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Spaceflight Secondary Payload System (SSPS) and SHERPA Tug - A New Business Model for Secondary and Hosted Payloads

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ABSTRACT

Since the termination of the Falcon 1 program, the opportunities for access to space for small spacecraft have been limited. Spaceflight, Inc. (Spaceflight) is addressing this market need by providing commercial launch services for secondary and hosted payloads by using its Spaceflight Secondary Payload System (SSPS) and SHERPA in-space tug. The SSPS is a system designed to transport up to 1,500 kg of secondary and hosted payloads to space using the excess capacity on Medium and Intermediate class commercial launch vehicles. The SSPS can accommodate up to five 300 kg spacecraft, or many smaller spacecraft, on each of its five ports and operates independently from the primary launch vehicle to simplify payload and mission integration. SHERPA is an in-space tug that builds upon the capabilities of the SSPS by incorporating propulsion and power generation subsystems, which creates a free-flying tug dedicated to maneuvering to an optimal orbit to place secondary and hosted payloads. Spaceflight has manifested the SSPS on a Falcon 9 launch in 2013 and the SHERPA on launches in 2014 and 2015. This paper and presentation will outline the design details and payload capabilities of both the SSPS and SHERPA, with specific details on the payload interfaces, the available payload volume, predicted environments and expected launch integration flow.

KEYWORDS: Spaceflight Secondary Payload System (SSPS), SHERPA Tug

INTRODUCTION

The Spaceflight Secondary Payload System (SSPS) is a standard secondary payload accommodation system for Medium and Intermediate class launchers (e.g. Falcon 9, Antares, EELV). The SSPS (Figure 1) has at its core a new Moog CSA Engineering ring, derived from an ESPA Grande ring, which features five 24 inch (61 cm) diameter ports, each capable of carrying payloads weighing up to 660 lbm (300 kg). The SSPS provides two common mechanical interfaces (top and bottom) and attaches to the launch vehicle upper stage while the primary payload sits above the SSPS.

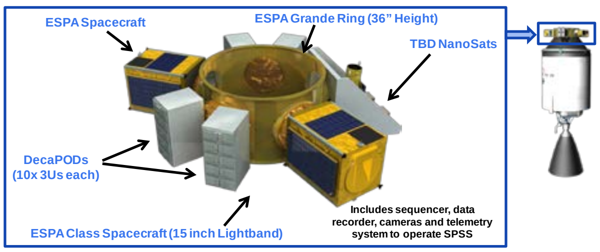

Figure 1: Spaceflight has developed the Spaceflight Secondary Payload System (SSPS) to simplify certification for flight and integration with the launch vehicle.

To simplify integration and coordination with the Launch Service Provider, the SSPS has its own avionics suite, with integral batteries, to control the deployment of the secondary payloads. This avionics system (SSPS avionics / electronics) receives simple commands from the launch vehicle to start its pre-coordinated deployment sequence and is capable of receiving / storing telemetry from each deployment event as well as capturing video and photography of the deployments. The SSPS avionics / electronics are responsible for the following functions:

- SSPS mission management
- SSPS orbit and attitude determination
- SSPS electrical power system storage and distribution
- Secondary payload trickle charging prior to launch
- Secondary payload telemetry monitoring and recording
- Video recording for verification of deployment events and marketing purposes
- Secondary payload deployment sequencing
- Transmission of telemetry, secondary payload health, and video information to the ground via the launch vehicle or dedicated telemetry system

The SSPS operates very similar to a standalone spacecraft with a flight computer, electrical power system, orbit determination capability, and payload power switching. The avionics suite uses Andrews' existing line of products and components including its 100-Series avionics, Pyxis imager, and the Cargo Module Power Unit for providing regulated 28Vdc power to each of the payloads. The first flight of the SSPS will be on a Falcon 9 launch vehicle in 2013. Spaceflight has contracted with its sister company: Andrews Space (Andrews); to develop and fabricate the SSPS.

The SHERPA leverages the structure and subsystems of the SSPS, and incorporates a power and propulsion system to create a free-flying spacecraft capable of large (ΔV >400 m/s) orbit changes to relocate secondary payloads from the primary payloads' orbit to their target orbit. Spaceflight / Andrews is also developing an enhanced SHERPA capable of 2200 m/s of deltaV to support GTO to GEO missions, as well as deep space missions. These two systems are known as the SHERPA 400 and SHERPA 2200 respectively (Figure 2).

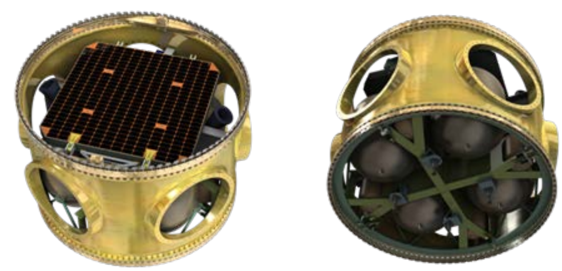

Figure 2: Andrews Space develops and builds the SHERPA product line which currently includes 400 m/s ΔV and 2200 m/s ΔV versions.

SHERPA OPERATIONAL APPROACH

Both SSPS and SHERPA use an ESPA ring to maximize launch availability to GEO and other orbits. The SHERPA vehicle will be launched as a secondary payload on an intermediate class vehicle (Figure 3).

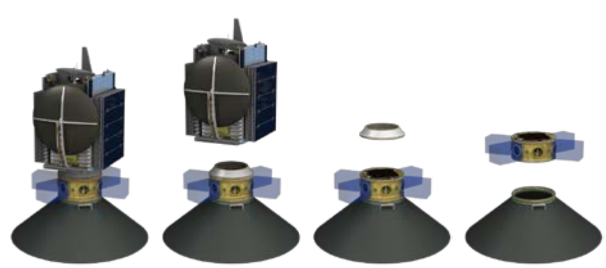

Figure 3: The SHERPA vehicle will be launched as a secondary payload on a Falcon 9 or equivalent intermediate class vehicle and deployed into orbit after the primary payload is deployed.

After insertion the SHERPA vehicle will use its onboard propulsion system to maneuver the spacecraft to complete its mission. SHERPA has a single 333W array for nominal operations. Enhanced versions of SHERPA can accommodate a three panel, articulated array to provide 700W of orbit average payload power. The SHERPA vehicle is capable of deploying one or all of its payloads and still conduct controlled operations. The SHERPA's attitude determination and control system is capable of fine attitude pointing to align its payloads to meet mission objectives. The vehicle's communication and power system is architected to allow the payloads to operate while conducting precise payload pointing operations. Figure 4 summarizes SHERPA 400 and SHERPA 2200 performance capability.

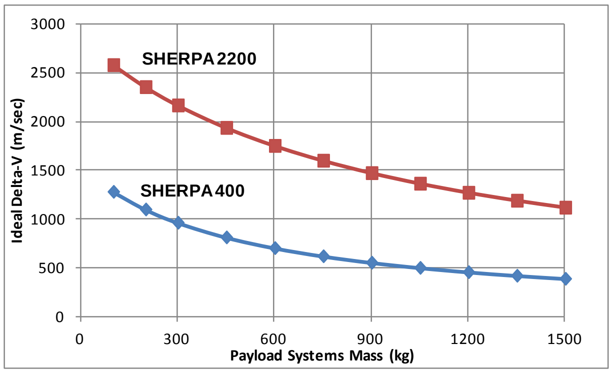

Figure 4: Spaceflight has developed the Spaceflight Secondary Payload System (SSPS) to simplify certification for flight and integration with the launch vehicle.

SHERPA CONFIGURATION OVERVIEW

SHERPA is designed for at least one year of on-orbit operations. The SHERPA uses the SSPS avionics for payload support and deployment operations, and an Andrews 100 Series spacecraft C&DH avionics suite currently in development for a GEO spacecraft.

The SHERPA platform uses a modular construction approach. The SHERPA platform is comprised of a five-port 36" height ring and two integrated decks: an integrated propulsion pallet and an integrated avionics pallet. This approach simplifies integration and reduces cost (Figure 5).

Figure 5: The Andrews SHERPA platform is a modular spacecraft bus that leverages the Avionics Deck and Propulsion Deck currently being developed for the SHERPA in-space tug.

INTEGRATED PROPULSION PALLET

The Andrews SHERPA platform uses an integrated propulsion pallet (Figure 6). The SHERPA 400 propulsion system uses four blow-down monopropellant tanks and four 22N thrusters arrayed such that they can accommodate a large change in spacecraft center of gravity associated with payload deployments. The SHERPA 2200 uses four 90N thrusters and a bi-propellant propulsion system to achieve the higher required delta-velocity.

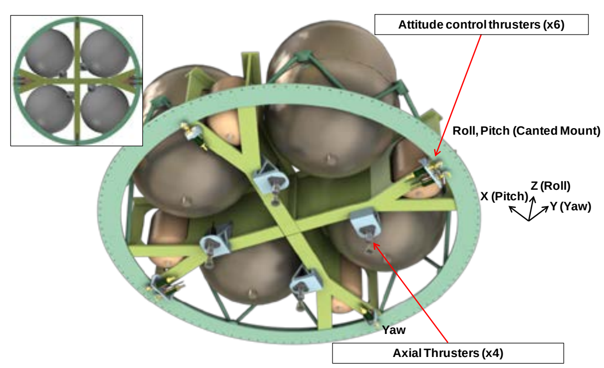

Figure 6: SHERPA uses a propulsion pallet to provide modularity and flexibility to meet a wide range of mission requirements.

INTEGRATED AVIONICS PALLET

The Andrews SHERPA platform uses an integrated avionics pallet (Figure 7). The pallet structure, avionics elements and batteries are manufactured by Andrews and integrated at Andrews' facility near Seattle, WA.

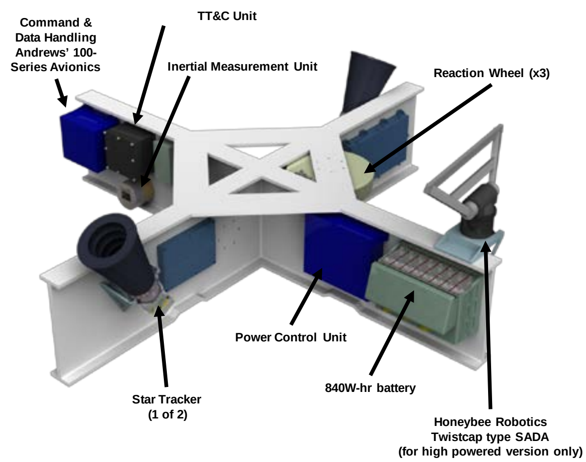

Figure 7: The Andrews EAGLE Platform uses an integrated avionics pallet that is common to the SHERPA and EAGLE spacecraft.

A summary of SSPS and SHERPA subsystems is shown in Table 1.

PAYLOAD ACCOMMODATIONS

The SHERPA platform interfaces with each of the payloads using a dedicated Payload Computer / controller. The Payload Computer (PC) functions as the main data and command interface between the payloads. All payload command, data collection, and data storage is via the Payload Computer, which communicates with the C&DH system through an RS422 connection. The Payload Computer interfaces with three other electronic elements to provide a wide range of analog and discreet I/O, as well as payload telemetry (Table 2). Additional cards can be added to increase the amount of payload I/O.

The Payload Computer provides total mass memory storage of 24 Gbit of EDAC validated memory space. The memory is shared amongst all four payloads for high rate, real-time and stored state of health data. The Payload Computer design allows for four software partitioned buffers corresponding to storage of each payload's high rate data. Memory partition size is allocated by flight software and sized to fit individual payload's storage needs.

Table 1: SHERPA builds upon the Spaceflight Secondary Payload System.

	SSPS	SHERPA	
		400	2200
ESPA ring	36" high, five 24" SPIs		
Avionics			
- CD&H	N/A	Andrews 100 Series	
- Payload Control	Andrews PC	Andrews Payload Controller	
- Power Power	Andrews XPU	Andrews Payload Power Unit	
- Software	Linux RTOS	Linux RTOS	
ACDS			
- Star Tracker	Andrews Pyxis	Andrews Pyxis	
- IMU	Andrews Pyxis	Andrews Pyxis	
- Reaction Wheels	N/A	3x Surrey SP-200	
- GPS	Surrey SGR-05U	Surrey SGR-05U	
- torque rods		Surrey MTR-30	
Power			
- Battery (28V)	1x 840Whr	1x 840 Whr	
- Solar Power Array		1 body-mount panel (333W max)	
Comm			
- S-band	L3 Cadet-S	L3 Cadet-S	L3 Cadet-S
Propulsion	N/A		
- Propellant		Hydrazine	NTO / MMH
- Primary Thrusters		Four 22N	Four 90N
Performance			
- Payload	5x 300 kg	5x 300kg	3x 300kg
- Ideal Delta-V	N/A	~400 m/sec	~2200 m/sec
- Lifetime	< 1 week	~1 year	~1 year

Table 2: The Payload Computer interfaces with three other electronic elements to provide a wide range of analog and discreet I/O, as well as payload telemetry.

Element	Card Type	Features
Payload Computer	Model 160 High Performance Flight Computer	Xilinx Virtex 4FX with embedded PPC405 (400MHz) processor with 64MB SDRAM, 24GB of EDAC FLASH, Two parallel digital camera inputs, Ethernet, I2C, RS422, Uart
Payload Digital Communication	Model 140 Communication Card	1553B interface, two Power over Ethernet, two SPI or I2C, two RS-232, four RS-422, eight RS-485, Bluetooth, WiFi
Payload Telemetry	Model 120 Instrumentation Card	Eight discreet inputs from payload, Sixteen analog inputs from spacecraft
Payload Discreet	Model 110 Valve Driver Card	Twelve discreet commands to payload

All payload data (high rate and real-time) is polled and ingested in a "round robin" scheme ensuring that no payload can monopolize the bus. Both the payload high rate and real-time data are time-stamped at the time of receipt. The Payload Computer ingests payload high rate mission data, encapsulates this data in a Consultative Committee for Space Data Systems (CCSDS) compliant Channel Assess Data Unit (CADU) format and stores the formatted CADU for subsequent transmission to the ground. All high rate data is transferred via either an asynchronous UART EIA-422 link or a synchronous EIA compliant RS-422 link. The choice of synchronous or asynchronous data transfer method is selectable for each payload and is fixed prior to launch. The total high data rate available is 2 Mbps shared among all the payloads. The PC provides for collection of payload real-time data. One EIA-422 UART is provided on each payload data port. Payload real-time data is collected and interleaved into the real-time spacecraft downlink and is also stored on the Payload Computer for retransmit. Each payload's real-time data is limited to 240 bytes/sec.

The Payload Computer also functions as the gateway for commands issued to the payloads and delivering spacecraft status message (time, spacecraft ephemeris, spacecraft attitude and payload interface temperature) information to the payloads. Each payload data port is provided one EIA-422 UART command link.

Each of the four payloads is powered by one of two Payload Power Units, which are off the shelf power conditioning/supply units based on the Andrews Cargo Module Power Unit (CMPUs). The CMPUs were developed by Andrews for the Orbital Science Corporation Cygnus cargo module to power the NASA ISS experiments on their trips to the International Space Station. Andrews successfully delivered four flight qualified CMPUs in 2011. Figure 8 shows the overall Payload Power and Control System architecture. Each of the Payload Power and Control System avionics elements will be at TRL 9 prior to EAGLE hardware delivery.

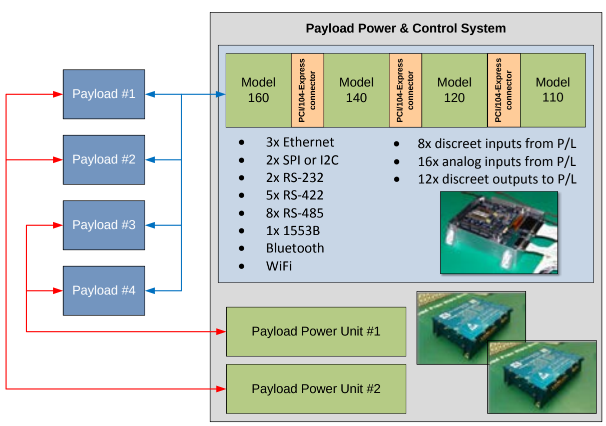

Figure 8: The SHERPA Payload Power and Control System provides extensive I/O and flexibility to meet customer objectives.

SHERPA DEVELOPMENT APPROACH

The first SHERPA flight will be on a Falcon 9 launch vehicle currently scheduled for early 2014. The flight will be to a 720km Sun Synchronous orbit, and SHERPA will lower this to a 450km circular orbit before deploying its complement of secondary payloads. Spaceflight has contracted with Andrews to develop and fabricate the first SHERPA. Andrews has strong interest from customers in the SHERPA capabilities to deploy constellations of small LEO spacecraft and has scheduled two commercial SHERPA flights on Falcon 9 sun synchronous missions in 2014 and 2015.

The Spaceflight manifest excerpt depicted in Figure 9 shows the planned launch progression and technology demonstration schedule, with the SSPS first flight contracted for early 2013, and first SHERPA flight manifested for early 2014.

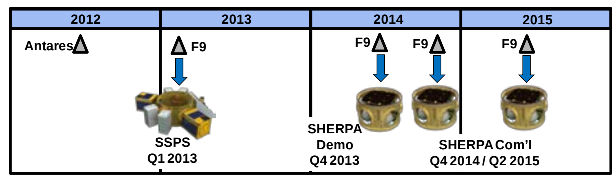

Figure 9: SHERPA builds upon the Spaceflight Secondary Payload System.

SUMMARY

Increased demand for affordable access to space for small payloads has driven the need for secondary launch service platforms such as SSPS and SHERPA. These two products accommodate multiple payload configurations, on a variety of launch vehicles, with competitive commercial pricing. Both platforms offer the same hosted services historically available only to large, primary payloads—at a fraction of the cost. SHERPA's onboard propulsion enables customized orbit insertion and maneuvering, further expanding the available launch opportunities for secondary payloads.