

Electric Propulsion Mounted Exploration Satellites Space Race

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1. Introduction

Many types of electric propulsions had been developed and equipped to spacecraft over last 50 years. Furthermore, the 702 SP satellite which was the all electrification satellite was developed by The Boeing Company. This satellite was not equipped chemical propulsion but electric propulsion. The satellite with only electric propulsion was the world-first. And, the asteroid explorer “Hayabusa” with electric propulsions was succeeded sample return mission. From these case, the electric propulsion was expected for further space development.

As the characteristics of the electric propulsion, the specific impulse was higher than it of chemical propulsion. Therefore, it was achieved reduced propellant weight and long lifetime of thruster.

It is considered the race of satellite with electric propulsion was carried out for further development of the electric propulsion. And, the technical strength of the world was improved through this race.

2. Summary

The race of satellite with electric propulsion is international race. The satellite using this race is manufactured by participating team. As major promise, the electric propulsion must be equipped. And, the rules of the convention must be protected. Moreover, the several tasks are configured and divided them into Full mission and Sub mission. The Full success must be succeed. The Sub mission is evaluated according to the number of success mission. And, advanced mission is set in addition Full success and Sub mission. As the example, the contents of the task are shown in chapter 3. Finally, the race is a point addition method and a team with a high overall score is a victory.

3. Example race (the moon exploration race)

The moon exploration race is suggested for the example. The Full success is decided to the moon exploration and sampling of the moon. And, the Sub mission is decided to operation confirmation of equipment used in Full success. Finally, the advanced mission is planned to provide functions that are unnecessary for the Full success. For example, shooting movies when the satellite is approaching the moon and flagging the moon. The advanced mission is shown several tasks and participating teams are selected at least 3 missions. The score is changed by the difficulty level of the mission.

The satellite of summary in this race is shown in table 1. And, it is considered the satellite of each participating team is carried out the launch in a short span. Because, the superiority or inferiority by the environment is eliminated to the satellite. The score in this race shows table 2 as the example.

Table 1 Design conditions of satellite

The target heavenly body	Moon
Satellite weight	Max 1000 kg
Cost	Max \$100,000,000
First orbital altitude	600 km
Mission limit	Max 5 years

Table 2 Score example

	First place	10 points
	Second place	8 points
	Third place	6 points
	Fourth place or less	5 points
Cost	+ 1 point for every \$ 10 million decrease	
Satellite weight	+ 1 point for every 100 kg decrease	
Sample weight	+ 1 point for every 0.1g increase	
Certainty	- 1 point for every error	
Advanced mission	+ 1 point for every success	

As the example, team A, team B and team C are compared in this method. The satellite of summary of 3 teams show in tables 3, 4 and 5, respectively. The winner is team B. However, the winner is not the first place but the team which earned more points. However, team C is put out of the race, because the Full success is failed.

Table 3 team A

content	result	score
Mission success	First place	10
Satellite weight	962 kg	0
Cost	\$ 82 million	1
Sample weight	0.5 g	5
Advanced mission	3missions success	3
Certainty	one error	-1
Total point		18

Table 4 team B

content	result	score
Mission success	Third place	6
Satellite weight	850 kg	1
Cost	\$ 90 million	1
Sample weight	1.0 g	10
Advanced mission	3missions success	3
Certainty	non error	0
Total point		21

Table 5 team C

content	result	score
Mission success	Not success	0
Satellite weight	600 kg	4
Cost	\$ 70 million	3
Sample weight	Not success	0
Advanced mission	4missions success	4
Certainty	non error	0
Total point		11

4. Prohibited matter

In order to be fair, some prohibitions on racing were established a rule. If it break this rule, it will be disqualified. Even if there are spare satellites, it can't participate in this race.

- Prohibit acts of disturbing and destroying satellites of other countries.
 - Prohibition to equip devices (guns, lasers, radio waves, coil guns, etc.) for disturb.
 - Prohibit destroying by colliding with other country's satellites.
 - Acts of connect to the other satellites in tether or the arm, obstruct, act to reduce propellant, destroy, etc.
- The propulsion device can use only the electric propulsion device.
- It is possible to use two satellites per one team.

5. Precaution

1 team launch the two satellites, it admitted that fulfill one of the missions. However, the provision of production cost, total weight, etc. must be satisfied in total.

Table 6 Possible example

Case1 (pass)	Satellite 1	Satellite 2	Total
Weight	500 kg	300 kg	800 kg
Cost	\$ 80 million	\$ 15 million	\$ 95 million
Mission	Full success	Sub mission Advanced mission	/

Table 7 Impossible example

Case2 (failure)	Satellite 1	Satellite 2	Total
Weight	700kg	500kg	1,200kg
Cost	\$ 80 million	\$ 50 million	\$ 130 million
mission	Full success	Sub mission Advanced mission	/

6. Others

Production cost of the satellite was paid participating teams. However, the launch cost to make the Executive Committee, such as ICO, so that it can be covered by donation. As an alternative, it is proposed to seek cooperation in Space Development Organization in each country.

7. Problems

There are some problems in carrying out this race.

- Preparation period, race period, and scoring period will take many years.
- When it is a difficult task, achieving itself becomes difficult.
- If it is a 1000 kg class satellite, it will be a national project.
- The budget is enormous.
- Whether launch is possible in the first place or not.

8. Advantages

The purpose of this race is to make new needs, to draw interests of the general public and to share technologies from around the world.

Making needs of the race will cost the money to make rockets, satellites, electric propulsions and so on. Costing the money at the same time progressed research, which leads to making better products.

Next, attaching interests of many companies and universities. It is possible to draw an interest in placing the entertainment that race, companies and universities that had been hesitant to enter so far became easier to enter, it believes that it can contribute to the future development.

In addition, to create the occasion to show off the technology outside of the conference, the opportunity to know the technology of the world believers that it possible. The idea of this race will also be a fire for new space development.