Universal Small Payload Interface – An Assessment of US Piggyback Launch Capability

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Abstract. Small satellites are becoming the solution of choice for planners trying to reduce space mission costs and shorten schedules. Secondary launches are a quick, frequent, low-cost, reliable solution for small satellites. Most international small spacecraft are launched as secondary piggyback payloads, aboard larger more efficient rockets. However, piggyback accommodations in the US are rare, done only on a case-by-case basis, and far from low cost. AeroAstro is presently developing the Universal Small Payload Interface (USPI), a standardized template for integrating and launching small spacecraft. It is designed so that mission developers can design to its requirements in order to be compatible on demand with a number of different secondary launch vehicle slots. The 'Phase A' USPI, based exclusively on existing secondary opportunities, will be complete by August 2000. Phases B and C, based on potential modifications of existing launch vehicles, will be complete by the end of the year. Missions will be quickly designed to a common interface standard, decreasing their dependence on a specific launch. When the spacecraft is ready, the next USPI launch available will be used, bringing 'launch on-demand' closer to reality.

Introduction

This paper discusses an assessment of US capability to launch small or micro-satellites using secondary or "piggyback" launches on large commercial or military launch systems. Secondary launches are payloads that constitute less than 40% of the overall payload being launched into orbits dependent upon the orbit of the larger – primary – payload. The assessment is a part of the Universal Small Payload Interface (USPI) project sponsored by the US National Reconnaissance Office (NRO) Office of Space Launch (OSL).

The motivation for the USPI project is to foster US small satellite development by allowing cheaper access to space for small, micro, and pico-satellites. Per-kilogram launch costs for small launchers are roughly three times higher than for large capacity launchers, while the larger launchers tend to have unused payload mass at launch. Therefore, exploiting that extra mass capacity for small satellites with standard piggyback payload adapters would allow cheaper access to space for these satellites. Anecdotal evidence suggests that US government policy – as the major launch systems customer – has not fostered piggyback launches for small satellites in the US. This paper examines that issue with historical data on piggyback launches and current and future piggyback accommodations. The assessment used the European Ariane 4 launcher and its ASAP 4 adapter as a benchmark to highlight the opportunities available for small satellites with standard piggyback payload adapters and proactive launch policies.

The following section describes the criteria used in the assessment of US piggyback launch capabilities. Following the assessment criteria is the assessment of historical, present, and planned US piggyback capabilities and a discussion of the conclusions based on the assessment.

Assessment Criteria

A launcher's ability to launch small secondary payloads with a much larger primary payload is the primary criterion of assessment.

To qualify as a piggyback, a payload has to:

- Be less than 100 kg
- Be launched with a much larger payload – the piggyback payload should be less than 40% of the total mass launched on that particular mission
- Be listed as an auxiliary payload on the launch manifest data

For some small launch vehicles (most notably Pegasus XL), 100 kg payloads are a large fraction of available capacity. Since these piggyback payloads tend to skew the piggyback launch data, they are considered shared or co-manifested payloads. Multiple payload launches (like Iridium and Orbcomm) also are not considered, as they control the insertion orbit and are basically treated as primary payloads.

Piggyback capabilities can be assessed by:

- The launcher's historical record of piggyback launches
- The consistency of the launcher's piggyback payload attachment (i.e. is there a standard attachment interface)
- The provider's policy regarding piggyback payloads
- The transparency and ease of the process for getting a piggyback payload on a launcher

Assessments should not be made in isolation, so US piggyback launch capabilities need to be assessed vis-à-vis the strongest competition – a benchmark. Historically, the Soviet Union – and now Russia – has been the US' major competitor in space. However, the geopolitical competition between the two powers has always overshadowed and strongly influenced their competition in space. On the other hand, the Ariane 4 launcher, commercially offered as a launch service by Arianespace SA, has become the dominant commercial satellite launch system over the last two decades. The Ariane 4 – with the Ariane Structure for Auxiliary Payloads (ASAP 4) – is also the major adapter for piggyback launches to Low Earth Orbit (LEO) and Geo-stationary Transfer Orbit (GTO). Therefore, Ariane has been chosen as the benchmark for US piggyback capability assessment. ASAP 4 has proven the technical and commercial viability of piggyback payloads. It has also demonstrated the viability of the European Space Agency (ESA) policy of nurturing small satellite development by supporting standard piggyback accommodations on Ariane 4 launches. For these reasons, Ariane 4 is the most appropriate benchmark for assessing US piggyback capability.

Historical Piggyback Capability

Figure 1 shows piggyback payloads as percentages of all payloads launched through 1999. The raw data are skewed by the launch of Russian and US (Orbcomm) satellite clusters. These data show small/piggyback payloads accounting for 6% of the global total and 8% of the US (i.e., the US piggyback payload launch rate is on par with the global rate in overall percentages). However, the US should have launched more piggyback satellites compared to the benchmark Ariane 4, because they had more launches with the same or better payload mass margin available.

Figure 2 shows piggyback payloads as a percentage of all payloads launched by each active US launch vehicle (the high percentage of Pegasus small payloads are co-manifested launches, mostly for the Orbcomm constellation). US vehicles have launched a smaller percentage of piggyback payloads than Ariane 4. Ariane 4's dominance of the commercial communications satellite market has also forced the majority of Ariane 4 launches to GTO, reducing its share of piggyback launches (since GTO does not seem very attractive for small spacecraft users/ designers). The higher proportion of Ariane 4 piggyback launches therefore reflects a much weaker historical US position vis-à-vis piggyback payloads. The major reason for this discrepency between the two sets of data is that ESA policy has effectively forced Arianespace to offer piggyback accommodations whenever possible.

Figure 3 shows the global distribution of piggyback payloads by mass with the majority in the 40-80 kg ranges. Soviet/Russian payloads dominated the 60-80 kg range while the only range with predominantly US payloads is the 40-60 kg range. Russian predominance in the 60-80 kg range is primarily a historical artifact (although there have been a significant number of Soviet/former Soviet piggyback launches, a large number of launches in the early years of the space age were below 100 kg because of lesser payload capacities). Ignoring the Russian data, there is again a very strong representation by Ariane piggyback payloads across the mass ranges. This highlights ASAP 4's capability of handling a wide variety of payloads with the standard piggyback adapter.

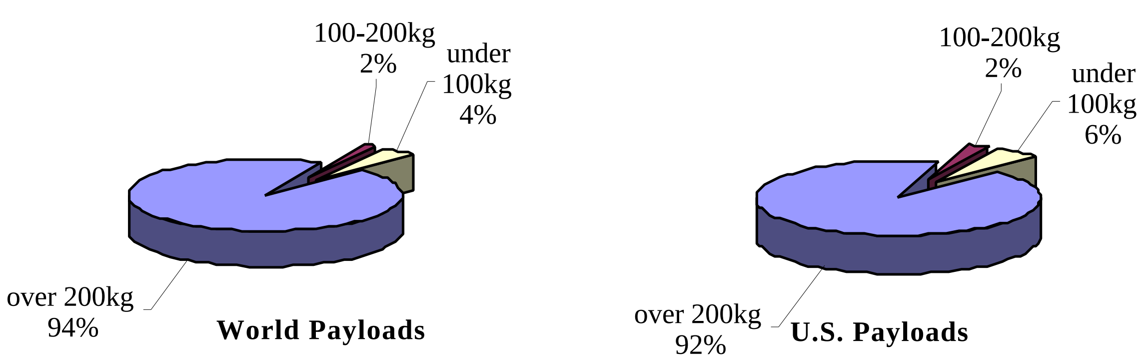
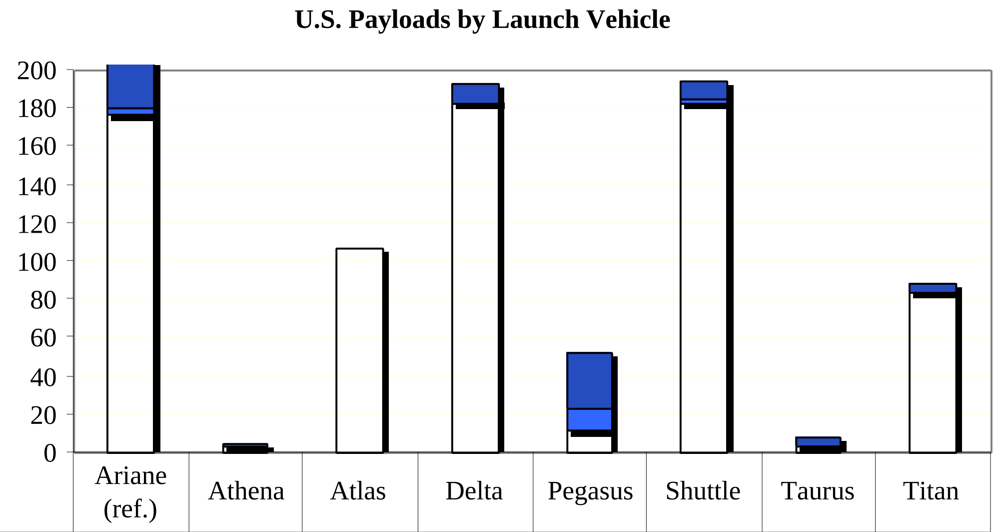
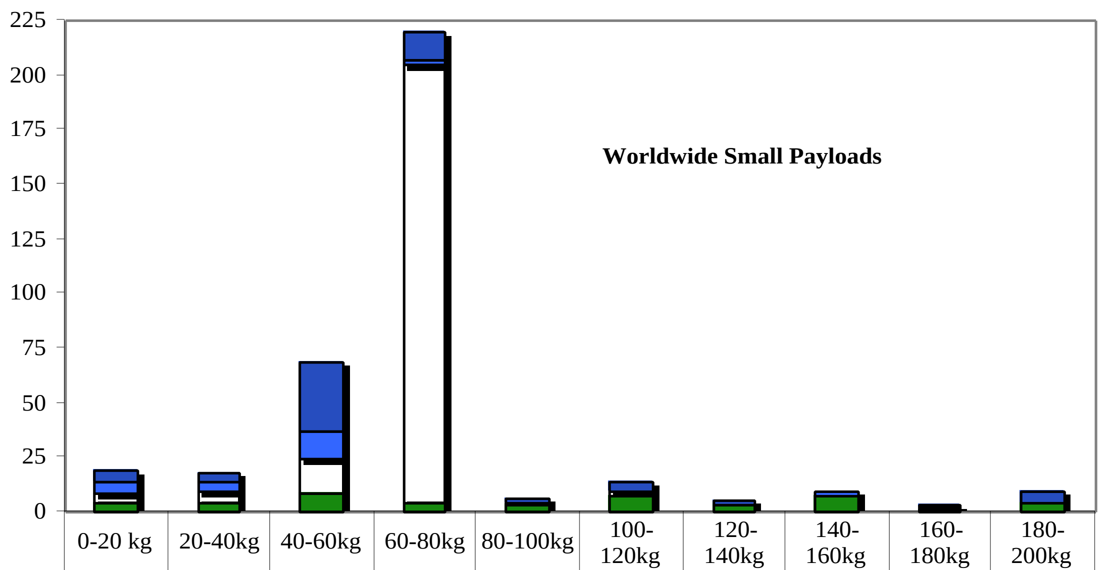


Figure 1. Piggyback Payloads Launched Through 1999[1]



	Ariane (ref.)	Athena	Atlas	Delta	Pegasus	Shuttle	Taurus	Titan
Total under 100kg	25	0	0	10	29	9	4	4
Total 100-200kg	3	1	0	0	11	3	0	0
Payloads over 200 kg	177	4	107	183	12	182	4	84

Figure 2. Piggyback Payload Launches by Launch Vehicle for US Vehicles[1]
The majority of payloads under 100 kg are actually co-manifests – mostly for the Orbcomm constellation..
Ariane data provided for reference.



	0-20 kg	20-40kg	40-60kg	60-80kg	80-100kg	100-120kg	120-140kg	140-160kg	160-180kg	180-200kg
US Vehicles	5	4	32	13	2	5	2	1	1	6
Ariane	6	4	13	2	0	0	0	2	1	0
Russian	4	6	16	201	1	2	0	0	0	0
Other	4	4	8	4	3	7	3	7	1	4

Figure 3. Distribution of Small Payloads According to Size[1]
The majority of US piggybacks (45%) are in the 40-60 kg range.
Ignoring the Russian payloads in the 60-80 kg range, Ariane piggybacks are generally across the range.

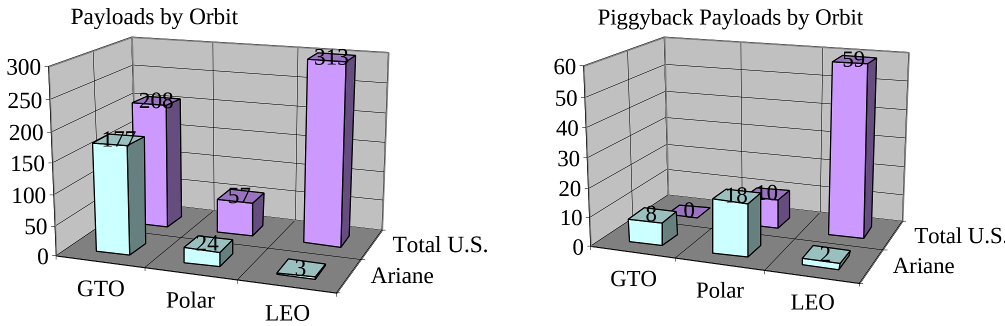


Figure 4. Distribution of Payloads According to Orbit Type[1]

Some of the small payload data is skewed by small US payloads launched as primaries. Note no US piggyback launches to GTO.

Figure 4 shows all payloads launched by orbit type. The balanced mix of US scientific/ military and government/commercial communications payloads accounts for the distribution between LEO and GTO. Polar and sun-synchronous orbits tend to be for earth observation and reconnaissance satellites, again borne out by more US launches in the polar orbit group. On the other hand, the predominance of GEO for communications satellites accounts for the Ariane 4 launch data.

Piggyback payload data by orbits show the majority of US small satellite launches went to LEO, but the data are skewed by Pegasus and older vehicles launching smaller primary payloads. Most remarkable is the large percentage of Ariane piggyback payloads. Even the least desirable GTO orbit (piggyback satellites tend to go mostly to LEO – low inclination or polar/sun-synchronous) has 4.5% Ariane piggyback launches, contrasting with 0% (of 208 total) for US launchers. Two of the three total Ariane 4 LEO launches and 75% of Ariane 4 launches to polar and sun-synchronous orbits have had piggyback payloads. This contrasts with less than 18% for US polar and sun-synchronous launches.

This data contrasts with the fact that a considerable number of US scientific and commercial satellites that would be excellent candidates for piggyback launches have had to pay for dedicated launches or wait for lack of inexpensive access. The US has generally failed to use its strong position in launch systems to foster small, cost-effective satellites by offering launch payload margin as accommodations for secondary/piggyback payloads.

Three major standard adapters are available for piggyback payloads:

- The US STS systems controlled by the Hitchhiker Customer Accommodations and Requirements Specifications (CARS) 740-SPEC-008:
    - Hitchhiker Ejection System (HES)
    - Payload Ejection System (PES)
    - Shuttle Hitchhiker Experiment Launch System (SHELS)
- The Delta II secondary payload facility
- The Ariane Structure for Auxiliary Payloads (ASAP) 4 – now being updated to ASAP 5

STS piggyback launches are exclusively for US Government payloads, and its unstable manifest often adversely affects piggyback launch schedules. The Delta II secondary requirements and accommodations are unstable because the primary payload variation and customized secondary payload accommodations complicate piggyback payload design. The ASAP 4 standard is easier to use than Hitchhiker CARS and Delta II because it has precise and clear piggyback payload design and integration requirements. If an ASAP 4 ring is carried on a mission, the piggyback customers have stable requirements they can design to. Piggyback launches– especially for US organizations – have been literally or nominally free. But that does not reflect the hidden costs for qualifying and integrating the payloads.[*] Piggyback payload customers on Ariane 4 pay for the service. The fee possibly reflects less the actual ASAP 4 costs and more an active ESA policy to encourage small and auxiliary payload launches. Consequently, piggyback customers, given a choice between paying for the convenience of ASAP 4 piggyback launches to limited orbits and on limited launches, or free US piggyback launches to more orbits on more launches on sufferance from the primary payload, have opted for the former.

Current Piggyback Capability

Current piggyback capability assessment involved all operational launchers commercially available worldwide as well as US launchers used solely for government launches.[**] Most operational launch systems[†] can carry piggyback payloads but only a few have standardized accommodations for them. Therefore only the following five launchers have been included in current piggyback capability assessment. [††]

Ariane 4

The Ariane 4 has been operational since 1988, with a 96% launch success rate. It is now being phased out in favor of the Ariane 5. There are 20 commercial Ariane 4 launches manifested to 2004.[3]

Multiple small payloads can be mounted on the ASAP 4 structure installed around the primary payload adapter. Each piggyback payload must be less than 50 kg with a combined piggyback mass no more than 200 kg. Each payload has to fit in a 0.45m x 0.45m x 0.45m cube.

No published costs are available, but costs per piggyback are estimated at $1–$3 million. Piggyback slots are allotted through a commercial application. No published data are available on the piggyback manifest. The last ASAP 4 piggyback launch was in 1997.

Delta II

The Delta II has been operational since 1990, with a 94.5% overall success rate. There are 16 Delta II launches manifested to 2002.[3] Piggyback payloads can be attached to the sides of the second-stage avionics section, between the second stage and the payload fairing. The available space is a slice of a toroidal section 0.33m thick and 0.78m tall.

Piggyback payloads are paid for by NASA, USAF, or the payload user. Piggyback slots are awarded ad hoc based on government manifests with available space. It is possible to examine the published manifest, confer

[*] Essentially, the pricing (free) is driven by policy directives (patron of science) that do not necessarily coincide with NASA policy directives for the safest possible STS mission.

[**] For example, the US Titan II-23G and Titan IV systems were examined but not discussed because they do not offer piggyback accommodations.

[†] Most Soviet launchers have carried piggyback payloads but published data suggest they have no standard piggyback accommodations.

[††] Piggyback carriage on OSP/Minotaur is not yet standardized but the stated policy for this launcher to carry small secondary payloads for the scientific/government community merits inclusion.

with the prime payload customer to discover available space and payload margin and convince NASA to allow a piggyback payload on that launch. The process is somewhat opaque and piggyback launches are not guaranteed. No published data are available on the piggyback manifest. The last piggyback launch was in 1999.[*]

OSP/Minotaur

The Minotaur is a refurbished LGM-30F Minuteman II ICBM, primarily for government sponsored sub-orbital or orbital payloads. It has been operational since January 2000. The Teal Group[3] forecasts an average of 2 launches per year, with 450 Minuteman II missiles in storage and available for conversion.

Piggyback payloads can be co-manifested or shared with other payloads with all piggyback masses, volumes, and facilities determined by the primary payload. Payloads can be – depending on available volume – stacked, installed in load carrying structures, or carried in multiple payload dispensers.[2] The payload carriage design is still very fluid and there is no discernible standard.

Piggyback launches are government subsidized,[**] and there is no established procedure for getting piggyback payloads on a Minotaur launch. The only Minotaur launch thus far – in January 2000 – was a piggyback launch of ten satellites.[†]

Pegasus

Pegasus has been commercially operational since 1992, with an 80% overall success rate.[1] OSC is also capable of launching piggyback payloads on the Taurus launcher using the DPAF attachment. The accommodations for piggyback are similar, so the information for Pegasus XL is also applicable for Taurus. The Pegasus XL is the commercially available version, and there are 62 Pegasus XL launches forecasted to 2008.[3]

Pegasus XL piggyback payloads are really co-manifested payloads. Co-manifests can be load-bearing custom or non-load-bearing configurations using the Dual Payload Attach Fitting (DPAF). DPAF payloads have a 0.22m tall, 0.26m diameter allowable volume. Co-manifest masses are defined by the overall mission payload capability available.

Pegasus costs $18 million per launch, and co-manifests share the cost. The Orbital Sciences Corporation (OSC) creates co-manifests through commercial application for use.

STS

The Space Shuttle (STS) is the world's only reusable and the only manned US launch system. The four operational orbiters are each designed for 100 flights, so the fleet is good for about 300 more missions. Current flight rate for the fleet is about 8-10 missions per year.[3]

Piggyback payloads use the Shuttle Hitchhiker Ejection System (HES) in the STS main payload bay. The HES system can be enclosed or open to the payload bay and can eject the payload with a given velocity. The payload mass can be up to 68 kg and must have a 0.48 m diameter and 0.52 m height. The number of piggyback payloads carried on a given STS mission depends on payload bay availability.[7]

Table 1 summarizes the piggyback capabilities of the launchers mentioned above.

[*] Two 64 kg payloads – one Danish and one South African – to sun-synchronous orbits

[**] The government agency sponsoring a payload has to pay up to $11-$13 million per launch

[†] JAWsat, ASUsat, OPAL – carrying 6 picosats, OCSE for AFRL, and Falconsat

Table 1. Summary of Piggyback Capabilities for Selected Launchers

Launchers	Mass (kg)	Space (m)	Piggyback Procedure	Orbits	Commercial	Cost/ payload ($)
Ariane 4	50 kg	0.45m X 0.45m X 0.45 m	Transparent. Application for use	LEO, GTO	Yes	$1-$3 million per slot
Delta II	Open	Open	Fluid. NASA application	LEO, GTO	Commercial or Govt. sponsored	Nominally free
Pegasus XL	Dependent on other payload	0.26m dia. 0.22m ht.	Transparent. Application for use	LEO	Yes	Sharing $18 million per launch
OSP/ Minotaur	Dependent on other payloads	Dependen t on other payloads	Open. Not yet defined	LEO	Govt. sponsorship reqd.	$11-$13 million per launch
STS	68 kg	0.48m dia. 0.52m ht.	Opaque. Ad hoc, secondary to manned mission	LEO	Govt. payloads only	Nominally free

Orbital Sciences Corporation (OSC) is the only US provider actively pursuing piggyback payloads for their launchers. Specifically, OSC is seeking piggback payloads for the Pegasus/Taurus systems.[4,5] The Delta II and STS piggyback application and mission approval procedures remain opaque and subject to primary payload mission objectives. Although STS has well-established piggyback specifications, the integration and review procedures remain onerous. The OSP/Minotaur is a promising low-cost small satellite launcher, but it is not yet fully operational with well-defined piggyback application procedures.

Projected Piggyback Capability

There are four major initiatives that could significantly affect US piggyback capabilities:

1) EELV Secondary Payload Attachment (ESPA)
2) Piggyback launch brokering
3) ASAP 5 for Ariane 5, PSLV (The Polar Satellite Launch Vehicle now being marketed by the Antrix corporation for the Indian Space Research Organization), and Soyuz ST/Fregat
4) Aggressive marketing of decommissioned Russian ICBM's

The first two present a potential boost to US piggyback launch opportunities while the latter two represent commercially available cheap and reliable alternatives.

ESPA

The USAF Space Test Program (STP) and the Air Force Research Labs (AFRL) are developing ESPA for the planned Evolved Expendable Launch Vehicle (EELV). ESPA is an annular ring above the Spacecraft Interface Plane (SIP) with the piggyback payloads cantilevered out from it. ESPA can carry up to eight 180 kg piggyback payloads in a 0.61m x 0.61m x 0.97m volume.

ESPA is scheduled for operation by 2003. Its major design limitation is the requirement to fit the piggyback payloads above the SIP without impinging on the primary payload volume. This has forced the piggyback payloads to be cantilevered out radially – making them more susceptible to launcher axial vibration and constraining their available volume. According to STP analyses, typical EELV missions may have more than 25% mass margins but piggyback payloads may not always be allowed. With the ESPA location above the SIP it is not entirely clear who has ultimate responsibility for it – the payload or the launch vehicle side. The launch vehicle providers do not consider it their responsibility and have yet to qualify it on their vehicles.

If successful, ESPA could potentially launch a significant number of US piggyback satellites. The USAF estimates that the operational EELV system would have 18-20 launches annually. Assuming half of those launches could carry 6 piggyback payloads each, 54-60 piggyback payloads could be launched annually. This rate would surpass the total number of US piggyback launches (see Figure 4) in less than two years!

ESPA is a good design effort to exploit excess EELV* capability, but it may be infeasible to standardize ESPA across other US platforms. Because the piggyback payloads are radially placed, the piggyback payloads are volume constrained between the payload adapter side and fairing envelope. Furthermore, because of the specialized piggyback payload interface design, payloads designed for other launch systems cannot be changed over to ESPA. Although that does insulate ESPA payloads from being "poached" by ASAP 5, it does reduce US piggyback customers' options.

Launch Brokering

The US firm Space Operations International (SOI) has a commercial initiative to broker excess payload mass margin to small payload customers as piggyback opportunities. A US launch services provider with excess payload margin on a launch engages SOI to market that capacity. SOI solicits the customers, helps them design and qualify the payload, and integrates it with the primary payload. SOI claims to have memoranda of understanding with Boeing, Lockheed-Martin, Kistler Aerospace, and Sealaunch. Partner/investor Ball Aerospace will probably provide the technical and integration expertise.

SOI has an innovative idea to commercially exploit excess capacity on launch manifests. Launch service providers are interested in selling excess payload margin for profit but don't want the overhead of finding a piggyback customer and helping them integrate with the launcher and primary payload. The SOI initiative outsources piggyback marketing for the launch service providers. The exact business plan and potential for profit or success is unclear, but this concept could potentially provide cheap piggyback payload access for US small satellite developers and users. SOI is hamstrung by ITAR and other US government restrictions that considerably narrow their field by limiting them to US launchers. A freer hand for SOI could potentially free up more piggyback opportunities for small satellite users.

ASAP 5

ASAP 5 is the ASAP 4's adaptation for the Ariane 5. Ariane 5 is now operational, although there has not been an ASAP 5 mission to date. Two versions of ASAP 5 are available:

1) Carry up to 8 piggybacks with a maximum aggregate mass of 800 kg; allowable volume per payload is 0.6m x 0.6m x 0.8m; allowable mass per payload is 100 kg maximum
2) Carry up to 4 piggybacks with maximum aggregate mass of 1,200 kg; allowable volume per payload is 1.5m diameter and

* Other launch vehicle designs, most notable the Kistler K1, plan to use a variation of ESPA

1.5 m height; allowable mass per payload is 300 kg maximum

Ariane guarantees a piggyback launch – once contracted – on any one of three launchers:
1) Ariane 5
2) The Indian Polar Satellite Launch Vehicle (PSLV)
3) The Soyuz ST/Fregat vehicle marketed by Starsem

The PSLV is not yet commercially operational while the Soyuz ST/Fregat is the latest iteration of the workhorse Soviet/Russian launcher. The Soyuz ST/Fregat version has an Ariane 4 type payload fairing and is being marketed by Arianespace as its medium lift vehicle for polar and sun-synchronous orbits and for LEO constellations.[6] Soyuz ST/Fregat will be operational by the second half of 2001.

ASAP 5 is a bigger threat to US piggyback launch efforts than ASAP 4 for a few reasons.

- ASAP 5 allows larger piggyback payloads with more mass. Small satellite makers will be less constrained by mass and volume than they were with ASAP 4.
- The larger mass allowance may let some piggyback customers add propulsion modules* to optimize orbits. For example, Arianespace has an entered into an agreement with AeroAstro Inc. (authors of this paper) for the SPORT™ – Small Payload Orbit Transfer – system. SPORT will take a piggyback payload from GTO to LEO by reducing the apogee with drag and then circularizing at LEO. SPORT will allow more piggyback payloads on launches to GTO, reducing another weakness of the ASAP 4 system.
- The Ariane 5, PSLV, Soyuz ST/Fregat combination gives Arianespace better coverage of orbits. Figure 4 suggests there would have been more piggyback launches if more Ariane 4's had gone to LEO. This will no longer be an issue with ASAP 5.
- ASAP 5 will have more available launches. Ariane 5 has 62 projected launches to 2007[3] and Soyuz ST/Fregat has 5 launches planned per year.[6]
- Finally, the recent addition of the Eurockot launcher (see section below on "SALT" launchers)[6] broadens Arianespace product coverage. The larger ASAP 5 can take a larger variety of piggyback payloads. If more capacity is required, a customer can move up to the Eurockot.

There is as yet no concerted effort to counter the ASAP 5 threat from any launch service providers, combination of commercial organizations, or any other government organization in the US. As is, Arianespace will further enhance experience in small satellite development at the expense of US small satellite developers limited by US policies of exclusivity for US-sponsored projects and policy restrictions against using foreign launchers. The lack of a standardized US piggyback launch adapter also does not allow US small satellite developers to design, build, and use standard small and micro-satellites buses.

"SALT" Launchers

The SALT II treaty has decommissioned a large number of ICBM's from Russia, Ukraine, and the US. The US has successfully converted one LGM-30F Minuteman II to the OSP/Minotaur launcher and plans the same with more of the 450 in storage.[3] The Russians are marketing a number of their decommissioned ICBM's, most successfully the Eurockot launcher. Table 2 summarizes the information about these launchers. "Start" in this case means "launch" in Russian.

* Unlike US launchers, ASAP has been less stringent about pyrotechnics and propulsion on piggyback payloads

Table 2. Summary Information about "SALT" Launchers

Launcher	Lineage	Cost/Launch ($)	Launch	Comments
Dnepr	SS18/Yuzhnoye RS20	$10 Million	UoSAT 12, 1999	Silo launched above ground. Commercially marketed by Kosmotras and Thiokol Technology
Eurockot	SS19	$5-12 Million	Two Iridium (US), 1999	Silo launched above ground. Smallest Arianespace launcher
Minotaur	LGM-30F Minuteman II	$11-13 Million	Multiple microsats (US), 2000	Managed by OSC. Not commercially marketed
Shtil	R29RM SSN23	$100-300 K	Two TUBsat, 1998	Submarine launched. Commercially marketed by Russian Navy
Start & Start 1	SS25/RT-2PM Topol	$9-10.5 Million	Gerwin 1 (ISR), Unamsat (MEX), Early Bird 1 (US)	Commercially marketed by Puskovie Uslugi & United Start

All the launchers in Table 2 have good payload capability to LEO, in the Pegasus XL and Taurus launchers' range. They compete against piggyback launch by offering very cost effective launch services for satellites above the 200 kg range. The launch environments for all these launchers are very robust, but they are reliable and have fast turnaround times.

The Eurockot is the most commercially stable of the SALT launchers, it was previously marketed by Daimler Chrysler Aerospace (DASA) and is now a part of the Arianespace line. The European Space Agency (ESA) officially considers the Eurockot its light launcher of choice.[6] Government restrictions notwithstanding, two of the launchers – Eurockot and Start 1 – have launched US satellites and two – Dnepr and Start – are marketed by US companies.

Pegasus was conceived for small satellite launches but is now more expensive per kilogram launched[*] than large launchers. The Minotaur, as a recycled missile, was considered its biggest competitor. Table 2 suggests the SALT launchers will compete very strongly with those as well as the piggybacks on larger launchers.

US payloads may not be allowed on the Russian SALT launchers,[**] but commercial small payloads have no such restrictions. Surrey Satellite Limited of the UK is not under any such restrictions and has built an enviable experience base on most small and piggyback launchers.[†] Therefore, non-US organizations are building a better experience base launching small and micro-satellites using piggyback facilities unavailable to US users because of US government policies.

Policy Issues

Launch vehicle providers do not see any technical hurdles to more piggyback launches. There is some overhead cost in dealing with piggyback customers and they would prefer

[*] FAA price data suggests Pegasus/Taurus are nearly three times more expensive in $/kg terms than larger launchers. FAA data is usually considered optimistic.

[**] The ITAR status of Eurockot is unclear. Iridium has been launched on Eurockot. Ariane 4 and 5 launches are unrestricted for US payloads. US government-sponsored payloads still have to be launched on US launchers.

[†] Surrey has launched micro-satellites piggyback on ASAP 4, Zenit, Dnepr, Shtil, Tsiklon, and Kosmos.

someone else (like a broker) taking care of them. Overall, they don't see an attractive enough business case for standard piggyback accommodations on their launchers. They contend that the government – under constant budget pressure – would pay them less for the prime payload if they charged fees for piggyback launches. There is insufficient evidence to rebut that. Therefore, launch vehicle providers are not likely to be open to piggyback launches – or standardized adapters for them – until the government mandates they do so or allows them to keep the resulting profits.

There is some government interest in piggyback launches. There is also some belief that US launch vehicle providers are uninterested in piggyback launches because USAF Material Command (AFMC) is not pushing them. AFMC does not have a formal operational requirement for small and piggyback launches from USAF Space Command (SPC). SPC very probably agrees with the piggyback launch concept and supports efforts like ESPA, but until small satellites and piggyback launches prove operational capability for war-fighting – or they are mandated by policy to do so – they have no reason to issue a requirement. The timing might be right for a large government prime payload customer to push for such a requirement.

Conclusions

1. Historical US piggyback launch rates are on par with global data but the US has not exploited its payload margins as well as the competition.

2. The EELV Secondary Payload Adapter (ESPA) is a good design effort to exploit EELV payload margins but it cannot be standardized for other US launchers.

3. Government policy and the business case, not technical challenges, are the significant hindrances to more US piggyback launches.

4. US Government policy to restrict government-sponsored payloads to US launchers harms small/micro-satellite development by not allowing them more cheap missions to space.

5. Free piggyback payload launches are not enough; transparent procedures for reliable piggyback payload slots are also critical.

6. Decommissioned ICBM launches overseas provide cheap, reliable access to space for small satellites but US small satellite developers are restricted by US government policy to US launchers.

7. The NRO should push for an operational requirement for piggyback payload launches to encourage large launch vehicle contractors.

8. ASAP 5 provides a single, standardized piggyback payload adapter that covers GTO and low inclination & polar LEO orbits with three major launchers: Ariane 5, PSLV, and Soyuz ST/Fregat. There is no comparable US piggyback initiative.

9. Ride brokering may give the US a competitive advantage but the business plan is unproven.

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