Research on Three-Dimensional Digital Assembly Technology of Communication Satellite Cable

Zhibin Liu¹,²*, Xiaohui Song¹,², Pu Yin³ and Xuewei Zhou¹

¹Beijing Institute of Spacecraft Environment Engineering, Beijing 100094, China
²Beijing Engineering Research Center of the Intelligent Assembly Technology and Equipment for Aerospace Product, Beijing 100094, China
³Communications Satellite Division, Beijing 100094, China

*Corresponding author’s e-mail: raindown@126.com

Abstract. With the development of information technology and the increasing task of communication satellite products, higher requirements are put forward for the design and manufacture of cables. The traditional cable design is based on the two-dimensional deployment layout. The design efficiency is low and the error of cable length is large. It is difficult to check the interference in the cable channel. In view of the new technology status of a telecommunication satellite, a comprehensive study has been carried out from cable design, production and manufacture to field laying of assembly. The design and production modes have been analysed and expounded, and the field laying of assembly has been summarized, which not only improves the efficiency, but also strengthens the quality and reliability. The three-dimensional digitization of subsequent satellites has been carried out in an all-round way. Design, manufacture and assembly technology provide technical basis and experience for reference.

1. Introduction

Digital technology is based on virtual reality and simulation technology. It unifies the modelling of product design, production, manufacturing and assembly process, realizes product design, processing, manufacturing and assembly on computer, simulates and simulates the whole life cycle, so as to optimize product design quality and manufacturing process, optimize production management and resource planning, and effectively reduce product research. The risks and costs of the system. [1][2]

Cables play a very important role in the manufacture of communication satellites. All instructions are transmitted through cables. In order to ensure the accuracy and smoothness of signal transmission on the satellite, ensure the normal and stable operation of the satellite in space, ensure the quality of the whole satellite, and avoid any abnormal quality. [3]

Therefore, the digital prototype design of cable can be realized in product design stage by using computer three-dimensional modelling technology, focusing on the rationality of cable layout and wiring, processing and assembly technology, so as to ensure the smooth progress of the actual production process.

The power requirement of a satellite is 7200W, which not only has a large number of cables, but also has a very complex trend. In order to ensure the high quality and high efficiency of the whole life cycle work, from the beginning of the design stage, three-dimensional tools have been used to design
the cable network, and a new mode has been applied to design, produce, manufacture and assembly work.

2. 3-D Digital Design

2.1. Traditional mode
AUTOCAD is used to design cable alignment. As shown in Figure 1, this model only contains the information of cable alignment and possible binding points. It cannot grasp the information of cable length, nor can it accurately and stereoscopically describe the rationality and correctness of cable alignment.[4]

2.2. Digital mode
In CATIA software, every cable is modelled entirely, as shown in Figure 2. In this way, the BOM tables with key information such as cable orientation, binding point, length, cable code, plug start and end code can be obtained in advance. This information can be transferred and transmitted in the form of Excel table, as shown in Table 1. The whole process realizes the online collaborative work mode between designers and designers, designers and manufacturing technicians, designers and assembly process. The technicians are involved in the process of cable three-dimensional digital design in advance. According to the connection relationship of cable, the cable diameter is calculated and assigned, so that the three-dimensional design result of cable is similar to the actual cable diameter. In the process of digital design, the rationality of the main channel and layout of cable design can be checked, and the design efficiency can be improved.

Figure 1. Traditional cable design mode
Figure 2. Digital Cable Wiring Effect

Table 1. BOM Table of Cable Information.

| No | Cable number | Name               | Line type | Length (mm) | Beginning end | terminal | Remarks     |
|----|--------------|--------------------|-----------|-------------|---------------|----------|-------------|
| 1  | XXW110       | X2Z(T). 30->XPN1-1.4 | 1124-24   | 7253        | X2Z (T)       | XPN1-1   | Twisted pair |
| 2  | XXW110       | X2Z(T). 38->XPN1-1.2 | 1124-24   | 7253        | X2Z (T)       | XPN1-1   | Twisted pair |
| 3  | XXW110       | X2Z(T). 37->XPN1-2.2 | 1124-24   | 7255        | X2Z (T)       | XPN1-2   | Twisted pair |
| 4  | XXW110       | X2Z(T). 29->XPN1-2.4 | 1124-24   | 7255        | X2Z (T)       | XPN1-2   | Twisted pair |
| 5  | XXW110       | X2Z (T). 36->XPN2-1.2 | 1124-24   | 5628        | X2Z (T)       | XPN2-1   | Twisted pair |
| 6  | XXW110       | X2Z(T). 28->XPN2-1.4 | 1124-24   | 5628        | X2Z (T)       | XPN2-1   | Twisted pair |
| 7  | XXW110       | X2Z(T). 35->XPN2-2.2 | 1124-24   | 5629        | X2Z (T)       | XPN2-2   | Twisted pair |
| 8  | XXW110       | X2Z(T). 27->XPN2-2.4 | 1124-24   | 5629        | X2Z (T)       | XPN2-2   | Twisted pair |

3. 3-D Digital Manufacturing

3.1. Traditional mode
According to the cable direction, the accurate cable length can be obtained through the actual simulation of wood mould processing. It depends on the operator's experience, and takes a long time and period, and the accuracy needs to be improved. [5]

3.2. Digital mode
According to the BOM table of cable information given in the digital model, the cable is manufactured and processed according to the pin layout projected by the digital model. The pin layout is shown in Figure 3.
4. 3-D Digital Technology

4.1. Traditional mode
Previously, in the assembly of communication satellites, the traditional assembly process card was still used as the main form of process documents. Assembly process planning process cards usually have only text content. Process documents are compiled by CAPP software. Kanban Production System (MES) is used to view process documents and two-dimensional drawings on the assembly site. For complex assembly operations, it is difficult to accurately transfer information.

4.2. Digital mode
Through the construction of a three-dimensional structured process planning system, the assembly process simulation and assembly implementation based on digital model are completed on some satellites, and a new mode of collaborative design, process design, assembly simulation and verification and field execution based on unified data source is preliminarily realized. As shown in Figure 4.

Figure 3. Digital nail layout.
Figure 4. 3-D Structured Process Planning System

In the digital mode, through combing the design requirements and forming a three-dimensional process digital prototype, as a unified data source of process design. It links the preceding with the following, takes the three-dimensional design model and file as input, is the source of information for process design and material preparation, and is also the basic framework for connecting satellite package. At the same time, the three-dimensional process digital prototype includes product structure tree, three-dimensional model and product attributes, in which product attributes refer to generic attributes such as name, code number, specification and special attributes that different types of products need to contain.

The organization of three-dimensional process documents refers to the structure of current two-dimensional process documents, which includes five parts: cover, process description, process route, process catalogue and process card. The structure of three-dimensional temporary process documents is the same.

5. 3-D Digital Assembly

5.1. Cable marking
In view of the change of cable design, manufacture and process mode, digital tools and means are adopted to carry out assembly work.

Traditional model: Cables need to be laid on wooden moulds for the following identification work:
1) Mark the direction of the cable on the main beam;
2) Make detailed labelling for each branch, branch point and reference points (span cable bridge, hatch hole, etc.).
3) The exit cables should indicate the location and length of the exit cabin.

Digital mode: In the process of cable production and manufacturing, the direction of cable is marked, and the work is carried out synchronously in advance, without occupying the main line time.

5.2. Site Laying Work
Traditional model: According to the logo, the two-dimensional orientation is not intuitive and takes a long time to lay the cables according to the cable orientation diagram and documents.

Digital mode: Field configuration workstation and large display screen, relying on three-dimensional process documents, combined with product lightweight model, model on-site display, by
switching different views, you can see the corresponding cable model, and see the laying details, greatly simplify the operation, improve the laying efficiency, as shown in Figure 5:

![Cable model diagram](image)

**Figure 5.** Schematic diagram of field lightweight model.

6. **Concluding remarks**

The three-dimensional digital design, manufacture and assembly of telecommunication satellite cables have realized real-time communication, improved design efficiency, laying speed and implementation quality, avoided the need for secondary processing of input files and error accumulation, and directly went to the factory using three-dimensional model of cables. It is more intuitive, the length of cable branches is more accurate, the weight and occupied space of cables on the device are reduced, and ultimately through. After displaying the three-dimensional model on the assembly site, the cable laying is more accurate and the efficiency is greatly improved.

Through the analysis of engineering requirements and the summary of practical results, the three-dimensional digital cable technology can greatly improve the efficiency and quality of cable design, manufacture and assembly, and meet the increasing demand of communication satellite production.

**References**

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