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Naval Postgraduate School CubeSat Launcher (NPSCuL)

Space-Available Manifesting Process and Requirements

Version 1

November 30, 2008

Naval Postgraduate School

Space Systems Academic Group

Approved for public release; distribution is unlimited

UNCLASSIFIED

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ACRONYMS

ABC	-	Aft Bulkhead Carrier
Cal Poly	-	The California Polytechnic State University (San Luis Obispo)
CDS	-	CubeSat Design Specification - maintained and released by Cal Poly
CSEWI	-	California Space Education & Workforce Institute
DoD	-	Department of Defense
EELV	-	Evolved Expendable Launch Vehicle
ESPA	-	EELV Secondary Payload Adapter
NCQ	-	NPSCuL CubeSat Queue
NPS	-	Naval Postgraduate School
NPSCuL	-	NPS CubeSat Launcher
NPC	-	NPSCuL Payload Coordinator
P-POD	-	Poly Picosatellite Orbital Deplorer
SERB	-	(STP) Space Experiments Review Board
STP	-	Space Test Program
WIRED	-	Workforce Innovation in Regional Economic Development

INTRODUCTION

The Naval Postgraduate School (NPS) CubeSat Launcher (NPSCuL, pronounced "NPS cool") is a high-capacity CubeSat launcher designed to work with US evolved expendable launch vehicles (EELV). NPSCuL is an adapter that can attach multiple California Polytechnic State University (Cal Poly) Pico-satellite Orbital Deployers (P-POD) to a single EELV Secondary Payload Adapter (ESPA) slot. NPSCuL is a simple and inexpensive adapter that should allow these proven technologies to be used jointly, thereby facilitating high-capacity US based CubeSat launches on US Government, Department of Defense (DoD), and Commercial ESPA compatible launch vehicles.

There are two varieties of NPSCuL, "Standard" and "Lite". NPSCuL-Standard has 10 slots for 3U or 5U P-PODs. Additionally 6U (also known as the NASA Ames "six pack") P-POD can be accommodated by using two slots each. NPSCuL-Lite has 8 slots which can accommodate 3U P-PODs or 6U P-PODs. NPSCuL-Standard has been developed to maximize capacity for use on the EELV ESPA adapters. NPSCuL-Lite, while still ESPA compatible is designed for use on smaller secondary payload adapters, such as the Atlas V Aft Bulkhead Carrier (ABC), having less volume and mass .

The purpose of this document is to describe the current method to manifest non-US Government DoD-relevant payloads on US government sponsored space launches, and to introduce a new process to manifest non-Government CubeSat payloads on a space-available basis on US Government space launches through NPSCuL. Government payloads and CubeSats may be manifested through processes already in place such as the US Air Force (USAF) Space Test Program (STP).

THE DOD SERB PROCESS OVERVIEW:

The STP is part of the Air Force Space Development and Test Wing at Kirkland AFB in Albuquerque, New Mexico, and was created in 1965 with the purpose of providing spaceflight for the DoD research community. From creation until present, STP has facilitated launch for over 120 missions using dedicated free-flyers, the space shuttle, and other piggyback payload opportunities.

Since there are more experiments requesting space launch opportunities than are possible to launch, the STP reviews and ranks experiments through the DoD Space Experiments Review Board (SERB) process. Experiments which compete for launch through the DoD SERB must be sponsored by a DoD agency. Although typically originating from one of the DoD services, laboratories, or research institutions, experiments can also come from other federal agencies or U.S. universities. Partnerships between non-DoD and DoD experimenters qualify for consideration in the SERB process.

The DoD SERB meets in October or November of each year and the panel consists of representatives of the various services and other DoD agencies and partners, such as NASA. Each experiment will be presented to the panel by the DoD sponsoring agency, after which each experiment is ranked according to DoD relevance, experiment quality, and service priorities. The SERB produces a prioritized list of space experiments.

Each rideshare opportunity for launching a SERB payload is analyzed, including launch mass margin, mission sensitivity, orbital parameters, and other constraints for compatibility with STP secondary payload experiments. The DoD SERB list is used to identify experiments which may be best suited for the rideshare mission. The STP will requires comprehensive technical information on each experiment identified for possible manifestation onboard the launch. The remaining process varies and depends on the complexity and unique requirements of the mission.

There is no standard process to gain sponsorship from a DoD agency by a non-DoD experiment provider. If a non-DoD space experiment developer felt their experiment was of some DoD relevance, and wanted to find a launch opportunity through

the SERB process, they should contact individual DoD agencies and request an opportunity to present their experiment to that agency. If an agency found an experiment to be of particular interest and wanted to become a partner in the experiment, it may choose to sponsor and present the experiment to the DoD SERB. Experiments not of interest to the DoD would probably find it difficult to find a DoD sponsor. Nano-satellites and CubeSat developers, even if they have a satellite of DoD relevance, may find the STP rideshare process arduous since it typically serves larger (400 lb – 6000 lb) secondary payloads, by their nature, more complex, with higher budgets and more team members than usually found with nano-satellite and CubeSat developers. While NPSCuL fills the needs of the DoD and SERB process, it should also enable non-DoD CubeSat developers to fly on a space-available basis. The next section of this document describes that process.

THE NPSCUL MANIFESTING PROCESS OVERVIEW:

NPSCuL is a means to provide CubeSat launch on US EELV compatible launch vehicles. NPSCuL-Standard and NPSCuL-Lite are both compatible with the ESPA. In addition to the ESPA, NPSCuL-Lite is compatible with other secondary payload adapters such as the new ABC adapter being developed for Atlas V launch vehicles, and may be compatible with an adapter for NASA's Minotaur rocket.

NPSCuL has been presented to the STP SERB and has received a favorable ranking on the SERB list. NPSCuL was presented as an experiment, but also it is an enabling technology for deploying a large volume of CubeSats. While it is expected that the NPSCuL will be manifested by the STP to enable launch for DoD CubeSat payloads on the SERB list, it is possible that NPSCuL could be manifested by other government flight providers when necessary to launch specific government CubeSat payloads.

Although the primary motivation for STP, or any other government launch provider, to launch an NPSCuL may be to provide a launch opportunity for DoD CubeSat payloads, DoD experiments may not necessarily use the entire NPSCuL CubeSat payload capacity. When excess CubeSat launch capacity is available, rather than waste the remaining CubeSat payload capacity NPS has developed a process to provide launch opportunities for non-DoD educational and commercial CubeSat developers not traditionally served by the SERB process.

NPS expects certification requirements to launch on NPSCuL to be consistent with those already required for launch by most CubeSat launch providers. CubeSats interested in being manifested on NPSCuL must, at a minimum, have the ability to communicate with a ground station and serve some useful national, scientific, or educational purpose. US developers launching on NPSCuL will have the added benefit of avoiding many, if not all, ITAR related complications often encountered on foreign launches. While launch onboard NPSCuL is expected to be free, the cost of integrating a developer's CubeSat into a P-POD are expected to be similar to current Cal Poly integration costs.

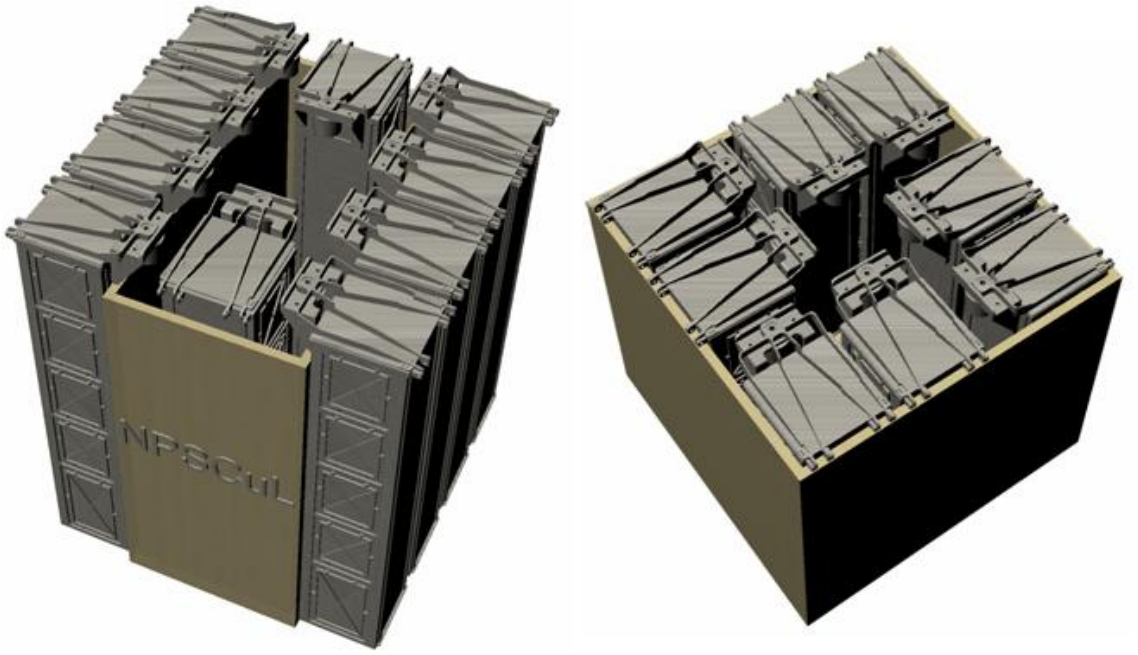

Figure 1 – NPSCuL-Standard (Left) and NPSCuL-Lite (Right)

The NPS Space Systems Academic Group will be responsible for all aspects of the NPSCuL launcher, including construction, testing, and integration of loaded P-PODs with NPSCuL. NPS will make all necessary arrangements with the appropriate US Government flight provider, typically the STP, and will work with Cal Poly regarding P-POD acquisition and CubeSat to P-POD integration.

Domestic CubeSat developers will be listed on the NPSCuL CubeSat Queue (NCQ) on a first-come, first-serve basis. CubeSat developers seeking space-available deployment by NPSCuL will be offered opportunities in the order they fall on the NCQ. Developers requesting launch for multiple CubeSat experiments will be permitted one CubeSat experiment per launch, with their other CubeSat experiments then in line for the next launch or potentially as current backups. To be included on the NCQ a developer needs to complete the form included at the end of this document and mail or email a copy to NPS. Details for mail and email are found on the questionnaire. Once received, NPS will notify the sender of receipt and confirm their CubeSat payload has been placed on the NCQ, including the date and time their completed questionnaire was received for purposes of NCQ listing order. After all available domestic CubeSats have been

manifested on NPSCuL, any remaining space-available capacity may be allocated for CubeSat launch for our international CubeSat partners. While the intent is to launch on a first-come, first-serve basis, the US Government reserves the right to launch any CubeSat in whatever order deemed to be in the national interest.

CubeSat developers should contact Cal Poly as early as possible to verify proper testing requirements for their CubeSat payloads. Some typical testing and documentation that should be expected for all CubeSat includes random vibration testing, multiple bake-out cycles and associated documentation, and a materials list for all materials in their CubeSat. The testing required by Cal Poly is to guarantee that each CubeSat payload will not present a hazard to the primary payload or other secondary payloads including other CubeSats in the same P-POD. Testing required by Cal Poly is not designed to guarantee CubeSat functionality after deployment – each CubeSat developer is individually responsible to conduct whatever testing and analysis is necessary to guarantee functionality of their CubeSat payloads after launch and deployment.

When a flight opportunity is announced and the launch date and orbital parameters are known, CubeSat developers will be asked to state whether they are interested in that opportunity or whether they want to pass until the next opportunity. Once NPS knows the expected number of space-available slots on NPSCuL, CubeSats on the NCQ will be assigned a status of “tentatively manifested” or “tentative alternate”. The “tentative” before each label meaning that this is their intended status but can not yet be confirmed until STP provides the final number of space-available slots to NPS. The purpose of assigning tentative status categories is to allow CubeSat developers as much notice as possible of possible flight opportunities. NPS will assign CubeSats on the NCQ the status of “manifested” and “alternate” after the final number of space-available slots is confirmed by STP and after STP approves the proposed manifest and alternate lists. Manifested status indicates the CubeSat is manifested to use one of the space-available slots. Alternate status indicates a CubeSat part of the group who are in line for launch if any of the manifested CubeSats (both space-available manifested and DoD manifested) fail to make launch. There may be multiple CubeSats in any status category. Once begun, the NCQ will remain a single continuous list, or queue across multiple launches. This avoids tying specific CubeSats only to specific flights, but allows more flexibility in

scheduling. If CubeSats on the NCQ are not able to make a launch, they will keep their position in line for the next available launch.

Developers with CubeSats on the NCQ will be informed of their status as soon as possible so they can commence preparations and begin coordinating efforts between themselves and Cal Poly. To prevent launching NPSCuL with empty slots that could have been used by other CubeSat developers it is imperative that CubeSat developers meet certain milestones once manifested for flight on NPSCuL. The specific milestone schedule will be released at the same time or shortly after the announcement to solicit CubeSats for launch. A milestone review will take place ten months before launch. Any CubeSats which have not met the necessary milestones may be required to undergo a second review two months later and possibly be de-manifested. If the necessary milestones are still incomplete at the second review, to ensure NPSCuL is fully loaded for launch, CubeSats on the alternate list which have met their milestones may be manifested. Informal status and coordination between formal reviews will take place as needed.

TYPICAL TIMELINE FOR NPSCUL LAUNCH

L – 24 months:	NPSCuL chosen for flight by STP
L – 24 months:	NPS releases announcement for CubeSat launch.
L – 20 months:	NPS notified by STP of the tentative number of space-available CubeSat payload slots. Tentative space-available manifest list distributed by NPS including back-up list as soon as possible thereafter.
L – 15 months:	STP notifies NPS of the number of space-available CubeSat payload slots. NPS distributes the manifest and alternate lists for the launch.
L – 10 months:	Formal milestone review of manifested and back-up CubeSats. Manifested CubeSats that have not met the necessary milestones may be required to undergo a second milestone review in two months.
L – 9 months:	CubeSat to P-POD fit check at Cal Poly.
L – 8 months:	Second milestone review for any manifested CubeSats which failed to complete necessary milestones at the L-10 month review. Manifested CubeSats may be replaced with back-up CubeSats at this time if necessary milestones remain incomplete.
L – 5 months:	CubeSats delivered to Cal Poly for integration and testing.
L – 4 months:	P-PODs delivered to NPS for integration onto NPSCuL
L – 3 months:	NPSCuL delivered to STP for integration onto launch vehicle.
L – 0 months:	Launch

GENERAL GUIDELINES FOR ALL CUBESAT PAYLOADS.

All CubeSat payloads should adhere to the following guidelines; exceptions are highly discouraged and may disqualify a CubeSat for flight. Any exceptions should be discussed with the NPS as early as possible.

1) CubeSats developers must fill out the attached questionnaire describing their CubeSat and its required orbital parameters.

2) CubeSats must serve some useful national, scientific or educational purpose.

3) CubeSats must have the ability to communicate with a ground station.

4) CubeSats may not request an orbit that would cause their CubeSat to remain in orbit longer than 25 years after the end of their mission, unless they have received a waver from the FCC. CubeSat developers are solely responsible for requesting and acquiring any wavers if necessary. Unless a waver is obtained, CubeSat developers are required to calculated the orbital lifetime after mission end and provide this calculation to NPS.

5) CubeSats should meet all requirements outlined in the most current revision of the CubeSat Design Specification (CDS) published by the California Polytechnic State University (Cal Poly).

6) The most current version can be found at the following website: http://cubesat.atl.calpoly.edu/media/Documents/Developers/CDS%20R9.pdf

7) CubeSats must pass qualification and acceptance testing for the Pre-launch and Launch environment outlined in the most current revision of the appropriate Secondary Payload Planners Guide and provide appropriate documentation to Cal Poly.

   The most current version of the ESPA Payload Planners Guide can be found at the following website:

http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA435515&Location=U2&doc=GetTRDoc.pdf

8) It is recommended that CubeSats meet minimum cleanliness requirements of class 100,000 cleanroom.

9) CubeSats may not impose requirements on the launch provider or program office.

10) In general, due to the large number of potential CubeSat developers, space-available CubeSat developers chosen for launch should direct any communication with the launch provider through the Cal Poly and NPSCuL Payload Coordinators.

11) Additional testing and requirements could possibly be required by the Primary Payload. If so, this will be provided as soon as it is known.

THE PRE-LAUNCH AND LAUNCH ENVIRONMENT:

The Launch environment varies for each secondary payload adapter. For complete details please see the appropriate secondary payload planner's guide.

In the spirit of not impacting the primary payload, expect requirements to be imposed that support this objective. For example, it is possible that a CubeSat developer may not have access to their CubeSat once delivered to Cal Poly, and it could be up to six months from time of delivery to launch. Therefore CubeSat developers should not expect to be recharge or access their CubeSats during this time.

The specific environmental testing requirements for each launch will be a combination of the requirements found in the applicable secondary payload planners guide, the CDS, and any additional requirements on a mission unique basis. Specifics requirements for each launch, including mission unique requirements will be released shortly after the NPSCuL manifesting process begins. In general requirements should be consistent with the pre-launch and launch environments found in the applicable secondary payload planner's guide and the CDS.

NPSCuL CubeSat Queue (NCQ) Questionnaire

Once Complete Email or Mail this Application to one of the following:	Email: NPSCuL@nps.edu Mail: Naval Postgraduate School NPSCuL Team 215 Bullard Hall Monterey, CA 93943

CubeSat Name:			
Short Description:			
Administrative Contact:		Title:	
Organization:			
Street:			
Street:			
City:			
Postal Code:		Country:	
Phone Number:			
Email:			
Website:			

Initial Launch Capability (Date):	
Mission Duration:	

Desired Orbital Parameters			
Apogee (km):	+/- (km)	Perigee (km):	+/- (km)
Inclination:	+/- (deg)		
Estimated orbital Lifetime after mission completion:	Shortest (months)(largest apogee/perigee):		
	Longest (months)(smallest apogee/perigee):		
Describe basis for shortest/longest orbital lifetime calculation after mission completion (included atmospheric model, reasoning, etc):			

Other orbital parameters / notes:
Should NPS contact you about potential launch opportunities even if the orbital parameters do not meet your desired orbital parameters? YES / NO (Circle one)

Are there any pressure vessels on the CubeSat? (If so list pressure vessel type, contents and pressure)
Does the CubeSat contain hazardous materials? (If so list type and quantity)
Is there any onboard Propulsion? (If so please describe including propellant type, etc)
Are there any deployable structures? (If so please describe)
Are there any special considerations? (Safety, ITAR, classification level, proprietary, etc.):

Abstract: In 500 words or less describe the mission of the CubeSat.

Note: If desired, attach a more comprehensive description of your CubeSat (no more than 8 pages) as necessary.