6.2 Minimum Knowledge Needed to Proceed with Design to Cost

In order to proceed with DTC, the following are required as minimum core knowledge in addition to the DTCN Methodology.

6.2.1 Decision-Making Based on Creation of Information of Difference

Refer to "Decision-Making Mechanism by Information of Difference" in Chapter 2. (Figure 6.2-1)

6.2.2 Cost Driving Factor

In this procedure, the cost will be considered in advance as a portion. To control the cost, the term and idea of "cost driving factor" will be introduced.

It costs money to produce something. Hence, when you come up with an estimate or forecast, the cost can be divided into the 3 portions which are listed below. In this way, cost control becomes simple and convenient.

Portion A: Minimum portion necessary to achieve the objective of the product and prepare for the worst.
Portion B: Variable portion which changes as assumed conditions change. (i.e., subject to cost driving factor)
Portion C: Usually called noise portion, which covers errors in estimate or forecast.

Figuratively speaking, in a casting example, Portion A is the cost of the exact metal weight needed to make the final product (i.e., same weight as that of product). Portion B is an assumed condition: cost varies depending on the number of cores for casting, manufacturing method, yield rate, and lot size difference. To control the cost of production, Portion A should be minimized by drawing the product's basic idea. Furthermore, to gain control, Portion B should be broken down according to assumptive conditions. Also, a list should be made according to the size of the expected effect. If you can control the assumptive conditions

in terms of the design and manufacturing methods, cost can be controlled.

Therefore, the cost driving factor of the DTC method influences the elements of the assumptive conditions, which control the fluctuation of the cost of Portion B.

6.2.3 Grade of Estimate

While working on a new design, we are aware of a large gap between the estimated margin of error in the early stages, and the finished trial piece, even when the costs themselves are the same. The margin of error depends on the obtainable limited data and knowledge needed for an estimate. The "grade of estimate" signifies the idea of grade management using such means. (Figure 6.2-3) For instance, the cost estimated in the process of demand comprehension using limited data may be called "Grade 7" of the grade of estimate. The cost estimated after the production based on the result may be called "Grade 1" of the grade of estimate. The grade of estimate allows you to divide the whole stage into 7 grades. (Figure 6.2-3) These grade numbers allow you to clearly indicate the relationship between the level of the data and the possibility of error bars (Note 1). The graph below Figure 6.2-3 shows the estimated error ranges in various stages based on the experience of one industry. Cost Minimum-Cost Maximum curves (Note 2) have been used.

The management of an estimate gap will use this graph as a guiding concept (Note 3).

The two graphs below Figure 6.2-3 show the tendency of change in estimate cost depending on the size of the relevant projects and the range of contingency.

(Note 1) Grade of estimate may be called the thinking grade of fuzziness adapted to the information.

The thinking grade corresponds to the 7 grade phases of Steplist Management as follows:

-Thinking/Fuzzy Grade 7: Understand the level of Key Word by PMD

-Thinking/Fuzzy Grade 7A: First information collection (belongs to Grade 7 level because it is still in the information collection stage according to PMD)

-Thinking/Fuzzy Grade 6: Hit on an idea

-Thinking/Fuzzy Grade 5: Formulate a plan (Structurized Plan)

-Thinking/Fuzzy Grade 5A: Second information collection (belongs to Grade 5 level because it belongs to information collection backing the result of Grade 5)

-Thinking/Fuzzy Grade 4: Basic design

-Thinking/Fuzzy Grade 3: Detailed design

-Thinking/Fuzzy Grade 2: Actualization

-Thinking/Fuzzy Grade 1: Review

(Note 2) These curves are known to be drawn by the U.S. foundry industry using estimates and actual results.

(Note 3) The concept does not directly mean that the numerical value of the error ranges should be followed. It only means that the error ranges decrease according to these curves.

6.2.4 Recognize Differences among DTCs for Mass Production Unit Cost, Development Cost, and Lifecycle Cost

(1) DTC for Mass Production Unit

Using Figure 6.2-4, the following can be said:

- The subject of a DTC for mass production is the unit production cost based on a fixed yearly production cost. (Within each procurement year, cost should be revised according to the labor cost index, decreased rates of the price index and man-hours, and lot size, etc.)
- The unit production cost is a fixed yearly production cost calculated by a provisional quantity and rate of production, which are set in advance.
- The unit production cost in Figure 6.2-4 shows the average in a gradually decreasing curve (learning curve), where production cost decreases as the number of production units increases to the right.
- To proceed with DTC for unit production cost: Using the activity cost of Design to Cost within the development cost, set and assure the mass production drawing, manufacturing procedure, and purchase conditions which are necessary to produce products at the target unit cost during the developmental stage.

(2) DTC for Lifecycle Cost

Using Figure 6.2-5, the following can be said:

- Set a provisional value of the average operation time, until mass production units are scrapped.
- Using the above as a premise, the total operation cost, including fuel and repair expenses for the same time phase will become the operation cost.
- Add development, procurement, and abandonment costs to the above, and consider this to be the lifecycle cost.
- Some part of the above total operation cost can be calculated as a fixed amount. However, a larger portion cannot be understood. As a result, the margin of error will be very large.
- Considering the above, a DTC for lifecycle cost cannot come up with an accurate target cost.
- Hence, a DTC lifecycle cost should not set an overall target cost. Examine and compare the comparable design plans to minimize the area within the graph in Figure 6.2-5.
- Examining to minimize the area within the graph line in Figure 6.2-5 (lifecycle cost design), we can

proceed in the following ways:

(1) Compare two comparable design ideas. Look into the difference in the lifecycle costs of the two design ideas. Choose the one with the higher investment efficacy rate.

(2) Besides the design work, prepare the maintenance system, operation plan, and overall operation system from the beginning to lower the lifecycle cost.

(3) Moreover, even for those design jobs considered advantageous in i) or ii), their advantage may change with time and the introduction of new techniques . Therefore, specify and approve a review to cover minimum changes every two years in the implementation document. Plan for the whole lifecycle so that any new persons in charge during the lifecycle period can easily provide explanations. This is the key to implementing DTC for lifecycle cost.

- Definition of carrying out DTC for lifecycle cost:

Using the activity cost of Design to Cost within the development cost,

a) develop a product or system to effectively achieve the mission in the overall lifecycle. At the same time, implement a plan to minimize the necessary lifecycle cost.

b) complete a structural implementation plan to regularly carry on maintenance, improvement, advancement, and review, even when the persons in charge are replaced.

(3) DTC for Development Cost

An explanation of Figure 6.2-6 is given below.

① The final development output is the technological information of a development product with performance verification and backing.

② A target of DTC for development cost is the total cost required to produce the product as output.

③ Implementation of DTC for development requires that the cost which covers the whole development phase to be included in the target cost. When doing so, the Design to Cost activity cost within the development cost (marked with diagonal lines in the graph) must be used.

The content of the above includes the total of the cost used after each phase contract in the overall target cost. Therefore, when there is the possibility that the estimate of the rest of the development cost will exceed the target cost, the cost may be reduced using the DTC Method and the necessary activity cost. However, effective reductions in the development cost using the DTC method and compare-and-choose design plan can only be achieved up to the end of the basic design (preparation of plan drawing) phase. After that, you can only accumulate small reduction effects. Even so, if you decide to use the DTC method, further cost increases will be prevented. Keep this in mind.

-When implementing DTC for development, there are unexpected costs. Because we cannot know what

they are until they occur, unexpected costs should not be included in the target cost of development cost. This is an indispensable condition to carrying out the DTC for development.

In order to control unexpected costs, an estimate and implementation of the unexpected cost should be carried out every time one arises. To deal with unexpected costs, it is first necessary to have a reserve fund .Next, when the unexpected event happens, compare-select-implement multiple measures (ideas) to recover from the event, and implement a countermeasure DTC. However, the cost of emergency measures taken at the site of the event are excluded from the scope of this DTC. The management of this reserve fund becomes another indispensable condition when you implement the Design to Cost for development cost.

④The development target cost sometimes includes risk countermeasure cost. Deal with the risk in the following manner:

Initial estimate cost and target cost for the development include the risk countermeasure cost for the development process in order to fulfill the set development period. Risk countermeasure cost is for alternative plans developed simultaneously, and parallel development. Moreover, material costs necessary for an advanced order for alternative plans and parallel development, which may end up as waste, are also included. Alternative plans and parallel development are used to list the size of risk factors calculated from the product of the probability of the emergence of the contingency and the scale of its effect on the project, after seeing the results of the experiment.

To complete the development according to the schedule, the content of the risk countermeasure cost should be clarified. Moreover, its cost should be included and sorted accordingly in the development cost.

⑤ Ways to decrease the risk cost:

Use the thinking and procedure stated in Episode 14, described at the end of this chapter. Also include a study to lower the risk cost in the DTC activity.

6.2.5 Difference Between Development Step Portion Which Implements DTC and Development Step Portion Which Does Not Implement DTC

(1) Regular Development Step Portion

The development step portion for aerospace-related development is described in Figure 6.2-7 as an example. (Bibliography 1)

Consider the contents of these 8 phases as bases, and change the contents by realizing which characteristics they belong to among the following: development for mass-production; development first aiming at ultimate performance and then targeting inexpensive mass-production, as in missile production;

development of a single unit as in a space station with no mass-production; joint production among more than 2 countries requiring a consensus in values to cope with the different systems, customs, and cultures, where changes in elements are a must to reach consensus. You can use the above 8 phases as bases and change the content as necessary.

See below for further explanation.

(2) Phase Portion for the Development Phase to Implement DTC

① The specific characteristics of the phase portion when implementing DTC are preparation and approval of the DTC implementation plan document in the first phase, and then deciding when to determine the target cost based on that document.

② Products such as missiles require extreme development and focus on high performance, and mass-production development emphasizes the cost and productivity. When applying DTC in either case, development should be carried out by dividing the overall development into the following 2 phases:

A : Performance development phase: state your desirable unit cost in mass-production, and do not allow mass-production cost to become exorbitant. While doing so, focus on development seeking the highest performance. At the same time, carry on parallel development to search for a product or element that will reduce costs in mass-production.

B: Production development phase: After attaining the highest performance, again set the target cost for mass-production. Taking the introduction of mass-production facilities as a premise, implement mass-production development following the DTC procedure.

Fundamental rules of the above are listed in Table 6.2-1.

③ When implementing DTC for the development of a single unit product or DTC for development cost, development cost becomes the only subject for DTC. Hence, the main DTC activity will be completed as the activity of the development becomes clear, before the end of the basic design phase.

Although the development phase portions are called the same thing, the content of DTC management differs from the DTC work for the mass-production cost. Moreover, where management largely differs is that unexpected costs (*) and risk management costs greatly increase compared to DTC only for mass-production cost, as stated in the previous section.

(*) The unexpected costs stated here indicate the recovery costs for the experiments not included in the initial estimate, and additional costs incurred by measures to cope with additional requests.

iv) For joint development or research with other countries, consensus in values must be reached in order to

overcome the differences in laws, systems, customs, culture, and language. To do so, the people involved must first prepare a PMD and then decide the phase portions for development and research. Contents of phase portions will differ from those of domestic development.

The phase portion of the DTC implementation plan document will largely be affected and vary depending on which phase the target cost setting (sometimes divided into 2 phases: setting a tentative target cost and setting a final target cost) is carried out in.

(3) DTC Development Step Portion for Various Cases

① Follow the basic procedure of DTCN Method by drawing up a PMD for DTC implementation for each case.

②Take into consideration various elements extracted from the established PMD, and prepare the eight basic phase portions. By matching the characteristics of the project, you will be able to see whether the development phase should be subdivided.

If necessary, break down the phase portions and make a new steplist. Use this to come up with the overall DTC implementation plan document.

This way, the DTC implementation plan document will be equivalent to the development implementation phase plan for the whole project.

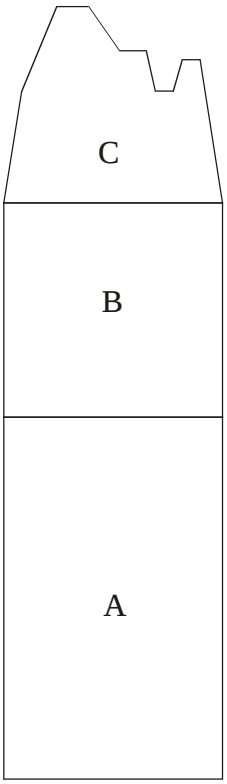
<Reference>

The Japan Society for Aeronautical and Space Sciences. (1992). Aeronautical and Space Engineering Hand book, Maruzen Book co., p.270.

Fig, 6.2-1 Decision mechanism by information of difference

- There is no decision made if there is no "information of difference".
- "Do nothing" and "Do something" are also two feasible plans.

Fig. 6.2-2 Meaning of cost driving factor



C : Noise portion
The portion which is error portion of estimation or forecast.

B : Conditional portion
The portion which can be changed if condition change
Example: Cost varies depending on whether press forming or hammer forming process choosed.

A : No conditional portion
No change portion if the conditions change.
Example: The weight of the manufacturing materialis not less than the weight of the product.

Fig. 6.2-3 Grade of estimate (It can be called grade of thinking or grade of fuzziness as necessary)

Design phase	Descriptin of data obtainable in each phase Refer to steplist for DTC Table 7.1-1 and 7.1-2	Grade of estimate and obtainable datain each phase 7	6	5	4	3	2	1
Requirement definition	Basic function (In brief to do ～)	○	○	○	○	○	○	○
Conceptual confirmation	Conceptual sketches, development plan Conceptual drawing or image sketches		○	○	○	○	○	○
Breakdown structure Configuration optimization	General program plan Configuration drawing (Three view, structural, system chart, general arrangement drawing) + WBS			○	○	○	○	○
Basic design	Preliminary design report, design calculation, qualification test plan, long lead time procurement request, assembly sequence chart, R&M spec. Layout drawing (Three-view, lines, structure system, part layout) Specification control drawing draft, tooling specification, production facilities spec. Q/A spec.				○	○	○	○
Detailed Design	pa Manufacturing drawing (Assembly, specific control, source control) Specification control drawing draft, tooling spec. production					○	○	○
Producti on	Manufacturing operation sheet STD. time, bill of materials						○	○
Review	Actual time data, material release data, corrective action							○

Grade of estimate

Note:

1. The numerical value shown in this table of garde for estimate are to be used as a criteria, since they have been picked from a certain statistic and value of experimental tendency.
2. Contingency means the factor which is added to estimate cost having uncertain elements, in order to avoid unforeseen loss of profit.
3. A portion of this data is quoted from “Manufacturing Planning,& Estimating Handbook”(McGraw Hill Co.)
4. This graph can be used as grade of fuzzy.

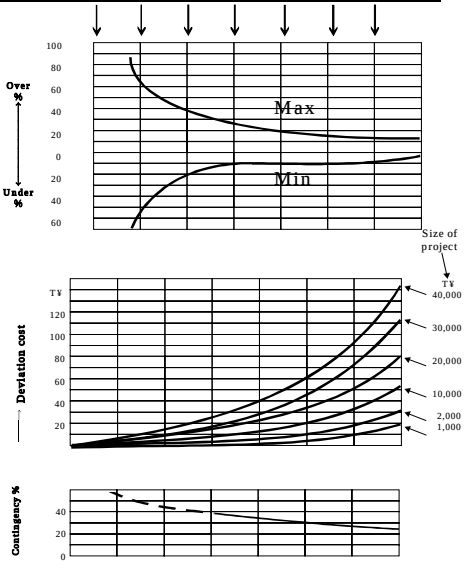
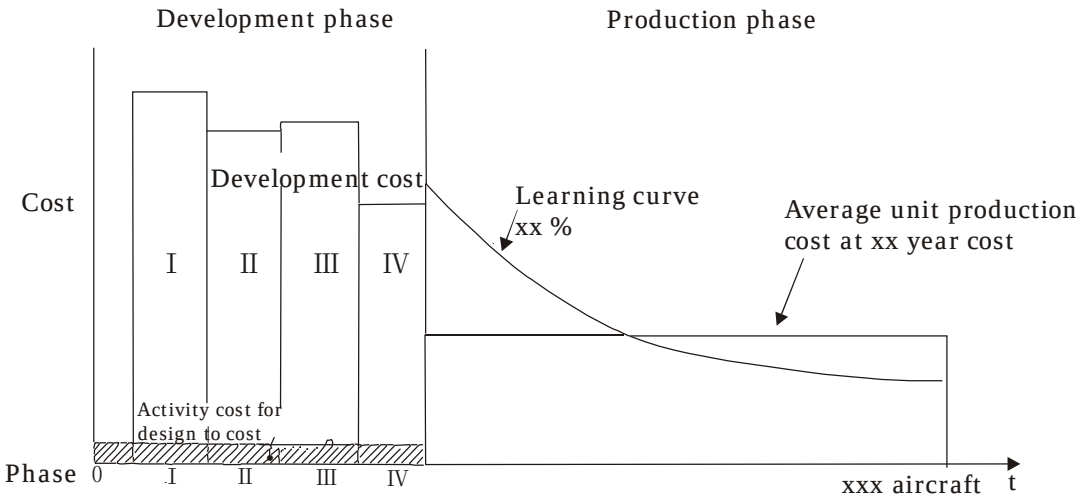
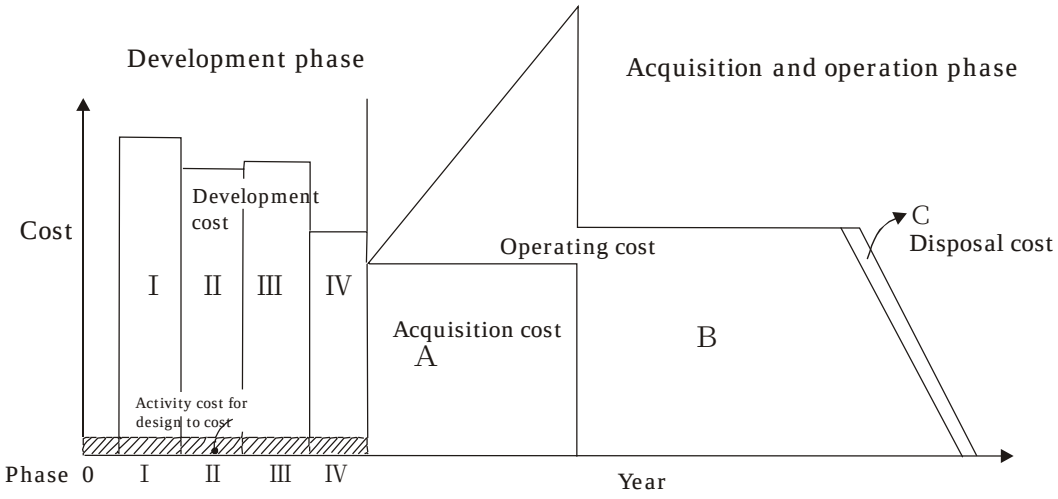


Fig. 6.2-4 DTC activity image for unit production cost



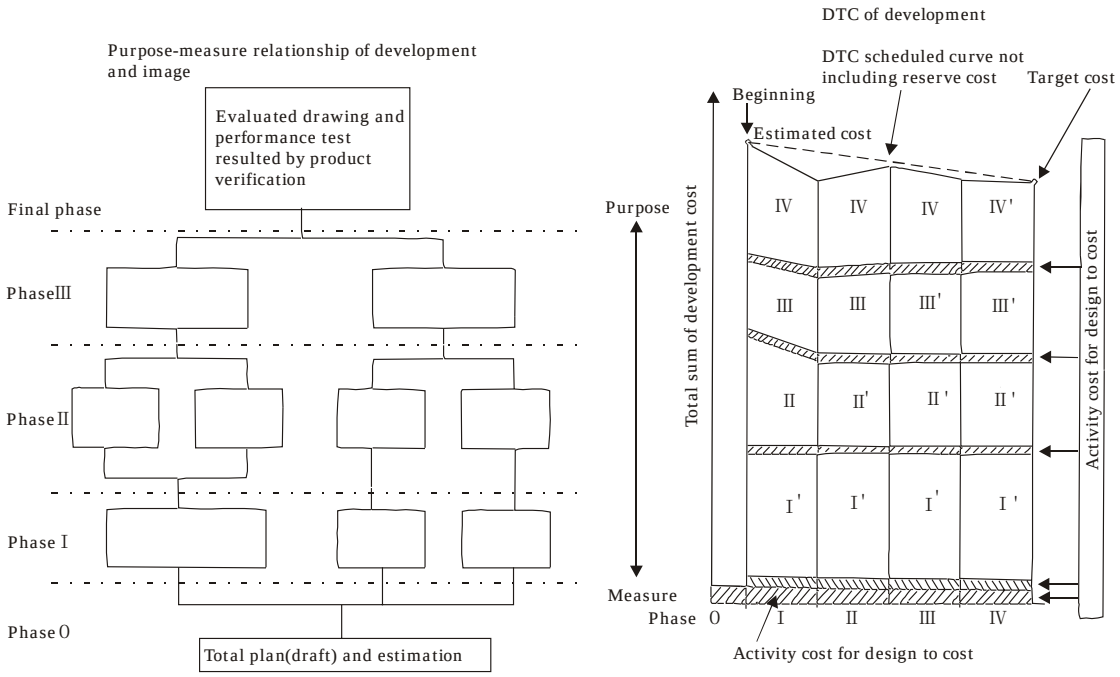
The activity of DTC for unit production cost is the activity to assure the unit production cost using established drawings, manufacturing operation sheet and purchasing conditions during the development activities.
The activity cost for DTC is allocated in the development cost.

Fig. 6.2-5 DTC Activity for Lifecycle Cost



The activity of DTC for lifecycle cost is the activity to minimize the total cost of the lifecycle cost〔Development cost+A+B〕, by using the allocated activity cost for the lifecycle.

Fig. 6.2-6 DTC activity image for development cost



Rule 1. Contract each phase content using the results of DTC activities in the previous phase to control or reduce the cost of all later phases.
Rule 2. Complete each development activity at the contracted cost, however, if unexcepted trouble occurs, the additional must be considered.
Rule 3. It is necessary to have reserve fund at order side to recover the cost of unexpected trouble.
Rule 4. The development cost are paid for each phase after each phase contract.
The cost of phase-0 is necessary cost to make an implementation plan for all phases.
Rule 5. DTC activity cost must be added to create the comparable ideas and examine them in order to reduce later phase development costs.
Rule 6. Because the cost of recovering from unexpected trouble can not be estimated before the trouble occurs, we will not include its cost in the contract development cost. However we will include the cost of preventive and alternative measures.
Only after the unexpected trouble occurs, are we able to estimate the appropriate cost, by creating, comparing and choosing the created countermeasure to recover from the unexpected trouble.

ISBN 0-941243-00-1

Fig, 6.2-7 The comparison of phase characteristics for each development objective (Prepared by M. Esaki)

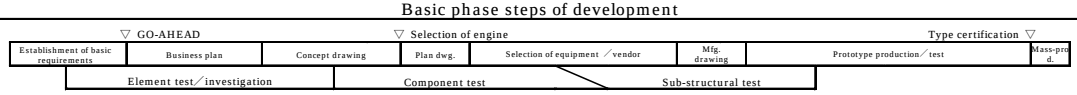
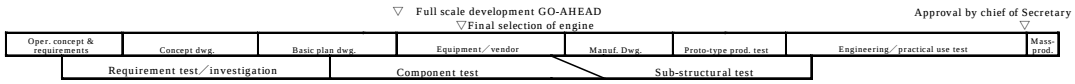
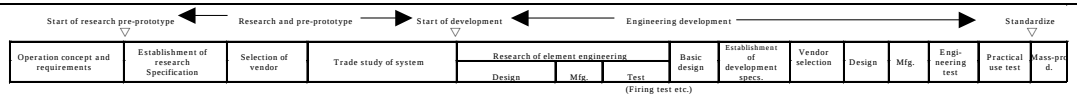
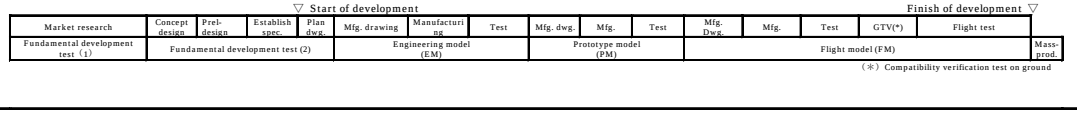
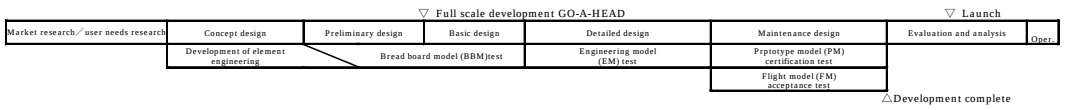
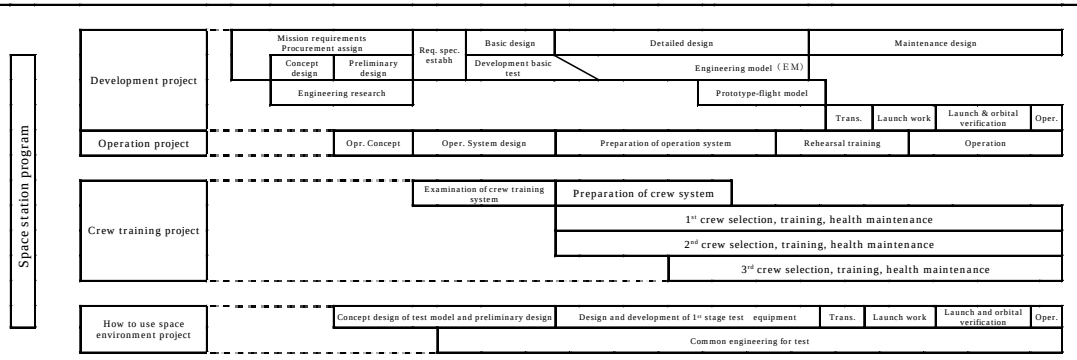
Object		Characteristics of development	Basic phase steps of development
Aircraft	Commercial	1. Start from market needs 2. Mainly develop by using established technology 3. Important points are economy and safety	
	Military	1. In order defend own country , the requirement of performance and feasibility are the starting points.	
Missile		1. The operating concept and requirements for defense are the starting points. 2. The high precision and reliability are required, because of severe operating environment. Because it is impossible to observe the detail phenomena by human inside of missile as inside of aircraft and because of no recovery after hitting, total measuring devices such as optical and measure simulation must be provided	
Space rocket		1.The capability and functions to succeed the mission are required 2.Because it is impossible to test everything before launching, enough tests and evaluation must be done in the sub-system level 3.There is a limitation in the test on the ground 4.Final evaluation of design and manufacturing are only done by remote monitoring after launch	
Satellite		1. The first priority is optimization of design for the mission of satellite. 2. Because repair during the operation is almost impossible. High reliability is required. 3.There is a limit in ground testing. 4.Final evaluation of design and mfg. are only done by remote monitoring.	
Space station program		1.Because the project is huge, the international operations are required. 2. Because there are many unexpected area and in order to make it possible to operate the many functions by manned or non-manned operation in space station, there must be a tremendous number of tests. 3. Training and safety of the space station crew are of most importance. 4. Many interface adjustments must be made, because there is so many participants and customers. 5.Because space station programs are divided into projects, exact interfaces between the projects are essential.	

Table 6.2-1 Phase step to divided into performance development and production development as for missile development

Caution for the cases in which phase must be divided into performance development and production development phase

Performance development phase
Proceed development by the relationship of "in order to defend own country, how to challenge and realize maximum feasible performance".
(If DTC for unit production cost is not required, development will be finished at this point.)
However, if DTC is required for production cost, it is necessary to develop a comparative design and do a preliminary comparison test at this phase.

Production development phase to improve production efficiency.
Proceed the production development in the relationship of "keeping the attained performance in order to increase production efficiency and reduce costs by creating the most feasible plan."

Efficiency in the case of missile, the production quantity between the development phase and mass-production phase is quite different.
Therefore it is very difficult to proceed the performance development and cost reduction development at the same time.
Therefore, the development phase for performance and the development phase for cost reduction and efficiency improvement must be separated.

As in the case of aircraft development and production, the lot size will not vary so much between the development and production phases.	As in the case of missile development and mass-production, the lot size of production quantity varies a lot between development and mass-production.
1.Research prototype 2.Development prototype 3.Engineering test/ practical use test 4. Mass-production	1. Research prototype 2. Development prototype 3. No.1 engineering test/practical use test 4. Development for mass-production 5. No.2 enginering test/practical use test 6. Mass-production