The research on the management strategy of exclusive parts for satellite integration

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Abstract. As an important component of satellites, the demand characteristics of exclusive parts for integration are short cycle, large quantity and low cost. It is urgent to solve the problem of meeting the demand with the current production capacity without affecting the quality level. Based on the analysis of the management strategy of the exclusive parts, it is indicated that the root cause of the problems such as the left backup and the structural shortage is the separated management system. It is also indicated the generality of some exclusive parts. In this paper, the general strategy is proposed to form a unified management system for general exclusive parts for integration, which is conducive to the full use of resources, and cost reduction.

1. Introduction

As one of the most important parts of satellites, exclusive parts for integration indicate connectors for satellite integration. With the rapid growth of the quantity of satellites, the demand for exclusive parts is growing rapidly. However, in the case of relatively stable production capacity, it is necessary to make more reasonable arrangements for resources to meet the rapid growth of demand and reduce the cost without affecting the quality level. The management of the exclusive parts for integration is relatively extensive, and the research on the management mode is rare. This paper analyzes the management of the exclusive parts for integration, studies the cost characteristics and demand characteristics of the exclusive parts for integration to discover the existing problems, and puts forward new suggestions for the problems.

2. The current management strategy of exclusive parts for satellite integration

Satellites are highly customized products. Each satellite has its own independent design-management system. The exclusive parts for integration belong to the separated management system of the satellite who uses them. The management mode of "separated design, separated manufacture, separated storage and separated management" is adopted.

Because the actual use of some exclusive parts is not clear at the beginning, in order to avoid shortage, there will be a lot of backup when making production plan. These unused backups remain in the warehouse of the satellites launched. Because the scope of use is limited to the satellite which the parts belong to, they will be kept in the warehouse all the time and accumulate with the increase of the number of satellites. As shown in Table 1, the remaining unused exclusive parts in the warehouse of 5 launched satellites are counted.

| Satellite | Exclusive parts | Amount |
|-----------|-----------------|--------|

Table 1. The exclusive parts left
There are 975 exclusive parts for 5 satellites remaining in the warehouse in Table 1, with an average of about 195 for each satellite. Washers and grounding lines are exclusive parts commonly used on satellites. Taking the washers as an example, the washers in Table 1 are all of similar structures. Taking the washers of Satellites 1 and 4 in Table 1 as an example, it is indicated that there are two kinds of washers in satellite 1, one of which is the same with the ones in Satellite 4 in material and size. Washers of the same configuration are also used in other satellites. It is indicated the washers are widely used in satellites. The same conclusion can be get in the analysis of the ground lines. More analysis shows these exclusive parts are interchangeable.

### 2.1. The cost characteristics of exclusive parts for satellite integration

The cost $C$ of exclusive parts for satellite integration consists of four parts.

$$C = C_1 + C_2 + C_3 + C_4$$ (1)

- $C_1$: Design and manufactured cost. The design of satellites is complex, and the cost of exclusive parts is considerable. Manufactured cost is the entity cost. Due to the particularity of aerospace materials and devices, the cost of exclusive parts is quiet high. Since the case of backup is normal, there are 975 useless exclusive parts left in warehouse at present, because of the limitation of the current management mode, resulting in waste of resources and the increasing cost.
- $C_2$: Inventory cost means holding cost. Due to the high requirements of environment for satellite product storage, requirements on the warehouse is quiet strict. There are a large number of non reusable exclusive parts in the warehouse due to the problems of the management system. They occupy the inventory space, resulting in increased cost. Furthermore, the inventory of exclusive parts is predicted to grow with the rapid growth of the number of satellites, resulting in the rapid increasing of inventory costs.
- $C_3$: Quality cost. Quality is the most important factor for satellite products, and the quality investment is also astonishing.\(^\text{[1]}\)
- $C_4$: Shortage cost refers to the punitive cost induced by the failure for exclusive parts meeting the demand during integration. The project progress is delayed because of the shortage of exclusive parts, that induces the shortage cost.

### 2.2. The demand characteristics of exclusive parts for satellite integration

During the integration of a specific satellite, the requirements of exclusive parts are distributed discretely in time ($t$), usually corresponding to a specific integration stage; in the parallel integration of multiple satellites, the demand distribution of exclusive parts for a specific satellite with time is independent with others. Suppose Part 1, Part 2 required for Satellite A, Satellite B are completely interchangeable. In general, when satellites integrate parallelly, due to the different progress, the demand time nodes for the parts are different, that is, the possibility of superposition referred to multi-satellite integration at a specific time point is relatively small, and the total demand usually maintains a relatively stable state in unit time.
The time from the release of production plan to the demanded time node of integration is defined as the leadtime, which indicates the time for producing. As satellite projects implement the production plan of exclusive parts separately, it may exist time point T, as shown in Figure 1, at which exclusive parts have been delivered to Satellite A, but it is not necessary to install Part 1, while Part 2 has not been delivered, but Satellite B urgently needs Part 2. Due to the independence of satellite project management systems, Satellite B can not use Part 1, resulting in structural shortage, and a substantial increase in the shortage cost.

3. The solution strategy

It is indicated that a considerable number of exclusive parts can be used interchangeably between satellites. However, with the current strategy, the root cause of problems such as backup legacy and structural shortage is that the exclusive parts are managed by separated management systems. In order to solve the problems above, it is necessary to break the barriers between satellite projects and manage the parts as a whole.

The requirements of satellites are considerably diversified. The research [2] believes the use of general parts can well adapt to the diversity needs. Based on the generality of the exclusive parts, the general strategy is adopted, which is to separate the exclusive parts with generality from the separated whole-satellite management system to form a unified general management system of the exclusive parts. The general parts have a unified code system. The general part managers unify the production plan as a whole, and form the mode of "unified production, unified inventory".

A unified warehouse is used to avoid structural shortage, and because the parts are no longer belonged to the separated systems, the backups are cyclically utilized. Furthermore, the general parts strategy can reduce inventory cost through risk sharing [3]. It is also indicated [4] the cost of development and design, the cost of manufacturing are reduced by generalization. The general parts have successful flight experiences, which are of higher maturity and lower quality cost.

The specific flow chart of the production planning process is shown in Figure 2. According to the total demand Q and the existing inventory level W, the net gap quantity L can be obtained. In the actual manufacture, the parts delivered at a certain time point may not match the demand, inducing the risk of shortage. Under the original management mode, such risks cannot be avoided. In the general mode, in order to avoid shortage, dynamic supervision is carried out on the inventory, and a certain safety stock S is set up. The sum of the inventory of the exclusive parts W and the ones to be produced in the plan P is greater than or equal to the sum of the safety stock S and the net gap quantity L.

Figure 1. Structural shortage
\[ Q = \sum_{i=1}^{n} Q_i \]  

\[ L = Q \cdot W \]  

\[ P + W \geq S + L \]  

At any point in time, the inventory \( W \) should be maintained higher than the safety stock level. 

\[ W \geq S \]  

4. Conclusion

Some parts are universal, while in the current strategy of satellite integration, a separated management system is used for the exclusive parts. The analysis indicates the problems, such as backup residual, structural shortage and so on, are induced by the separated management. In this paper, the general parts strategy is proposed to form a unified general management system for exclusive parts, which is conducive to the full utilization of resources and cost reduction.

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