

The Development of Small-Payload Rideshare Capabilities: A 2000–2008 Summary

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Abstract—This paper summarizes the development from 2000 to the present of rideshare capabilities by various Government Agencies and Organizations. This development will allow acceptable, low-cost access to space for small satellites and payloads. The paper reviews the needs for such capabilities and provides an overview of the development and status of the enabling technologies, hardware, etc. required to achieve the desired capability. It reviews the development and status of each principal element necessary in developing an acceptable, low cost, access to space capability for small satellites and payloads. This includes a review of:

- The development and status of new and emerging small launch vehicle capabilities, i.e., Minotaur I and IV, SpaceX Falcon, etc.
- The development and status of compatible payload adapters for single, dual and multiple payloads.
- The development of interface standards, planners guides, etc., to assist potential users.
- The development of the launch and ground support/tracking facilities for small launch vehicles to support the low-cost access to space for small satellites and payloads, i.e., Wallops, Kodiak and Kwajalein, Facilities.

In addition, this paper also addresses the potential opportunities for low-cost access to space for small satellites and payloads as either auxiliary payloads (i.e., piggyback satellites on operational launches) or as hosted payloads on operational satellites (including civil, Department of Defense [DoD], or commercial programs). Specific examples (as presented at the recent 2008 Small Payload Rideshare Conference) [1] will include summaries of on-going DoD/SDTW activities in the development, demonstration, and utilization of these evolving capabilities, such as the Minotaur I and IV launch vehicles, Evolved Expendable Launch Vehicle (EELV) ridesharing via the EELV Secondary Payload Adaptor (ESPA), future plans utilizing the Standard Interface Vehicle (SIV), etc. Also, it presents a brief overview of on-going and emerging small satellite/payload development activities at the Government (NASA, DoD), university (CubeSats/P-PODS), and commercial levels. Finally, it gives a brief review of various, recent Government agencies/stakeholders collaborative activities, policies, etc., which are necessary to

utilize these emerging capabilities, including some of programmatic factors and issues that must be dealt with in a ridesharing arrangement; including schedules, cost/cost sharing, risks, standard interfaces, and processes.^{1 2}

TABLE OF CONTENTS

1. INTRODUCTION	1
2. SMALL PAYLOAD RIDESHARE CONCEPTS (1999–2003)	2
3. SMALL PAYLOAD RIDESHARE DEVELOPMENT (2003–2006)	4
4. SMALL-PAYLOAD RIDESHARE UTILIZATION (2006–2008)	7
5. SUMMARY	9
REFERENCES	11
BIOGRAPHY	11

1. INTRODUCTION

The use of small payloads, either as small individual satellites or as individual experimental packages on a host spacecraft, which are developed to demonstrate and verify “in space” advanced space technology, has been on-going throughout the Space Age, beginning in the late fifties and early sixties. Throughout these early periods, each individual agency developed, launched and operated its own missions to demonstrate critical, enabling technologies. For example, there were NASA’s early experiments in space power, the United States Navy experiments in space navigation and the United States Air Force (USAF) experiments in space communication. In the late sixties the United States Department of Defense (DoD) (USAF) established a single focal point for the execution of such missions into a single organizational function known as the Space Test Program (STP). To-date STP has flown almost 200 missions comprising over 470 experiments. The STP is an element of the current USAF Space Command’s Space Development and Test Wing (SDTW). As such, the STP is responsible, within the DoD, for the conduct of all DoD and non-DoD experiments flown on DoD launch vehicles, as well as DoD experiments flown on non-DoD launch vehicles. This distinction of DoD and non-DoD launches leads, in part, to the notion of “rideshare”, the sharing of

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² IEEEAC paper #1302, Version 1, Updated 2009:01:07

expensive launch costs to enable flight experiments and small missions. As noted, many and varied missions have been flown over the years, including missions on the NASA Space Shuttle and the International Space Station (ISS). NASA, of course, has also pursued an aggressive program through individual launches and numerous Space Shuttle and ISS experiments.

While STP is the focus for the coordination, development, and execution of DoD small payloads, the Rocket Systems Launch Program (RSLP), also an element of the SDTW, is the DoD focus for small launch vehicle development and services. They also have supported the space experiments activities for many years, including both suborbital and orbital missions. Beginning in the mid-nineties, they began to focus on the development of small launch vehicle capabilities. A principal element of that was the use of decommissioned rocket motors from the USAF ICBM Program, which has resulted in the development of the MINOTAUR series of small launch vehicles. An excellent overview of the MINOTAUR Program was presented at the August 2008 AIAA/USU Conference on Small Satellites [2].

As the small satellite/payloads technology improved, including that at university levels, the demand for low-cost access to space for these payloads has increased dramatically. This was particularly so beginning in the late 1999/2000 time period. This growing need spurred continued development not only in the small payload technologies and small launch vehicles, but also in the additional enabling technologies such as single-, dual-, and multiple-payload adapter technologies, and in the development of low-cost launch facility capabilities consistent with the small launch vehicle concept.

Another major development during the past decade of particular importance to the small payloads community has been the bringing on line by the USAF of the Evolved Expendable Launch Vehicle (EELV) series of medium launch vehicles, the DELTA 4 and the ATLAS 5. As this new capability is being integrated into the operational satellite programs, considerable excess launch capabilities have become available in many cases. The desire to utilize this emerging capability for low-cost access to space for small payloads, as secondary or auxiliary payloads, has fostered additional developments in the multi-payload adapter technology. Most notably among these has been the development, qualification, and flight demonstration of the AFRL/SDTW EELV Secondary Payload Adapter (ESPA). The ESPA is a multiple payload adapter capable of accommodating as many as six auxiliary payloads with masses as great as 400 kg each [3].

In addition to the varied and numerous technology developments cited above, there has been the evolution of the various agency policies, implementation plans, payload design guides, standardization interface technologies, and

interagency working/coordination procedures that are required to actually utilize this new access-to-space capability.

The objective of this paper is to present a broad overview of these development activities for the past, approximately, 10 years. The primary focus will be to review the development activity within DoD and how the use of that capability has evolved within the small payload rideshare community. Section 2 will summarize some of the more significant activities during the initial period, 1999–2003, that leveraged prior work in small payload space launches, i.e., STP activities, small launch vehicle developments, etc. Section 3 will summarize some of the more significant activities during the period of 2003–2006, including many of the implementation processes necessary to utilize the evolving capabilities that were identified and defined; application studies which examined the utilization of single- and multiple-payload adapter capabilities, as well as, various piggyback applications, continued development and demonstration of payload adapter technology; and, the on-going evolution of the small launch vehicle/launch facility capabilities. Finally, Section 4 will summarize some of the more recent activities (2006–2008) which demonstrate the current small payload low-cost access to space capabilities along with the identification of various remaining issues that still need to be addressed.

2. SMALL PAYLOAD RIDESHARE CONCEPTS (1999–2003)

Prior to 2000, many of the individual small experimental payloads, a number of which were piggyback experimental packages on a host spacecraft, were dependent upon “targets of opportunity” for access to space. This included early opportunities on various spacecraft, such as DMSP, GPS, and DSCS III. Other experiments, such as the NRL MPTB, were provided access on special National Reconnaissance Office (NRO) Missions. Exceptions to this were the more organized activities of the STP, which included dedicated launches and space shuttle payloads [1]. Starting in about 1999, early studies, sponsored by the NRO, began looking at ways of evolving a more comprehensive approach to low-cost access to space, such as “brokering” concepts, and development of more universal payload adapter concepts. Figure 1 is a conceptual definition, from these early studies, of a possible brokering approach for several small payload types. Although this concept is rather simple and straight forward, it did stimulate further thought and encouragement to pursue more detailed development of the rideshare concept.

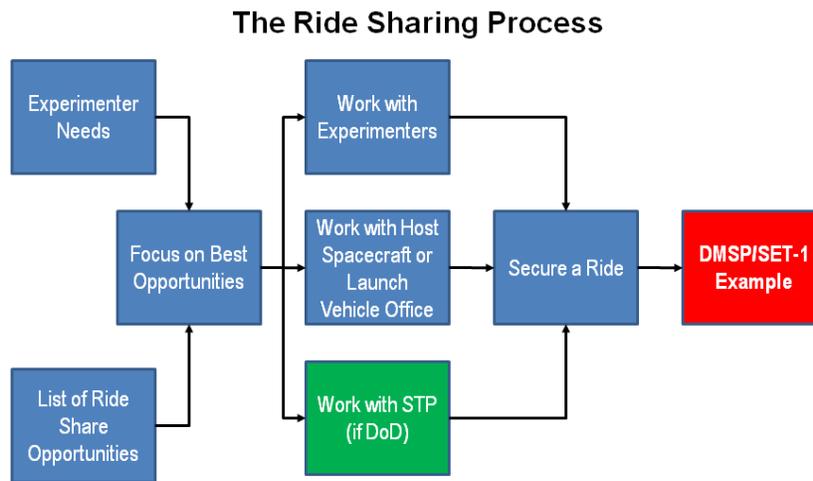
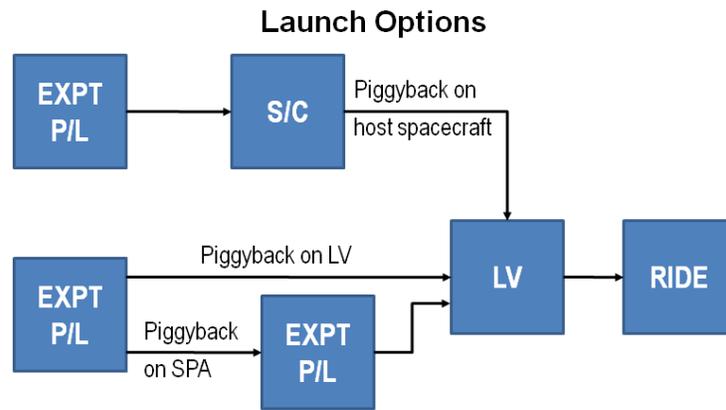


Figure 1 – Small Payload Rideshare Concepts

A significant activity that started in 1999, that further stimulated discussion and coordination within the small payload community, was the Annual Small Payload Rideshare Workshop supported by the NRO, STP, NASA, and others. This annual workshop continues to provide the single most important coordination within the Rideshare community. This renewed focus provided further coordination for various studies of possible auxiliary payload missions, both as piggyback experiments on host spacecraft and as secondary, either dual or multiple, payloads. As noted above, several new launch services capabilities were also being developed during this period. The concepts of multiple secondary payloads on the new EELV launch vehicles was rapidly developing. Most notably among these was the ESPA being pursued by AFRL in Albuquerque, NM and the STP. Figure 2 shows the basic ESPA structure, while Figure 3 is an illustration of a fully loaded ESPA stack on an EELV [3].

Considerable activities were also progressing in the development of small launch vehicle capabilities to support the low-cost access to space objectives, specifically, the Minotaur I space launch vehicle (SLV), which utilizes de-

commissioned Minuteman II engines as its first two stages, was brought on-line with its first launch in January 2000, see Figure 4 [4]. The development of several new commercial SLVs were also initiated during this time, i.e., Space X Falcon, etc. Based upon these developments, increased dialog and coordination began between the Air Force Space and Missiles Center (AFSMC) System Program Offices (SPOs), STP, and NASA. Specifically, the NASA New Millennium Program (NMP) and the Living With A Star Program (LWS) conducted early concept studies with the DMSP and EELV SPO's to assess the possibilities for both piggyback payloads on the DMSP spacecraft and secondary payloads as part of the DMSP/EELV launches numbers 18, 19, and 20. These early concept studies resulted in more detailed engineering studies, to be discussed below, for each of these types of rideshare configurations. During this time, the STP, of course, continued to conduct a variety of space experiment payloads, primarily in support of its Space Experiments Review Board (SERB) objectives. These launches utilized a number of SLV, including the Pegasus SLV [1].



Figure 2 –ESPA Solid Model

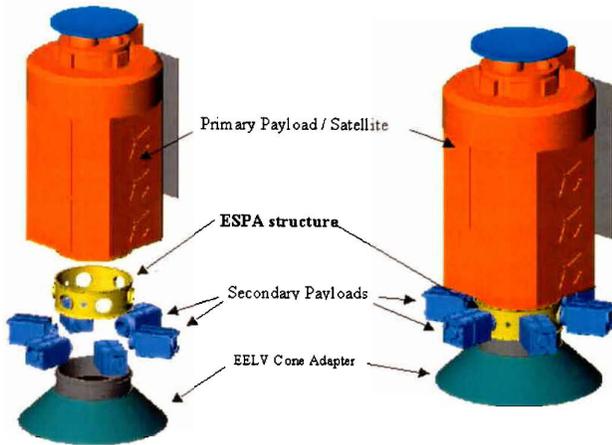


Figure 3 – Fully Loaded ESPA Stack on EELV Illustration



Figure 4 –Minotaur I Space Launch Vehicle

3. SMALL PAYLOAD RIDESHARE DEVELOPMENT (2003-2006)

3.1 LWS/NMP Rideshare Studies

As noted above, the increased dialog and coordination between the AFSMC SPOs, STP, and NASA led to detailed studies of possible piggyback and secondary payloads on the remaining DMSP/EELV launches (numbers 18, 19, and 20). This interest was stimulated by the fact that the DMSP/EELV launch configurations (both Delta IV and Atlas V) could provide possible excess launch capabilities of greater than 9000 lb (4100 kg), depending upon the specific launch vehicle configuration, to a low-Earth orbit (LEO). The LWS Space Environment Test Bed (SET-1) initiative (during the 2003–2004 time period) was the first to study the possibility of including a piggyback payload, such as SET-1, into a host DMSP spacecraft. SET-1 is a rather large piggyback payload of approximately 100 lb (45 kg), and requiring about 100 W of power, in addition to experiment command and control and data storage/downlink support.

The preliminary design study funded by NASA/LWS and performed by the DMSP SPO, showed that the DMSP spacecraft could easily accommodate the SET-1 payload within the rear (trailing) location that previously housed the apogee kick motor that was no longer required by the DMSP spacecraft when launched on an EELV, see Figure 5. The required 100 W of power could also be readily provided during the first year of the DMSP mission utilizing the excess solar array power margins required in order to meet DMSP spacecraft end-of-mission power requirements. Similarly, the command and control and data storage/downlink requirements could also be readily provided, in this case, through the main DMSP payload. Unfortunately, though this pathfinder piggyback payload study showed that the technical integration of such an auxiliary payload into a host spacecraft would be relatively straight forward, other factors, (such as, programmatic, risk assessment, non-recurring engineering analyses and early estimates of the overall integration costs) were such that the project did not move forward. However, the study did provide further encouragement to the rideshare stakeholder

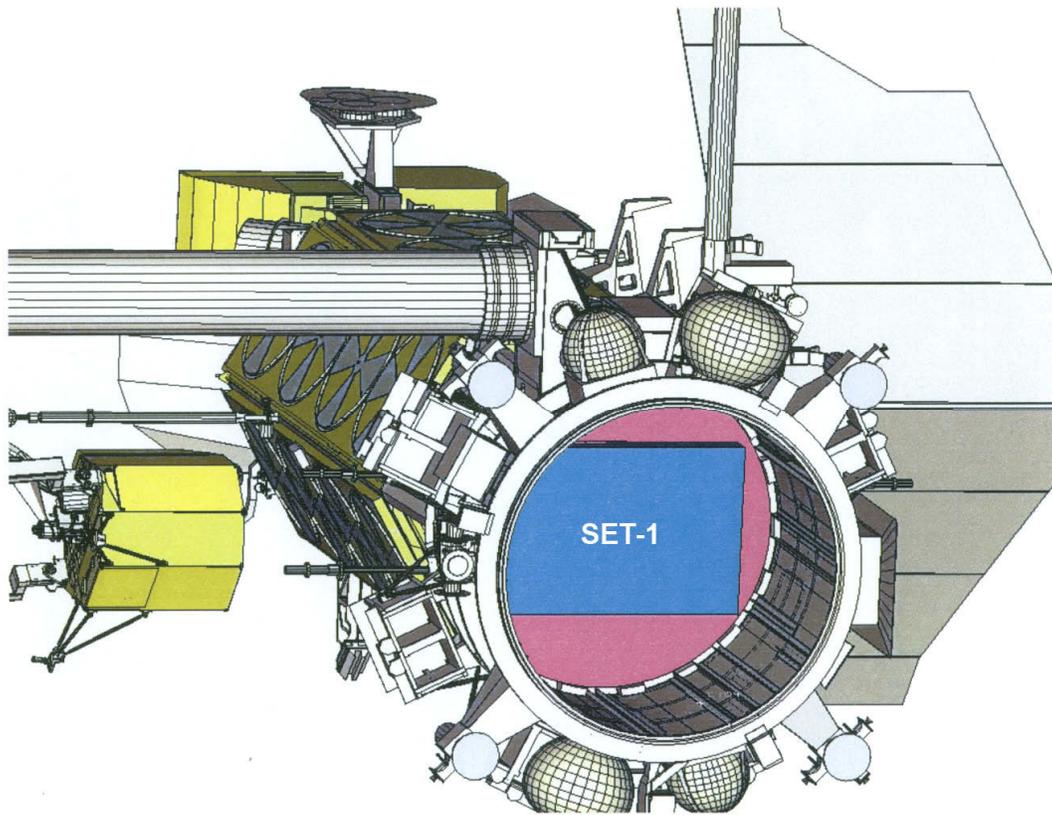


Figure 5 –DMSP/SET-1 Piggyback Configuration

community to pursue the development of appropriate policies, guidelines, etc, to overcome some of these obstacles.

Another early rideshare pathfinder study examining the integration of secondary payloads (free flying spacecraft) into an EELV launch configuration was one sponsored by the NASA LWS and NMP programs, also in the 2003–2004 time period [5]. This study also assessed the possibility of incorporating various types of individual secondary payloads into one of the remaining DMSP launches (i.e., Missions 18, 19, or 20). As with the LWS/SET-1 study, the objective of this study was to assess the possibility of utilizing the large excess launch capability to LEO orbits available on the DMSP EELV launches.

This study, sponsored by the NMP, was conducted by the Aerospace Corporation through the EELV SPO with coordination with the DMSP SPO and looked at the integration of several classes of secondary payloads utilizing the ESPA multiple payload adapter concept. This study included single and dual secondary payloads, several of which required expansion of the standard ESPA configuration, deployment of the secondary payloads following release of the DMSP primary including re-ignition of the upper stage to deploy the secondary payloads to different orbits than the primary. This was a comprehensive study which included the impact on ground

support and on-orbit deployment support, as well as, an examination of possible risk to the primary mission. Utilization of the basic ESPA concept, shown in Figure 2, was the approach followed in this study. One such configuration is shown in Figure 6, which demonstrates an approach that accommodates a secondary payload that would require an increase in the height of the ESPA ring from the standard 24 inches to 41 inches. Relocation of several of the fairing access doors would also be required to accommodate the primary for this configuration. The overall results of the study can be found in [5].

As noted above, this was an early pathfinder study that examined a number of issues, including technical integration and operational issues, risk assessment issues to both the prime payload and the launch vehicle, and agency coordination and policy issues. As with the previous DMSP/SET-1 study, this study showed that the technical integration and operational accommodations for such secondary payloads would be straight forward, although many details of the process would still be required to be identified. The major impediment to the process of moving forward at that time was the lack of detailed policy, integration, guidelines, and implementation plans that would define the interagency working relationships (in this case between NASA, EELV SPO, DMSP SPO, and associated contractors) and contractual arrangements and responsibilities. As with the DMSP/SET-1 study, this study

brought to the forefront the various issues that would have to be addressed by the various stakeholders in the rideshare community.

As will be shown later, many of these issues have been addressed by the responsible agencies, in the intervening years, including policy guideline, implementation plans, contractual arrangements, and responsibilities, non-recurring engineering tasks, etc. that should allow the process to move forward.

3.2 Rideshare Process/Hardware Implementation

As discussed above, these early studies, plus other related activities, led to a series of formal policy definitions, user guidelines, implementation plans, etc., which have allowed the process to move forward. A key AFSMC memorandum delineating responsibilities processes and roadmaps for implementing auxiliary payloads/ridesare missions on EELV DoD assets was issued in 2004 (see [6]). This memorandum identified STP as the “front door” for all auxiliary payloads, both DoD and non-DoD, to be launched on DoD launch vehicles. This applies to both SERB payloads and cost reimbursable payloads. The development

of further planning and user guides were also completed during this timeframe by the STP and others. The principal ones included:

- ESPA Users Guide [3]
- Experimenter’s Guide [7]
- Auxiliary payload Implementation Plan [6]
- Minotaur I Users Guide [4]
- Minotaur IV Users Guide [8]

In parallel with the above process developments, various enabling hardware concepts were moving forward in development. The STP initiated a development program for an ESPA-Class Standard Interface Vehicle (SIV) The SIV is compatible with multiple launch vehicles and adaptors including the ESPA and EELV launch vehicles. Other “standard bus” concepts for small satellites were also being pursued, notably the ST-8 mission developed by the NMP. On a smaller scale, the Microsat technology was also being developed. This was mainly driven by the “CubeSat” development lead by Stanford University and California Polytechnic State University (CalPoly, San Luis Obispo, CA) at the university level.

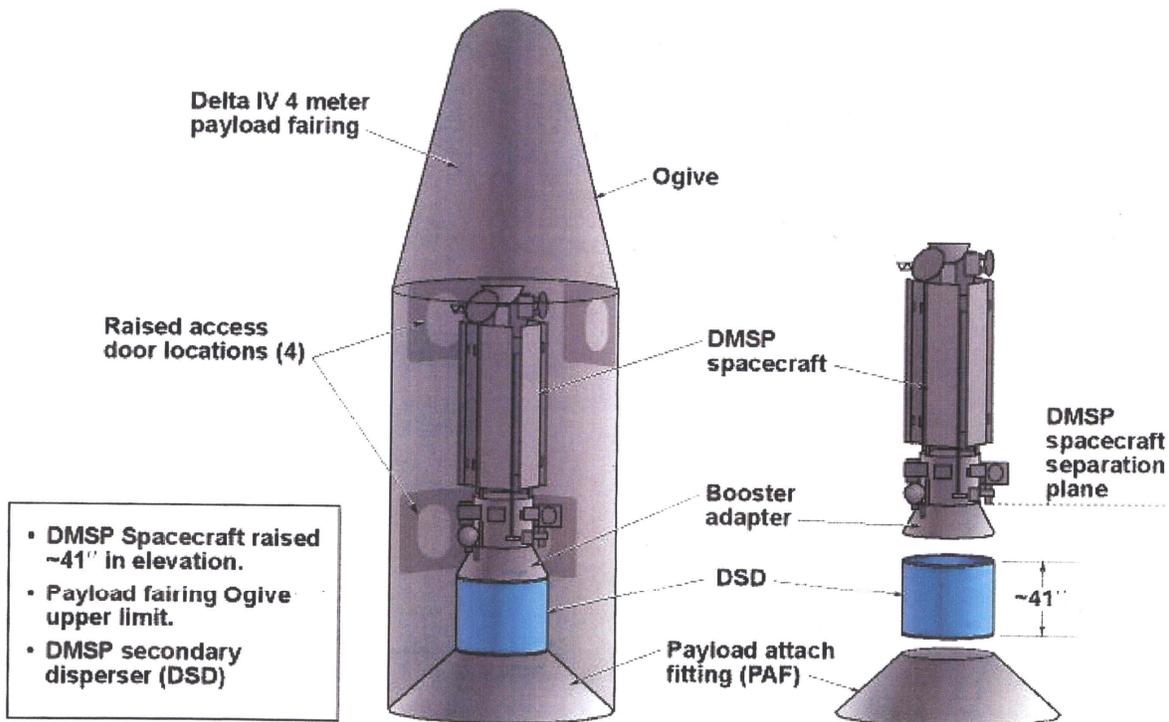


Figure 6 –DMSP Notional Secondary Payload Concepts

Also, during this time period, a major effort to demonstrate, on-orbit, the implementation and viability of secondary payloads utilizing the ESPA adaptor was undertaken by the STP. The STP-1 mission was a very aggressive effort to demonstrate the ESPA compatibility with the EELV (in this case the Atlas IV EELV). The STP-1 goal was to deploy six auxiliary payloads from the ESPA ring along with a separate prime payload. As will be shown below, the project, which took over three years to integrate, was a very complex mission that required many system engineering challenges to identify and overcome the myriad of programmatic and hardware interfaces. In the end it was successfully launched in March 2007 and represented a significant benchmark in demonstrating to the various stakeholders the viability of the ESPA rideshare concept.

The small launch vehicle capabilities also continued to evolve. Most notable was the SDTW/RSLP Orbital/Suborbital Program development of the Minotaur family of space launch vehicles utilizing both decommissioned Minuteman II and Peacekeeper assets. Figure 7 illustrates the current Minotaur Launch Vehicle Family [2], along with a summary of their capabilities. In addition to the Minotaur developments, several commercial initiatives continued to evolve, most notably the Space X Falcon 1 and Falcon V initiatives. Consistent with the utilization of these emerging small launch vehicles to achieve low-cost access to space, the cost of the ground launch facility also had to be considered. Thus, the capabilities at the launch facilities at Kodiak Launch Complex (Alaska), Wallops Flight Facility (Virginia), and most recently the Reagan Test Site (Kwajalein) have been developed to be compatible with these small launch vehicles.

4. SMALL-PAYLOAD RIDESHARE UTILIZATION (2006–2008)

As was noted above, the STP-1 mission was, in addition to providing access to space for numerous experiments, critical to demonstrating the viability of the multiple payload rideshare concept for EELVs. A summary of the STP-1 mission launch configuration and payload features is shown in Figure 8, taken from [1]. The mission was successfully launched in March 2007, and as presented in [1], it demonstrated a number of unique features critical to the rideshare community, including:

- First flight of ESPA necessary to demonstrate compatibility with EELV
- Integrated payload stack of seven auxiliary payloads
- Very complex launch vehicle mission with six deployments and two LEO orbits

In addition, the system engineering and programmatic interfaces that had to be worked and resolved has formed a valuable basis for going forward in formalizing the process for this type of ridesharing. For example, this successful program has provided the impetus for the 2008 DoD/AF policy memorandum on EELV/ESPA utilization.

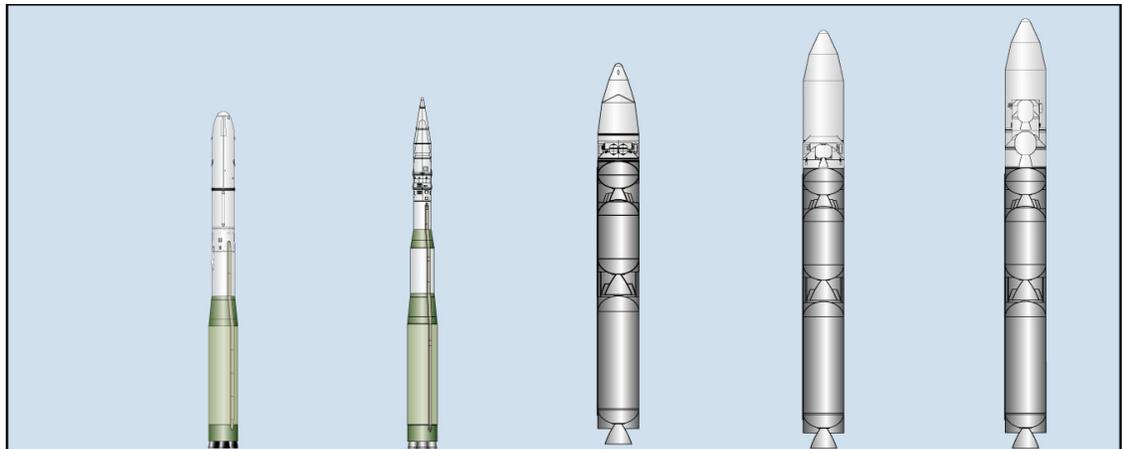
In addition to the EELV-type mission, other missions continue to evolve utilizing the growing number of small satellite rideshare technologies. For example, at the micro satellite level, the development of the Poly-Picosat Orbital Deployer (P-POD) utilizing the CubeSat Standard continues to rapidly evolve with increased interest within NASA, STP, and universities. A summary of the P-POD attributes is shown in Figure 9 [1].

The STP S26 mission, planned for a December 2009 launch, will utilize a number of the emerging technologies, including:

- First use of the STP SIV
- Five-stage Minotaur IV with multiple payload adapter
- First P-POD on Minotaur IV
- Dual orbit deployment (from a 650-km circular orbit, to a second circular orbit)
- Kodiak Launch Complex launch site

As mentioned previously, the SDTW/STP continues to be the prominent provider of low-cost access to space for small payloads either through their SERB process or direct cost reimbursable arrangements. Figure 10 shows a recent planned STP launch schedule through 2014 [1], illustrating the range and breadth of rideshare-option availability.

In addition to the above Government-sponsored rideshare opportunities, ridesharing on commercial launches may be becoming increasingly available, see [10 and 11]. These opportunities already exist for so-called hosted payloads, i.e., hosted on the primary spacecraft. Indeed, a number of such missions have been flown or are in the planning process. For example, the NASA/GSFC GeoQuick Ride (GQR) initiative is pursuing these possibilities. The unique feature of these potential opportunities is that they provide access to the difficult to achieve GeoSync Orbits.



	Minotaur I	Minotaur II	Minotaur III	Minotaur IV	Minotaur V*
S1	M55A1 (GFE)	M55A1 (GFE)	SR-118 S1 (GFE)	SR-118 S1 (GFE)	SR-118 S1 (GFE)
S2	SR 19 (GFE)	SR 19 (GFE)	SR-119 S2 (GFE)	SR-119 S2 (GFE)	SR-119 S2 (GFE)
S3	Orion 50XL	M57 (GFE)	SR-120 S3 (GFE)	SR-120 S3 (GFE)	SR-120 S3 (GFE)
S4	Orion 38	(N/A)	Super HAPS	Orion 38	Star 48V
S5	HAPS (Optional)	(N/A)	(N/A)	HAPS (Optional)	Orion 38
Application	<i>Spacelift</i>	<i>Suborbital/Target</i>	<i>Suborbital/Target</i>	<i>Spacelift</i>	<i>Spacelift</i>
Performance:					
Orbital:					
100 nmi, 28.5°	1280 lbm	N/A	N/A	3800 lbm	N/A
400 nmi, S/S	700 lbm	N/A	N/A	2200 lbm	N/A
GTO	N/A	N/A	N/A	N/A	1236 lbm
Suborbital:					
<3600 nmi, 20° FPE	N/A	973 lbm	6755 lbm	N/A	N/A

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* Conceptual - not part of current OSP contract

Figure 7 –Minotaur Space Launch Vehicle Family

Purpose

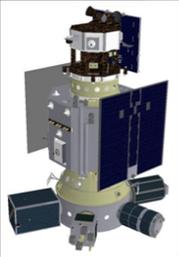
STP-1 will provide a dedicated medium EELV for spaceflight testing of 9 SERB experiments. The mission is manifested with the Orbital Express payload and the ESPA with 4 small satellite payloads & 1 mass sim.

Specifics

Launch	March 2007
Location	CCAFS
Booster	Atlas V - Medium
Orbit	492 km circ; 560 km circ
Inclination	46.0°; 35.4°
Mission Duration	1- 3 Years
Total Mission Cost	~\$450M
Customers	DARPA, AFRL, NRL, AF & Naval Academies
SD&TW Team	STP, RDSMO

SERB EXPERIMENTS

- Orbital Express
- CFE
- SHIMMER
- CITRIS
- CFTP
- IC SAT
- FLAPS
- MPACS
- PLANE

Mission Goals

Demonstrates autonomous rendezvous & docking technologies, situational awareness capabilities, weather forecasting. Trains Academy cadets. Demonstrates first auxiliary payload carrier for EELV: ESPA

Figure 8 – STP-1 Launch Configuration

- Design standard developed by Stanford and Cal Poly in 2000
 - 10 cm cube, < 1 kg mass (1U cube)
 - 3U cube NASA GeneSat-1 flown in Dec 08 as secondary payload on TacSat-2 mission
- NASA exploring standard integration of P-PODs on all NASA Taurus and Atlas V launchers
- Wide range of payloads – optical & magnetic sensors, tethers, computer processors, ADCS components, batteries, solar cells, MEMS
- Qualified LVs: Rockot, Dnepr, Minotaur I
- In Development: Falcon-1, Minotaur IV, Taurus, Atlas V



NASA
GeneSat-1

Total Mass (Satellite + PPOD)	7.1 kg (4.1+ 3 kg)
Satellite Power (on-orbit average)	4 - 5 W
Satellite Volume	3 "Cubes" (14" x 4" x 4") incl beacon
Science Data/Command Up/Downlink	~200 kB/day, 15M band (2.4 GHz)
E/PO Beacon/Data Downlink	Amateur band (~437 MHz)
Flight hardware Delivery	11/13/2006
Mission Duration (spacecraft design life);	≥ 21 days (Experiment Duration ~ 100 hours)
Orbit Altitude	390 km
Orbit Inclination	46°
Launch Vehicle	Minotaur I (TacSat-2 Primary)

Nominal Integration Schedule	6 mos.
Payload	3 kg 10 cm x 10 cm x 34 cm



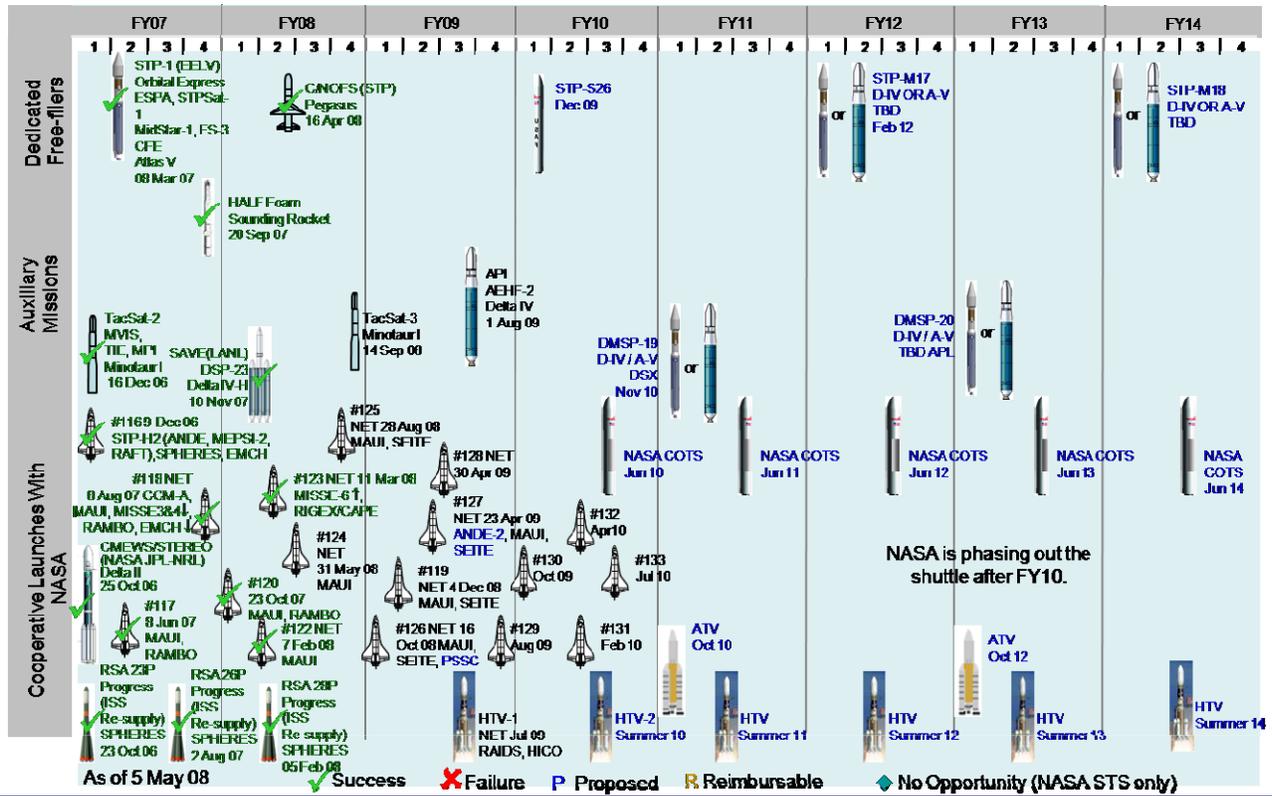
Figure 9 –Poly-Picosat Orbital Deployers (P-PODs) Concepts

As the technology base grows for viable options for small satellite low-cost access to space considering the choices of launch vehicle types/opportunities, payload adapters, standard buses, etc., and how to match them to a particular small satellite mission, the need for a readily accessible, user-friendly data-base is becoming increasingly desirable. One such data-base and mission design tool currently in existence is the Access To Space (ATS) tool that has been developed and maintained by NASA/GSFC [12]. The tool provides access to an extensive database on launch vehicles, spacecraft buses, secondary payload adapters, etc. In addition to this extensive data base, the ATS Tool provides the user with additional capabilities to assist in identifying viable access to space options in the design of a specific mission. An example of the process of matching secondary payload features to potential launch vehicles is shown in Figure 11. Here, a display of various payload types, as defined by their power and mass characteristics, are correlated with various launch vehicle options considering launch vehicle capability, risk and cost. This initial correlation provides guidance in the selection of potential rideshare options, with more in-depth analyses and assessments required in order to establish the viability of a particular option. [Note: this is, indeed, rocket science. It is complex, in large part due to the multiplicity of parameters that must be assessed.] It is here that the use of a tool, such as the ATS Tool, is of invaluable assistance.

5. SUMMARY

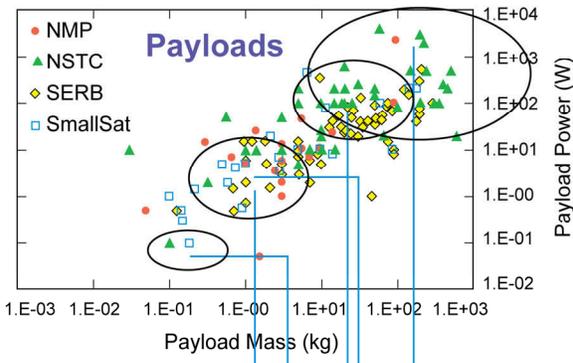
The small satellite rideshare capabilities and opportunities for low-cost access to space have been rapidly evolving over the past 10 years. The small space launch vehicle technology is rapidly being developed and demonstrated, including the Minotaur series and the Space X Falcon, among others, along with the lower cost launch facilities at the Kodiak Launch Complex, the Wallops Flight Facility, and the Reagan Test Site . Demonstrated capabilities for the launch of multiple payloads have increased (and continue to increase) significantly. This will allow more efficient and cost effective use of the various launch opportunities, including utilizing the excess capacity of the emerging EELV based missions.

The definition of standardized interfaces and processes, along with various user guides and payload implementation plans, have been developed and continue to be refined. Top-level agency policies for the support of low-cost access to space for small experimental payloads, such as the DoD policy structure on auxiliary payloads, have been defined and provide the basis for the continued refinement and implementation of these evolving technologies.



This launch schedule is intended for planning purposes only; it is not an official launch range schedule. POC 8D&TW/8DDX

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Options

	TRL	Cost	Comments
Delta II replaced by EELV	High	>\$150M	Cost will limit missions for NASA.
Pegasus, Taurus	High	\$50-100M	Phasing out.
Taurus II	Low	unknown	Possibly available in 2012.
Minotaur I	High	<\$50M	Available today, but policy constrains NASA use.
Minotaur IV	Medium	<\$50M	First launch in 2009. NASA policy will constrain NASA use.
Falcon I	Medium	<\$10M	First successful launch September 2008.
UAV	High	<\$10M	Available for low-TRL payload.
High Altitude platform	Low	<\$20M	Longer mission duration than UAVs.
Cubesat	High	<\$50K	Good for experiments. Available today.
ESPA	High	<\$20M	Available today but policy constrains use.

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Most importantly, the coordination and cooperative interfaces between the various stakeholders continues to evolve, with the STP being the focal point for this coordination with the DoD. The degree of this coordination and technical interchange was demonstrated by the wide stakeholder participation at the recent 2008 Small Payload Rideshare Workshop. This annual workshop has been the major platform for coordination and technical interchange within the rideshare community and with the various sponsoring agencies.

The above developments have provided the foundation for a robust low-cost small payload rideshare capability. However, the continued evolution, sustainment, and utilization of these capabilities will require continued stakeholder recognition, support, and nourishing. The continued coordinated effort, partnering, and support between stakeholders is essential to acquire the improved organizational processes and efficiencies required to meet the needs of the growing small payload community for low cost access to space [1].

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BIOGRAPHY

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