SMALL PAYLOAD ACCOMMODATIONS (SPA) for the ATLAS Family of Launch Vehicles

SS-88-60

2nd Annual AIAA/USU Conference on Small Satellites

September 19-21, 1988

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Abstract

The history of small, secondary payload accommodations on early ATLAS boosters is reviewed. Design and flight operations concepts for small payloads on current ATLAS launch vehicles are presented and discussed. ATLAS launch vehicle system capabilities are presented in terms of launch site integration schedules and the excess performance which will be available to launch small payloads.

Introduction

General Dynamics' Commercial Launch Services, Inc. (GDCLS) is offering launches by the ATLAS Launch System on a commercial basis. The current offering consists of ATLAS I and ATLAS II, IIA, and IIAS launch vehicles whose performance cover the range of geo-synchronous transfer orbit (GTO) payload weights to nearly 7000 pounds. With an apparent increase in demand for the launch of small payloads, CLS is considering reinstituting the 1960s General Dynamics program of launching small, secondary payloads with the ATLAS. The following is a brief recap of the early ATLAS history of launching these payloads, an overview of current design and operations concepts and concerns, and a discussion of their future on the ATLAS family of launch vehicles.

Historical Perspective

In 1960, GD developed the Scientific Passenger Pod (SPP; Figures 1, 2, and 3) for use as low cost space research vehicles to take advantage of unused payload or fuel capacity on ATLAS flights. The pods were side-mounted on the booster, separated, and flew a ballistic trajectory for about 35 minutes. This flight duration doubled the capability of sounding rockets and offered longer, higher flights for the gathering and telemetering of data. The

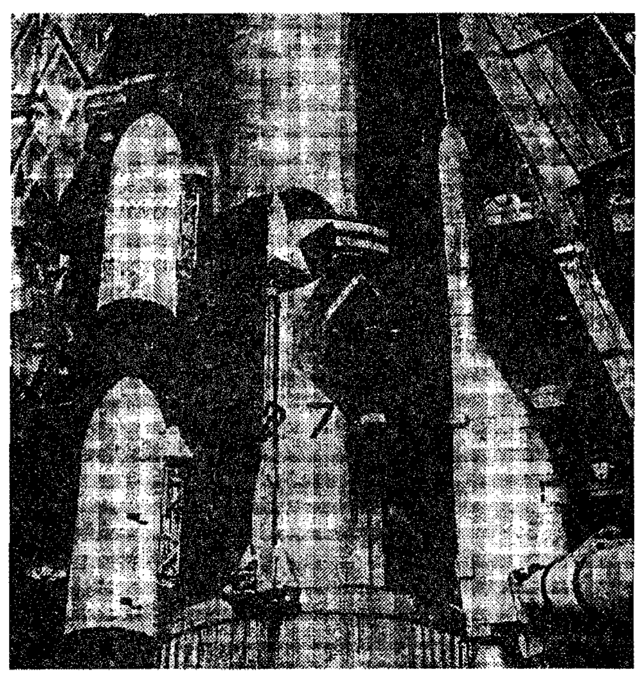


Figure 1. Tandem SPPs Ready for a 1960s ATLAS Launch.

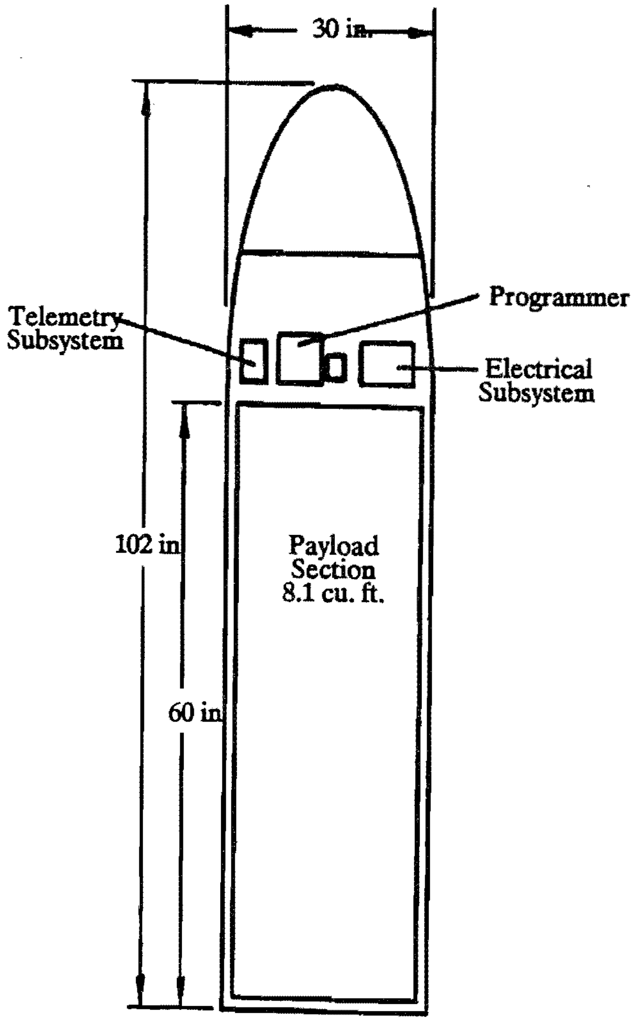


Figure 2. The Standard SPP Accommodated Canisterized Payloads.

SPPs were designed in two sizes for widely different missions. The standard pod (Figure 2) was designed for captive flight of small payloads (8.1 ft^3 and 450 pounds). The large pod (Figure 3) was designed to house and deploy a small satellite with a self-contained propulsion system (GD's OV-1 with its 300 lb payload and 800 lb propulsive stage). More than fifty SPPs were flown during the 1960s for the Air Force Office of Aerospace Research, the Naval Research Laboratory, the Defense Atomic Support Agency, National Aeronautics and Space Administration, and the Advanced Research Projects Agency.

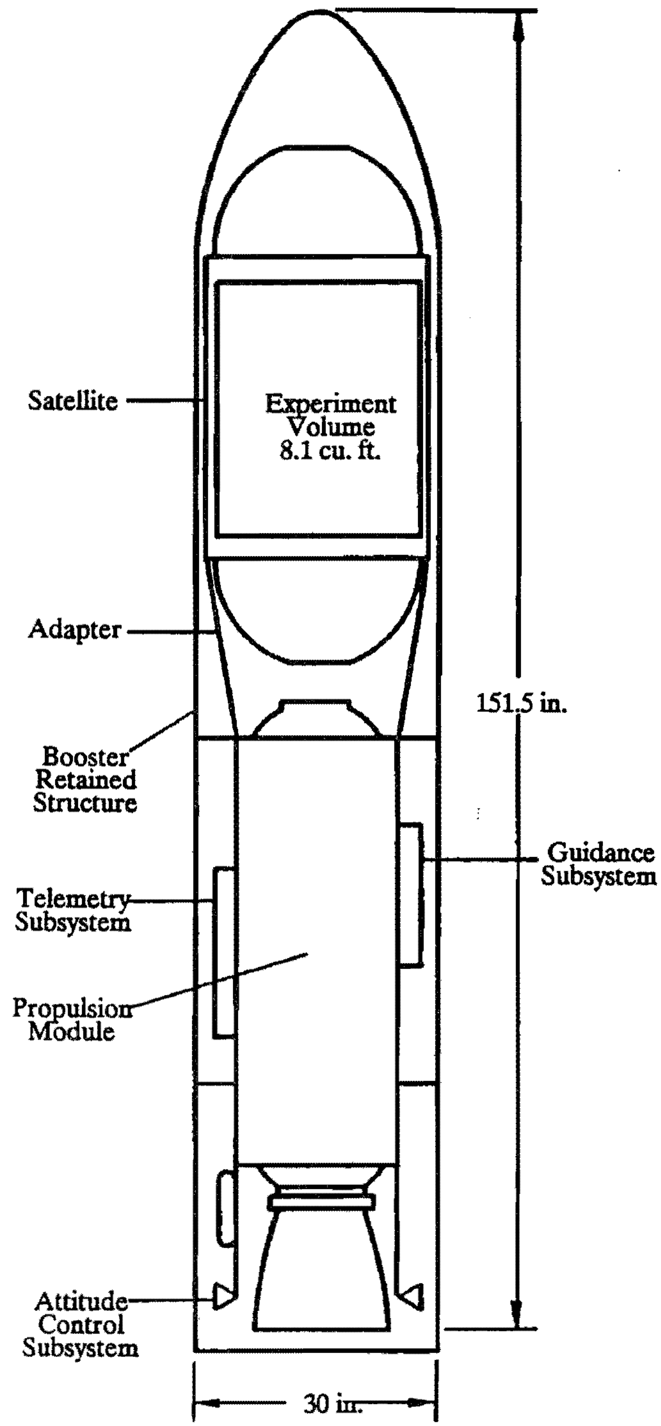


Figure 3. SPPs Also Supported Propulsive Payloads (GD's OV-1 Depicted).

The only SPP interface with the ATLAS was its physical attachment. There were no electrical, guidance, nor telemetry interfaces. The small pods remained fixed to ATLAS or were separated pneumatically from the support cradle at sustainer engine cut-off (SECO). The large pod remained attached to the vehicle, the pod's hatch opened, and the propulsive payload jettisoned. The SPP's payloads then performed their mission, either reentering the atmosphere or, in the case of the propulsive satellites, injecting into low earth orbit (LEO).

The SPPs provided battery power, signal conditioning equipment, commutators, subcarrier oscillators, an FM/FM transmitter, RF and pod-separation switches, and two antennas. The pod's controller sensed SECO then supplied an output signal to eject the passenger pod from the booster. It also provided step or pulse outputs to operate payload equipment.

SPA Concepts

Building upon our early experience with small, secondary payloads on the SPP program and utilizing the current excess performance available from the ATLAS family of launch vehicles, CLS is studying concepts for Small Payload Accommodations (SPA) as a follow-on to our history of low cost, assured access to space.

ATLAS-Mounted

Similar to the 1960s SPP, the ATLAS-mounted SPA pods can be available in two sizes, short and long, for payload canister(s) and payloads with integral propulsive stages. Each pod will offer power, command sequencing, and telemetry services. All SPA pods will follow the fully autonomous regimen of the original SPP. SPA payload customers will be offered the option of providing their own integrated pods utilizing this same guideline.

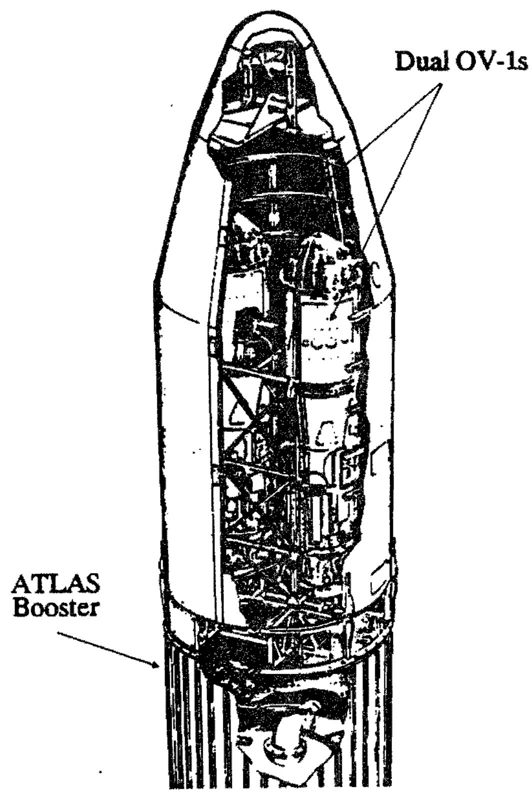
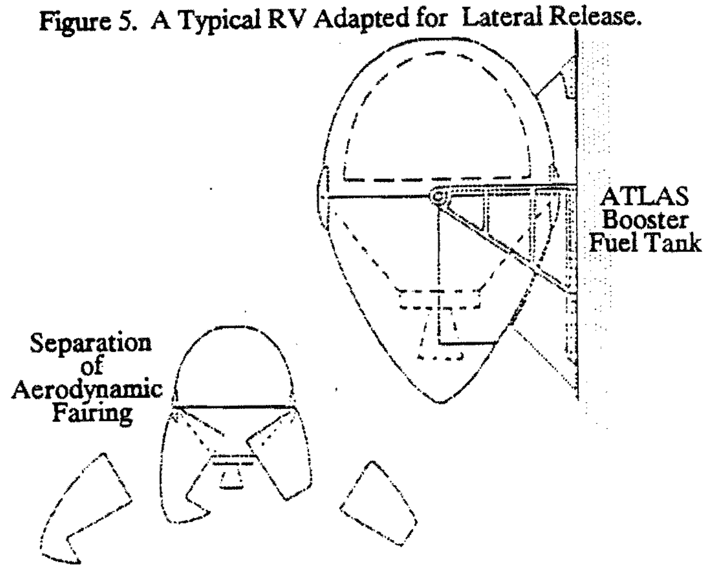


Figure 4. Dual OV-1s on an early Atlas booster.

During the 1960s, ATLAS flew multiple small payloads as shown in Figure 4. Today's ATLAS is available for the launch of multiple payloads (with or without the use of our Centaur upper stage).

Figure 5. A Typical RV Adapted for Lateral Release.



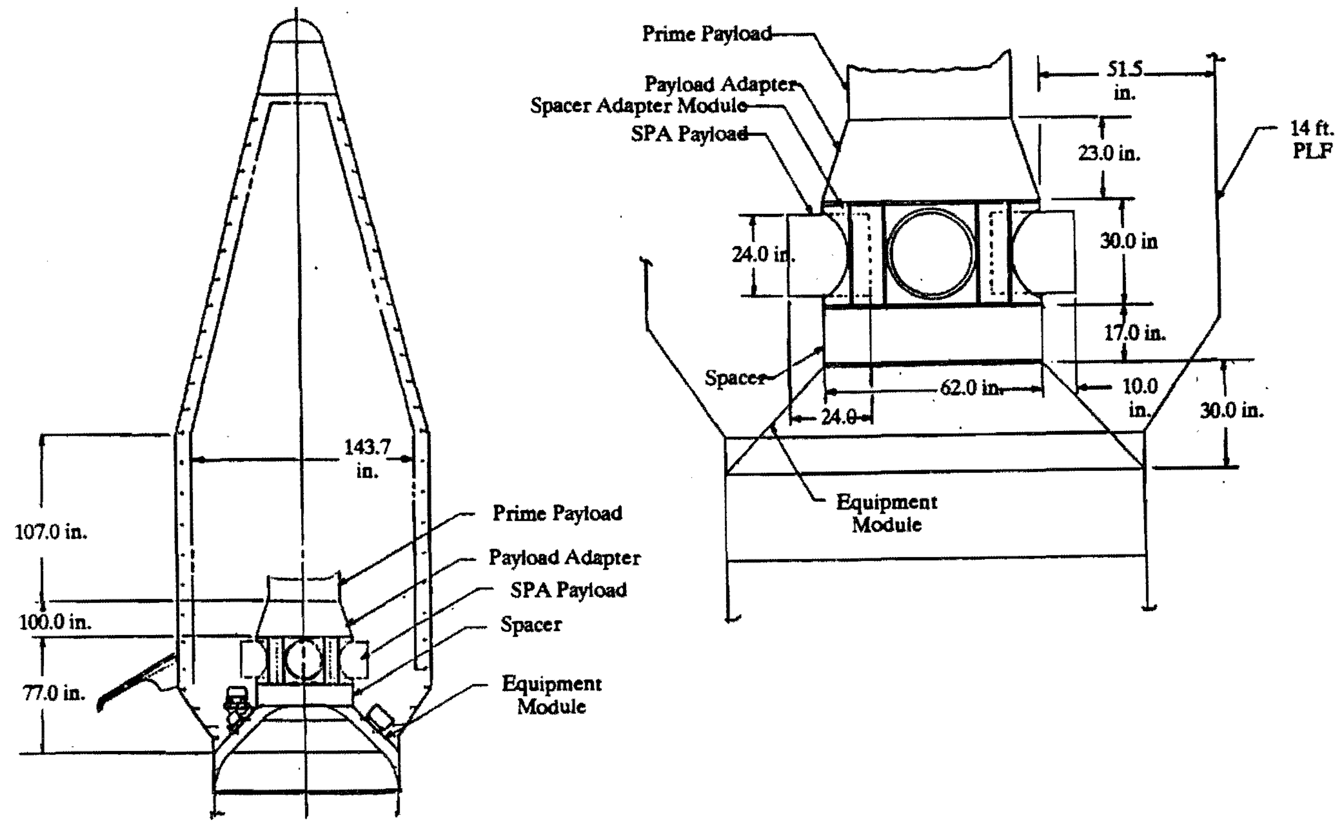


Figure 6. Spacer Adapter Concept for Centaur-Mounted SPA Payloads.

Another ATLAS-mounted SPA design concept is to provide compatiblity with domestic or foreign recoverable vehicles (RVs; Figure 5). Such an RV would be adapted for lateral release and could be encapsulated in an aerodynamic fairing. The recovery of the RV and its payload would be the responsibility of the RV contractor.

Centaur-Mounted

In addition to the original 1960s SPP side-mount concept, small, secondary payloads may be mounted on the ATLAS upper stage (Centaur; Figure 6) and offered a variety of high energy orbits to captive, free-flying, and propulsive payloads. The ATLAS payload fairing (PLF) will adequately protect these payloads during the launch and ascent environments. Similar to the ATLAS-mounted payloads, all Centaur-mounted payloads will utilize isolated power, command, and telemetry services.

SPA payloads investigating the LEO regime must be separated from the Centaur during the park orbit coast. Payloads interested in GTO orbits (with the potential of recovery by retro-powered RVs) or geosynchronous orbits (with an integral propulsion stage) will be constrained to remain attached until after prime payload deployment, possibly even after the Centaur's Collision and Contamination Avoidance Maneuver (CCAM).

Prime Payload Considerations

In the highly competitive world of commercial launch services, CLS has accepted the responsibility for on-schedule mission success. Consequently, CLS's prime objective on every flight is to ensure on-schedule prime payload delivery.

CLS will integrate the flight requests of SPA payloads on commercial ATLAS missions on a conservative non-interference (technical and schedule) basis. SPA manifesting will be based on excess mission performance, compatibility of payload requirments with the prime payload's ATLAS mission (mission planning and flight operations) and SPA resources (optional services), as well as the ability of the SPA payload customer's to meet the integration and launch schedule of the primary payload.

The assessment of non-interference will include impacts on the launch, ascent, and on-orbit environments of the prime payload. Orbital operations of the launch vehicle system (booster and upper stage) will satisfy the prime payload requirements then accommodate the requirements of the SPA payloads. Additionally, SPA propulsive modules must be inhibited from ignition in the vicinity of the prime payload.

Once a SPA payload has been accepted, CLS will be responsible for the integration of the payload with the GD-provided module as well as the flight manifesting, interface design, and launch operations. The SPA payload customer will be responsible for all payload activities in support of the integration analysis, design, and verification and meeting the schedule requirements of the prime payload.

Typical integration activities are expected to average nearly two years (Figure 8). This time will be spent ensuring the compatibility of the SPA payload with the prime payload mission and ATLAS launch system to the satisfaction of both CLS and Range Safety. Figures 9 and 10 outline the SPA payload's launch site processing timeline.

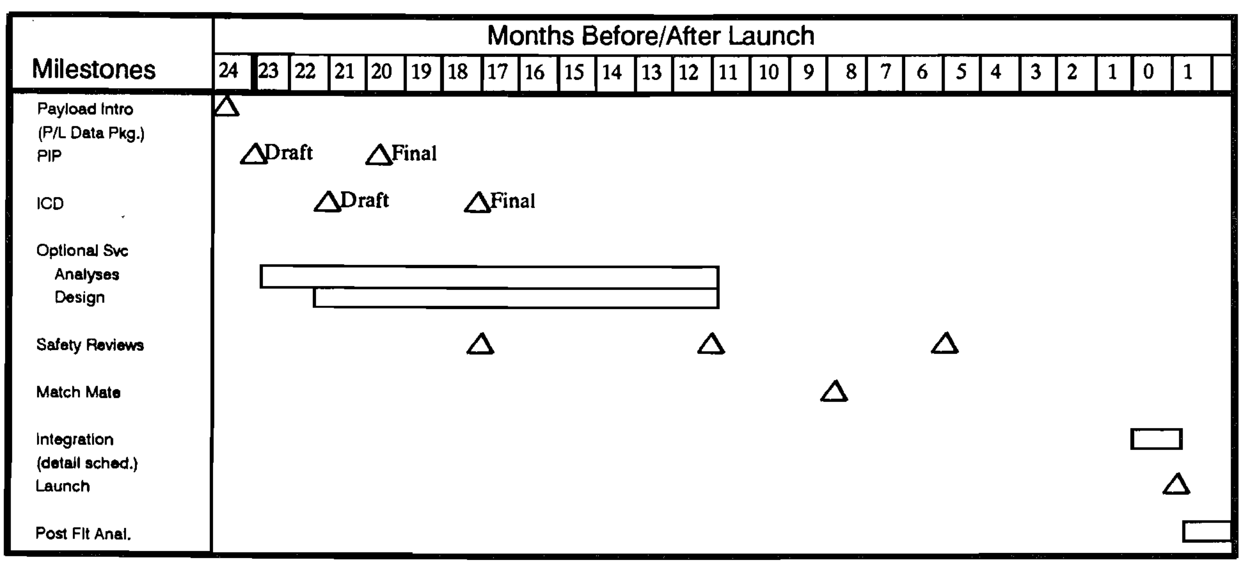
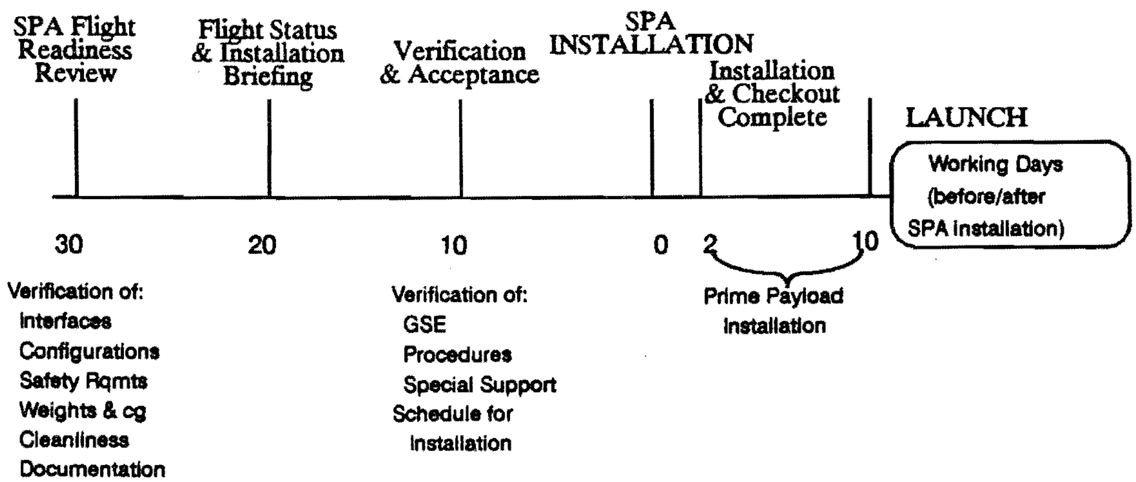
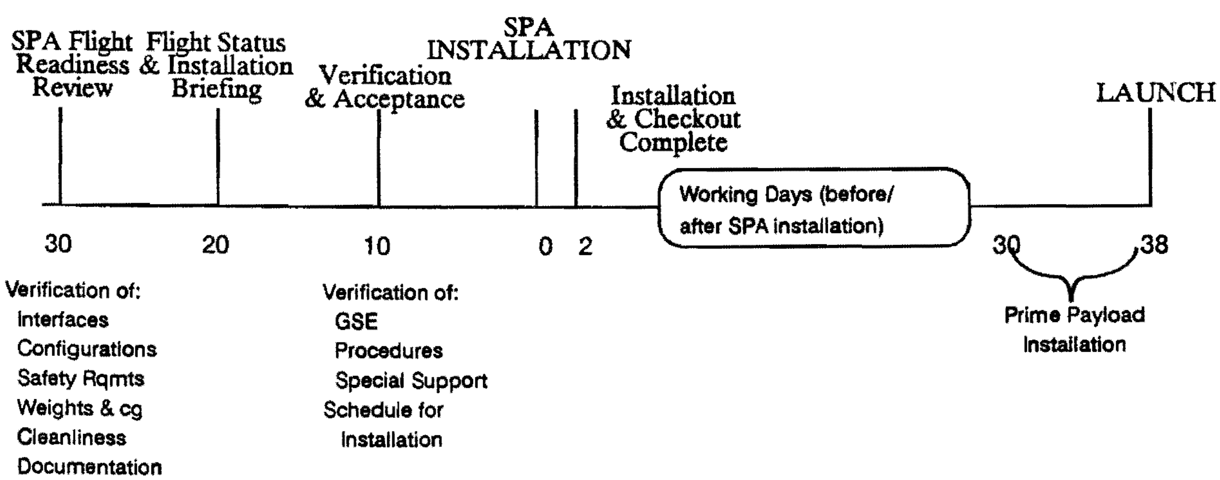


Figure 8. A Typical SPA Integration Schedule.



NOTE: Payloads should be capable of on-pad holds of up to 60 days without access (electrical umbilical for monitoring and battery charging is permitted).

Figure 9 ATLAS Booster-Mounted Launch Site Integration Schedule.



NOTE: Payloads should be capable of on-pad holds of up to 60 days without access (electrical umbilical for monitoring and battery charging is permitted).

Figure 10. Centaur-Mounted Launch Site Integration Schedule.

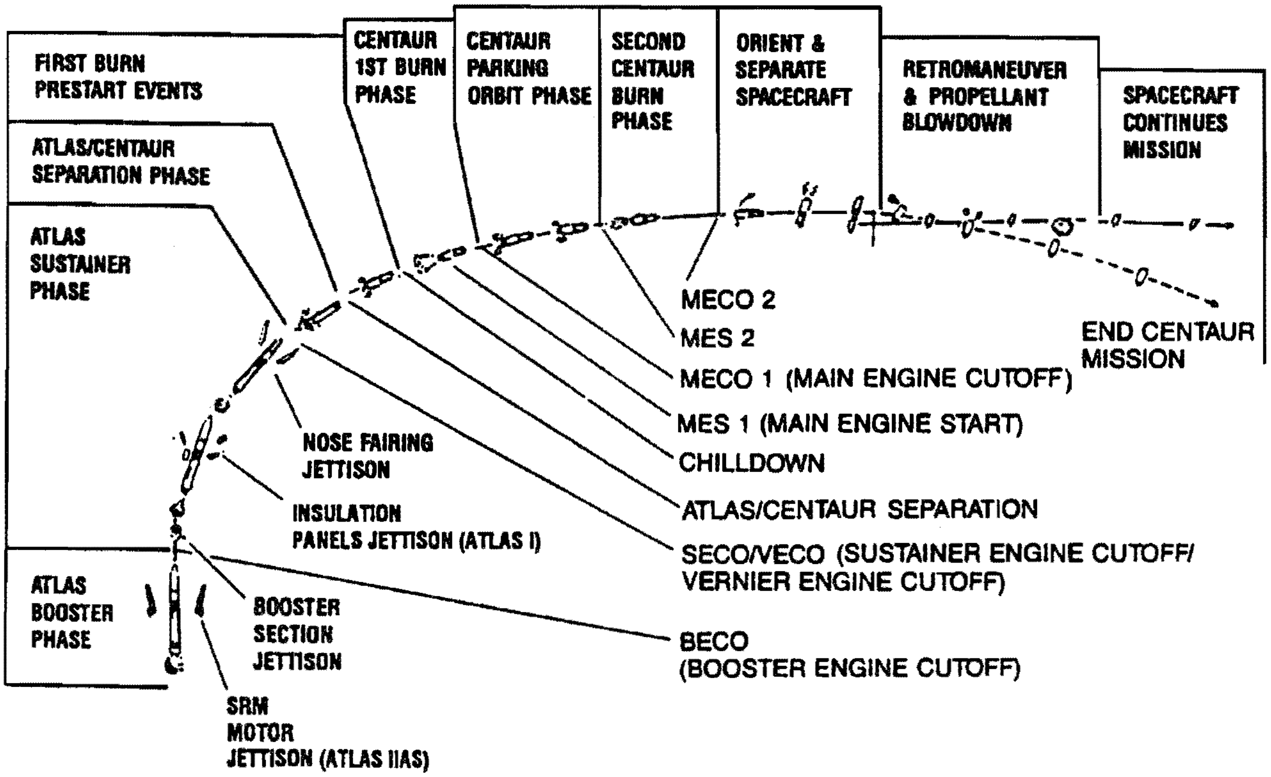


Figure 7. Overview of a Typical GTO Mission.

SPA Mission Orbits

SPA mission orbits are defined by the ATLAS mission profile of the prime payload (Figure 7). ATLAS lower-stage mounted payloads are separated with a suborbital trajectory (see Table 1 for typical timelines). Constraints on propulsive payloads would key SPA ignition to payload fairing jettison or after MES-1 (near lower stage apogee).

Centaur-mounted SPA payloads will normally have a choice between LEO and GTO for their separation (fixed payloads, of course, are relegated to remain with Centaur to GTO). The Centaur's LEO park orbit is nominally 80+ nm (perigee) by less than 400 nm (apogee) and inclined at 28.5 deg. Injection into GTO normally occurs at the first equatorial crossing and results in an apogee of 19,323 nm at about 27.25 deg. Some prime payloads may require that the inclination be reduced and a super-synchronous transfer orbit be provided.

Table 1. REPRESENTATIVE ATLAS I AND ATLAS II/IIA GTO MISSION TIMELINES.

Event	Time (sec) ATLAS I	Time (sec) ATLAS II/IIA
Liftoff	0.0	0.0
BECO (5.5g)	156.0	171.2
Jettison Boost. Pkg	159.1	174.3
Jettison Insul. Panels	181.0	N/A
Jettison PLF	227.3	223.4
SECO	264.3	278.6
{Deploy SPA	265-266	279-280}
ATLAS staging	266.3	280.6
Centaur MES-1	276.8	291.1
Centaur MECO-1	610.0	677.1
{Deploy SPA	615-1358	681-1413}
Centaur MES-2	1478.5	1533.0
Centaur MECO-2	1555.6	1632.0
Prime Payload Separation Attitude	1557.6	1643.0
Prime Payload Sep.	1690.6	1767.0
CCAM	1705.6	1782.0
{Deploy SPA	any time up to Centaur deactivation}	

ATLAS Programs

With its beginnings as an intercontinental ballistic missile, the ATLAS heritage spans 30+ years in service to the free world's space programs. The ATLAS launched the first U.S. manned orbital space flight. Coupled with the Centaur, the world's first liquid hydrogen/liquid oxygen stage, the ATLAS/Centaur vehicle has provided launch services to 37 communications spacecraft (GTO), 9 planetary and 7 lunar missions (earth escape), and 14 payloads to low earth orbit (LEO).

The current ATLAS consists of a stage-and-a-half booster vehicle and the Centaur upper stage (Figure 11). The vehicle launches from Complex 36B at Cape Canaveral Air Force Station, Florida (CCAFS) and accelerates to 5.5g before separation of the two booster engines and their thrust structure. ATLAS flight continues under power of the sustainer engine. Centaur's two main engines then inject the Centaur and payload into park orbit.

The typical GTO mission will provide a park orbit coast of about 13 minutes prior to Centaur restart for the GTO injection burn.

Figure 12 identifies the current vehicles in the ATLAS family, their programmatic status, and GTO performance capability. The ATLAS I is the first vehicle in the continuing evolution of the long line of ATLAS vehicles (492 launches since 1957) and is the first ATLAS to offer a large (14 ft. diameter) metal payload fairing. Increased performance and higher reliability are obtained with the steps to the ATLAS II, IIA, and IIAS. (It should be noted that the U.S. Air Force selected the ATLAS II for the Medium Launch Vehicle II (MLV II) program.) Figure 13 shows the potential of these vehicles for carrying multiple SPA payloads of different sizes and types as a function of prime payload mass and ATLAS family member selected for launch by CLS and the prime payload customer.

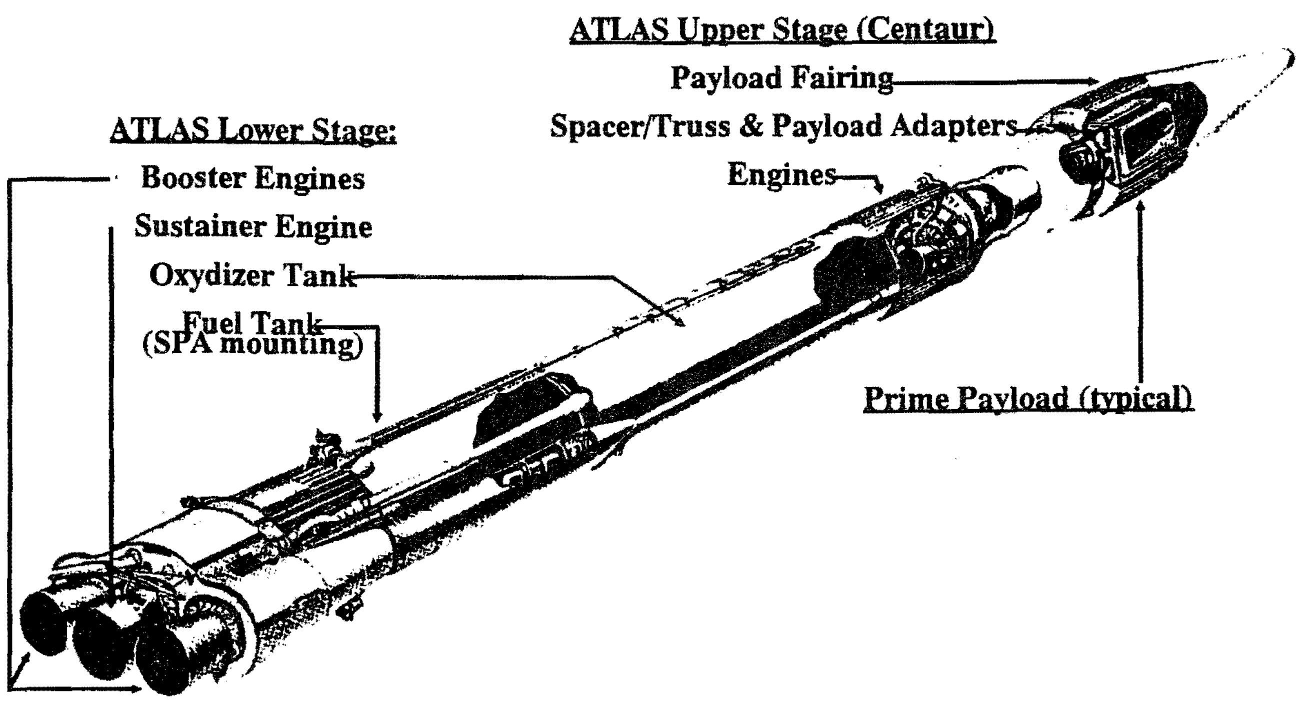
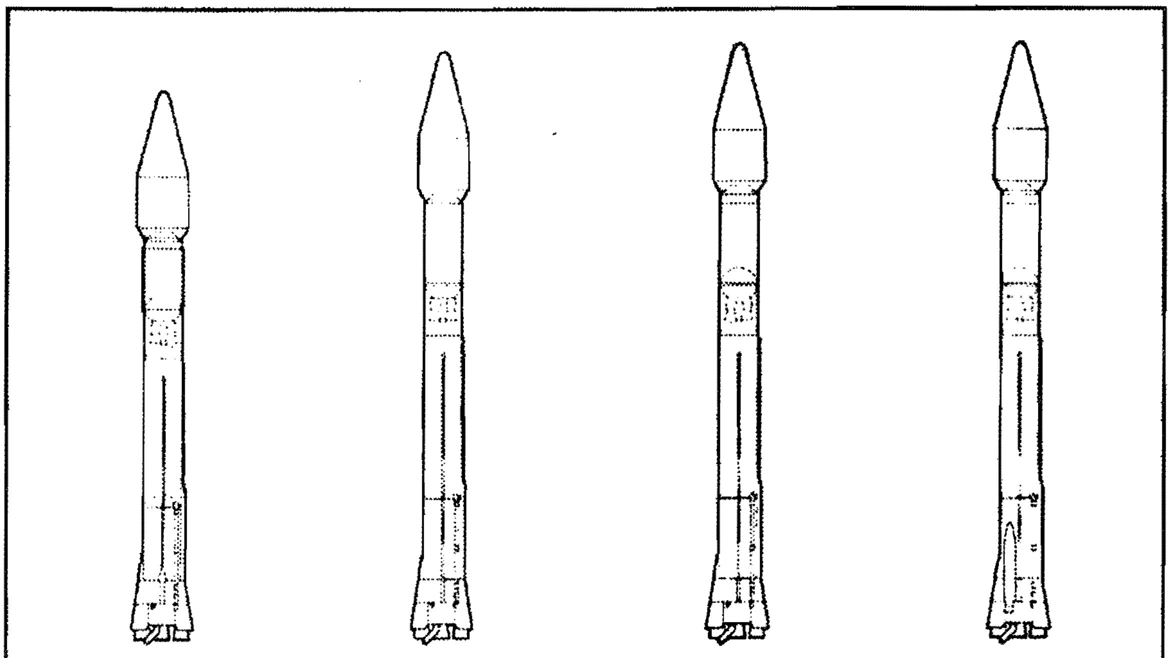


Figure 11. ATLAS Configuration.



	ATLAS I	ATLAS II	ATLAS IIA	ATLAS IIAS
PAYLOAD TO GTO 11 FT PLF	2335 KG (5,150 LB)	2765 KG (6,100 LB)	2900 KG (6,400 LB)	3158 KG (6965 LB)
14 FT PLF	2245 KG (4,950 LB)	2675 KG (5,900 LB)	2810 KG (6,200 LB)	3068 KG (6765 LB)
STATUS	IN PRODUCTION	IN DEVELOPMENT PRODUCTION		PLANNED

14 FT PLF SHOWN (11 FT PLF OPTIONAL)

Performance shown is for payload system weight of spacecraft, payload adapter, and mission-peculiar hardware. Typical payload adapter and mission-peculiar hardware weight is 60 kg (130 lb.).

Figure 12. The ATLAS Family of Launch Vehicles.

Commercial ATLAS launches are from Complex 36B at a rate of four per year (with a surge capability to five).

ATLAS launch services can include provisions for the small payload community. With our broad range of experience, we can accommodate small payloads as fixed and jettisoned payloads, single and multiple payloads, and as secondary or primary payloads.

We recommend the standardization of simple interfaces and will support their definition to assure early incorporation into the ATLAS family of launch vehicles and commercial launch services.

Summary

The early days of space exploration may be behind us but we are finding that the need for low cost access to space is greater than ever. From one-time experiments to constellations of small spacecraft, the need for such launch services appears to be expanding. General Dynamics' Commercial Launch Services, Inc. is recognizing this need and is in the process of accommodating you, the small payload community.

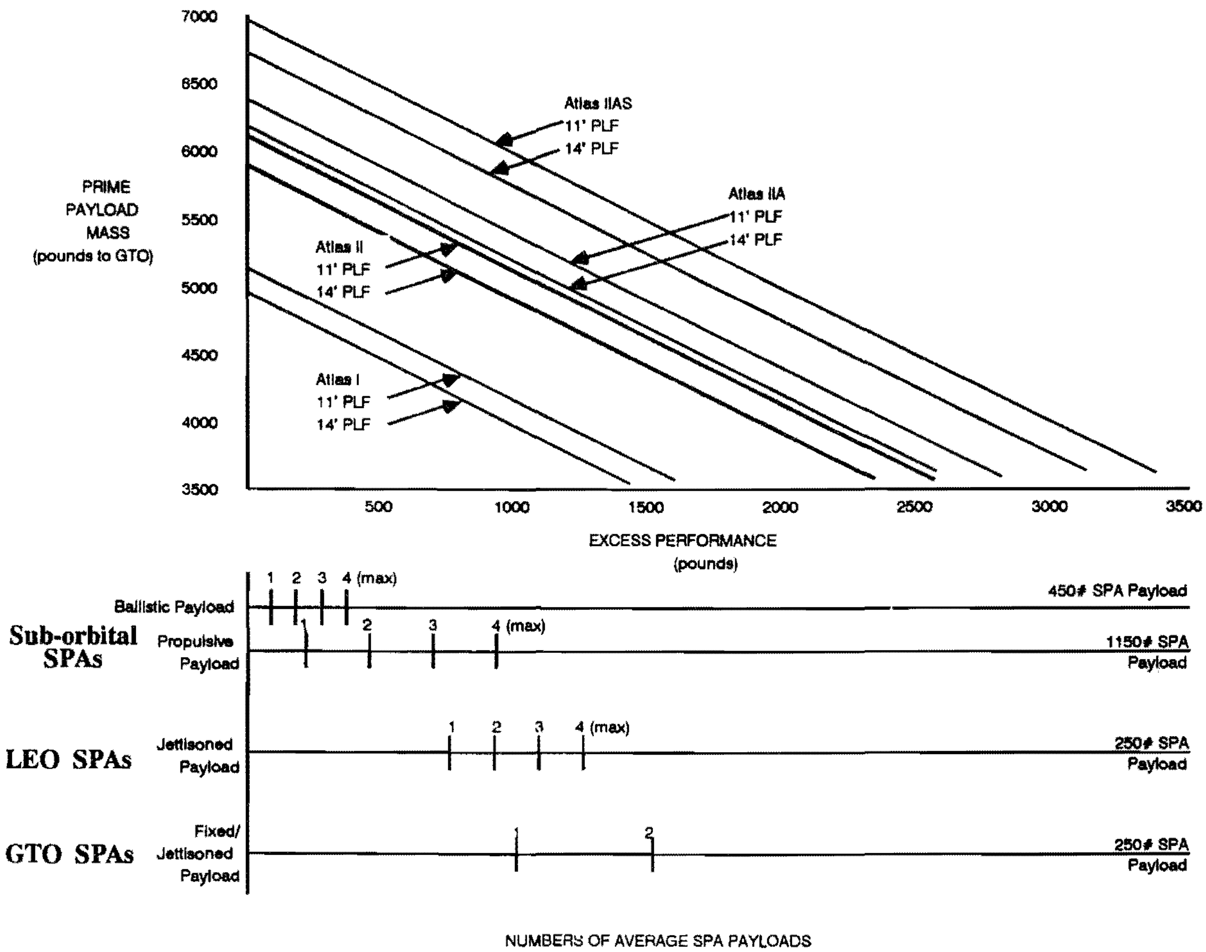


Figure 13. SPA Capabilities are Dependent Upon Launch Vehicle and Prime Payload Mission Mass.

We welcome the opportunity to discuss ATLAS's potential application to your program. Please direct any requests for information to:

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