sure everyone agrees the idea should be dropped.
2. SUITABILITY EVALUATION
	1. Record all of the remaining ideas for each function that have not been crossed out and list their advantages and disadvantages. List the ideas for that item numbering consecutively (A-1, A-2, A-3; B-1, B-2, B3; etc.)
	2. Rate each idea from "poor" to "outstanding" (1 to 10). The rating is used to guide the team during the Development Phase ensuring the best ideas are developed first.

EVALUATION PHASE

Objective· Task:

* Evaluate alternatives - Speculate on evaluation criteria
	+ Evaluate alternatives
	+ Select the best alternatives

Key Questions: Techniques:

* How might each idea work?
* What will be the cost?

· - Will each idea satisfy the function?

* What is the better alternative?
* What are the chances of selling the idea?
* Weigh alternatives
* Choose evaluation criteria
* Refine ideas
* Place dollar value of each idea

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**Evaluation Phase**

Des & Contract Number: Route Number:

Location: Date:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ItemNo. | Creative IdeaListing | IdeaAdvantage | EvaluationDisadvantage | IdeaRating |
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**Instructions for Completing Evaluation Phase - Matrix Analysis:**

This is an **optional** worksheet for the EVALUATION Phase. It is a Matrix Analysis Form that you can use to assign numerical ratings to the subjective analysis you carried out on Form VE-7. It permits the team participants to weigh and rate various aspects of each alternative, while remaining free of any bias or predisposition about the alternative as a whole.

The Matrix Analysis is used to compare a variety of alternatives affecting a single project function. It is especially useful where there is no clear consensus among the VE team.

1. OBJECTIVES OR CRITERIA

List all the design objectives or performance criteria that apply to the project under study. Weigh them from 1to 10 according to their relevance or importance (10 = high and 1 = low. Enter this weight in the horizontal line of boxes.

1. ALTERNATIVES
	1. List the ORIGINAL item and all the alternatives from Form VE-7 that you want to compare. Rate how each of the alternatives satisfies each objective or criterion, i.e., 1 = poor and 5 = superior. Enter the rating for each alternative in the top part of the box.
	2. TO ELIMINATE BIAS, it is essential to WORK DOWN each column, rating each alternative according to the same objective or criterion.
	3. Multiply the rating by the weight for each combination. Enter the weighted rating in the lower part of the box.
	4. Add the weighted ratings for each alternative together and enter its total score in the Totals column.
	5. Rank the alternatives according to the total score (1 = highest, 2 = second highest, etc.). Now determine how the alternatives should be used and how they might be modified to improve the product.

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**Evaluation Phase - Matrix Analysis**

Des & Contract Number: Route Number:

Location: Date:

 **EVALUATION CRITERIA**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **WEIGH****ALTERNATIVES:**5 Superior4 Good3 Average2 Fair1 Poor1 Poor |  |  |  |  |  |  |  |  |
| **ALTERNATIVES**  **/ WEIGHT** |  |  |  |  |  |  |  | **TOTALS** |
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**Instructions for Completing Development Phase – Recommendation:**

1. Once you identify the project elements and/or functional areas that can be modified, develop each area into a workable alternative solution. Complete Form VE-9 **for each recommended alternative**. Do not show any calculations or sketches on this sheet. Attach all backup calculation sheets used to develop the idea.
2. Keep in mind; the decision makers who will be reviewing these items are not familiar with the team's work this week. Develop your alternatives in a logical and complete fashion showing all calculations for documentation and listing all assumptions made.
3. The justification area is where you must state your reasons for making the change. Remember, you must "sell" your idea. Be complete. Use additional sheets of paper if necessary. Anticipate possible reasons to reject your idea and provide adequate responses to counter these objections.
4. Costs used on this sheet should include both initial and future costs. Detailed cost calculations should be shown on separate sheets. Future costs are the sum of lines 6 and 8 on the life cycle cost analysis worksheet (see Form VE-9D).

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**Development Phase - Recommendations**

Des & Contract Number: Route Number:

Location: Date:

**Original Design** (Sketch attached?

**Proposed Change** (Sketch attached?)

**Justification** (Describe advantages/disadvantages, reasoning, and compliance with

 standards and requirements)

|  |  |  |  |
| --- | --- | --- | --- |
|  Life Cycle Cost Summary |  |  |  |
|  (Present Worth Method) | Initial Cost | Future Cost | Total Cost |
| Original Design |  |  |  |
| Proposed Change |  |  |  |
| Savings |  |  |  |

**Instructions for Completing Development Phase – Sketches:**

1. Having identified which functional areas can be changed, make a SIMPLE SKETCH of the project element as designed and as proposed. Be sure to include enough information to clearly identify the proposed changes.

HINT: A clear, easy to understand sketch is the best sales tool.

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**Development Phase - Sketches**

Des & Contract Number: Route Number:

Location: Date:

**Original Design**

**Recommended Design**

**Instructions for Completing Development Phase – Calculations:**

1. Show sufficient calculations to enable all reviewers to analyze your proposed change and determine that it is a workable and realistic alternative. Calculations should show technical data only. Reserve cost calculations for the cost worksheet. Be sure to identify and explain all assumptions you made if specific data is not available.
2. Include as many sheets as necessary.

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**Development Phase - Calculations**

Des & Contract Number: Route Number:

Location: Date:

**Instructions for Completing Development Phase - Cost Worksheet:**

1. A major element in "selling" your recommendations involves showing that they are not only viable engineering alternatives, but that they will result in a COST SAVINGS. This sheet allows for a comparison of the costs for the various proposed alternatives to their original costs.
2. Be as detailed in your costs as possible. Use the same unit costs for both the original and proposed estimate for each item of construction. List any assumptions made and indicate where your costs were obtained.
3. Item: This is the item of construction, such as; fill, concrete, 24" RCP, etc. Unit: This is what units express the item, such as; CY, LF, SF, EA, etc.
4. The unit costs for this worksheet should either be pulled from the Stage 1 estimate, or the average price for the item in Bid Tabs Express

INDOT VE - 9C SHEET \_\_ OF \_\_\_

**Development Phase - Cost Worksheet**

Des & Contract No.: Route Number:

Location: Date:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Construction Element |  |  | Orig. | Cost |  | Prop. | Cost |
|  |  | # of | Cost / | Total | # of | Cost / | Total |
| Item | Unit | Units | Unit | Cost | Units | Unit | Cost |
|  |  |  |  |  |  |  |  |
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**Instructions for Completing Development Phase - Life Cycle Cost:**

This sheet is used to determent an item's LIFE CYCLE COST using the Present Worth method.

This worksheet is NOT required for each alternative, only those that evaluate costs other than initial construction costs.

Single payment factors and uniform series factors can be found in Chapter 50 ([Figure 50-2C](http://www.in.gov/indot/design_manual/files/Ch50_2013.pdf)) of the Indiana Design Manual (IDM).

* 1. Estimate the Economic Life for the Item (10, 15, 20, 35, 50, etc. - Years)
	2. Determine the Discount Rate to be Used (4% Interest Table from Figure 50-2C in the IDM)
	3. List Initial Cost
	4. List and Determine the Present Worth of all Future Single Costs
	5. List and Determine the Present Worth of all Future Annual Costs
	6. Sum the Costs to Determine the TOTAL Future Costs Include this Cost on Sheet VE-9

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**Life Cycle Cost Analysis - Present Worth Method**

Des & Contract No.: Route Number:

Location: Date:

Discount Rate: Economic Life: \_\_ Years

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Original | Design | Alt. | No.1 |
|  | Cost | PW | Cost | PW |
| **1. Initial Cost:** |  |  |  |  |
|  |  |  |  |  |
| **Single Expenditures:** (i.e., stage Construction, Major Maintenance) |  |  |  |  |
|  a. Year \_\_\_\_ PWF \_\_\_\_\_\_ |  |  |  |  |
|  b. Year \_\_\_\_ PWF \_\_\_\_\_\_ |  |  |  |  |
|  c. Year \_\_\_\_ PWF \_\_\_\_\_\_ |  |  |  |  |
|  d. Salvage / Unused Service Life |  |  |  |  |
|  Year \_\_\_\_ PWF \_\_\_\_\_\_ |  |  |  |  |
| **2. Future Single Costs:** |  |  |  |  |
|  |  |  |  |  |
| **Annual Costs:** |  |  |  |  |
|  a. General Maintenance PWF \_\_\_\_\_\_ |  |  |  |  |
|  b. Other Annual Costs PWF \_\_\_\_\_\_ |  |  |  |  |
| **3. Future Annual Costs** |  |  |  |  |
|  |  |  |  |  |
| **4. Total Future Costs: (2 + 3)** |  |  |  |  |
|  |  |  |  |  |
| **5. Total Life Cycle Costs: (1 + 4)** |  |  |  |  |
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**Instructions for Completing Development Phase - Summary of Cost Savings:**

1. This sheet provides a summary of all your recommended alternatives and their cost savings. List each of your proposed alternatives and its cost savings.
2. The TOTAL projected project savings should also be shown on this sheet to indicate the maximum potential savings. In determining the TOTAL savings, remember that some recommendations may overlap and therefore FULL credit cannot be taken for each. Use an asterisk in the last column to indicate which proposals are included in the TOTAL.

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**Development Phase - Summary of Cost Savings**

Des & Contract Number: Route Number:

Location: Date:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | Original | Proposed | Initial | Future | Total |
| Idea | Description | Design | Change | Cost | Cost | Cost |
| No. |  | Cost | Cost | Savings | Savings | Savings |
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**Instructions for Completing Development Phase - Executive Summary:**

The executive summary should include a concise, abstract of the VE study. It should be confined to one page if possible. This will serve as a summary document for the project and your recommendations. It is the executive action document from the team to the decision makers, highlighting the study and recommendations. As a minimum it should include:

1. General
2. Project description including the total estimated construction cost Site and date of the VE study.
3. Results Obtained
4. Number of recommendations
5. Total projected savings
6. Savings as a percent of the project cost
7. Highlights
	1. Summarize significant recommendations (if many) or all recommendations (if few).
8. Constraints
	1. Identify any conditions (political, social, or site) that influenced the team's recommendations.

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**Development Phase - Executive Summary**

Des & Contract No.: Route Number:

Location: Date: :

**Introduction:**

**Study Results:**

**Constraints:**

**Highlights:**

**Resources**

**Economic Analysis:** <http://www.in.gov/indot/design_manual/files/Ch50_2013.pdf>

**FHWA Value Engineering Final Rule**: <http://www.gpo.gov/fdsys/pkg/FR-2014-09-05/pdf/2014-21020.pdf>