CUBE SAT LAUNCHING INVESTIGATION

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ABSTRACT

Today different groups started to manufacture cubesats because of the low cost of manufacturing and launching the satellites. With the growth of cubesat manufacturing, the scientist has tried to produce the small launchers to respond the needs of new researchers and young scientists. In 1980 the U.S.A. manufactured the commercial small launcher and starting launch in 1990. Also Russia with improvement of their ballistic missile and performing changes and improvement tried to manufacture small launchers with a minimum cost to launch the cubesat in the planed orbits.

The cubesat will be launched into space together with other cubesats inside a so called P-pod it will be placed on top of the launch vehicle as a secondary payload and a principal feature of the cluster launch cubesat is to mitigate the technical and financial risk shared by the orbital deployers who are partners in a particular launch. While maintaining reasonable costs and ensuring time delivery. In accordance with the investigations, more than 10 launchers in the world which has the experience of launching cubesats have been identified. Out of these launched cubesats some of them due to the problems and malfunction of launch vehicles have been failed. Some of the successful and failed launch vehicle has been investigated and mentioned below.

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1. INTRODUCTION

Today most of the countries in the world which they have enough potential in the space, are willing to progress in the aerospace science and in the respect they would like to be independent and pioneers. Therefore with utilization and selection of different ways and small or big projects in the space they intend to customize the aerospace science their own countries.

One of this projects that we can mention is the cubesats project which during the recent years in most universities, companies and schools are paying special attention on them. Cubesats have low weight, small dimension and the cost of manufacturing and production are comparatively low when comparing to other project. Cubesats can perform sensitive and important missions in the direction of science and experience progress. Since cubesats have small size and weight, launching of them will be easer and cheaper

because they will be launch as a secondary payload and they can position in the orbit form of cluster.

Damaged by unpredicted, incorrect deployment (from p-pod), incorrect activation and no available launches are potential launch problems. Particular attention to the cost and expenditure, safety and reliability of the launcher, successful percentage of the launch vehicle, geography situation and also the acceptance and waiting time for getting permission of launching of the cubesats should be considered. So launcher selection of the cubesats can be considered as an important factor in successful of sat project. Investigating the function of launchers makes it possible to select the best launcher to send cubesats to space.

2. INTEGRATION AND LAUNCH

A unique feature of the Cubesat Program is the use of a standard deployment system P-pod standardization is used to reduce mission cost and accelerate development time. This framework allows universities and organizations worldwide to develop and launch Cubesats without directly interfacing with launch providers. The P-POD also protecting Cubesats from hazardous environmental factors such as dust.

It is basically a rectangular box with a large spring inside, on one side. These springs provide enough torque to quickly move the door. There is a hatch door where the cube sat will enter & exit. When a cubesat is placed in the pod, it compresses the spring which at launch time, will push the cubesat out in to orbit. P-Pod's duty is to open the door at the right time and push Cubesats out. Also, the fully enclosed P-POD has proven itself to isolate the primary payload(s) from any bad behavior of the low-cost, low-priority Cubesats inside.

It is very important that P-POD is compatible with a wide variety domestic and foreign LV. Some Launches are often delayed. we should be prepared for this, with procedures to charge batteries while in storage, verify functionality, even update software fix bugs Traditionally, Cubesats were considered low-priority and risky, and so were ejected last from the rocket as a safety precaution. This severely limited the orbits available to Cubesats. However, thinking vis-à-vis Cubesats is now changing, as rockets are now willing to release Cubesats at low orbits before the primary payload is released because for example carrying just 3 P-POD deployers (9 1U Cubesats) is worth \$0.5M to the launch company. It's good business for them.



Figure 1 P-POD

The Test & Integration (T&I) stage may be the first time your Cubesat is verified by a third party against the specification. Traditionally, 1U Cubesats must conform strictly but 3U Cubesats (10x10x30cm) have more leeway, as they are alone in the P-POD.

3. NUMBER OF LAUNCHERS

Many countries with using different types and advanced launcher have tried to send the various payloads to the space. According to international statistics and information published, the Russian has had the most activities in the space in year 2008 and the USA has stand in the second position.

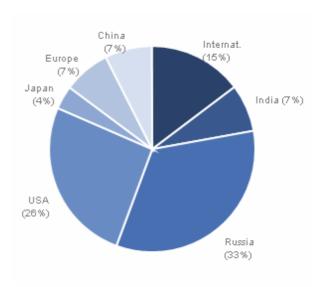


Figure 2 Percents ratio of launchers

3.1. PSLV

PSLV is the workhorse launch vehicle of the Indian Space Research Organization (ISRO) with nine consecutively successful flights so far. Since its first successful launch in 1994, PSLV has launched seven Indian remote sensing satellites, an amateur radio satellite, HAMSAT, and four small satellites for foreign customers into 550-800 km high polar SSOs. Besides, it has also launched India's exclusive meteorological satellite, Kalpana-1, into Geosynchronous Transfer Orbit (GTO). PSLV will also be used to launch India's first spacecraft mission to moon, Chandrayaan-1, during 2008.

The 44 m tall PSLV has a lift-off mass of 295 tones. It is a four-stage launch vehicle. PSLV's first stage is one of the largest solid propellant boosters in the world. Its second and fourth stages use liquid propellants. PSLV's payload fairing has a diameter of 3.2 meter. The vehicle has S-band telemetry and C-band transponder systems for monitoring its health and flight status. It also has sophisticated auxiliary systems like stage and payload fairing separation systems.

Launching period and duration is substantial in schedule and investment on projects of satellite. If it is possible to determination and to know the exact time launching the project duration and completion can be exactly selected and will be adjusted to finish the project in a shortest time and with the lowest time for integration payload with the launcher for the required orbit. Also with knowing the planning and policy of launching the cubesats, waiting time for integration reduce and can launch payload faster without any delays in time so starting the operation in the space.

With reviewing the time of launching PSLV (Polar Space Launch Vehicle) during the last eight years we determine the in year 2001 to 2005 only one launching in year has been happened. But in year 2007 payload transmission with this launch vehicle has increase two per year. In 2008 four launching has been scheduled. Up to now in year 2008 there has been 2 successful launches which one of them carried batch of cubesats. This secondary payload contain of 6 cubesats from different countries. Maybe this success causes sending further cubesats to the orbit in next coming years. Other launching will be done next coming month by PSLV so we can conclude that the duration and interval of launching in the recent years has been reduced. so that from one launch in years between 2001 to 2005 increase to four launching per year (every 3 months) has been performed. From all this changes we can result the following important subjects:

Space activities and launching satellite particularly cubesats to the space are expanded and improving. Attention of authorities and policy makers has increased in space industries.

PSLV potential indicates that without any malfunction and defects can carry the payloads. Safety and reliability of launcher has increased since all of the nine launching to the space has been implemented successfully so that percentage of success is 100.

3.2. **DNEPR**

Dnepr launch vehicle which is the ballistic missile launches SS-18. Launch service provided by a Russian-Ukrainian company Cosmotrons. up to now it had ten launches and out of these nine of them had successful launching. But the launch which was done in year 2006 that was included of fourteen cubesats was crashed because the first stage did not properly separate from the Dnepr rocket and all of the payloads were lost. Dnepr launch vehicle had the responsibility of carrying 21 satellites and because 14 of them were failed. But in April 2008 performed successful launch and was delivered cubesats in the space. So we can say that the success of Dnepr in launching the cubesats was in total 15 percent.

Launch costs to the developer include: P-POD and LV interface development, Cost to launch 1 kg of Cubesat, cost to launch mass of the P-POD, manufacturing, testing and, Licensing.

Cost per cubesat that weights one kilogram or less is \$30000 - \$40000 in year 2003. Cost to complete a Cube Sat mission (inception to launch to operation to end-of-life) ranges from <\$100,000 to \$1,500,000, depending on a variety of factors (2005).

3.3. *ROCKOT*

The Eurockot is other launcher that we are investigating. Rockot is a fully operational, three stage, liquid propellant Russian launch vehicle which is being offered commercially by EUROCKOT Launch Services for launches into low earth orbit. EUROCKOT, a German-Russian joint venture company was formed specifically to offer this vehicle commercially. Launch services provide commercial launch services with the Rocket launch system to operators of low earth orbit satellite formed in 1995.

The booster unit which provides the first and second stages of Rockot is taken from existing SS-19 missiles and is accommodated within an existing transportation/launch container. The third stage which provides the orbital capability of the launcher is newly

manufactured. This upper stage contains a modern, autonomous control/ guidance system which controls all three stages. The upper stage multiple engine ignition capability allows implementation of various payload injection schemes.

The first series of cubesats has been delivered in arbitrary orbit in year 2003. This cubesats has been launched be Rockot launch vehicle. The Rockot launcher also the same as PSLV only assigned one launch for the cubesats payload in to space .This vehicle in year 2003 has launched 2 times from the plestsk in northern Russia site. At the 2005 is also 2 launches has been accomplished from same site

Which one of this launches due to technical failure was not successful and encounter with the fail of operation so the payload was destroyed. In the year 2006 only one launch and for the years 2008 and 2009 four launches have been planned.

As the statistics shows and it is clear this launcher has increase activities and decide to reduce the intervals to improve the launching condition so they can properly send the payloads to the space. We can believe that year 2008 has been the highest level of activities for Rockot launcher.

Declaration and introducing of future planning and scheduling of launch it will provide the possibility for the satellite manufacture with consider the launch time and schematization of sat project to reduce the cost and time delay and integration of required payloads with launcher.

3.5. Falcon-1

Falcon-1 is a small liquid fueled orbital launch vehicle, which is currently under development at SpaceX (Space Exploration Technologies Corporation).

The first stage, which will be reusable after recovery by parachutes, is to be powered by the SpaceX built Merlin engine. The second stage will be propelled by the Kestrel engine, which uses technology derived from of the Lunar Module Descent Engine.

Planned launch sites are SLC-3W at Vandenberg for high inclination launches and a launch site on Omelek Island in the Marshall Islands. A Cape Canaveral launch pad is also considered for launching.

The basic Falcon-1 vehicle will carry up to 420 kg payloads to low earth orbit. SpaceX claims, the Falcon will reduce the costs for an orbital launch by the factor of three - a price of \$ 6.7 million for the basic version is planned.

The operational Falcon-1 uses the regenerative cooled Merlin-1C engine beginning with the third Falcon flight in mid 2008.

This launcher in year 2006 and 2007 could not perform mission. In 2008 there is going to be two launching which in every launch several cubesats will be delivered to the orbit. This is for the first time that the falcon-1 will be transferred cubic satellite.

3.4. VEGA

Although there is a growing tendency for satellites to become larger, there is still a need for a small launcher to place 300 to 2000 kg satellites, economically, into the polar and low-Earth orbits used for many scientific and Earth observation missions. Europe's answer to these needs is Vega. Vega is designed to launch a wide range of mission and payload configurations to respond to different market opportunities and therefore provide the flexibility needed by the customer. Vega has been designed as a single body launcher with three solid propulsion stages and an additional liquid propulsion upper module used for attitude and orbit control, and satellite release. It is 30m high, has a maximum diameter of 3m and weight 137 tons at lift-off. Unlike most small launchers, Vega will be able to place multiple payloads into orbit.

The Vega is example of small launcher which investigates in this paper. Because this small launcher attempt to send 11 cubesats with LARES and pw-sat primary science payload in to arbitrary orbit.

Each launcher for acceptance of payload has requirement which must be attend. Some requirements have been mentioned in below:

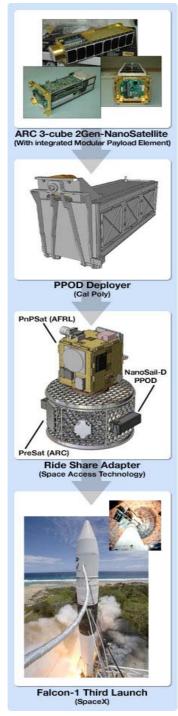


Figure 3 Preparing the Cubesats launch

The concept of double and triple cubesats, with dimension of $10\times10\times20$ and $10\times10\times30$ respectively and a corresponding increase in the mass, have also been developed, but for the peruse of the Vega new flight only single cubesat modules will be accepted by ESA.

All Cubesats proposed for launch on the Maiden Flight shall undergo a test campaign showing their compliance to the launcher requirements. Besides this, the test plan shall include also any additional testing requirements deemed necessary to ensure the safety of the payload. The tests levels shall be in accordance with the proposed model philosophy including therefore qualification testing in case of absence of previously developed flight models covering the requirements of the VEGA launcher The schedule of the payload has to comply with the Vega Maiden Flight schedule requirements. ESA for the flight opportunity, each educational institution will be required to sign a legal agreement committing to the provision of all deliverables by the schedule. Cubesats team must be submitting proposal.

The proposal should contain: a description of the objectives of the Cubesat, with mission profile and duration, a technical description of the Cubesat (including development and off-the shelf items), the test plan and envisaged test facilities, a discussion of the compatibility with the envisaged orbit, a description of the envisaged ground station or ground station network and its readiness, detailed planning schedule, including the availability of any non-flight models which may be built purely for test purposes, until the earliest flight model delivery date, composition of students involved in the project through all stages (numbers, academic level, relevant background and experience) and academic credit available to the students for this project work, the names of the key people in the project, including a central point of contact for the team with email address and phone number and a cost breakdown and a description of the funding sources.

4. CONCLUSION

Special attention to the cubesat launching in the scientific center is growing and developing to the last year and the indication is that lot of launchers has been transfer the satellite to the orbit. According to reviews and research in paper can recognize this main subject that has been the cost of launch, launching interval, high performance and reliability are the factors which have been effective in selection of launch vehicle. The launcher's project managers are considering factors till the customers more satisfied.

Due to globalization of nanosatellite program it is suggest providing special launch vehicle flexibility for nanosatellite.

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