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2.4 FBS (Function Breakdown Structure) Technique to Create the Image Structure

2.4.1 Introduction

Steplist and 3-5 Phase Improvement are methods to create procedures to achieve the objective. This section explains a way to create an effective image structure of the objective using the FBS (Function Breakdown Structure) Method.

(1) Its content is derived from image structuring in casual modes of thinking, but because of detailed analysis and reconstruction, significant improvement is made. The conventional concept that "Creativity enters from ideas," is switched to “Effective creativity enters from themes or ideas," when creating a system to produce broader, deeper, valuable pieces of wisdom.

(2) In system engineering, the Function Tree Structure in value engineering and WBS (Work Breakdown Structure) used in project management were recognized to be similar, but the relationship between them has not been clarified.

The FBS technique clarifies their relationship and establishes their proper use.

2.4.2 Explanation of the method using examples

When we plan or design new things, we always have a theme. In this section, we examine what we are doing casually and express it as a diagram, for example as in Fig. 2.4-1. We use this diagram as a map, and show the process of improvement in the form of procedures. (The step name is shown in angle brackets < >).

(1) Suppose we are given a design theme "A desk for easy study"

<Establishment of theme>

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(2) We then wonder "What would a desk for easy study be?" or in brief, "What are we going to do?"

<Questions regarding the function>

(3) We consider various possible answers, and arrive at the conclusion "To provide a surface of suitable height which has enough space for reference books."

<Fixing the most appropriate expression for the basic function (Key Word)>

(4) We start thinking of the actual size and various other items, compare the ideas, and select the most cost-efficient one to fit the purpose. For example, consider whether it should be a desk hanging from the ceiling, a desk with legs, or a cantilever desk. Compare them and select one.

<Creating ideas, and comparative selection>

(5) Next, consider the components necessary, and choose how they should be combined. If you choose a desk with legs, you consider the Breakdown Structure: board, legs, and metal fittings for leg installation. However, if the leg is directly attached to a hole in the board, the metal fittings would be unnecessary.

<Creation of breakdown plan, comparison, selection >

(6) The board and the legs are taken as the given theme in the next level, and then asking "What are we going to do with it?" ideas are devised, compared and selected.

<Breakdown plan component name as a given theme in the next level>

(7) Successively repeat these operations until a complete plan is obtained. (Repetition of theme, function definition, ideas, breakdown structure of theme, function definition,) This prepares the way for a concrete blueprint of the desk.

<Detailed operation>

(8) Usually at this stage, the designer incorporates the discussions into a plan drawing, and the people concerned agree on it.

<Making the plan drawing>

(Note) The phases to this point are usually called the basic design phase to create and identify a feasible image structure.

(9) The designer next prepares detailed manufacturing drawings. A final assembly drawing is made by going from the lower level components to the upper levels, reversing the order to draw the plan drawing.

<Making the manufacturing drawing>

(Note) The phase at this point is usually called the detailed design phase.

Fig. 2.4-1 is a visual representation of this process, and Fig. 2.4-2 is a generalization.

The above only describes the detailed process steps of what we have been doing. Whether following these steps leads to the optimum solution is open to question. Further sophistication is therefore necessary.

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In the following, we describe steps (3)(4) and (5) in more detail, in a more advanced manner than conventional brainstorming or value engineering.

The resulting block diagrams, such as in Figs. 2.4-1 or 2.4-2, are called FBS (Function Breakdown Structure) diagrams.

2.4.3 Method for creating the most appropriate expression of the basic function (Key Word) (Detailed explanation of 2.4.2 (3))

We first describe the procedure, and then explain why the expression selected by the procedure is the most appropriate for the basic function (It is the same as grasping the Key Word in the PMD Method.)

(1) Procedure

1. Identify the theme given as the design or plan object.
2. Next, ask "In brief, what are we are going to do with it?" in relation to the theme, and write down as many responses as possible on paper: "In brief, do something (verb and noun)." (In this case, a minimum number of adjectives and adverbs may be added. See Note 1.)
3. Cut the paper into cards with scissors and compare the cards in pairs. Arrange them from top to bottom in the repeating sequence "In order to do A, it is necessary to do B."
4. After finishing the arrangement, read down again to check whether it makes sense. If it does, fix the expressions with transparent tape.
5. Looking at the sequence around the middle, find an expression "In brief, this is just the thing to do" which summarizes both the expressions above and below it. As if magic, such an expression always turns up. This is the most appropriate expression of the function. Fig. 2.4-3 gives an example for a small handy light.

(2) Explanation of the effectiveness of the procedure

Using Figs. 2.4-3 and 2.4-4, we may explain why the expression selected is the most appropriate expression of the function as follows:

1. The result of the procedure read downwards is a repetition of purpose and measures "In order to do A, it is necessary to do B."
2. However, if we look at the expressions with the most appropriate expression of the function (Main Key Word) at the center, we realize that the upper level expressions are abstract purpose relationships, whereas the lower levels read upwards give rough procedures to reach the expression level of the basic function.

3. From this, we may say that the most appropriate expression is the end point expression of procedures, and hence the expression of the objective result.
4. From 2 and 3 above, we recognize that purpose can mean abstract purpose or desired result.
5. When we say, as in procedure (1)-5, that, as if by magic, the most appropriate expression appears, it suggests that we subconsciously have the ability to utilize this mechanism.
6. The purpose-measure relationships link the abstract purpose with the actual measure, so it means that the Direction of Value based on the theme is fixed on paper.

Due to this fixing of the direction of value and expression of function, a mechanism is simultaneously created on the paper where thinking up ideas, comparing, weighing, and selecting them becomes easy.
(Note 1) The characteristic of this procedure is that by allowing a minimum number of adjectives and adverbs in the expression of basic function, a mechanism is introduced by which the integration of lower level ideas is easily possible. This contrasts with value engineering, where only nouns and verbs are allowed.

2.4.4 How we can come up with effective ideas, and compare and select from them

(Detailed explanation of 2.4.2 (4))

(1) Procedure

Think up several ideas which satisfy the most appropriate expression of the function decided in the previous phase. Ideas may be thought up with the conventional NM method or brainstorming. However, when summarizing the ideas, the following standards should be followed to obtain a reasonable result.
(Refer Appendix A for of NM method)
1. First think up several ideas, develop them, and summarize them in a maximum of 3 optimal plans.
2. Next, prepare realizable plans close to the optimal plans.
3. Assuming that the optimal plan lies within the triangle of the above plans, search for it by comparison.
(Note) Use the DTC/LCC trade worksheet shown in Fig. 2.4-5 to create the plans for comparison. This worksheet is convenient since it contains a matrix column Possible Combinations of Design Plans. The procedure for filling in the worksheet is given in Appendix E-7.
(1) Explanation of the effectiveness of the procedure

Why adopting the procedure above is effective for creating ideas, and comparing and selecting from them in a reasonable and appropriate way:
1. Making more than two plans means creating the Information of Difference by Comparison, which triggers the next and greater thought and action. Making the 3rd plan means augmenting the breadth of

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thought.

2. The extreme plans are the basis of F cost (see Note) in value engineering, and preparing realizable plans close to them corresponds to maximizing Value = F/C (see Note) (application of the Principle of Management by Objective).

3. Here, the Direction of Value is fixed in the process of extracting the Main Key Word, so the Information of Difference can be checked against it. Thus, reasonable weighing and comparative selection of plans becomes easy and accurate.

(Note) F cost means the minimum cost which satisfies the function requirements, and C is the current cost.

2.4.5 How we should create, compare, and select Breakdown Structures

The purpose of this phase lies in the creation of the most effective and efficient Breakdown Structure to realize the plan of the previous phase. The way of thinking and procedure are as follows:

(1) Itemize the components essential to realizing the selected idea. (They may be articles or process elements.) Consider as many combinations of the items as possible, even for a single idea, just as for the 2 comparative plans in 2.4.2 (5). Then, create the Breakdown Structure plans, and compare and select as in the following example.

If we consider the small handy light of Fig. 2.4-3, two Breakdown Structures are possible.

(Plan 1) bulb, battery, circuit, ON-OFF switch, case, lens, lanyard (total 7 items)

(Plan 2) lens bulb, battery, ON-OFF switch, case (total 4 items)

(2) Next, these Breakdown Structures are divided into three parts.

Part A: An item essential to achieving the desired result, and whose cost hardly changes with the design. In the small handy light example, the bulb and battery.

Part B: An item necessary to achieve the desired result, but whose cost varies with the conditions. In the small handy light example, the switch, case, and circuit.

Part C: An item not always necessary to achieve the desired result. In the small handy light example, the lens and lanyard.

(3) The items belonging to each part above are arranged from left to right according to the following rules:

Part A: from more costly to less costly

Part B: from items whose cost is highly variable to those which are less variable

Part C: in the same order as B.

(Note) The division into Parts A, B, and C is the same as the cost division in Chapter 6 for Design To Cost.

The factor which changes the cost of Part B is called the cost driving factor.
(4) Below each item, fill in the present cost, or estimated cost with a conventional design.
(5) Next, fill in the estimated cost when the optimal idea is realized (the cost of V =F/C).
(6) After that, fill in C/F and C-F.
(7) Fill in the ranks of C/F and C-F.
(8) Multiply the ranks of C/F and C-F.
(Note) The rank of C-F is merit, and the rank of C/F is feasibility.
(9) Proceed with a detailed examination to materialize the ideas according to the priority obtained above.
(10) For each idea, find an expression of function, as in 2.4.3, beginning from B and C. Next, think up several ideas to achieve the expressed function, and compare them. In this case it is useful to consider an optimal plan which integrates B and C, or if possible, absorbs them into A.

The above constitutes a mechanism for exhibiting creativity in fields where major improvements are possible. Fig. 2.4-6 is an image diagram for a small handy light based on the application of the above steps. Fig. 2.4-7 is a comparison of the resulting FBS block diagram with conventional Function Tree Systems. It is easy to see that some things, such as proper focus, are missing with the conventional Function Tree System. In short, Function Tree Systems should be drawn as in the style of the right-hand side of Fig. 2.4-7, and should be vertical.

2.4.6 Extended use of Breakdown Structures

Up to subsection 2.4.5, we considered hardware as an example of Breakdown Structure, but it can be usefully extended to other fields.

Here, we indicate examples of where the concept is applicable.

<Case 1> Breakdown Structure is classified into Element Breakdown and Function of the Product.

This case is demonstrated in Figs. 2.4-1 and 2.4-2. From these figures it is evident that the component division and function division are in one-to-one correspondence. This means that value improvement operations can be categorized into two kinds: changes in the combination of elements and the corresponding changes in the direct measures to realize the broken down function division.

(Note) Two or more function divisions may correspond to a single element division.

In the following, we give examples paying attention to Element Breakdown and Work Breakdown.

<Case 2> Design Work Breakdown Structure (to break down design work and function)

<Case 3> Manufacturing Work Breakdown Structure (to break down the production process work and

function)
<Case 4> Process Breakdown Structure (to break down the process element and function of a general process)
<Case 5> Index Breakdown Structure (the table of contents of a report or book)
<Case 6> Teamwork Breakdown Structure (to show the work assignments in a small group)
<Case 7> MIL-STD-881: Work Breakdown Structure for Defense Material Items (DoD)
<Case 8> Traffic Breakdown Structure (to break down the traffic system and its role)
<Case 9> Purchasing Work Breakdown Structure (to organize purchase routes and their functions)
(Example) Changing the purchase or supply route, and introducing competition can lead to large-scale cost reduction. Switching from procuring an item at a vendor to supplying an item to a vendor may sometimes lead to a large cost reduction, which can be regarded as the effect of a change in the Breakdown Structure. Another example is dealing directly with a vendor or supplier by fax or through the Internet instead of going through trading companies.
<Case 10 > Creative Thinking Step Work Breakdown Structure (to proceed effectively with creative thinking and to realize the idea)
(Example) PMD and eight-phased thinking Breakdown Structure by Steplist Management
<Case 11 > Management Organization Work Breakdown Structure (to organize work inside the company)

We may add the following comments.
(Comment 1) An FBS block diagram consists exactly of one pair of a WBS and FTS.
(Comment 2) As explained in 2.4.2 (5), the components of a WBS at a certain level are determined by the Breakdown Structure of the idea selected to satisfy the immediately higher function. As a result, lower level FTSs and WBSs will vary according to the chosen idea of the Breakdown Structure. The idea of the Breakdown Structure selected for the higher function (Key Word) is, therefore, the key to creating a valuable plan. The NM Method is a powerful way of obtaining the key using analogous thinking.
(Comment 3) The ambiguity in the functional analysis method of conventional value engineering arises for two reasons. One is that the function expressions in the Function Tree System do not include the Breakdown Structure; the other is that adjectives and adverbs are excluded from the basic function. In conventional value engineering, the basic function of a pen is simply "to mark," but the functions "to mark temporarily" and "to mark permanently" naturally lead to different ideas. For example, the idea corresponding to the former function may be chalk, whereas the idea for the latter may be a chisel.
(Comment 4) Being aware of FBS can lead to effective and efficient creation of new ideas in simple work, even if not formally written on paper.

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2.4.7 Using this method to improve existing products, and to develop new products and new markets

In previous subsections, we were concerned with effectively and efficiently creating new articles, but in this subsection, we will explain how to apply the concept to improve existing products, or sell products in new markets.

(1) The case of improving existing products

Reconstruct the FBS block diagram for the product from the beginning, and try to construct a new diagram for comparison. Unexpected clues may appear.

(2) Selling in a new field (a means of market creation)

i) Create a new FBS which includes the product as an item, and talk to the customer at that level.

ii) Link the uppermost purpose of the new FBS to social needs one or two levels above, and include the product in the A part (essential part) of the new FBS.

iii) To fit the product in the new FBS division, ascertain the functions to be added.

2.4.8 Considerations

(1) As the explanations of the procedures and Fig. 2.4-1 demonstrate, the chance for creation comes not only from ideas, but also from higher level themes.

(2) Conventionally, a WBS is a mode of expression that faultlessly separates the parent and child relation in a given theme. Also, FBS is a way to express the "Key Word," according to the parent and child relation, to answer the question "What are we trying to do?" for a given theme.

The relationships of the WBS and FTS undergo structural variation at lower levels according to the function expression in Fig. 2.4-1 (2) and (6), the corresponding idea and choice in (3) and (4), and the choices in (6) and (7). This solves the problem of the similarity between the FBS (Function Breakdown Structure) Technique, WBS (Work Breakdown Structure), and FTD (Function Tree Diagram) (See Fig. 2.4-2).

In particular, the FBS integrates WBS and FTD.

(3) The correspondence between FBS and the left and right brains given in Fig. 2.4-8 shows that an exchange between the left and right brain is necessary to create an image of the intended result. It also shows that the exchange is better started from the theme (left brain). This suggests that the conventional "creation of images starting from ideas" should be switched to "creation of images starting from themes."

With the conventional view, once an idea is negated, an atmosphere can arise in which the purpose or

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theme itself is negated. It may therefore become more difficult to present the next idea. This is avoided with the new view because starting from the theme, the idea is almost never negated. Furthermore, we can improve creativity by adopting the attitude "When proposing an idea, reconfirm the theme, consider the idea as a means, and try to create 2 or 3 ideas for comparison, thus broadening the choices."

Fig. 2.4-9 is a WBS which extracts only the theme level expressions from the FBS for clearer understanding. The principle that grasping the whole structure becomes easy by writing the WBS appears here. As in Fig. 2.4-9, it is convenient to write the WBS in vertical form. The form for this vertical WBS is given in the Appendix so that it may be copied and enlarged.

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Fig. 2.4-1 FBS diagram of "desk for easy study"

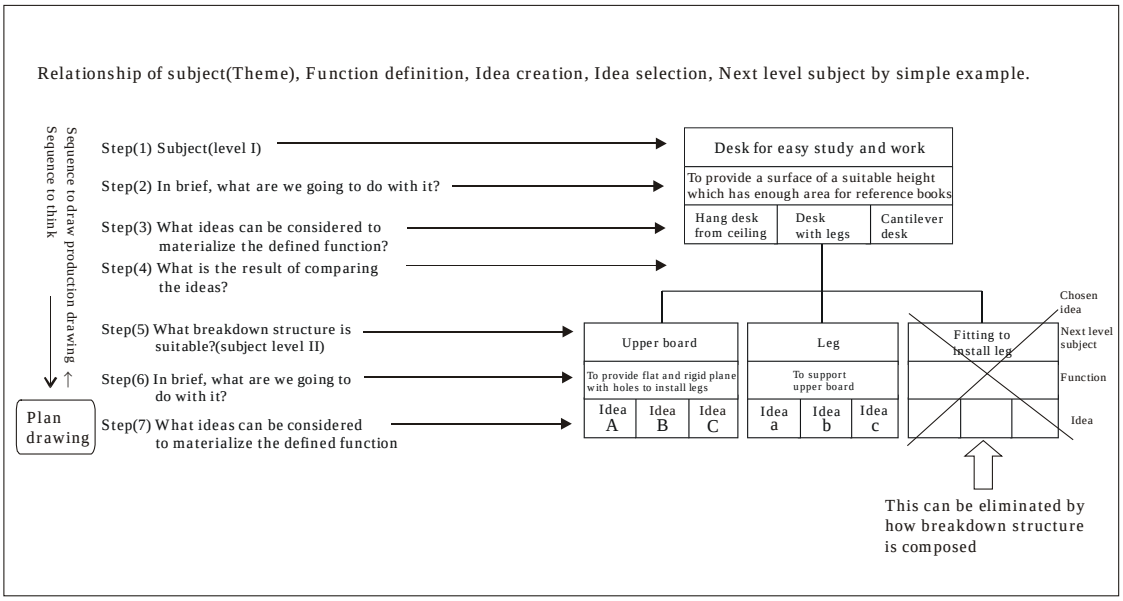
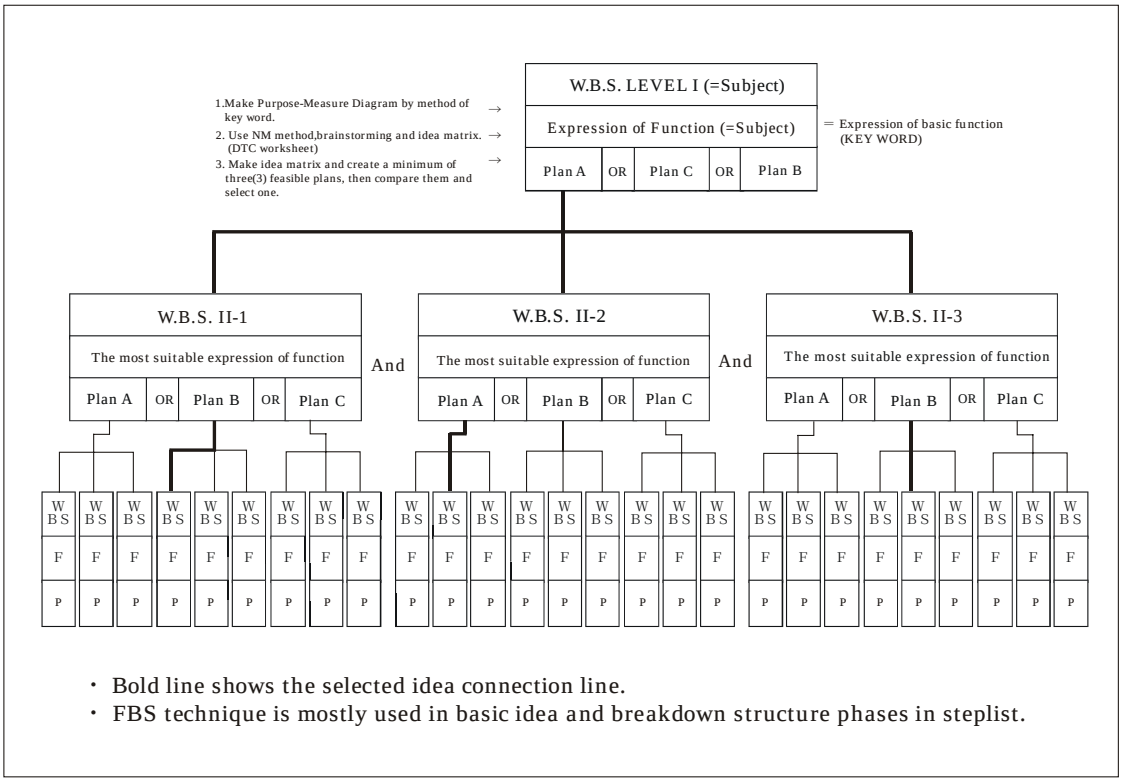


Fig. 2.4-2 Image sketch of relation between subject, function definition and its breakdown structure "FBS block diagram"



- Bold line shows the selected idea connection line.
- FBS technique is mostly used in basic idea and breakdown structure phases in steplist.

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Fig.2.4-3 PMD of small handy light and its most appropriate Expression of basic function

(Figure is almost same as Fig.2.1-2 but lowest block diagram content is slightly different, because having the knowledge of FBS(Function Breakdown Structure)

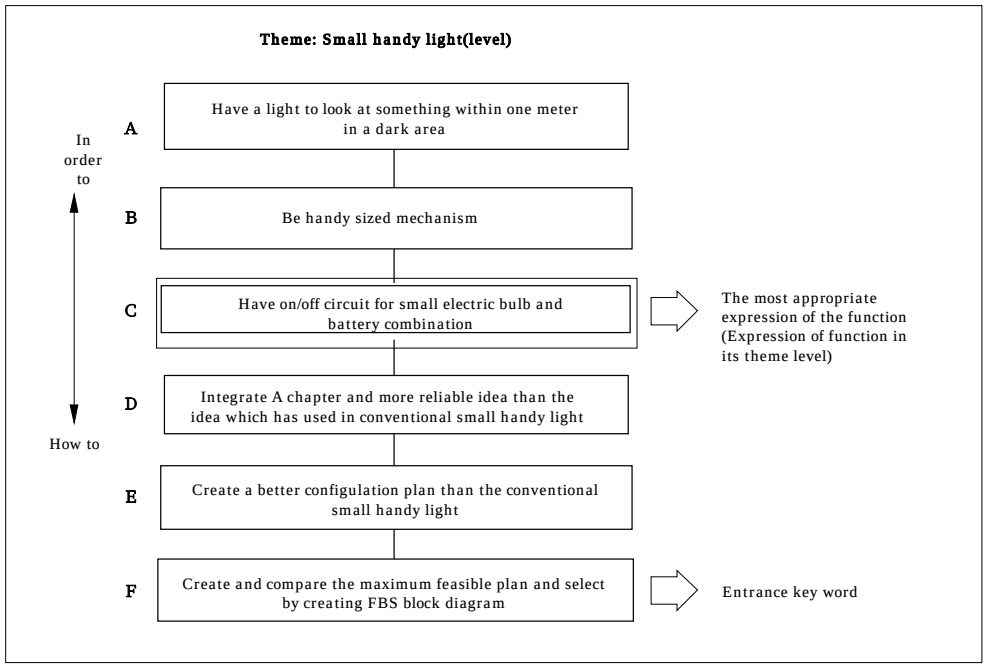

Fig.2.4-4 The image sketch of where locate the expression of basic function

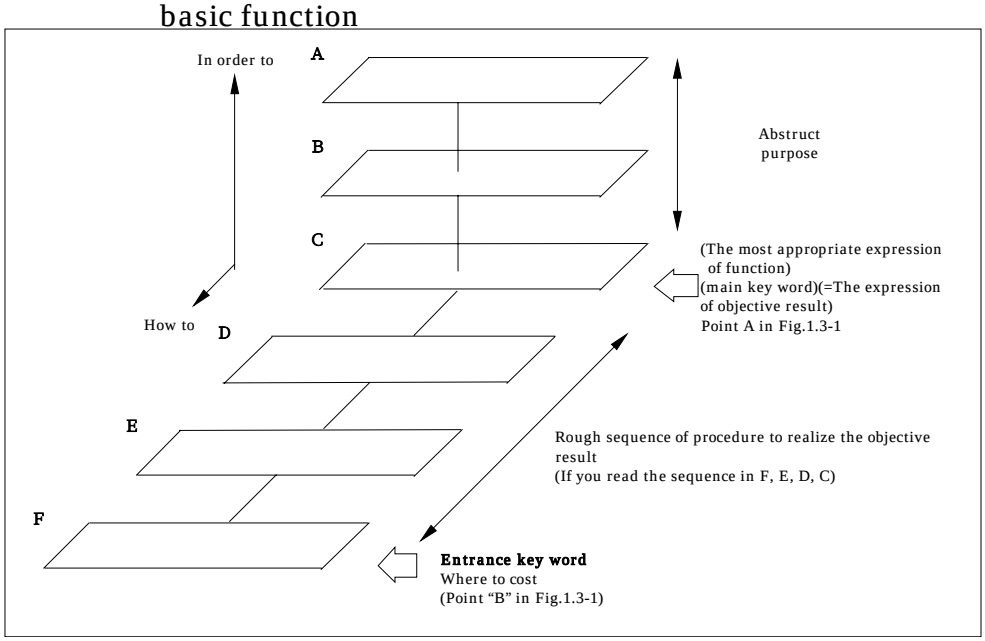

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Fig.2-4-5 DTC/LCC Trade study worksheet

This format is the official in NASDA-STD-4 design to cost implementation standard also in the Japan Defence Agency Project

DTC WORK SHEET		R'qt Check	Basic Func.	Ideas creation	Ideas comparison	Evaluation	Judge	Agree: Leader	Agree: Cost Gp.	Agree: Chief	Approval: Planning	Approval: Purchasing		Person in charge		Revision				Page
	Sch.Plan													Control No.		Drafted				
	Act.Date															Reviewed				
																Approved				

WBS Name	WBS No.	Theme	Basic Function

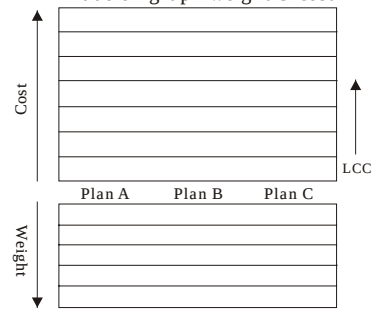
Target cost			Idea matrix: Type	Components	Materials	Mfg.ways	Sub-con etc.	Plan A Title	Plan B Title	Plan C Title	Sign column
Cost	Mfg.	M/H						(Sketch)	(Sketch)	(Sketch)	Drafted
	Material										
	Total										Checked
Weight		Kg									
Reliability											Approved
Maintenability											
(Other Requirement)							Explanation of contents and its distinctive charactor				Agreed

Notice on estimations
To proceed lifecycle cost design, only look at the cost difference between comparable plans

Cost Estimation (Average evaluation cost per XXX A/C)

	Plan A Mfg.M/H (H)	Plan A Material	Plan B Mfg.M/H (H)	Plan B Material	Plan C Mfg.M/H (H)	Plan C Material	
							Drafted
							Checked
							Approved
							Agreed

Trade-off graph weight & cost



Eval.Item	Wt.Coef.	Plan A Estimation	Plan A Ranking	Plan A Point	Plan A Wt.Point	Plan B Estimation	Plan B Ranking	Plan B Point	Plan B Wt.Point	Plan C Estimation	Plan C Ranking	Plan C Point	Plan C Wt.Point
Cost		$				$				$			
Weight		Kg				Kg				Kg			
Robustness													
Total													
Schedule & Comment													
Evaluation, Comment													
Total ranking													

Selected Idea	General comment & Conditions of selection	Sign	Chief Eng.	Sub-Chief	DTC suport

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Fig 2.4-6 Example of the simplest handy light

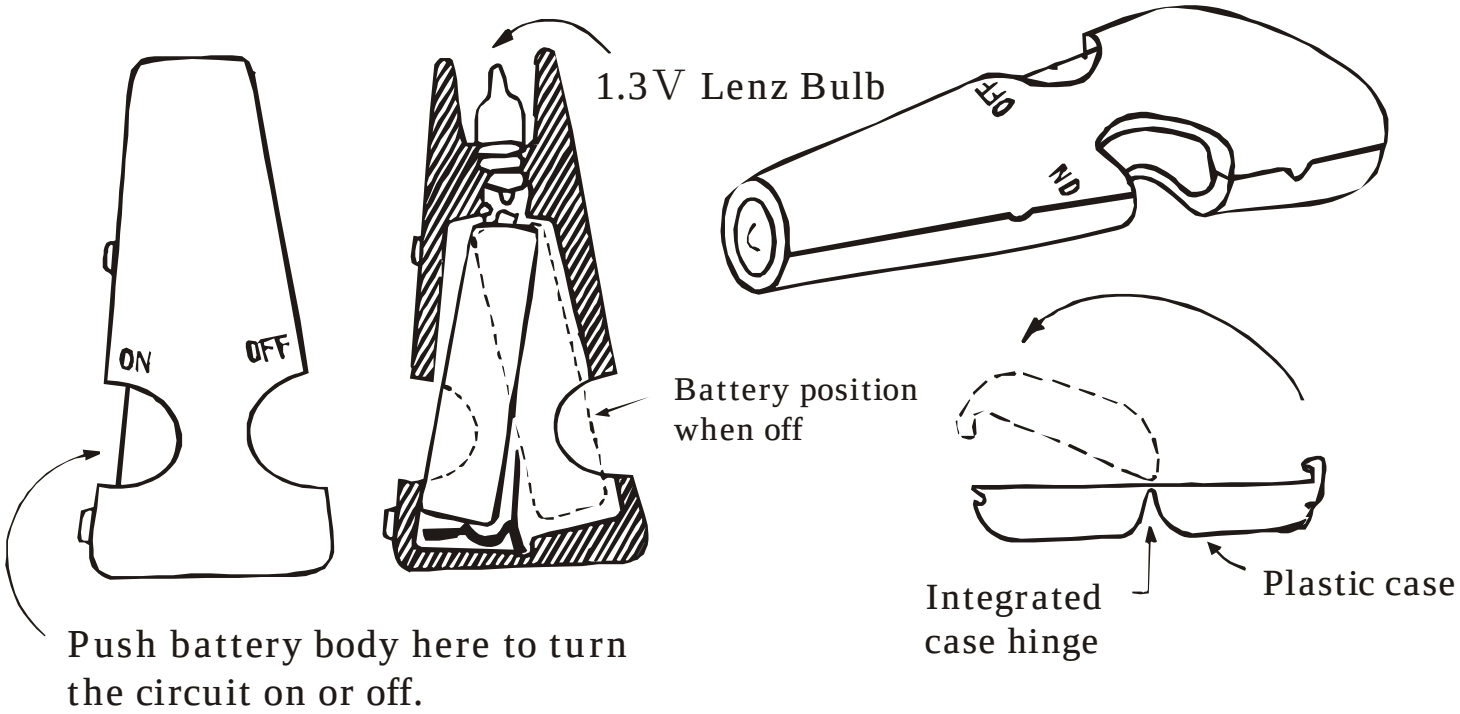

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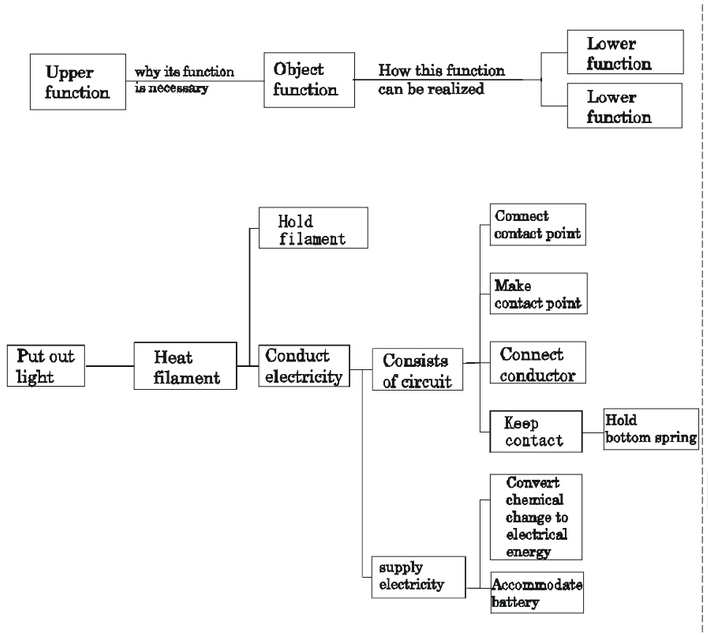
Fig.2.4-7 Comparison of function tree in Value Engineering and FBS block diagram

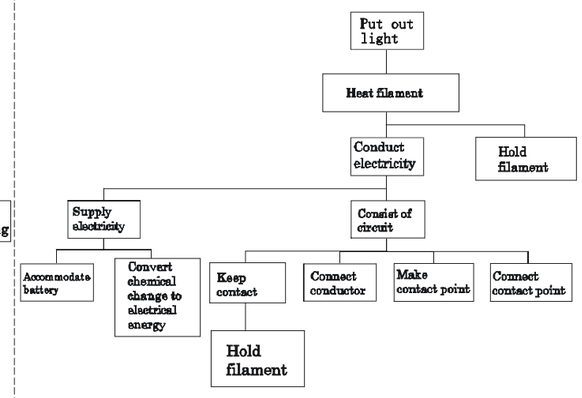
Conventional function tree



Function tree of small handy light

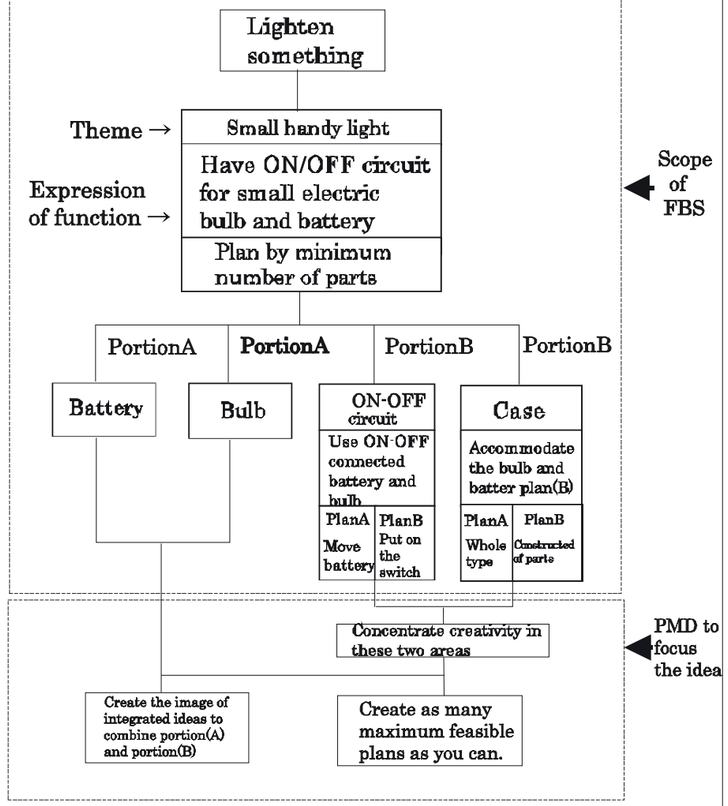
(Refered from 「Value analysis」 by masakazu TAMAI, MORIHOKU publishing Co.)

Same contents



By re-arranging the function tree shown above, we can see that balance is missimg in the horizontal.

FBS block diagram



FBS example of small handy light

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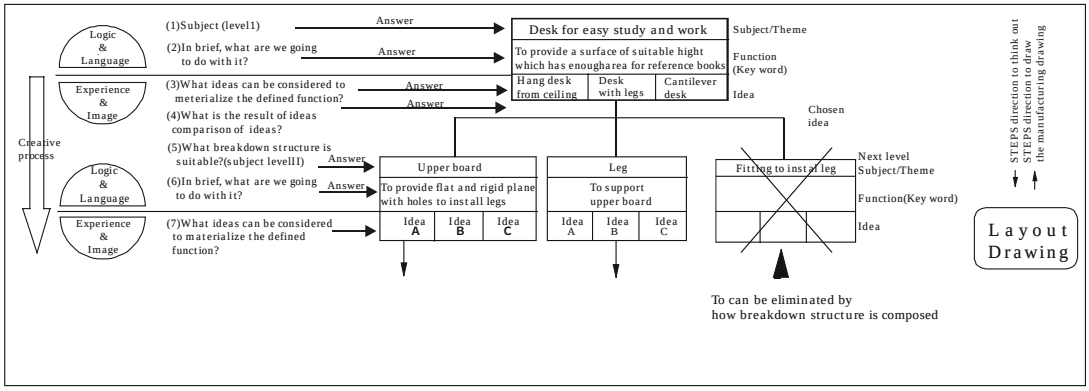
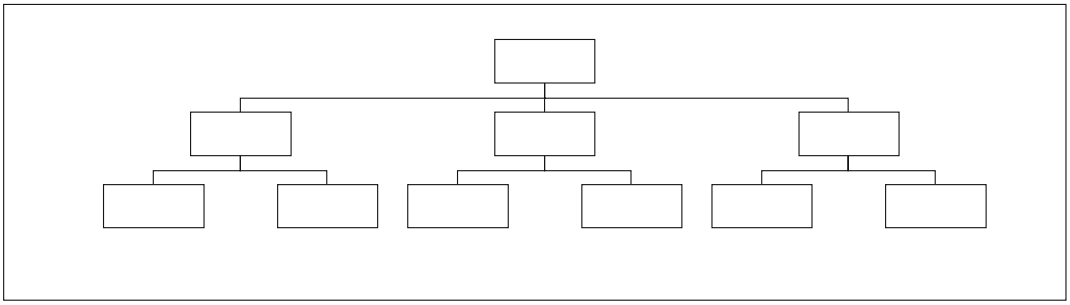
Fig.2.4-8 Correspondense between each level of FBS and left/right side brain



* The expression of theme and key word levels belong to the left brain
* Ideas and their selection belong to the right brain, because they are the same as trying to taste
* Therefore, the creation starts from the left brain, which understands the theme through a conversation between it and the right brain.

Fig.2.4-9 WBS（Work Breakdown Structure)

This WBS figure shows the themes only from the FBS diagram.
Wherease the Function Tree Structure shows only function from FBS diagram.
Both of WBS tree and Function Tree Structure vary depending upon selected idea at one higher level of structure.



WBS is useful.

(1) To show the scope of contents.
(2) Show the preliminary WBS which is going to be reviewed or examined.
(3) In order to accelerate creation, use WBS for keeping the rule of entering from theme level rather than from the idea level..
(4) To show the examined WBS
(5) There are four kind and combined WBS (Refer Fig.4.1-4).