Ticket To Space - How to get your small satellite from the cleanroom to orbit

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ABSTRACT
With the significant increase in small satellite activities and projects in Europe, the US, Asia, and other parts of the world, the availability of regular, affordable access to space for small satellites becomes even more critical than before. Obviously, there are many complicating factors in ‘arranging a ride’ for your small satellite. These can be technical and programmatic mismatches between the available launch opportunity and the small satellite mission objectives and planning. But (more) often these complicating factors also relate to export restrictions, political considerations, lack of standardization or a mismatch in requirements and expectations between the small satellite developer and the launch provider or primary customer.

Considering the number of rocket launches per year, one might expect sufficient excess capacity on board these launch vehicles to easily accommodate a large number of small satellites as auxiliary or piggyback payloads. In practice it is actually quite difficult to find an available, affordable launch opportunity for a small satellite. And when one is found, lead times to launch can be quite long, as many small satellite developers in the US are currently experiencing.

To address these challenges and provide a global network for the launch of small and secondary payloads, Spaceflight and ISILaunch have teamed and currently offer spaceflight services on a variety of orbital and suborbital vehicles for small and secondary payloads, with operations centered in the United States (US) and Europe respectively. Under this joint marketing agreement Spaceflight and ISILaunch will provide a global spaceflight service for the launch of small and secondary payloads by jointly marketing a combined set of products and services to prospective customers. Through these cross-Atlantic connections and agreements, launch opportunities become accessible for a broader range of foreign payloads, improving access to space for small satellites. The end goal of this is to be able to offer a ‘ticket to space’ for every nanosatellite mission and provide a global launch service.

BACKGROUND
This paper will discuss the Spaceflight / ISILaunch partnership and the standard processes and interfaces offered by the two companies. In addition, this paper will discuss some new technical developments that allow more nanosatellites to be launched on the same vehicle.

These modular payload decks are currently under development and allow tens of nanosatellites to be clustered into the volume of a traditional small satellite as secondary payload on a big launcher or primary payload on small dedicated nanosatellite launchers.

Spaceflight Services, Inc. (Spaceflight) was spun off from Andrews Space in 2009 to serve as a space access service provider for fixed and deployable cargo and spacecraft. Spaceflight has focused on three guiding business principles:
Innovative Space Logistics was established in 2009 as a subsidiary of ISIS – Innovative solutions In Space, a leading nanosatellite company from the Netherlands. ISIS recognized the need for regular commercial access to space required for responsive small satellite missions, essential to its own turn-key mission solutions as well as for third parties that want to fly their missions.

In 2010 Spaceflight and Innovative Space Logistics (ISL) teamed to provide an expanded global network of launch opportunities for foreign and domestic launch vehicles.

Through this partnership Spaceflight and ISL offer spaceflight services on a variety of orbital and suborbital vehicles for small and secondary payloads (Figure 1), with operations centered in the United States (US) and Europe respectively. Under the joint marketing agreement Spaceflight is the lead organization for integrating prospective orbital and suborbital payloads flying on US launch vehicles and being the primary interface for non-US customers that want to fly on US vehicles.

**SERVICE STRUCTURE**

The Spaceflight / ISL Team is a small payload integrator (Figure 2), working with the small / secondary payload customer and the launch service provider to manifest and integrate payloads for launch. In this manner the customer buys launch or flight services from either Spaceflight or ISL, depending on the customer and launch vehicle location.

This service structure gives any customer the possibility to obtain a launch for their satellite without having to address launch interface issues that are not directly related to the development of the satellite itself.

Particularly for satellite developers in a non-traditional space context –which are typically inexperienced with launching satellites– this approach is advantageous.

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**Figure 1** Spaceflight and ISL offer spaceflight services on a variety of orbital and suborbital vehicles for small and secondary payloads.
Within the service, the following roles are covered on behalf of the customer:

- The launch vehicle provider acts as a wholesaler of Secondary Payload Services.
- Spaceflight or ISL has agreements with the launch vehicle providers to market and contract for flight services at approved pricing.
- Spaceflight or ISL is responsible for analytically and physically integrating multiple payloads into a package that is treated as a major discreet payload for manifesting purposes.

In addition, the customer pays Spaceflight and ISL to bring payloads onto manifest while conforming to all launch vehicle technical and safety requirements. In this manner Spaceflight and ISL work with the payload customer to provide / conduct:

- Launch or Flight service,
- Customer manifest planning,
- Review and approval of flight documentation,
- Safety audits,
- Logistics support for pre-launch checkout campaigns,
- Coordination of launch and on-orbit services.

The Spaceflight / ISL Team provides additional services (for which pricing is to be determined) including but not limited to:

- Integration support to customer developed payloads: analytic and physical integration, testing or other verification services, and design review.
- Customer payload development services: take customer’s core concept or instrument and build, test, and integrate into an assembled secondary payload.
- Qualification and/or Acceptance Test Services for payload qualification and acceptance against (multiple) Launch Vehicle specific loads.
- Logistics services for satellite and ground support hardware between customer and launch site, where import and export management is done for the customer.
- Launch insurance coverage against Launch Vehicle failures, available for both microsatellites as well as for nanosatellites and even CubeSats.

![Diagram showing roles and services of Spaceflight and ISL](image-url)

**Figure 2** Spaceflight and ISL are Secondary and Auxiliary Payload Integrators.
‘TICKET TO SPACE’ APPROACH

The commercialization and marketing approach of the Spaceflight / ISL team for space access for micro- and nanosatellites is focused on the ‘Ticket to Space’ approach, where a customer buys a launch slot on board any launch opportunity within a certain period of time to any orbit within a specified range of parameters, rather than for a particular launch with specific orbit parameters.

With the ticket to space approach the Spaceflight / ISL cooperation provides launch opportunities from all over the world to customers from all over the world; a truly global and flexible approach to launching satellites. By combining efforts it is more likely for any customer to find a launch in the desired timeframe. With the technical developments standard launch interfaces and other secondary payload systems the Spaceflight / ISL team can accommodate any payload.

Especially in the application of the CubeSat standard the ticket to space approach is an expedient and logical approach for offering space access. Since the standard external satellite form factor is a part of the CubeSat standard, the launch interface also conforms to this standard.

By providing modular, standard payload dispensers for CubeSats and nanosatellites, the accommodation of multiple payloads becomes more efficient, enabling more rapid manifesting, and ultimately leading to the flexible ‘Ticket to Space’ approach with backup launch options.

When there is enough flexibility in terms of orbit parameters and timeline for the mission, a small satellite developer can procure a launch opportunity for his/her satellite, based on a certain launch that fits within the ‘envelope of launch and orbit parameters’, and then –in case of changes in the manifest or changes in the developer’s schedule- choose to either:

- Include flexibility in the contract to have a backup launch opportunity.
- Request for the option of an earlier launch opportunity.
- Stick to the baseline launch opportunity.

Figure 3 shows how the Spaceflight / ISL team manages the manifesting of payloads for such an approach.

![Spaceflight / ISL Launch Contract](image-url)

Figure 3  Flexible launch contracting can be achieved through the Spaceflight / ISL cooperation.
MANIFESTING CHALLENGES

There are of course many challenges to this flexible approach towards manifesting payloads, on technical, managerial, legal and political aspects.

Technical aspects:

- Orbital parameters matching; in some cases when the orbital requirements defined for a mission are quite specific it may be very difficult to find a suitable launch opportunity, let alone multiple.
- Mass, volume and number of payloads; constrained by the available space on the launch vehicle.
- Frequency matching; one of the most challenging puzzles is to prevent that frequency interference may occur between different payloads on a launch. Certainly as frequencies can not be changed easily.
- Test and acceptance requirements; not all spacecraft will be tested to environment levels that cover all possible launch vehicles.

Managerial:

- Launch opportunity availability; quite obviously, when only few opportunities are available, little to no flexibility in planning can be offered.
- Contractual negotiations; in some cases arrange for a contract or a contractual change would require a lot of effort on the side of the customer due to its organizational structure, making quick response times required for certain launch opportunities infeasible.

Legal:

- Export control or restrictions; when spacecraft contain certain items that require an export license to be transported to a certain country for launch vehicle integration and launch, this may require a significant amount of time. In some cases, for some technologies and for certain launch countries/sites, export is simply prohibited, eliminating that particular launch opportunity (or vehicle even) to be used, of course.
- Space Debris Mitigation rules (‘25yr rule’); more countries (more) strictly adhere to the space debris mitigation rules of having a spacecraft de-orbited no later than 25 years after its mission ends. For many (very) small spacecraft, this implies that launches to higher altitude orbits are no longer an option.

Political

The political challenges in arranging launches are mostly linked to the diplomatic relations between the countries of the satellite developer and the launch service provider, due to which certain launch opportunities are off limits for some satellite developers.

The cooperation between Spaceflight and ISL is the key to overcome and work through all these challenges, and to create a global ‘Ticket to Space’ launch service offering.

DEPLOYED PAYLOAD INTERFACES

To simplify spacecraft integration time and cost, the Spaceflight / ISL Team have developed and have access to a range of standard payload interfaces leveraging industry proven approaches such as the 15-inch lightband adapter and the ISIS 3U ISIPOD (Figure 4).

Deployed spacecraft can use the following standard interfaces or dispensers offered by Spaceflight and ISL. These are explained in further detail in the subsequent text.

- 1U ISIPOD dispenser
- 2U ISIPOD dispenser (2x1U or 1x2U CubeSat)
- 3U ISIPOD dispenser (1U – 3U CubeSats)
- 6U ISIPOD dispenser
- 12U NanoBox dispenser / ISIPOD QuadPack
- 24U NanoBox dispenser
- 8-inch (20.3 cm) diameter Lightband interface
- 15-inch (38.1 cm) diameter Lightband interface
- 24-inch circular interface

![Figure 4 Examples of the 3U and 6U ISIPOD Dispensers.](image-url)
SECONDARY PAYLOAD SYSTEMS

For each mission, the Spaceflight / ISL Team will integrate multiple spacecraft into a single discrete unit to simplify certification for flight and integration with the launch vehicle, whether this is part of a larger configuration or payloads or even a ‘dedicated cluster’ on board a small launch vehicle.

Different launch vehicles call for different solutions to integrate such a cluster of spacecraft. On the other hand, to keep the cost of (re)design and (re)qualification of such systems down, a modular system that can be accommodated onto different launch vehicles is desired.

The solution for US launch vehicles created by Spaceflight Services is termed the Spaceflight Secondary Payload System (SSPS), and leverages a new CSA Engineering ring, derived from an ESPA Grande ring, which features five 24 inch diameter ports and a series of shelves or payload adapters to launch up to 1,500 kg (Figure 6). Spaceflight, working with its sister company, Andrews Space, is developing the SSPS as a standard adapter for EELV (Intermediate) class launchers. The SSPS is unique, compared to a traditional ESPA ring, in that it can fly larger spacecraft weighing 300 to 500 kg in a vertical orientation. In addition, it can potentially accommodate multiple ESPA sized spacecraft on a single port.

In turn, ISL, working together with parent company ISIS – Innovative Solutions In Space BV, is working on a set of modular solutions for small launch vehicles.

ISL aims to provide modularity in launch interfaces not only with the ISIPOD dispensers that are available for 1 to 6 unit CubeSats, but also for larger payloads with the development of the Modular Payload Deck Elements (MPDE).

The MPDE enables more convenient clustering of secondary payloads, where sub-clusters of CubeSat dispensers are combined with multiple accommodations for larger nano or micro satellites.

The MPDE can also be used for cluster launches on smaller launch vehicles. The MPDE is in this case the single launch interface to the launch vehicle and the cluster is in fact the primary payload.

Figure 6  Spaceflight Secondary Payload System.

Figure 5  MPDE Payload System example.
A more detailed example of the modular payload deck elements developments is the 12U modular ISIPOD system (or ‘ISIPOD QuadPack’). This system has a composite exterior structure, and has a modular interior design that allows for the placement of different configurations of CubeSat form factor based payloads (Figure 7 below).

As such, the ‘QuadPack’ can be easily mounted on different launch vehicles and can accommodate a multitude of configurations, from four 3U CubeSats, or two ‘6 Packs’ to a 12U configuration, or even up to twelve 1U CubeSats, for that matter.

Figure 7 MPDE Payload System example.

### STANDARD INTEGRATION PROCESS

Commercial launch operations are designed for minimal complexity and time at the pad. Once integrated, the launch vehicle is typically moved quickly to the pad and erected for launch. Launch readiness approval is received via a Launch Readiness Review (LRR) held 24 hours before launch.

For most launch vehicles, integration and encapsulation of the primary and secondary payloads takes place off-line in an integration facility, followed by mating with the launch vehicle and transport to the launch pad. Secondary Payload integration to the Payload Adapter will be performed by the Spaceflight / ISL team prior to integration of the primary payload and encapsulation at the Launch vehicle facility (Figure 8).

For this reason, depending on which launch vehicle is used, the Secondary Payloads must typically arrive at the launch site up to 4 to 8 weeks prior to launch to allow enough time for final checkout and test, Payload Adapter and launch vehicle integration.

Standardizing the integration process removes uncertainty from the integration schedule, and keeps the secondary payload integration from driving the overall launch vehicle integration. If a particular spacecraft is known to be behind schedule, an alternate spacecraft or mass simulator can be substituted, depending on the integration timeline.

The first step in the secondary payload integration process is the integration of the Secondary Payloads to the Payload Adapter within Spaceflight or ISL facilities. Secondary payloads will be accepted at these facilities up to 4-1/2 months prior to launch, at which time they will be inspected and readied for integration with the Payload Adapter.

At the Launch Site, limited payload processing, including hazardous operations, may be conducted as a non-standard service. Any kitted parts will be assembled, and then the payloads and assemblies will be sent to the Payload Adapter integration facility for integration in a clean (<100k cleanliness) temperature-controlled environment prior to integration with the launch vehicle.

Launch vehicle providers will encapsulate primary payloads in either a vertical or horizontal orientation, depending on the integration and operational flow. Secondary payloads integrated with the Payload Adapter will be transported from the integration facility to the launch vehicle integration facility to be integrated with the launch vehicle.

Typically, the integrated Payload Adapter will be mounted to the launch vehicle adapter in a vertical orientation, then the primary payload will be mated to the Payload Adapter. The entire payload assembly will then be encapsulated vertically, or encapsulated horizontally using a break-over fixture.

Once encapsulated, the Environmental Control System (ECS) will be connected, and the encapsulated payload (or Space Head Module as it is called for instance for certain Russian launch vehicles) will be connected and integrated with the launch vehicle.

Post-mate checkouts will be conducted, followed by the Flight Readiness Review (FRR). With completion of the FRR, the launch vehicle is readyed for transport to the launch pad. Once weather and safety clearance are received, the vehicle is rolled out and erected on the launch pad.

Environmental control of the vehicle and payload during rollout is maintained by a portable ECS. After arrival at the pad, ECS function is transitioned to the pad ECS, which supplies environmental control until
launch. Once the launch vehicle is erected at the pad, a series of operational and functional tests are performed to ensure operational capability and launch readiness. Twenty-four hours prior to launch, a launch readiness review (LRR) is held with the range to confirm final readiness for launch.

**SERVICE SCHEDULING**

For an overview of what launches are available, Spaceflight and ISL have created a joint launch opportunity overview that is being kept up to date on a regular basis. These overviews can be found on the website www.spaceflightservices.com from Spaceflight Services or on the ISILaunch Service website www.isilaunch.com.

Spaceflight has established a standard payload integration process and milestone payment structure. The contracting process begins with filling out a Payload Questionnaire to provide payload information. This questionnaire can be found on the www.spaceflightservices.com website.

Once a payload customer decides to contract for launch services, they sign a Launch Reservation Agreement, associated with the first milestone payment. This starts the payload manifesting and mission planning process. Once a specific flight opportunity has been identified, the customer signs a Launch Services Agreement with a second milestone payment attached. The payload manifesting / integration process proceeds with a third payment required at finalization of the payload ICD. The final payment is made upon launch.

**CONCLUSION**

With the increase in small satellite activities and projects in Europe, the US, Asia, and other parts of the world, the availability of regular, affordable access to space for small satellites is more critical than before.

Spaceflight Services, Inc and Innovative Space Logistics BV (ISL) have teamed up to create a global launch services offering to small satellite developers worldwide, using the relatively scarcely available launch opportunities on a variety of launch vehicles in the most optimal way.

Spaceflight and ISL have created a range of standard launch adapters and modular payload deck elements to optimally accommodate different sizes of payloads on different launch vehicles.

By creating a standard service structure and a joint marketing approach, understanding and dealing with the different challenges in multi-payload, multi-national manifesting, Spaceflight and ISL can offer affordable launches for any payload worldwide.