7.2 Details of Each DTC Phase

7.2.1 DTC Preparation (DTC Phase I)

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7.2.3 Basic Design Work Using DTC Worksheet (Preparation of Plan Drawing) (DTC Phase III)

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7.2.6 Review Before Mass-Production (DTC Phase VI)

7.2.1 DTC Preparation (DTC Phase I)

Two important DTC jobs will be prepared in this phase.

7.2.1.a DTC Implementation Plan Document

Prepare a DTC implementation plan document including a DTC steplist covering the work plans of all phases. Establish a secretary for DTC implementation and get approval from related organizations. Refer to Chapter 6, 6.3.2, "Preparation of DTC Implementation Plan Document Using DTC Method and Effective Follow-up Utilizing Questionnaire Prepared in Advance."

7.2.1.b Output from Phase I

Besides the DTC implementation plan document, more than 2 conceptual or structural plans with the conditions listed below will be ready. A WBS for design area and the output listed below will be ready in this phase. (When preparing the WBS, utilize the FBS [Functional Breakdown Structure] technique as necessary.)

At this point, technological tasks in the design process, including the cost issue, must be broken down into certain specific levels as described in Chapter 4, "Method to Combine PMD and WBS (Moebius Strip method)." Also use Attachment E: "Management Flow of Total Design Work Which Includes DTC."

(1) Output and Conditions

① Investigate the needs of customers and the market, and the price trends. Following that, organize a WBS for the design area in the manner described in Figure 7.1-3. Add new ideas in comparative plans. Write down detailed aims and the necessary conditions of new ideas in a table of themes or ideas.

② Draw rough sketches for WBSs in similar styles, but with different ideas so that you will be able to visualize the differences in the WBS plans. Make sure that comparisons can be made.

③ Provide an explanation or detailed sketch of the WBS block, which may require big changes in cost depending on the ideas. Clarify the differences in costs and image f or ideas that may arise. (This becomes a minimum preparation for the next phase where the cost differences according to different plans will be confirmed.)

④ If you have more than two plans for low-level WBS blocks and cannot narrow them down to one, move on to the next process with both plans for now. After working on all of the above, decide the overall target cost (draft). (Refer to Tables 7.2-1 and 7.2-2.)

(2) Reminders for WBS for Design Area

① The preparation of the WBS differs depending on the project's size. In the beginning, it is appropriate to prepare downwards to 3 or 4 levels, starting from the highest management level. (The groups in charge of design should come up with more than 3 or 4 levels.)

② Two comparative plans for WBS indirectly indicate several middle plans that exist between the 2 plans.

③ When you have three optimal plans, suppose that the best plan exists within a triangle formed by the three plans.

④ Drawing up a WBS at this stage requires the following different approaches for products developed from conventional products, and for newly created products.

A. Steps for products developed from conventional products: call it α approach: Tentative plan $\rightarrow$Deduction $\rightarrow$Induction.
Make the WBS for design area from the start and move on.

B. Steps for newly created products: call it ω approach. Tentative plan$\rightarrow$Induction $\rightarrow$ Deduction.

Follow the steps below:

a. By applying the PMD (Purpose-Measure Diagram) method, determine the functional expression which will be the key to the basic concept for the targeted product.

b. Search for several kernels of ideas to realize the level of functional expression determined above. Arrange corresponding ideas in a matrix using creative techniques and brainstorming.

c. With the above ideas in a matrix, compare 2 or 3 tentative plans which can successfully actualize the functional level decided in the beginning. Use rough sketches. (Induction Approach)

(*This corresponds to the combinations matrix of the DTC worksheet plan.)

d. To confirm realization of the rough sketches, conduct necessary technological experiments and basic development experiments. Afterwards, prepare a WBS for the design area.

e. Follow the steps for products developed from conventional products.

7.2.2 Allocation of DTC Target Cost (DTC Phase II)

Phase II is divided into 2 steps. In the first step, the conceptual or structural plans of the products will be compared and developed. In the second step, the target cost will be allocated according to the WBS divisions given as a result of the first step.

(1) First Step: Comparison and Development of Conceptual or Structural Plans of the Product

Bring in every important block of the design WBS made in the previous phase. On these blocks, tentatively apply the roughly estimated costs which follow the conventional designs and manufacturing designs. Also, tentatively apply the cost calculated from past trends of the costs of similar products. Compare several WBS plans. (For the case of aircraft, weight control will be involved. Therefore, at the same time, compare the rough estimated weight using a WBS.) Comparisons sometimes bring about new ideas for WBSs. In such cases, compare the new ideas with the existing WBS.

Evaluate the overall comparative results of each plan. List plans in order of priority, and narrow them down to one structural plan. Because the estimated error range may be wide, it is sometimes difficult to compare and narrow down to one plan. When there is a need to continue flexible examinations, keep the last two plans by calling them Plans A and B. Move on to the basic design (plan drawings), which is the

output of Phase II. An integrated plan can be selected after examining various cases of information of differences. (I have found that the Boeing Company of the U.S. also uses this method.) Comparison of 2 plans up until this point creates a number of cases of information of differences, which allows you to hatch detailed examinations and development plans.

(2) Second Step: Allocation of Target Cost

This is the stage where you produce the first information of differences that will lead to the actions and ideas to achieve the goal. People with considerable business ability who are excellent in cost estimates and bringing in ideas will be indispensable.

First, understand the present cost as the baseline cost for information of differences. The present cost is what has been decided within the design plan in Phase I. (When you have Plans A and B, choose either one to be a baseline for the comparison meaning. The present cost is the estimated cost in the case of design carried out along the lines of conventional design and manufacturing know-how.)

Next, contrast the overall realizable target cost with the drafted target cost set in Phase I. Decide on the target cost. The overall target cost will depend on by how many percentage points you would like to decrease. If you do not want to make a decision unilaterally, the following is the allocation of target cost for WBS.

There are 2 ways to allocate the target cost. These 2 methods can be combined to allocate the target.

① Cutting Costs Evenly

To match the total of every WBS cost with the target cost, existing estimate costs can be evenly reduced. This is a rather simple method of allocation. Yet, it has a disadvantage in not influencing the strategies after the next phase. Therefore, try to use the next method as much as possible.

②Allocations Method with Possibility Condition

This method brings a clue to working with DTC following the next phase. Various detailed methods exist. Here are some examples.

A. Ask the people in charge of related sections to find out how much the cost may be reduced using the DTC and VE methods (Note), for what theme, and using which ideas and conditions. Also learn about other essential conditions.

(Note) VE (value engineering) here means the basic procedure of VE, i.e., starting from the question "What is it?" while examining cost and function. This procedure begins from the point where the object of examination already exists in a drawing or in reality. Improvement follows. On the other hand, the basic method of DTC commences either from a subject or theme without a drawing, or from the actual thing. (When there is no subject or theme, the theme may be found through PMD and the theme Key Word method, or through a WBS.)

B. Using A. and choosing the purchasing channel, bring about the conditional target cost.

When deciding on the purchasing channel, people in charge of technology and those dealing with the purchase must cooperate from the beginning to collect design information about the products. Both sides have to follow the strategy and purchasing channel to collect information. Never allow either side to choose an easy way. All is to be done for the customers. Keep in mind the methods and conditions to realize the target cost. Do not get caught up in precedents, but think only of achieving the target cost. See Table 7.2-4 for a specific example.

Extensive research of the purchasing channels at the beginning becomes the key to gaining good traders, excellent products, and a highly competitive price, leading to achievement of the target cost.

Never attempt to move the section which regards the price with traders from the beginning until the end of each project. If you change sections or organizations as you move on from the budgeting phase to the implementation phase, you are likely to face a change in the purchasing channel and conditions.

In many cases, exorbitant prices will be charged after placing the order. The same section should be in charge throughout the project to avoid such incidents.

Let us look at another example here.

When persons in charge of purchasing ask 2 or 3 importing firms for a comparison of estimates, all requests may end up in one specific company. This is not a problem if the products to be estimated are seen in great number within the market. However, when the requests of much less diffused products end up in a specific company, it becomes easier for the importing firm to raise prices. (This is mostly seen when the trading firms are involved in the joint development of products with foreign countries.)

For this reason, it is important to clarify the section which deals with information collection from the

beginning to the final price negotiation. Remember to collect information directly from the manufacturers.

C. Introduce new manufacturing methods or conditions, or a proper technology (e.g. Double the speed of metal cutting.) Calculate conditional costs with an explanation of the conditions.

D. Based on the idea of an adjustable cost driving factor of a design, set the conditions (i.e. number of parts will be reduced by XX% from the original design, bringing YY% in cost reduction) and target. By doing so, conditions on what will be done and how will be combined with the target.

E. Try to apply the ideas and costs which have proven to be highly cost effective with other products. Combine the above two methods, A and B. Allocate the target with a WBS. Repeat strategic creation and adjustment of essential conditions. Once the overall total reaches the target cost, allocation will be complete. Prepare the reserve cost if necessary. Table 7.2-5 is an example of a comprehensive list of target cost allocations with no figures.

Also, work on the following simultaneously as you allocate the target cost. Draw up the scheme and conditions to realize the target created through the process of target allocation using the WBS Phasing Theme Technique. Combining it with the DTC scheduled curve seen in Figure 7.2-1, prepare a report entitled "Measures and Conditions to Actualize the Target (Draft)". (Use the form in Chapter 2.5, Figure 2.5-5.) The output of this phase in the end will be: Comprehensive List of Target Cost Allocations, DTC scheduled curve (Figure 7.2-1), and Measures and Conditions to Actualize the Target (Draft). For these outputs, ask for approval from DTC participants and the top level. Once they have approved, go on to the next phase. Working on DTC denotes full completion of Measures and Conditions to Actualize the Target approved in this phase.

As you proceed with the DTC, it is possible for something more advantageous in terms of cost to show up. This could be said for the whole process. Announce a rule that will encourage participants or traders to bring in new themes or ideas. As you receive each proposal, check and compare them with the existing plan. If the new proposal is judged to be better, try to arrange it in time for prototype preparation, or hold on to it to see if it is applicable in mass-production. Provided here are explanations and measures to allocate the target cost.

7.2.3 Basic Design Work Using DTC Worksheet (Preparation of Plan Drawing) (DTC Phase III)

This phase is the core of the DTC. The LCC/DTC worksheet described in Figure 7.2-2 will be the main tool. Table 7.2-6 lists the procedure for the preparation of the worksheet. Before you reach the end of this design phase, ask the manufacturing sector to submit the request lists for each design. Do not miss the opportunity to allocate the examination period, and bring in ideas and requests to improve the function.

(1) Deciding the Work Order of Design Work Using DTC Worksheet (Call this Approach P: P for priority.)

Before working on the design through a DTC worksheet, designers must write down all themes or proposals that may become the theme in the DTC trade work. Do not worry about the WBS ranking. Then, list all themes or proposals into either approach A or B below.

-Approach A

Freely create ideas for the design plan and compare them. List advantageous rankings in terms of cost and schedule.

-Approach B

List ides with no cost comparison required, but needing a swift decision in terms of development procedure and schedule.

Next, list these 2 approaches at the same time in the opposite order, as shown in Figure 7.2-5 to allow approaches from both sides. Design workcan be carried out while working on Approaches A and B in parallel.

(2) Detailed Procedure of Approach A

Follow the order of steps indicated in the DTC worksheet, and begin the design work. (Refer to the FBS Technique in Chapter 2.4.) Further explanations of the procedure in line with the format of LCC/DTC Trade Steady Worksheet (Figure 7.2-2) are as follows:

Step I

① Fill in the name of the design object or theme under the section for names of WBS.

② Regarding the expected function of the design object, try to answer the question “In brief, what are we going to do?" Write using the procedure of the PMD method as the need arises.

③ Enter the key word from ii) in the section under Expression of Basic Functions.

④Have check-ups by the DTC and design leaders.

Step II

① Fill in the design conditions and requirements in the column for other demands.

② Write down the number of chapters and clauses for quoted rules so that it will be clear to everybody where they were cited.

③ Obtain a check-up by the design leader.

Step III

① Write down all the ideas that may be used to shape the content of Steps I and II in the idea matrix space in the appropriate columns. The column for ideas or methods of structures should be used for basic ideas drawn through various creation methods. (e.g., basic ideas for the case of a lighter will be a division of the basic method, piezoelectric or frictional type.)

②Combine the idea-matrix and come up with more than 3 plans following points a, b, and c below. Draw rough sketches in the right column. (Adopt the thinking that a realizable plan exists within the triangle of the 3 optimal plans, as explained in Figure 7.2-6.) If there is not enough space for rough sketches, use a separate sheet of paper. Draw the rough sketches in order to allow easy comparison by sight.

a. Cost Minimization Plan

b. Weight Minimization Plan

c. Maintainability and Reliability Maximization Plan

d. Optimization Plan (Add if necessary)

Note: In some cases, prepare two plans for each case, up to 8 plans if necessary. Adopt a method to allow for a comparative examination in a broad sense.

③ At this point, ask the people in charge of production design, engineering work, the materials section, the marketing section and VE to join to produce a wider idea-matrix. Prepare comparative plans and rough sketches.

④ Collect photos and cards of goods resembling the targeted objects. Organize the plans by looking at these photos and cards. You can expect detailed examination results because pictures provide minute information.

⑤ When a comparative plan comes ready, show the rough sketches and DTC worksheet filled with the related characteristics to the design leader. Inspect the plan to see if it has been thought out enough to move on to the estimate in the next step. Also ask for suggestions. Keys to work on the estimate comparison using rough sketches should be confirmed between the people in charge of design and those dealing with estimates. Also confirm other information, and arrange estimates for the coming step. Call this meeting a study group for the DTC worksheet.

Step IV

Based on rough sketches drawn up in Step III, have each person in charge work on estimates.

Step V

Use the results of the estimates carried out by the specialists in Step IV. Follow the procedures below for the final comparative evaluation of design plans.

① Ask each specialist to estimate various plans in terms of cost, weight, maintainability, and reliability.

② Based on the estimate results, prepare a trade steady graph for the design section, as illustrated in Figure 7.2-3. Or, bring in a comparative evaluation of the plan, using the weighting evaluation method. (Note 1)

③ To perform weighting evaluation, utilize the applicable columns in the DTC worksheet. (Note 2)

a. Obtain consent among those involved in choosing the plan, and determine the estimate evaluation elements and weighing values. (Note 3)

b. Give evaluation marks to estimate elements of each plan.

c. Multiply these evaluation marks by weighting values. Sum up the marks by plans

d. List the total marks in order. Adjust the ranking if you have any doubts.

(Note 1) Evaluation in this phase can be easily concluded by a simple comparison method (e.g. priority method). In such cases, omit the weighting.

(Note 2) When complicated comparative evaluation is necessary, compare using Scoring or the DARE Method. (Refer to Chapter 4.3, Evaluation and Structuring Method for pre-evaluation from a Rational Perspective.)

(Note 3) For aircraft and automobiles, find out the tendencies of payload (heavy load) in advance. Set a trade standard. Certain investment costs needed to lighten the aircraft by 1 kg should not exceed the trade standard. (Note: For aircraft, this trade standard must be changed from the beginning to a later phase in the development, as large gross factors decrease towards the end.)

④The design leader will select the final plan using the comparative evaluations provided above. Comments or conditions will be written down in the column regarding a comprehensive evaluation and the adopted plan. Appoint people to be in charge of follow-up, if necessary.

Step VI

The design leader will provide an explanation of the final plan in a design meeting. After deciding on the final plan, the head of those in charge of DTC will give approval. See Figure 7.2-7 for an example of such a work cycle.

After Step VI

①Keep in mind what was done in Step VI. Actualize the plan drawings. (A plan drawing is made to confirm the overall mechanism before preparing the manufacturing drawing.)

② The people in charge of follow-up must regularly report the status to upper level management.

Note: The LCC/DTC trade study format (DTC worksheet) in Figure 7.2-2 is currently recorded in the DTC implementation standard (NASDA-STD-4) of the National Space Development Agency.

Figures 7.2-8 and 7.2-9 are examples of DTC worksheets.

(3) Extracting requests from the production sector and its examination for design

Here are the main points of extraction.

-Follow WBS phasing theme technique. In the early stage of this design phase, ask those involved in manufacturing, materials, quality management, and users (if necessary) to submit a list of requests and the candidate theme or drawings which they wish to have. This will be the second extraction. (The first one was conducted when the target cost was allocated.)

-Before you complete this design phase, register in which phase what theme will be examined for which content, and when the implementation details will be decided.

-Examples of what may be listed are:

① Change the rules of drawing notes in a some way, or have them standardized.

② Measurements of the standard tools are listed according to a table. If there are no difficulties, we request the drawings using these tools (Note). Even for items already scheduled to be purchased, ask the trader to make drawings on your own company drawing paper.

③ The processing limit of the existing facilities are of this size. We request the drawing to fit within these dimensions.

④ Please take up the assembly and disassembly methods and the mating method as DTC trade themes.

⑤ We have been purchasing these kinds of things. Because their dimensions are unstable, price adjustment and negotiations with traders become troublesome every time we change the specifications. For now, we can work with in-house drawings. Once dimensions, specifications, and the precision are settled, and costs are understood, we can outsource or purchase such items.

Note: When the drawing is done on your company paper, the right to the drawing becomes your company's. If the drawing is done on the trader's paper, the ownership of that drawing will belong to the trader and your company will not have a free hand.

⑥ A precision casting can cost less than sand casting in some cases. When you are trying to decide whether to use in-house machining or casting, prepare estimate drawings that will reflect both estimates. Compare the estimates and select one to use for the final drawing. If you decide on casting, negotiate with the materials section to have them ask casting dealers to make up a manufacturing drawing. After finishing the prototype, the tooling hole (used as a base to position casting processed with in-house machinery) must be conversely picked up from the machinery processing jig. Make the tooling hole position for the mass-production casting known to the supplier.

⑦ In accurate drawings, 2 L-clips have angles of 90 degrees and 93 degrees, respectively. Adjustments of the angles up to 5 degrees are possible by pressing them with your hands while assembling. Could we use the same L-clip instead of 2?

⑧ Specification plans for goods to be purchased: instead of adding requirements to the list as we go, all possible requests and requirements should be listed from the beginning. We can eliminate requirements from the list as examinations are completed for each of them. This method is less likely to increase costs.

⑨ We ask for estimate comparisons. When there are several methods of estimate, we ask for all the estimate requests to be listed at the same time. There may be too many cases to be dealt with, but it will be better than receiving additional estimate requests later on.

-In addition to the above, designers should receive proposals from participants at an early stage. That way, more possible themes or ideas related to the designers' image will be ready in time for examination. In advance, schedule the date and time of regular design explanation meetings. Bring in prepared structural plans and plan drawings; try to pick up themes and ideas at the meetings. (These meetings are usually called plan drawing meetings before preparing manufacturing drawings.)

(4) Management of Target Realization and Confirmation of Output

To foresee the target cost realization in DTC work, reports on the prospect of reaching the target cost should be collected and organized. Estimate the effects of the proposals adopted before every interim report by WBS for designs and prospective effects (Note 1), assuming the extracted examination theme is realized. See what needs to be proceeded to achieve the target cost, and write it down in prospect reports. The secretary for the DTC implementation and design team will use these predicted reports to extend group support where needed, and to see how the target cost will be achieved.

(Note: Also, think of the yield rate of actualization.)

Use the format of predicted report (Figure 7.2-10) to realize the target cost. In this format, remember to include the overall results of DTC work in the process of plan drawing. After you obtain approval of the plan drawing (output from this phase), move on to the design and DTC work of the next phase.

(5) DTC Examination Items and Coexistence of Design Examination Items which should be Decided Regardless of the Cost

Up until the previous paragraph, creation of design plans and comparison selections were discussed in

relation to their effect on costs. However, to proceed with the design of new products, there are examination items which must be studied and decided on regardless of the cost. Indeed, there are many cases where such items must be examined before considering the cost. Here are the main points on how to proceed DTC including such items. See below for the rules.

① Classification of design examination items:

Classify all design examination items following Table 7.2-7.

② Flow of design steps of all the examination items, including studies of DTC and lifecycle cost:

Follow the flow diagram of the DTC/LCC examination steps given in Figure 7.2-11.

③ Lines of DTC steps for every stage:

In order to attain the target cost, follow the lines below to work on the DTC.

A. Try to fill in the contents of A1 and B1, "Cost also to be considered as an important factor," of Table 7.2-7. You will have more selections. Here are some specific examples.

a. Include the number of candidate manufacturers for equipment, main materials, test facilities and jig. Also include the number of design plans targeted for examination. You will have more choices.

b. Use a PMD and create the work levels and items which may compare more than 2 plans.

B. If the above is not enough to attain the target, make a trade off between performance and cost for the contents corresponding to A2 and B2. Reduce costs.

④ Ways to select the examination items:

Select items of theme/idea and items for DTC/LCC trade work in the following manner. The examination period should be decided as stated here.

A. At the design meeting, the DTC secretary proposes a draft of the extracted items which have to be studied to see whether their examination was proper. Then, items tentatively registered for design examination must be classified under each examination. At the same time, propose phased timing for the design work to examine each theme/idea. This includes work to create comparative ideas from the proposed WBS.

B. Have the chief engineer approve the plan. Officially register the theme/idea items which are to be examined.

C. Among the DTC trade study items above, the following should be considered.

a. Items that will go through DTC trade, of which cost is also considered to be an important evaluation factor. (A1T and B1T)

b. Items which will go through DTC trade, which are determined by factors besides the cost but which have an impact on the cost. (A2T and B2T)

7.2.4 Detailed Design Work Considering Cost-Driving Factors (Preparation of Manufacturing Drawing) (DTC Phase IV)

In this phase, a manufacturing drawing will be made to attain the target following the plan drawings and predicted report, prepared previously. Furthermore, the target cost to be attained will be fixed. (Methods to reach target cost from now on will include an improvement in the manufacturing method and managing the work site.) Take special notice of the following:

(1) Recognition of the Differences Between Plan Drawings and Manufacturing Drawings:

Let us confirm the difference of purposes in plan drawings and in manufacturing drawings.

Plan drawing: Its purpose is to confirm the structure and measurements which will fulfill the performance and requirement of the product or system. Preparation of this drawing is in the basic design stage.

Manufacturing drawings: Drawn in the detailed design phase. A concrete manufacturing method will be decided based on the plan drawings.

The order of the preparations of these 2 drawings is shown in Figure 7.2-12. For plan drawings, start from theme level 1 and advance to subsequent levels. For manufacturing drawings, begin from the lowest level and move toward level 1.

The DTC steps that can be worked out in parallel while preparing plan drawings are mainly the creation of plans centered on the DTC theme and the trade comparison. Those of manufacturing drawings will be deciding the ways to accomplish the most effective manufacturing method, by looking into the finished plan drawings (Note). You should team up with the manufacturing sector when doing this

(Note). Here, use the thinking mechanism of starting from the right brain which, by looking at plan drawing, brings out thoughts and ideas for the manufacturing drawing. Looking into the pictures of the plan drawing, ask yourself what it is that you are trying to do, and respond to that question. The phases up to the plan drawings mainly begin with using the thinking mechanism of starting from the left brain. This is because plan drawings usually start from the examination of the themes at each level.

(2) How to Proceed

Now that the conditions for preparing manufacturing drawings have been explained, follow the preparations and rules below and work to proceed from many sides.

①Preparations for a low-cost design manual and its use:

Organize a low cost manual using design request lists obtained from the manufacturing sector before the preparation of the plan drawings, and other materials accumulated for low cost design within the company. All designers must refer to this manual when working on the design. (You may also make a checklist.)

② Pay attention to the cost driving factors which can be adjusted while designing:

Prepare a list of cost driving factors as in Table 7.2-8, reflecting the ideas of Figure 7.2-13. Design to minimize the factors as much as possible.

There are subtle cases where a reduction in cost-driving factors may not lead to cost reduction. When you have doubts, compare the estimates with these subtle cases. Perform a trade study using a DTC trade worksheet to decide which is more advantageous. Also find the points where the tendencies of subtle costs shift conversely.

③Preparation of average man-hour list based on different processing methods:

The man-hours required for articles of the same shape change depending on the processing methods. Hence, draw up a list of the average man-hours of each processing method. Use that list as a base for quantitative comparison. (Organize a reference that will allow easy quantitative comparison, for instance, to select two parts whose assembly requires a low number of man-hours, or 1 united part with a high number of man-hours.) If you are not sure which is more advantageous, carry out accurate estimate comparisons using a DTC trade worksheet for each case. Choose the favorable one.

④ Standardization and compatibility of parts:

A. Use of standardized parts and the creation of compatible parts for the same products will not only reduce the cost in terms of procurement, but the time and labor used for safekeeping will decrease, and the cost of the supply goods will go down.

B. Try to process the systematic right and left parts simultaneously, or come up with one compatible part to cover the right and left part.

C. Use parts used in existing products.

⑤ Others:

A. When the shape may change between the prototype phase and the mass production phase, tentatively make some parts by machining and decide whether casting or forging should be used for mass-production.

B. Try to design in a way to cut down on further costs in the later stages of Purchase-to-Cost, Plan-to-Cost, and Manufacture-to-Cost. For example, design at the beginning assuming both in-house production and outsourcing. That way, you can more easily compare and create the competitiveness between two production processes.

⑥ Hold a drawing examination meeting with the manufacturing sector prior to the preparation of the manufacturing drawing:

Taking into consideration i) to iv), each manufacturing drawing group (generally organized for each plan drawing) should hold manufacturing drawing meetings with the manufacturing sector prior to the preparation of manufacturing drawings. (Call these meetings P-drawing meetings. P stands for Plan Drawings and Pre-Production Drawings.)

Because work methods in DTC examinations (especially P-drawing meetings) here are applied right before the preparation of manufacturing drawings, the examinations will be effective in minimizing adjustments after the completion of the drawings. Moreover, a team spirit will be generated among the participants to come up with positive solutions if problems emerge after the completion of the drawings.

(3) Management of Target Cost Attainment

Overall control of attaining the target cost should be carried out in the following way: (See Figure 7.2-14.)

① Set the scale of the vertical axis in units of percentage points. Draw a dotted line graph for the numbers of manufacturing drawings scheduled to be released.

② The horizontal axis should reflect the time period. Draw a dotted line graph of the expected DTC results for the period of the manufacturing drawings. This will be in parallel to the left of i), covering the P-drawing examination meetings which usually take place 1 to 2 months in advance of the manufacturing drawing release.

③ Plot the accumulated number of ideas to be included in the manufacturing drawing against the expected DTC results in bold line graphs. (When there is an element which might increase the cost, count it as a negative factor.) (If it is too troublesome to calculate the cost variation, assume, for instance, that each case has an average of e.g. 0.25 man-hours (Note), and draw the expectation and result line using the number of ideas.)

(Note) The numerical value here changes depending on the product or project. Consider it to be an averaged guess.

④ Compare the tendencies among the two expectation lines, the plotted actual idea results for DTC and the plotted actual numbers of manufacturing drawings release. Control the number of overall idea results of DTC. The manufacturing drawings are prepared considering the above and will be the output from this phase.

Figure 7.2-15 shows the overall expected DTC results and the actual finished number in line graph form, from the basic idea planning to the completion of the manufacturing drawings. An example is the XT-4 medium jet trainer of the Japan Defense Agency.

7.2.5 Prototype Production and Qualification Test (DTC Phase V)

(1) Understanding and What to Do

Whether the drawings on paper can actually be realized according to the estimated performance within the planned cost will be confirmed in this phase. As you have the actual product in front of your eyes, it is also the phase to re-examine cost efficiency and the possibility of additional improvements. You have been working to produce all that has been scheduled, and putting them into operation, and this whole process

will allow you to get information and ideas only obtainable at the work site.

Take photographs every time you notice something related to the above, and collect information that will be useful for the mass-production design. (Write ideas in a sentence directly on the photographs with markers. You can then easily understand the point visually.) (You could also use a digital camera.)

(2) Summary of the Output

The following is what you can expect as an output from this phase.

① Cost records: Look into factors unique to the prototype. Mass-production cost will be verified considering the rate of the learning curve.

② List of problems: Technical problems which must be solved, estimated cost of solutions to the technical problems, problems emerging from the verification of the cost records, problems in small readjustments, etc. will be listed.

③ Draft of a DTC implementation plan document for mass-production: The above cost records, problems, and other information gained from the prototype production will be used to draw up a planning document, clarifying how many DTC activities still have to be done.

④ Implementation plan document for operation and logistic support: Additionally, draw up a draft of how to develop the product (i.e. in terms of reliability) after the product reaches the users. This draft is usually called an implementation plan document for operation and logistic support.

Make the implementation plan document in a structured manner so that every new person in charge will be able to periodically review its contents. (Every two years is recommended).

Examples of parameters to look for in this implementation plan document for the operation and logistic support of an aircraft are the following (When dealing with other products, also think of parameters by determining what customers want.):

a. Commercial aircraft: Raise the rate of on-time-departures and the safety level within the lowest possible cost.

b. Military aircraft: Raise the system effectiveness within the lowest possible cost.

Table 7.2-9 shows the relationship of defense system effectiveness and the lifecycle cost of a military

aircraft. This table can also be effectively applied to civilian goods.

This table is is the most forcused objectives to proceed Design to Cost.

7.2.6 Review Before Mass-Production (DTC Phase VI)

(1) Understanding

Adding the new standpoint of mass-production to the previous phases, you will be reviewing the target cost in this phase. Furthermore, cost reduction will be worked out, placing a focus on the processing and purchasing methods and their conditions.

Use the content of the mass-production implementation plan document from the previous phase as the base. Re-allocate the target cost as occasion demands, and decide what has to be done to realize the target cost. Implement the work of Design-to-Cost centered around the Purchase-to-Cost, Plan-to-Cost, and Manufacture-to-Cost methods. (The target allocation here should also follow the procedures explained in DTC Phase II.)

The ranking of the difference, computed by comparing the present cost and possible cost, signifies the ranking of the magnitude of expected merit. Also, when you look at the ratio of the two costs, a ranking of the ratio's numerical value signifies a ranking of the ease of realization. The key here is to rank examinations when carrying them out, taking into account the above viewpoints.

(2) Output

Here is the list of an output.

① Manufacturing drawings for mass-production

② Stabilized mass-production cost and conditions

③ Sales price

④ Sales strategies

⑤ Implementation plan document for operational and logistic support

Table 7.2-1 How to decide the total target cost

1. Meet social needs
   (1)Compare the competitive product/system price
   (2)Re-construct after breaking down components and ascertain maximum feasible law and effective cost, because any new concept can be broken down into pieces of known components or similar components
   (3)Estimate from trend or cost estimating relationship formula
   (4)Combination of above (1), (2) and (3) methods
2. In order to easily to compare the created design ideas by design people, fix the estimating conditions as follows;
   (1)Fixed year cost
   (2)Assumed total production quantity
   (3)Production pitch
   (4)Learning curve rate
   (5)Price/cost escalation formula
3. Also, consider the appropriate the target cost in order to foster the new technology and domestic support system

Table 7.2-2 Example of estimating conditions in order to have the same basis of comparison for estimating cost, present cost and variable cost

Item	Conditions
1 Fixed year	1980 year cost
2 Production quantity	200 aircrafts
3 Production and delivery period	Production: 7 years; delivery 5 years; 40 aircraft/year
4 Material to estimate	Manufacturing drawing
5 Production sharing	
A Company	Forward fuselage (except canopy, windshield), aileron aAssembly, rudder assembly, final assembly (includes engine build up), Mid fuselage(includes speed brake), air-intake
B Company	Wing (includes fairing without aileron)
C Company	Empennage (includes fairing without rudder)
6 Aircraft Configuration	① Prototype spec. and prod. type spec. ② Mfg. drawing configuration(incl. special evaluation items) (Do not include test and measuring equipment or additional modification after flight test)
7 Government furnished equipment	GFE, includes electronics equipment and survival kits, but G.C.I.P must not be included)
8 Breakdown of Estimate	①Direct material cost ②Manufacturing cost ③Direct expenses, special amortizing cost(Jig, engineering cost)
9 Cost for first mass-production preparation and maintenance cost to maintaion production	These costs will be equally borne by each aircraft

Table 7.2-3 How to allocate target cost

1 **Basic rules**
1. Any new product is a combination of known products. And if it not, new product will not be realized. 2. If not, target cost itself can not be established. 3. In order to establish the target cost, a development element test and a fundamental development test must be proceeded. Then the target cost can be decided.

2 **How to allocate target cost**
1. Equal cutting method ・Easy, but few keys to reduce cost. **2. Possible conditions method** ・It requires an experienced person and team estimation work ・It makes the creation of the key to reduce cost possible ・It creates motivation among the people concerned (especially among the design people) **3. Combined method** ・Combination of 1 and 2

3 **What is the possible condition method ?**
・ **Present cost + conditions to reduce cost = targt cost** **DTC work is to realize these conditions.** ・ **Example for reducing cost** 1. Reduce number of parts from 500 to 400 items 2. Proceed value engineering 3. Change the purchasing conditions and route.(Also combine the design conditions and cost of dealing with vendor) 4. Change the cost and design information gathering channel in order to keep good position of offer and acceptance for dealing with the cost. 5. Introduce special superior technology (e.g. double the cutting speed of material)

Table 7.2-4 Essential points for gathering design information for conditional target allocation

Essential points (Get a superior negotiating position to have the appropriate relationship of "OFFER and ACCEPTANCE")

(1) Purchase cost and product support are dramatically changed by the method used to gather the design to cost information for the first time.
(2) In order to get a superior position, it is essential to communicate directly with the manufacturers from the beginning, and not through a trading agent.(For a long time in the past, purchasers accessed the nearest agency
(3) In order to do that, we can directly fax or access the manufacturer through the Internet.
By doing this, the design to cost people can keep a superior position in the relationship of "OFFER and"ACCEPTANCE"..
(4)However, there are two more important factors:
① Because price is agreed on between companies, based on various terms and conditions, the final agreement will be confirmed by the purchasing and the sales departments of each company.
② In order to do this, all official confirmations must enter and exit from the same place in each company from beginning .

A. Good: Designer/ purchaser → OK → Manufacturer

B. No good: Designer/ purchaser → Trading→ Agent (SHOSHA) → Manufacturer

Especially trading Agent (SHOSHA) with lobbyist will mark up the price.

(3) The reasons are as follows:
① The profit of the trading house is proportional to dealing price, so trading house makes an effort to mark up the dealing price as much as they can.
② The profit of the manufacturer depends on to be selcted or not as the vendor, so the manufacturer makes effort to reduce price as much as they can.
③ Therefore, these two companys' vectors go in different directions.
④ There are some companies in which people sometimes forge letters.
⑤ It is necessary to prevent this. If we send a letter directly to the potential manufacturer, first we can identify whether there is an exclusive agent agreement between the manufacturer and trading house or not.

Table 7.2-5 Example summary of allocated cost

WBS	System name	Target	Present Estimation	Difference	Ratio	Note
10	Lifting					
20	Fuselage					
30	Empennage					
40	Flight control					
50	Landing gear					
60	Power plant					
70	Standard equipment					
80	Electrical installation					
90	Final assembly & flight test					
	Reserve					
	Total	2,000 T.Yen	2,400 T.Yen	400 T.Yen	120 %	

Fig. 7.2-1 DTC scheduled graph (to be called DTC cost status curve)

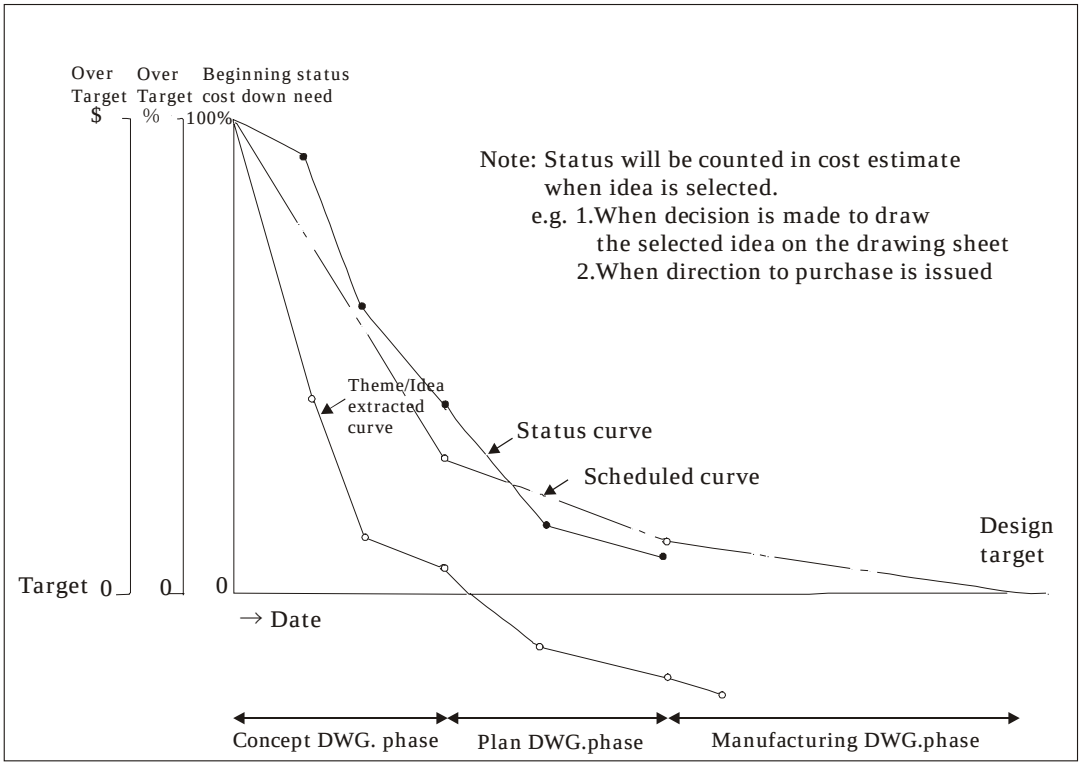

Fig. 7.2-2 Format of DTC/LCC Trade Worksheet

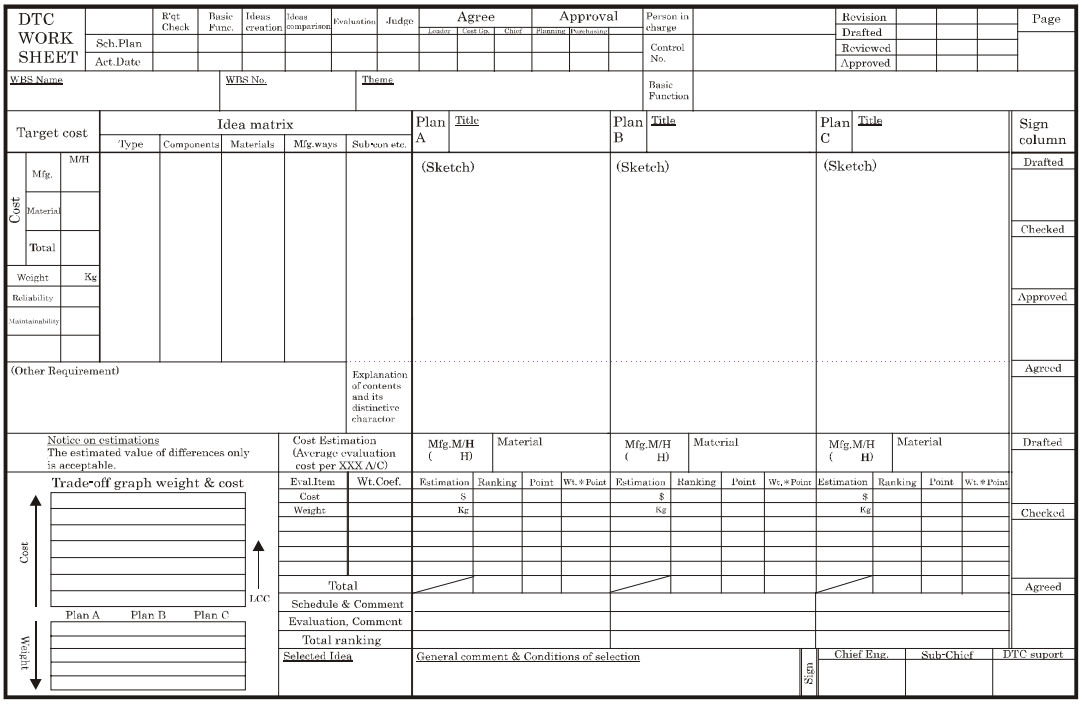

Fig. 7.2-3 The example of trade study graph

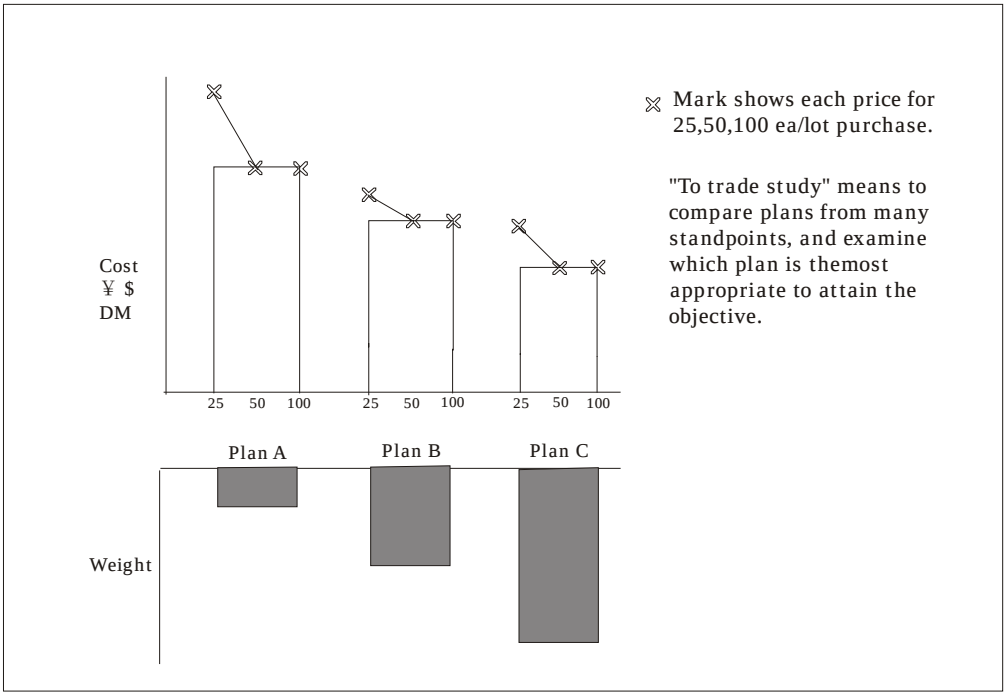

Table 7.2-6 Steps of Fig. 7.2-2 in brief

Work procedure by DTC worksheet	
Step	Work content
Ⅰ	Write and identify " design subject or theme"
	↓
Ⅱ	Write expression of basic function、target, requirements.
	↓
Ⅲ	Create and draw rough sketch of the ideas by which you expand the possible idea range.
	↓
Ⅳ	Estimate each rough sketch (cost, weight, reliability, maintainability) and compare.
	↓
Ⅴ	Evaluate the compared results, choose the idea which meets the necessary conditions and add in extra consideration.
	↓
Ⅵ	Reach agreement among the people concerned and get approval of design chief.
	↓
Ⅶ	Start to make the plan drawing and manufacturing drawing.

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Fig. 7.2-5 Combination of “A” approach and “B” approach

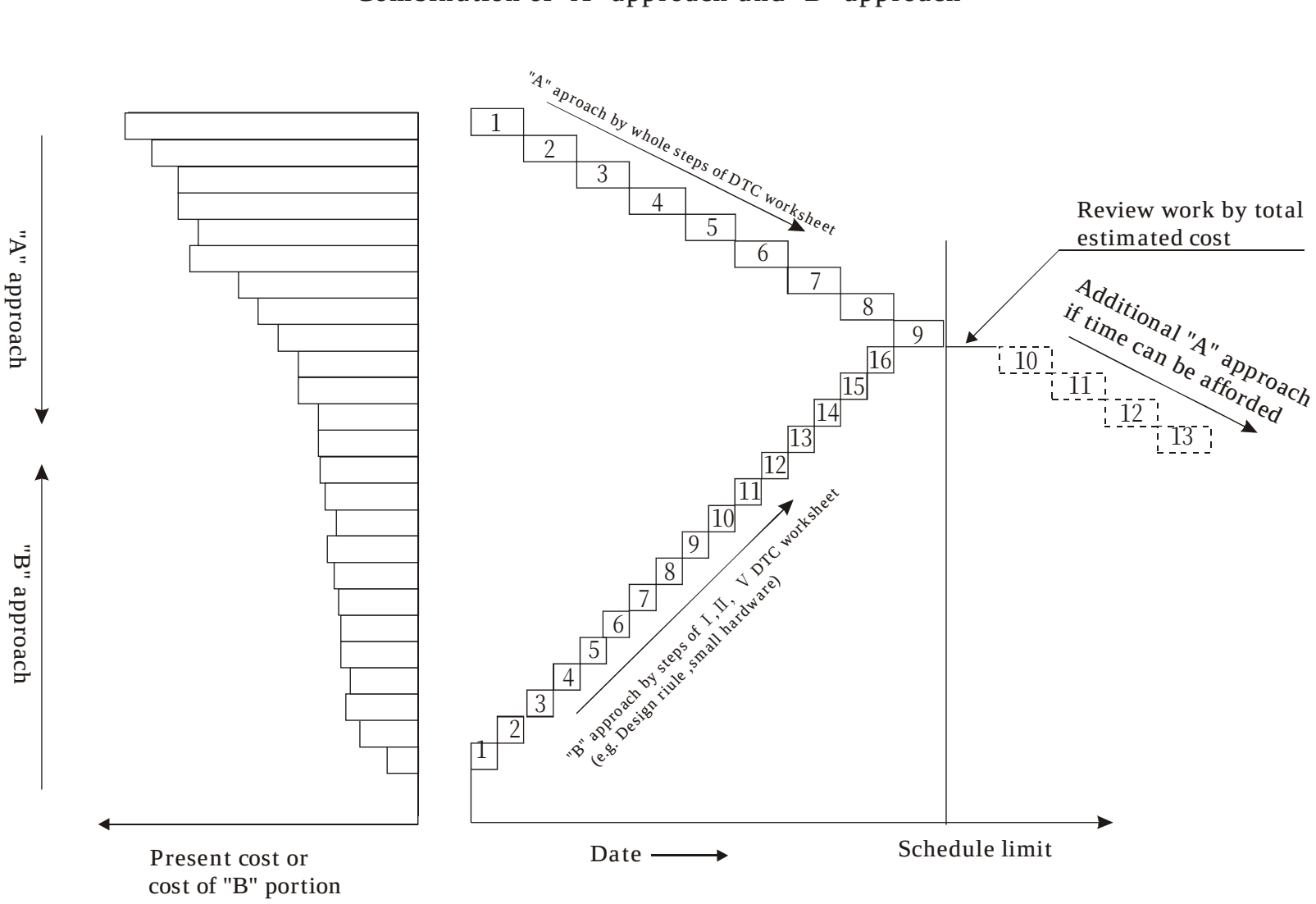

Fig. 7.2-6 The most appropriate idea exists in a triangle of three optimal feasible plans

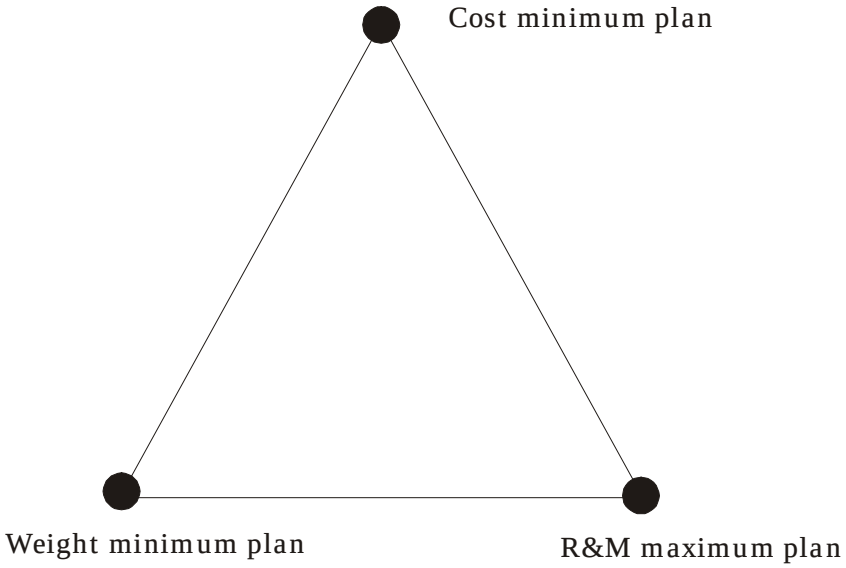

Fig. 7.2-7 Working cycle in DTC/LCC trade worksheet

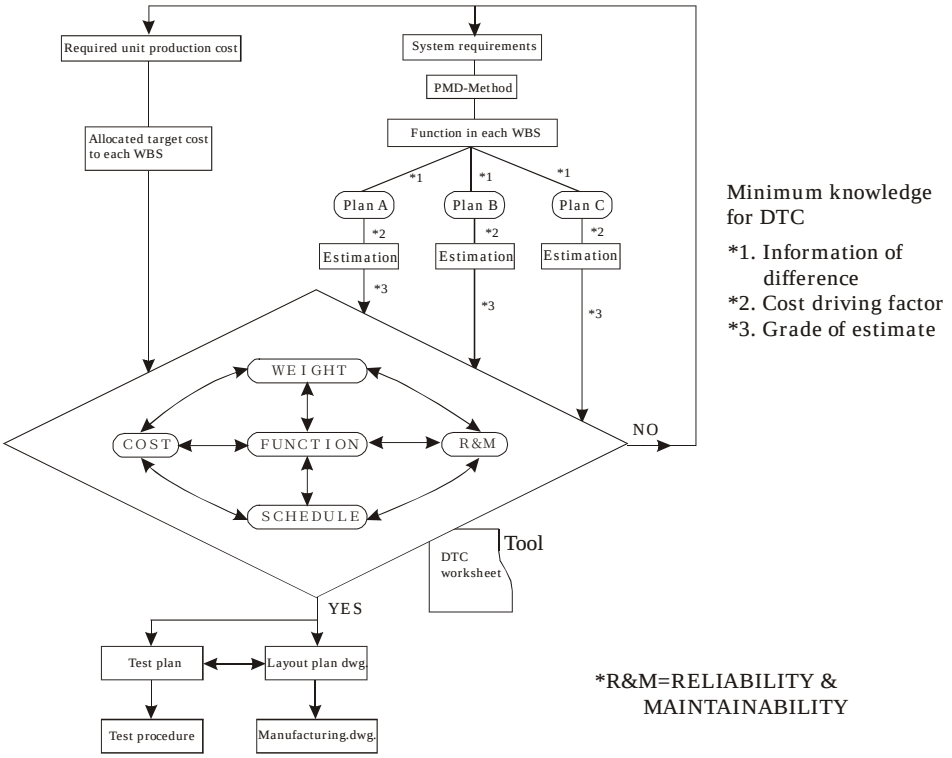

Figure shows DTC comparison trade study work.
There are also a few one-way creation cycle design methods.

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Fig. 7.2-8 Example of DTC/LCC Trade Worksheet (No.1)

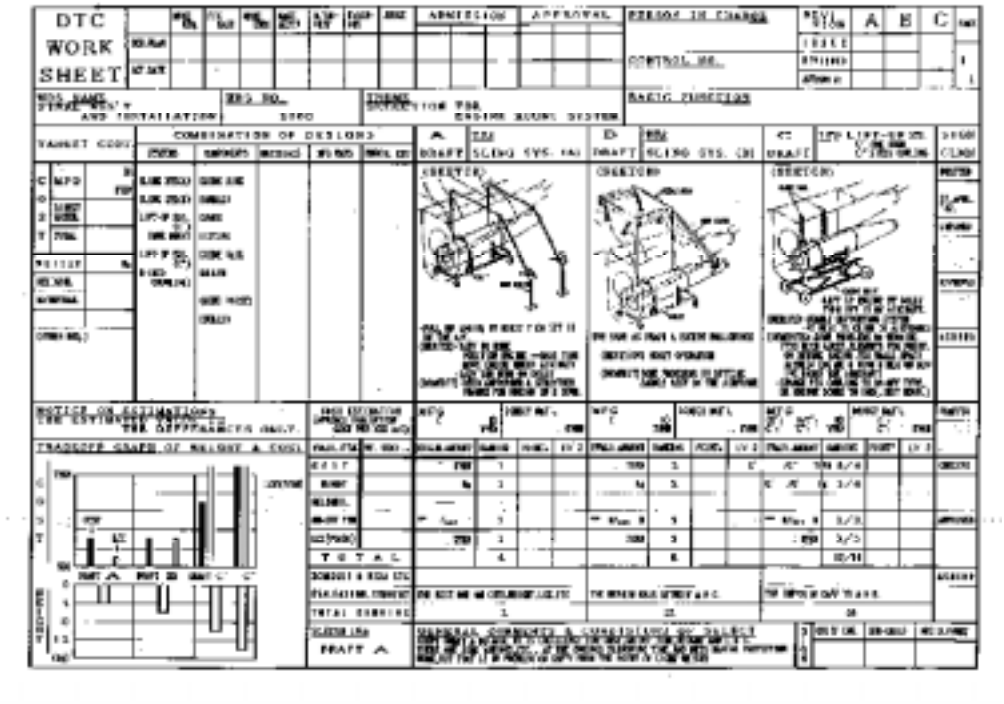

Fig. 7.2-9 Example of DTC/LCC Trade Worksheet (No.2)

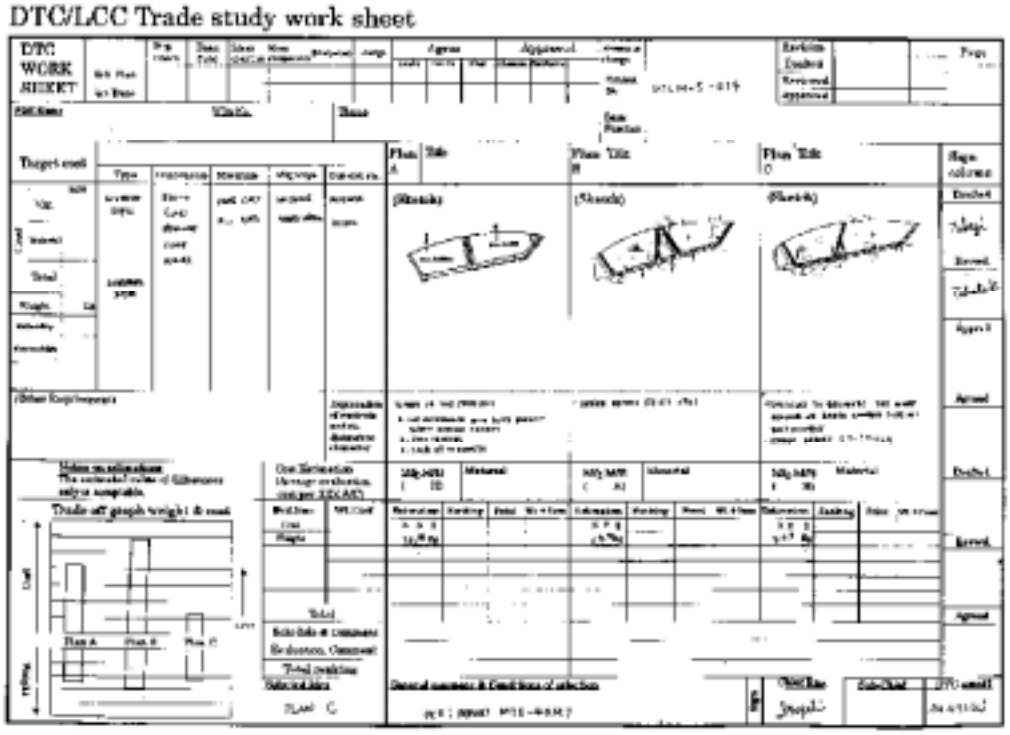

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Fig. 7.2-10 Format of predicted report to reach the target cost

Summary of predicted report to reach the target cost

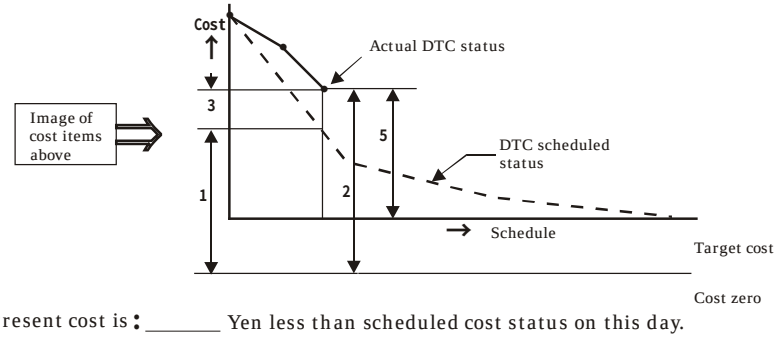
Scheduled date to repot on DTC scheduled curve

WBS No._____ WBS name_____ Company _____ Date ____

	Item	Contents
1	Scheduled value on DTC scheduled curve	The result was how much more than the scheduled cost reduction value on DTC scheduled curve ? ☐More ☐Less _____K Yen
2	Present cost status	Howmuch cost reduction must occur before reaching the target cost? _____K Yen _____
3	State the reason why	(Answer if the cost reduction was not obtained as scheduled on DTC scheduled curve)
4	Cost reduction needs to reach target	_____ K Yen
		See table below
6	Positive key action and its schedule to reach the target cost and its schedule.	

	No. of items	Possible Cost Effect *1	Realization %	Effect × realization %
Unadopted item		———	0 %	———
Adopted items		¥	%	¥
Hopeful Item *2		¥	%	¥
Before examination		¥	%	¥
Total		¥	%	¥

*1.Possible cost effect must be reported including G.C.I.P(In the case of in-house, net cost)
*2.The hopeful item must include all predicted items, but must not include the risk cost.



Present cost is : _____ Yen less than scheduled cost status on this day.
_____ Yen more than scheduled cost status on this day.

Table 7.2-7 Categorization of all design work to proceed with DTC/LCC theme selection work flow in Fig. 7.2-11

Category	Design work contents	DTC trade required item
P1	Theme to be focused to create a scheme image without cost consideration	
P2	Theme to be focused through creating PMD before design work (See note)	
A	Theme to be processed through creation of design ideas and comparison trade study	
A1	Cost is also an important factor to be considered	
A1T	Same as above (A1) and to be processed through DTC trade study	○
A2	The decision will be made without considering the cost factor, but a big cost impact exists	
A2T	Same as above (A2) and to be processed through DTC trade study	○
B	The comparable design ideas are already exist, but trade study is Necessary	
B1	Cost is also an important factor to be considered	
B1T	Same as above (B1) and to be processed through DTC trade study	○
B2	Decision will be made without considering the cost factor , but a big cost impact exists	
B2T	Same as above (B2) and to be processed through DTC trade study	○
B3	Decision will be made by other factors of cost and very small cost impact exists	
C	Theme to be processed through LCC trade study	

Note; Category P2 is the design work theme before identifying P1, A or B categories, in other words, in order to identify what examination theme work is necessary, or to identify P1 or A or B. P2 work is necessary to make PMD, so P2 is not shown in Figure 7.2-11

Fig. 7.2-11 Flow diagram to select DTC/LCC trade theme during design work

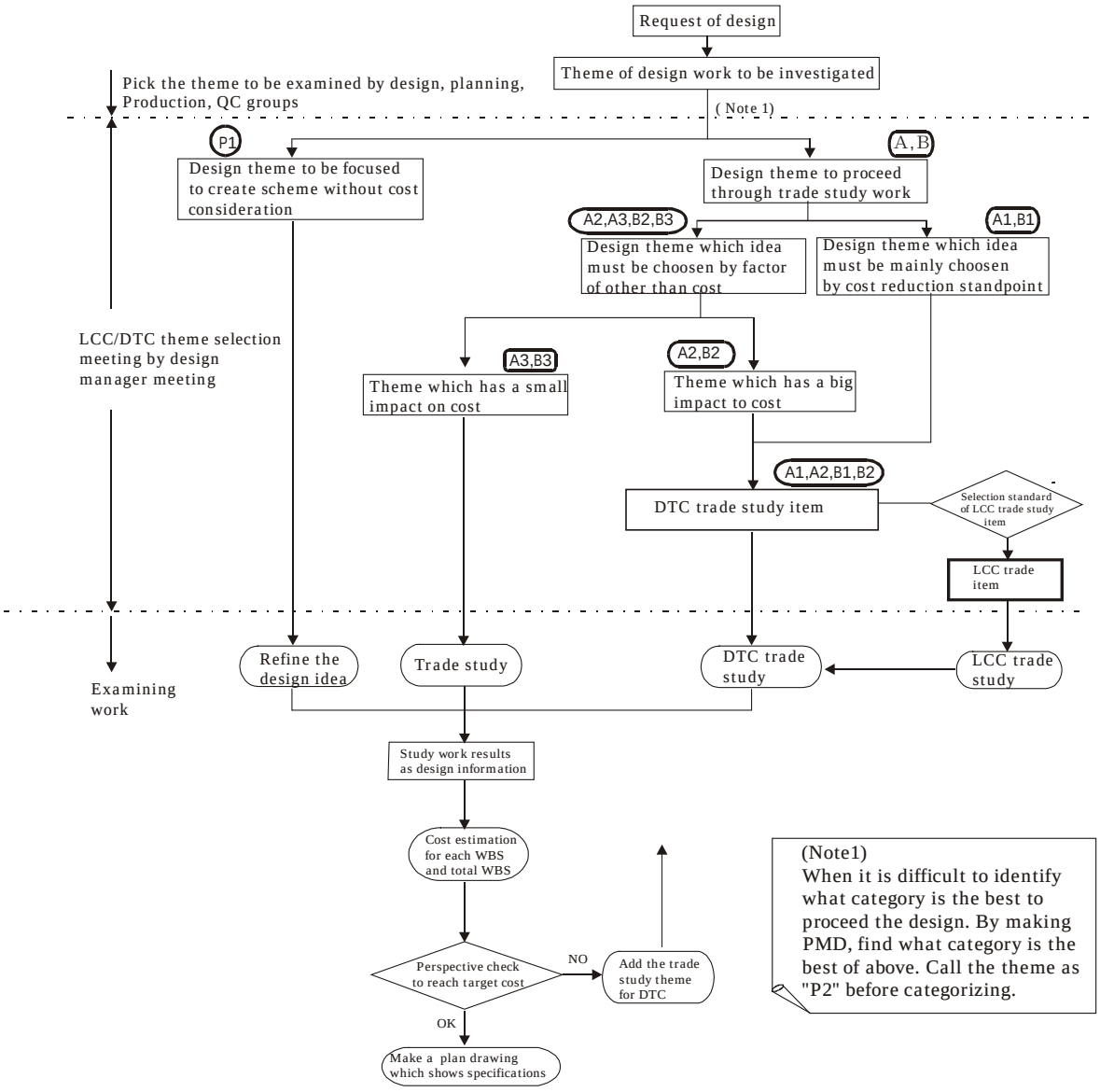


Fig. 7.2-12 How to adjust a design emerging technique between plan drawing phase and manufacturing drawing phase

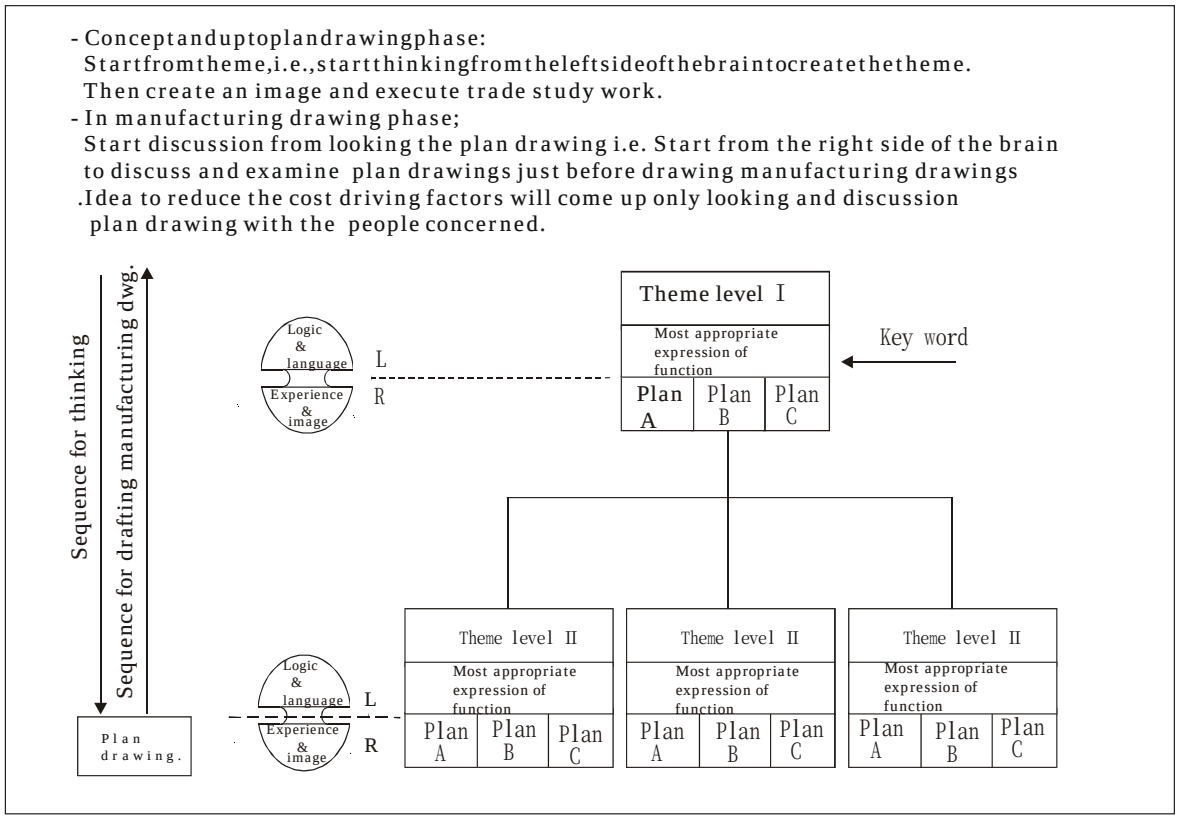


Fig. 7.2-13 What is the cost-driving factor?

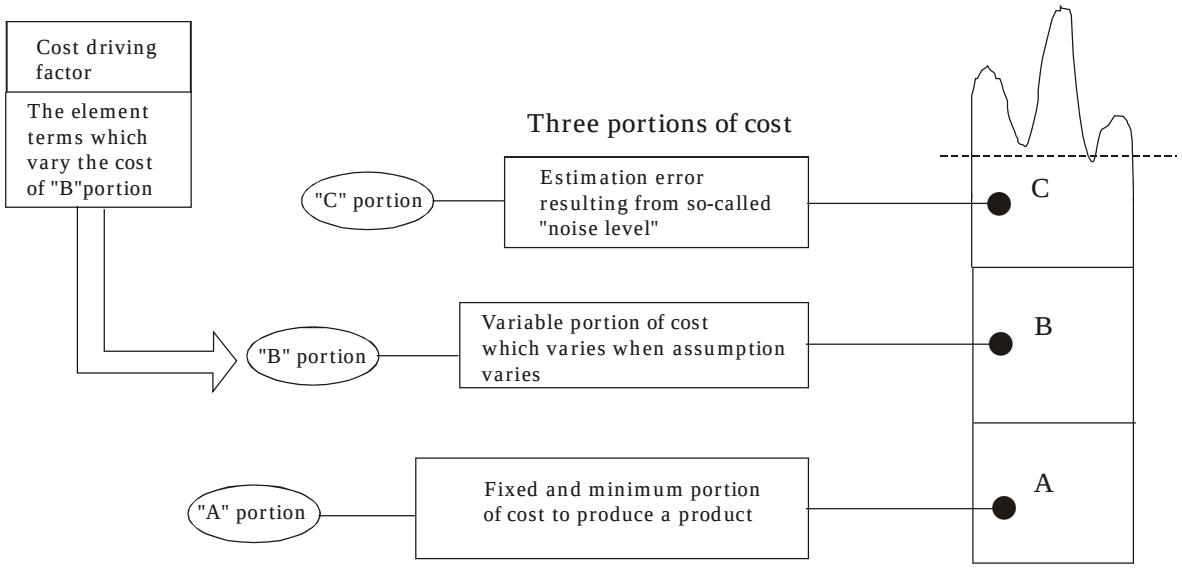


Table 7.2-8 Cost-driving factors to consider

System	Sub-system	Cost driving factor	Notes
Airframe & Control	1. Sheet metal parts a. Frame b. Bulkhead c. Skin d. Stringer e. Panel f. Beam	1. Number of part counts 2. Number of fasteners 3. Material 4. Number of manufacturing operations	Trade thoroughly with machining part. Cost reduction is obtainable by using automatic riveting
	2. Machining part	1. Number of planes to be machined	Try to lower one more grade of surface finish tolerance.
	3. Casting, forging	1. Number of part counts 2. Number of inside Molds	Consider two or more pieces in one forging and casting.
	4. F.R.P. part	1. Number of part counts	If F.R.P part can be replaced by sheet metal drop-formed part; cost can be reduced by about 1/5.
Equipment	1. Tubing 2. Hose 3. Support	1. Number of fasteners 2. Number of supports 3. Number of part counts 4. Number of hoses and tubes	
Electric	1. Wiring 2. Support	1. Number of connectors 2. Number of supports 3. Number of assembly groups	Install assy. on aircraft after assembling the parts in a way so as to reduce the number of units to be installed in the final assembly.
Transmission	1.Number of gears 2.Number of drive shafts	1. Special process 2. Tolerance 3. Number of part counts 4. Number of manufacturing operations 5. Number of machining surfaces 6. Reduction ratio 7. Weight 8 .Power to be transmitted 9. Item number of special inspection 10.Number of heat treatment processes	Try to lower one more grade of surface finish tolerance.

Note; If there is the possibility that reducing cost driving factors will cause an increase in cost, make a DTC trade worksheet of adjacent design ideas, and find the point where cost driving factor effects cross.

Fig. 7.2-14 Status chart to accelerate and control people's ideas in order to reach the target cost in the manufacturing drawing phase

(In the case, for example, in order to encourage the concerned people to be positively creative, assuming 0.25 M-H will be reduced by one idea, is adopted. The cost reduction status curve was plotted; very large changes in cost were the result of one idea.)

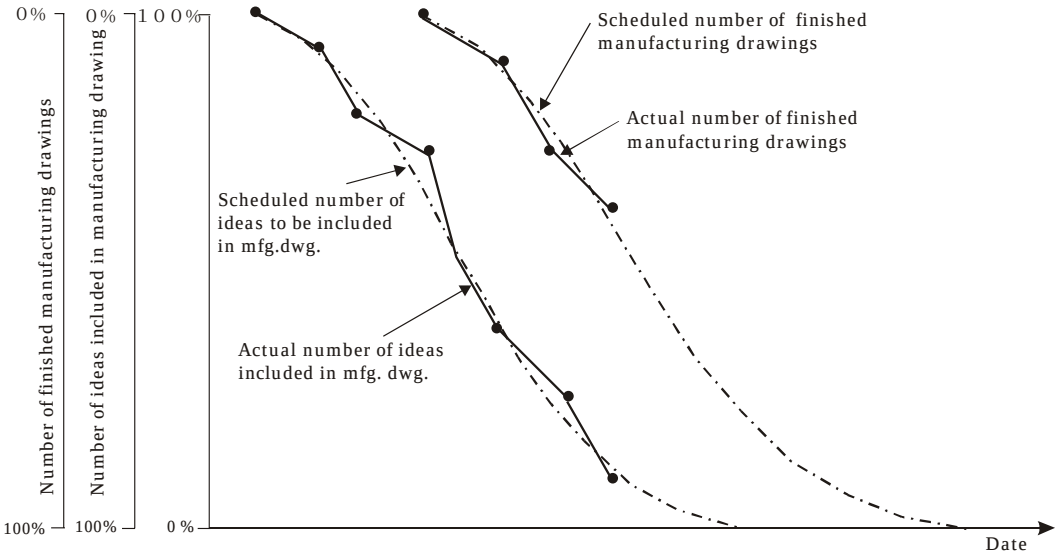


Fig. 7.2-15 Example of results of Design to Cost activity (Taken from Aerospace Handbook: Maruzen.)

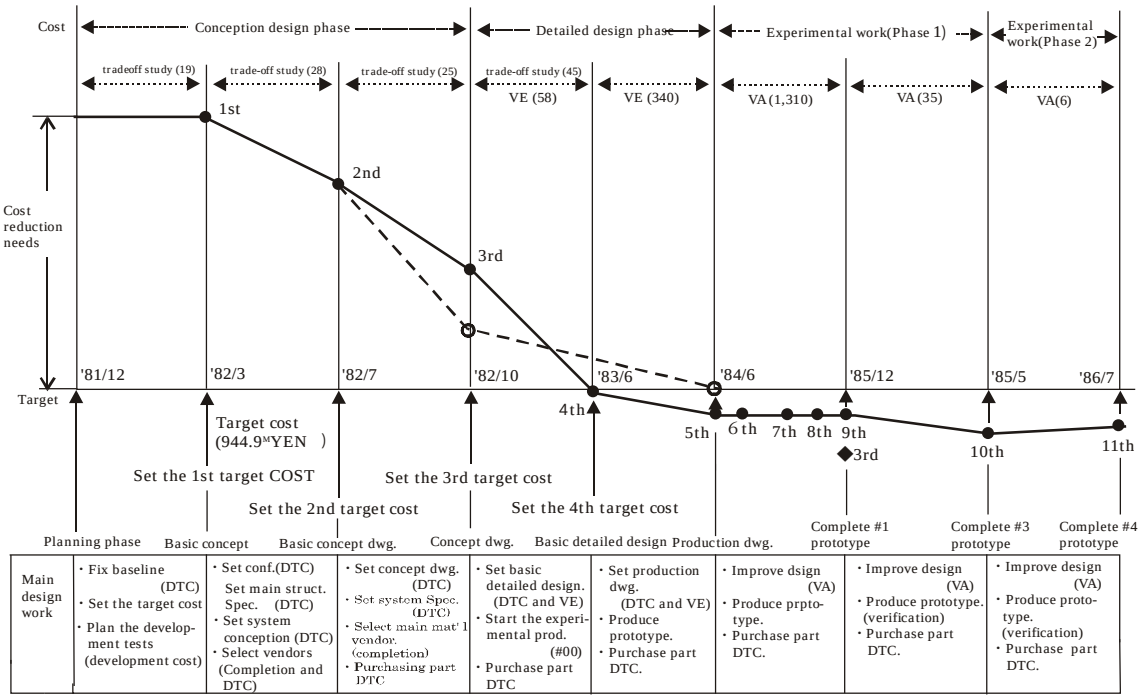


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Table 7.2-9 Relationship between system effectiveness and lifecycle cost

	Lifecycle cost			Logistic support cost		Maintenance manpower and cost		System effectiveness			
				Readiness				Mission Success			
				Maintainability parameter M	Reliability parameter R	Maintainability parameter M	Reliability parameter R	Maintainability parameter M	Reliability parameter R	Maintainability parameter M	Reliability parameter R
Work without pay to get first budget	**Cost** for effective development and related research including implementation cost to proceed DTCN/DTC activity	Unit production acquisition cost	Including tool manufacturing cost to improve to system effectiveness and to reduce the production, maintenance and logistic support cost	TPC per removal (Total parts cost per removal)	MTB removal (Mean time between removal)	DMH maintenance action (Direct manhour per maintenance action)	MTB maintenance action (Mean time between maintenance actions)	MTT restore systems (Mean time to restore systems	MTB downing event (Mean time between downing events)	MTT restore function (Mean time to restore function)	MTB critical failure (Mean time between critical failures)
		Cost to create and improve the system effectiveness and to reduce cost for production , and logistic support and maintence cost and manpower									

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