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THE SCORPIUS® EXPENDABLE LAUNCH VEHICLE FAMILY AND STATUS OF THE SPRITE SMALL LAUNCH VEHICLE*

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ABSTRACT

Microcosm and the Scorpius® Space Launch Company are developing a family of expendable launch vehicles that will provide low-cost, responsive access to space. The Scorpius® family includes single and two-stage suborbital and orbital vehicles with payloads ranging from 700 lbs to LEO for the Sprite Mini-lift Launch Vehicle to over 50,000 lbs to LEO (18,000 lbs to GTO) for the Heavy-lift vehicle. Two suborbital vehicles have been flown successfully from White Sands Missile Range, including the SR-XM-1 in March 2001, which was, effectively, a full-scale test of a Sprite pod, although not all of the Sprite components were flown. The first Sprite orbital launch is scheduled for 2006. This paper describes the technology and development plan of the Sprite Small Launch Vehicle (SLV).

Starting with a contract from the Air Force Research Laboratory in 1993, technology development has progressed with increasing maturity in design, manufacturing techniques, and component development and qualification. Low-cost and scalable ablative engines based on flight-proven technology, all-composite propellant tanks, and a Tridyne-based High Performance Pressurization System are all in the final stages of qualification. A low-cost baseline design has been developed for the Sprite upper stage. The Scorpius® modular design approach, built around scalable critical components such as the engines and all-composite propellant tanks, will allow us to transition from the Sprite SLV to the medium-lift Exodus and then to heavier-lift vehicles if the need justifies the economic investment.

In addition to carrying primary payloads, the entire Scorpius® family will have provisions to use the excess lift for any launch to carry multiple, small auxiliary payloads at little or no cost for universities, industry, and government organizations to obtain component testing with quick turn-around. These auxiliary payloads remain attached to the stage, but are given access to power and telemetry. This allows the system to realize maximum benefit from each launch. The Scorpius® vehicles are designed to facilitate encapsulated payloads, vertical transport of the assembled vehicle to the pad, and little or no on-pad preparation. The low recurring cost allows us to build to inventory and enables true launch-on-demand. The design incorporates operational features and procedures that will allow us to launch Scorpius® vehicles within 8 hours of arrival of the payload at the launch site or a request for launch for payloads stored on site in a launchable configuration. Thus, Scorpius® is fully capable of meeting the challenge of responsive access to space.

INTRODUCTION

The Scorpius® family of vehicles consists of sub-orbital, and small-, medium-, and heavy-lift vehicles with capabilities for LEO and GTO payload delivery. This new family is based on simple pressure-fed LOX/Jet-A boost and sustainer stages and optional LOX/Jet-A or hydrogen upper stages. The Sprite SLV is the first orbital vehicle in the Scorpius® family and is currently planned to be launched in 2006.

The technologies associated with the Sprite vehicle have been either developed or are in the final stages of development. The primary goal of the Sprite vehicle in particular and Scorpius® program in general is to develop technologies and demonstrate responsive systems that lower launch costs by a factor of five to ten when compared to current systems. The substantial cost reductions provided by the Scorpius® launchers stem from the non-traditional design. The Scorpius®

launchers are designed as expendable rockets for low cost and simplicity rather than high performance and reuse.

Whereas many new rocket designs use two-stage-to-Low Earth Orbit (LEO) configurations driven by high performance, pump-fed engines, the Scorpius® rockets employ a three-stage configuration using simple, very low cost, pressure-fed engines. This approach is enabled by a number of key design features including:

- Scalable and modular configuration
- Simple propulsion system
- Low-cost, light-weight, all-composite propellant tanks
- Low-cost, high-performance pressurization system
- GPS/INS and other COTS avionics
- Multiple similar components
- Incremental development
- Low complexity production
- Efficient operations infrastructure and logistics

Table 1 shows the Scorpius® program objective, payload delivery, and cost of the smaller members of the Scorpius® family.

BACKGROUND

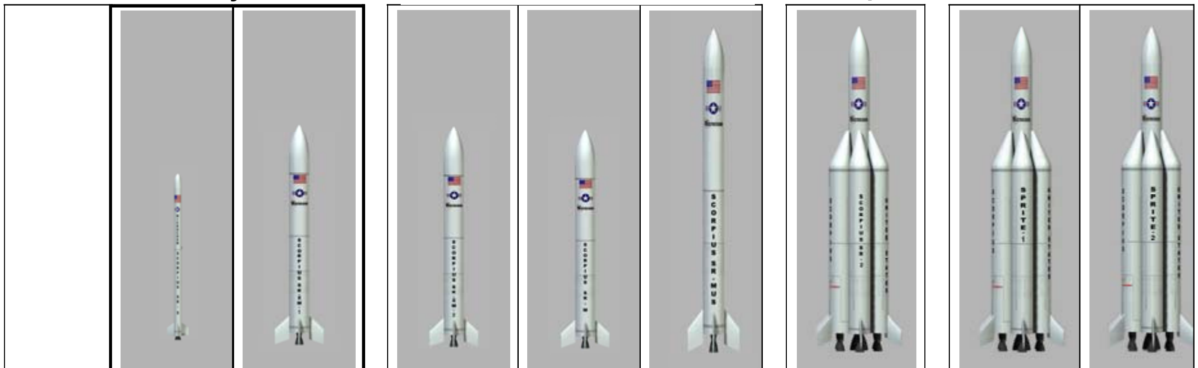
The Scorpius® program began in 1993 with development of the family of concept vehicles after a number of years researching how low-cost vehicles could be developed, using scalability to develop small sub-orbital vehicles and then progressively larger suborbital and orbital vehicles [Conger, et al., 2002]. Once the concepts were well defined, Microcosm set out to demonstrate the first key ingredients — a truly low-cost, ablative engine, composite tanks, and high performance pressurization system. Following engine development and testing, Microcosm in cooperation with the Air Force Research Laboratory Space Vehicles Directorate (AFRL/VS) and several key subcontractors, has designed and successfully flown two different suborbital vehicles. The suborbitals serve to validate the launch vehicle technology at much lower cost than is possible with orbital vehicles and create suborbital products at the same time. This allows far more test flights than would otherwise be done, increases the level of confidence in the technology, and allows the design to mature in response to operational experience. Figure 1 shows the planned system evolution of Scorpius® launch vehicles.

The near-term development focus is on the first orbital vehicle, the Sprite SLV. The sub-orbital vehicles on the left side of Figure 1 are designed to incrementally lead to the Sprite while providing useful suborbital capabilities for both target and sounding rocket applications. After the Sprite orbital capability is available, the next class of Scorpius® launchers will be developed commercially. Although we have designed and evaluated various derived vehicles, the size and capability of the next Scorpius® launcher will be adapted to meet the launch market conditions and commercial investment environment. In any case, Scorpius® launcher technology being developed in this program is designed to be scalable up to the largest launcher currently being produced or planned. The design and the technology also will meet the needs of the responsive space lift capability for various orbital and suborbital missions.

The first rocket shown in Figure 1 is the SR-Sa, first launched in January, 1999, at White Sands Missile Range (WSMR). The SR-Sa (Figure 2) was a proof-of-concept vehicle that demonstrated the feasibility of the Scorpius® approach. It used a single, fixed 5,000-lbf-thrust engine and flew unguided.

Table 1. Scorpius® Program Objectives (FY02$). All vehicles are designed for launch on demand, i.e., within 8 hours of identified need or arrival of the payload at the launch site.

Vehicle	LEO Payload (100 NMi)	SSO Payload (400 NMi)	Vehicle Price	Total Launch Price	LEO Price/lb to Orbit	SSO Price/lb to Orbit
SR-S Suborbital	440 lb Suborbital		$125K	N/A	N/A	N/A
SR-M Sub-orbital	2,400 lb Suborbital		$339K	N/A	N/A	N/A
Sprite SLV	700 lb	330 lb	$1.57M	$1.99M	$2,836	$6,017
Antares Intermediate-Lift	6,500 lb	3,580 lb	$5.44M	$6.69M	$1029	$1,868
Exodus Medium-Lift	15,000 lb	8,820 lb	$10.35M	$12.45M	$829	$1,410



	Already Flown		Suborbital			First Multi-pod	Orbital	
Vehicle	SR-S	SR-XM-1	SR-XM-2	SR-M	SR-M/US	SR-2	Sprite-1	Sprite-2
Status	**Flown**	**Flown**	PDR done; contract option to fly	In contract option 3	In contract option 4	SRR done	Partial SRR done	Partial SRR done
Demon-strated Tech-nology	5K eng GPS INS Avionics Operations	42" composite fuel tank Destruct sys 2-engine Gimbal	20K eng High altitude	HPPS Composite LOX Tank	Upper Stage Separation Fairing	Multi-pod Horizontal staging High vel.	Orbital GN&C Multi-staging High vel.	Second flight test
Date	Jan., 99	Mar., 01	ATP + 10 months	ATP + 14 months	ATP + 17 months	ATP + 25 months	ATP + 34 months	ATP + 38 months

Figure 1. The Planned Initial Flights of Scorpius® Launch Vehicle Family.

The SR-XM-1, flown in March, 2001, was a guided rocket that employed two, gimbaled, 5,000-lbf-thrust engines. It was designed to be the same size as the SR-M, which is similar to the Sprite pods. The SR-XM-1, shown in Fig. 3, flew with an all-composite fuel tank and the same basic propulsion system architecture to be used on the Sprite pods and the SR-M described below.

Figure 2. Scorpius® SR-S Launched January 1999.

Figure 3. SR-XM Launched March 2001.

SR-XM-2 is the next Scorpius® rocket. It uses a single 20,000-lbf-thrust engine and incorporates a roll control system (RCS). It will also incorporate as many Sprite/SR-M components as possible within its development schedule and cost.

SR-M is the full-performance single-stage Scorpius® sub-orbital vehicle. It will be the next to fly after the SR-XM-2, and will incorporate flight-weight composite LOX and fuel tanks, and a High Performance Pressurization System (HPPS). It will demonstrate the full-performance required for Sprite. SR-M will also be used as both a target vehicle for Missile Defense Agency (MDA) missions as well as a sounding rocket for short duration micro-gravity and space missions.

The SR-M/US will demonstrate the small third stage to be used on the Sprite vehicle. This stage will demonstrate a lower thrust derivative of the 5,000-lbf engine and smaller composite tanks. This upper stage will also demonstrate the baseline avionics with GN&C required for orbital flight. The SR-M/US will demonstrate the stage separation and split fairing release. The SR-M/US is a SR-M carrying the third stage of the Sprite. This configuration is planned as a low-cost test of the Sprite upper stage.

The SR-2 will demonstrate the Scorpius® staging approach. It is comprised of the first two stages of Sprite with a large payload or "dummy" upper stage representing the third stage of Sprite. SR-2 will also provide a high performance sub-orbital target and sounding rocket capability.

One other sub-orbital Scorpius® rocket has been considered. The SR-MS (not shown) is a stretched version of the SR-M with two 20,000 lbf-thrust engines and is being evaluated for higher energy, single-stage, sub-orbital missions. Table 2 lists the performance characteristics of various Scorpius® sub-orbital launchers.

Table 3 lists the performance characteristics of the Sprite orbital vehicle.

Table 3.
Performance of the Sprite Orbital Vehicle.

Payload, max	700 lbs to 100 NMi, 28.5 deg.
Payload, typ	330 lbs to 400 NMi, 98 deg.
Glow	83,000 lbs
Thrust	Same as SR-2
Burnout vel, max	25,000+ fps
Payload volume	38' dia X 63" Long
Launch response	Within 8 hours of payload arrival
Launch weather	Zero ceiling, zero visibility, moderate precipitation
Launch winds	99.5% KSC, Wallops, or VAFB

The incremental development of the various vehicles in the Scorpius® family shown in Figure 1 can follow various paths involving various degrees of risks and cost. Several approaches can be taken to get from our SR-XM-2 flight to the first flight of the Sprite vehicle. One approach will involve the design, development, and flight qualification of the SR-M vehicle where most of the component design and technology for a Sprite pod will be substantiated. The other option will involve going directly from SR-XM-2 to the design, development, and flight of the SR-2/Sprite vehicle following limited static testing of the propulsion system including the HPPS and the upper stage.

Table 2. Scorpius® Sub-Orbital Rocket Performance Characteristics.

Parameter	SR-S	SR-XM-1	SR-M	SR-MS	SR-2
Payload, max.	440 lb	2,400 lb	2,400 lb	2,400 lb	2,400 lb
Payload, typ.	110 lb	110 lb	2,205 lb	2,205 lb	2,205 lb
GLOW	1,810 lb	6,820 lb	13,070 lb	23,700 lb	78,500 lb
Thrust, vacuum	4,890 lb	10,060 lb	20,240 lb	40,480 lb	121,440 lb
Burnout velocity, max.	5,260 fps	2,230 fps	9,990 fps	12,200 fps	21,750 fps
Altitude, max.	92 NMi	30 NMi	310 NMi	459 NMi	1,526 NMi
Range, max.	190 NMi	36 NMi	650 NMi	1,000 NMi	4,200 NMi
Range, with typ. P/L	125 NMi	31 NMi	180 NMi	450 NMi	1,600 NMi

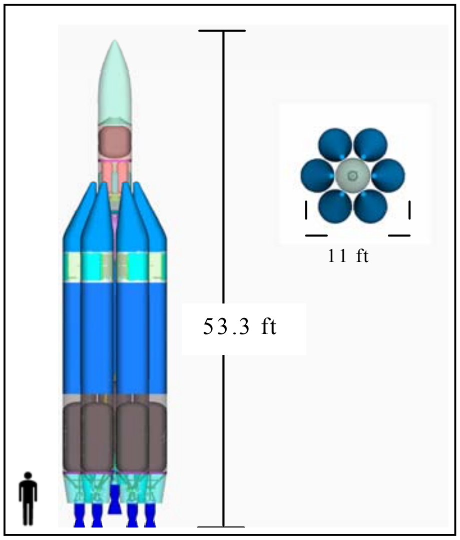


Figure 4. Sprite Vehicle Configuration.

Figure 5. Sprite Pod Static Testing.

In addition to the technical progress, substantial business progress has occurred. The Scorpius Space Launch Company (SSLC) was created with the objective of commercializing the Scorpius® low-cost launch products (both sub-orbital and orbital). SSLC will concentrate on the manufacturing and launch services aspects of low-cost launch. Microcosm will continue to concentrate on R&D and vehicle development.

THE SPRITE MINI-LIFT VEHICLE

The three-stage Sprite SLV is the first orbital vehicle in the Scorpius® family [Berry, et al., 1999]. The baseline configuration shown in Figure 4 is capable of carrying 700 lb to LEO (100 NMi due east) or 330 lb to Sun-synchronous orbit at 400 NMi. Sprite uses seven common "pods" and a small upper stage. A single pod shown in Figure 5 was static tested at the Mojave Test Site and successfully flown (as SR-XM-1) at White Sands Missile Range. Sprite is a three-stage, pressure-fed rocket consisting of six external booster pods comprising the first stage, a center or sustainer second stage pod, and a third stage affixed to the top of the second stage. The first and second stages share the same components with the exception of a modified high-altitude nozzle in the second stage. This commonality reduces the number of unique parts on the vehicle which ultimately reduces cost and manufacturing time. The third stage is designed to meet mission requirements as either a small satellite launch system or long-range, tactical, sub-orbital rocket and includes provisions for a deorbit maneuver to avoid becoming orbital debris. The Sprite vehicle is approximately 53 feet in length and 11 feet wide at its base. Six 20-Klbf first stage engines provide 120,000 lbs of thrust while the second and third stages provide 20,000 lbs and 2,000 lbs of thrust respectively.

The Scorpius® launchers are pressure-fed liquid rockets with mostly carbon composite structures. Liquid oxygen and kerosene (Jet-A) were chosen as propellants because of their low toxicity, good performance, and low cost. Jet-A is readily available and LOX can be brought in or produced on site. Because the vehicle is pressure-fed, the tanks are robust enough to support themselves and can endure casual handling expected during the transportation and launch campaign without problems. The shorter, wider nature of the vehicle makes it stable while vertical, enabling easier movement of an integrated vehicle to the launch pad. The dry weight of the Sprite vehicle is comparable to a small bulldozer (about 10,000 lbs) and can be easily towed by a standard truck tractor. All normal servicing of the vehicle on the pad is done at ground level thus eliminating the need for a gantry or tower.

The Sprite SLV addresses the need for small- and mini-payload capability with a price to orbit objective of less than \$2.5 million (FY02\$) for 700 lb to LEO. [Berry, et al., 2001] The minimum available payload volume is comparable to the Scout and Pegasus large fairing, i.e., 38-inch diameter by 63.25 inches long. The payload area, with provisions to deploy single or multiple payloads, can be accessed as needed with standard commercial equipment. The payload performance for different orbit inclinations is shown in Figure 6.

The larger configurations of the Sprite SLV can accommodate payloads up to 2800 lb (easterly, 100 NMi due east) by scaling up the engines and tank sizes without any significant increase in risk. The inherent design features of the Scorpius® vehicles based on scalability and modularity allow the incremental development of progressively larger launch vehicles. The payload performances of the larger vehicles in the Scorpius® family are shown in Figure 7. The mass fraction of the larger vehicles will be improved compared to the smaller vehicles.

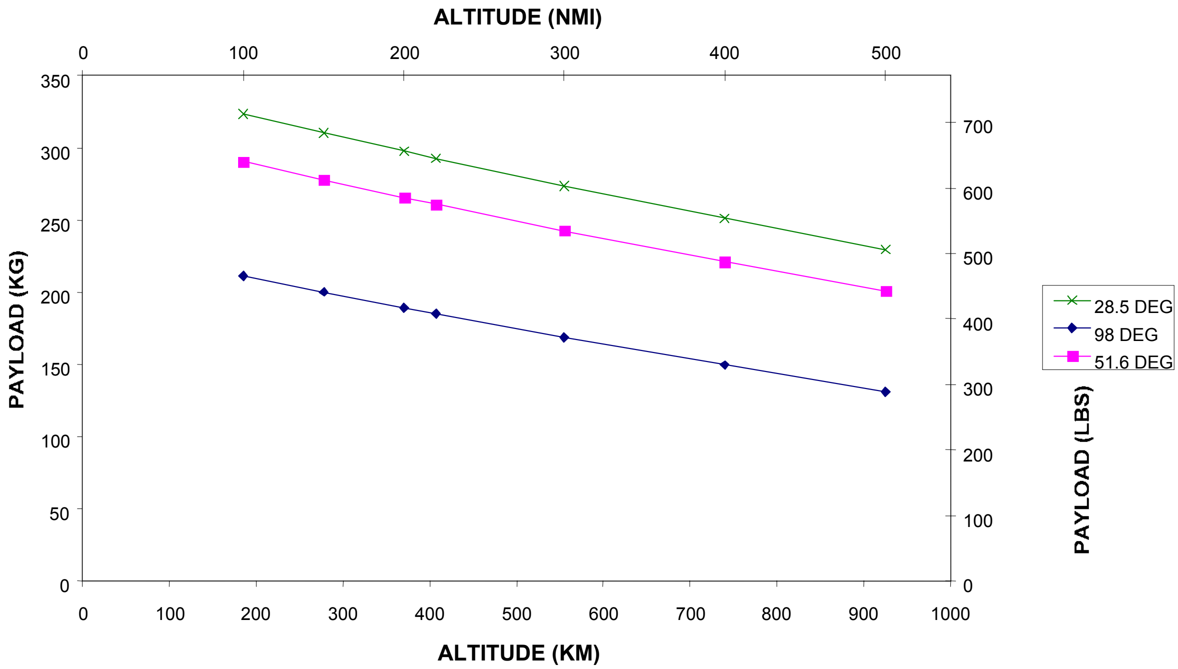


Figure 6. Sprite Performance to Circular Orbit at Various Inclinations.

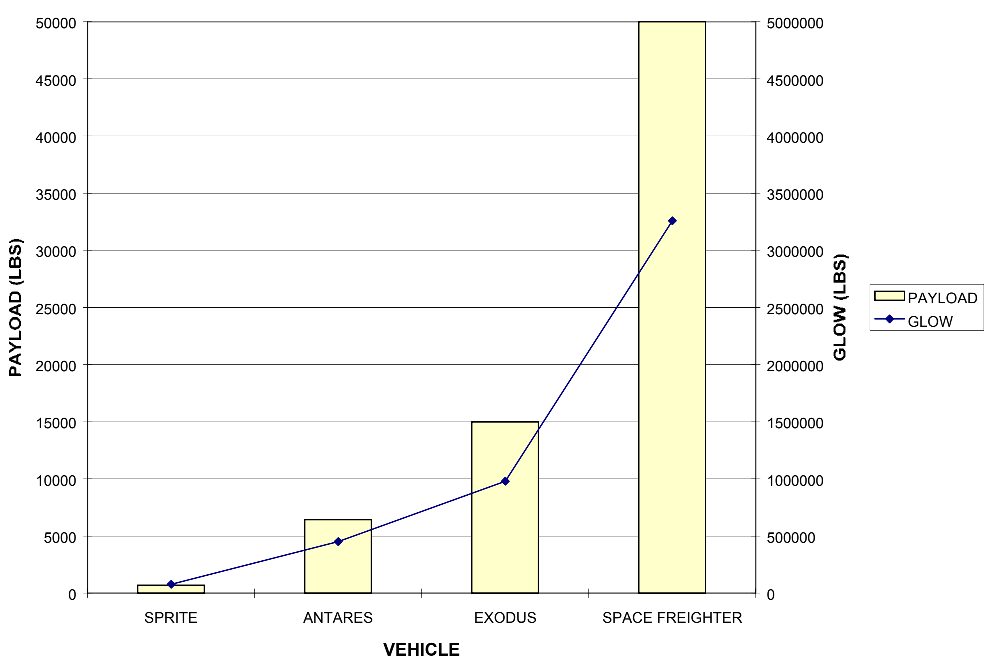


Figure 7. Payload Performance of the Scorpius® Family.

The Sprite SLV is designed to provide launch within 8 hours after arrival of the payload at the launch site, utilizing encapsulated payload-processing methods. The intent is to provide a responsive "launch-on-demand" service more characteristic of package delivery services than of the current launch services. Table 4 describes the operational characteristics of Sprite that enables its responsive, on-call, orbital access.

Table 4. Operational Characteristics of Sprite.

- **Air and Road Transportable Launch System**
  - Entire rocket shipped in two standard truck trailers
  - Easily-erected pods weigh less than one ton each
- **Less than 20-Person Launch Crew**
  - Three-person PC-based launch control system
- **Simple Launch Pad with Fly-off Interfaces**
  - Ground-level servicing, No gantry
  - Flat concrete pad with stool and thrust deflectors
  - Enables multiple sites, multiple pads per site
- **Designed for 99.5% Weather**
  - High structural margins
- **Self-aligning GPS / INS Guidance and Navigation**
- **No Hypergolic or Explosive Devices**
- **Thrust-Termination based FTS with GPS Tracking**

TECHNOLOGY DEVELOPMENT AND STATUS

Most of the critical technologies to be used in Sprite and other vehicles in the Scorpius® family are either flight-proven or in the final stages of qualification. These technologies include the engine, all-composite propellant tanks, and the High Performance Pressurization System (HPPS). The upper stage and separation system are in development.

Microcosm plans to complete the development and qualification of the critical technologies required to support the first orbital flight of Sprite in 2006. Our approach is based on incremental advancement in technology to derive more performance. The technologies are planned to be incorporated when they are fully qualified for the flight environment.

The engine technology is based on our flight-proven, 5-Klbf, ablative engine. Simple pressure-fed engines use LOX and jet fuel propellants to power all stages of the Scorpius® vehicles. The ablatively cooled engines provide good performance at greatly reduced cost relative to traditional expendable engines. We have designed and built a 20-Klbf engine based on the scalable 5-klbf engine technology. Short-duration hot fire testing of the 20-Klbf engine show stable combustion with a combustion efficiency of over 97%. We are currently testing the 20-Klbf engine at our Rocket Propulsion Test Facility (RPTF) in Socorro, NM to demonstrate the durability of the injector as well as the ablative chamber to support the burn duration expected for the various sub-orbital and orbital missions. Figure 8 shows a group of 5000-lbf thrust (vac) engine chambers as flown in the suborbital vehicles to date and the 20,000-lbf thrust (vac) ablative engine currently in testing. Figure 9 shows the 5,000-lbf and 20,000-lbf engine testing at the RPTF.

Figure 8. 5,000-lbf Thrust Chambers on the Left and 20,000-lbf Thrust Engine on the Right.

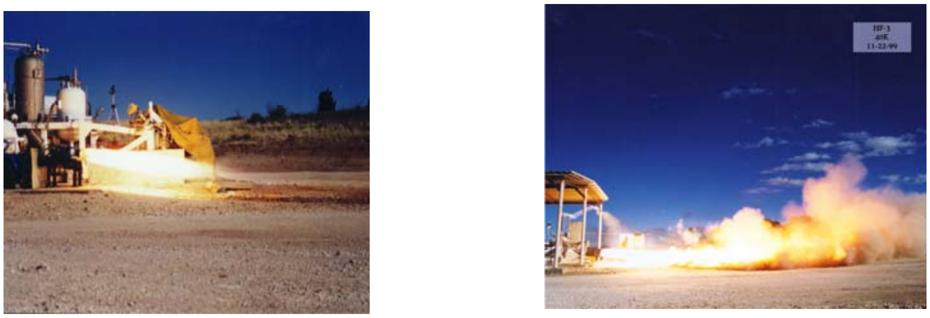


Figure 9. 5000-lbf and 20,000-lbf Thrust Engine Testing at RPTF.

Figure 10. All-Composite Fuel Tank.

Figure 11.
All-Composite LOX Tank During Cryo Testing.

The engine for the upper stage of the baseline Sprite SLV requires a 2000-lbf engine. We plan to use our flight-proven 5-klbf engine at reduced pressure to meet this requirement while pursuing the development of a more optimum 2-klbf design in a parallel path.

We have made substantial progress in the development of all-composite propellant tanks. We have successfully flown an all-composite fuel tank on the SR-XM-1 flight. This fuel tank is similar to the design to be used in the Sprite pods. The SR-XM-1 used an aluminum LOX tank. An all-composite LOX tank will be used for future vehicles, starting with the SR-M. Figure 10 shows the all-composite fuel tank flown in SR-XM-1 vehicle and Figure 11 shows the all-composite LOX tank during cryogenic testing. These light-weight tanks allow the use of pressure-fed systems for orbital vehicles without the complexity of turbo-machinery.

Composite tanks for aerospace applications typically have two major drawbacks. First they require expensive autoclaves for curing. Second, at very low temperature, composite materials become brittle and micro-cracking occurs in the laminate. The composite tank manufacturing technology pioneered by Microcosm does not require an autoclave, thus offering significant cost savings. These cost savings are also valid over conventional metallic tanks that require costly and time-consuming processes such as tooling for spinning the domes, welding of tank sections, and autofrettage. Autofrettage is also required for cryogenic tanks that have metallic liners and composite overwrap. Microcosm's tank has been developed for cryogenic application and the materials used in its construction have been chosen for LOX compatibility.

Microcosm's extensive experience in all-composite tank technology evolved with support from a number of sources, i.e., Internal Research and Development (IRAD), SBIR programs, and AFRL contract funds. Microcosm has fabricated and successfully cryogenically tested with LN2 both subscale 10-inch diameter tanks and full-scale 42-inch diameter tanks. The subscale 10-inch diameter version was tested with LOX and became the world's first all-composite LOX tank to be successfully launched on a rocket (*Space News*; July 3, 2000). The 42-inch diameter tank was successfully thermal shocked and proof pressure tested with LN2 to over 700 psi (1.2 Maximum Expected Operating Pressure (MEOP)) then thermally cycled 5 times with LN2 and pressure-cycled to MEOP during each thermal cycle. This 42-inch diameter tank is not cured in an autoclave, costs 70% less than an equivalent aluminum tank, and weighs 60% less than its aluminum equivalent. Further mechanical testing under cryogenic conditions will be performed and LOX compatibility will be verified in order to fully qualify the tank for use on the Sprite SLV.

We have used a pressurization system based on cold helium for our successful SR-S and SR-XM-1 flights. While we plan to use cold helium for the pressurization system in the upcoming SR-XM-2 flight, we plan to incorporate the High Performance Pressurization System based on Tridyne technology starting with the SR-M vehicle. Starting with an IR&D program and, subsequently with funding from the NRO, we have demonstrated the viability of this technology with a detailed analytical and test program. Figure 12 shows a ground test version of a full-scale HPPS hot gas generator to be used in each of the Sprite booster and sustainer pods. The use of the HPPS will reduce the weight of the pressurization system by as much as 50 percent thus resulting in significant gain in payload performance. The configuration design for the pressurization system and the propellant feedlines for the Sprite vehicle will be based on our low-cost, flight-proven design used in the SR-XM vehicle.

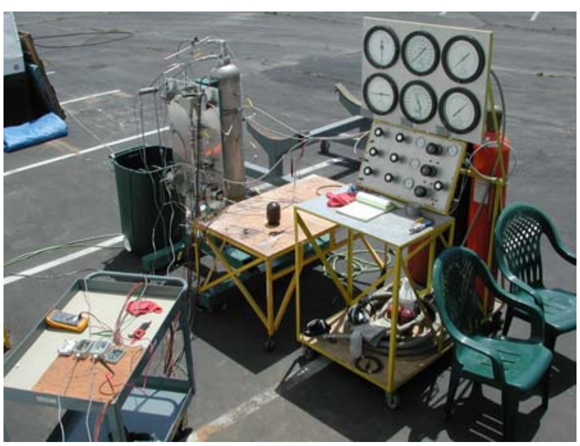


Figure 12. HPPS Based on Tridyne Technology in Testing at Microcosm.

The GPS/INS based GN&C system for the Sprite family of vehicles is based on an architecture with the primary avionics resident in the upper stage and a digital interface between the upper stage avionics and the individual pod/gimbal electronics. The upper stage avionics consists of the mission and flight processors, telemetry system, navigation and attitude sensors, power and signal conditioning, and the flight termination system. Flight termination is based on "thrust termination" that shuts down the vehicle propulsion system without the use of extensive explosives on board. This allows safer ground operation prior to launch and lowers cost. The GN&C algorithms are executed from within a software state machine that allows for easy transition between varying mission requirements (suborbital to orbital) and the associated mission phases. The GN&C software is implemented and tested in standalone fashion, then transitioned to a hardware-in-the-loop (HWIL) configuration for complete integration and testing, prior to vehicle-level testing. COTS industrial grade components and low-cost, orbital-capable avionics are used to increase reliability and reduce cost.

Table 5.
Scorpius® Performance Objectives for GTO.

Vehicle	LEO Payload (lbs)	GTO Payload (lbs)
Sprite	700	None
Antares	6,500	2,150
Exodus	15,000	5,200
Space Freighter	50,000	18,200

The core of the upper stage technology is the propulsion system which is based on using the flight-proven 5-klbf engine technology. The LEO upper stages are based on LOX/Jet A propellants to maintain lower cost and re-+liability. However, we will consider using LOX/LH2 for the high and GTO orbits. Table 5 shows the performance objective of the larger vehicles with these higher energy stages. The tank and structural design, feedlines, and pressurization system will be derived from the matured Scorpius® core technology and scaled down versions of the booster and the sustainer. For the orbital missions, we will need the upper stage engine to be restartable. Following a comprehensive trade study involving the evaluation of a large number of competing con-figurations, we have derived a baseline upperstage design, shown in Figure 13 that will provide multiple restarts for the orbital vehicle. Our developmental path includes the plan to qualify the upper stage concept by an integrated ground test and flight test with the SR-M vehicle before incorporating the design into the Sprite orbital vehicle.

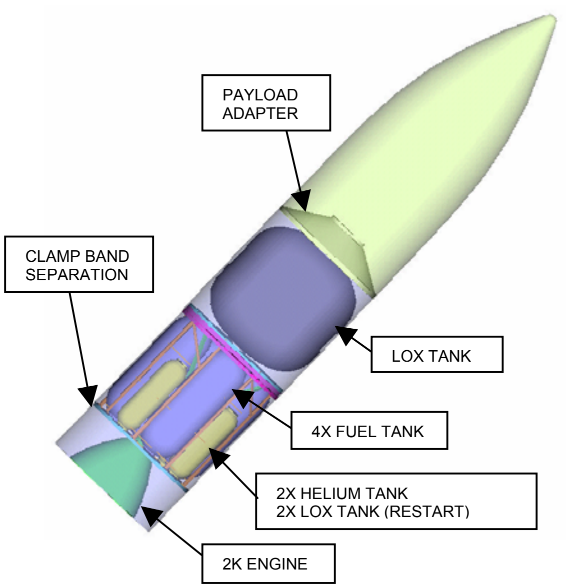


Figure 13. Sprite Upper Stage Design

OPERATIONS

The Scorpius® family is designed to provide low recurring operating cost, as well as high launch site flexibility and very fast response compared with today's launch vehicles. A principal difference of the Scorpius® from traditional programs is that most or all of the personnel will be located at or near the launch site. The primary launch site is also the site for most administrative functions and much of manufacturing and vehicle integration activities. Sprite vehicles are integrated and stored in the Integration Facility 3–5 miles from the launch pad.

Figure 14 shows the baseline concept of operations for the Sprite vehicle. The Scorpius® approach to providing responsiveness and surge capability is to have complete Sprite vehicles integrated and stored in the Integration Facility. Typically, multiple vehicles would be in storage, ready for launch at any time. Additionally, major Sprite components (i.e., first stage pods, second stage sustainers, and third stages) are stored as complete units, ready for integration into vehicles. The Sprite system is tailored for an 8-hour period from payload arrival to launch and a two-day period between launches. Even shorter periods may be accommodated with multiple launch pads and multiple integration and launch crews.

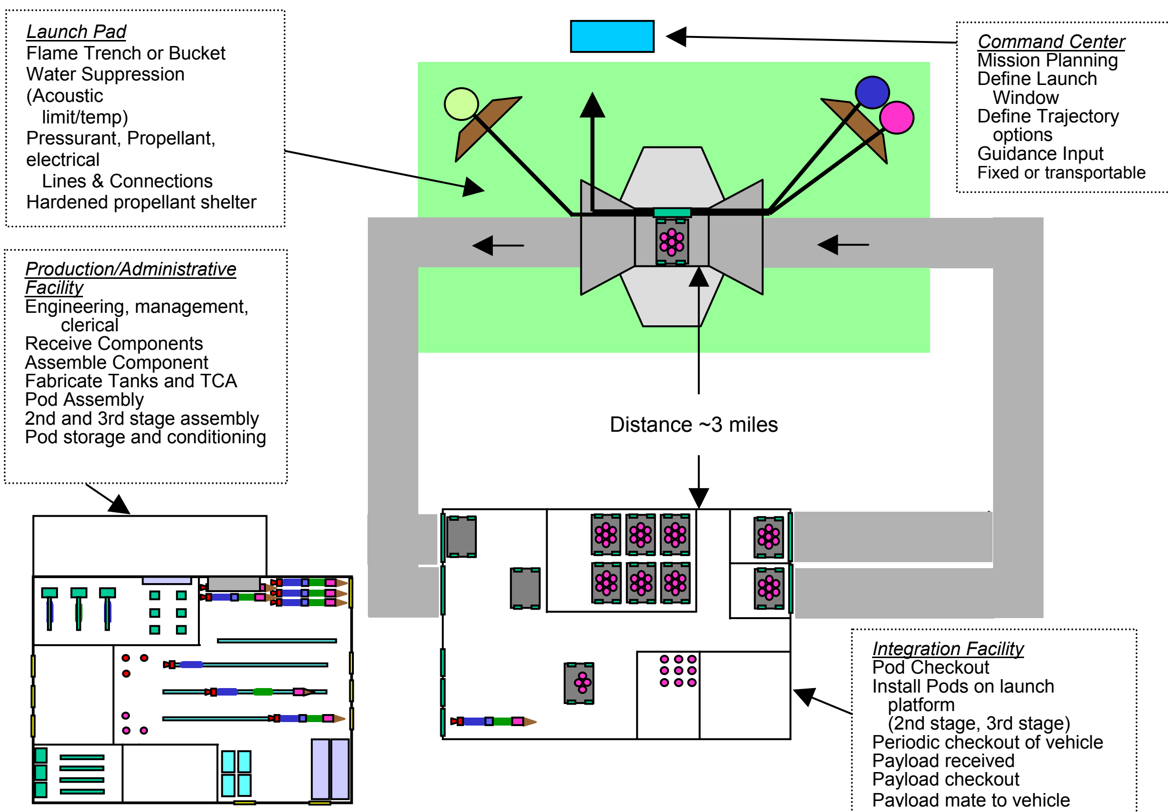


Figure 14. Sprite Baseline Concept of Operations.

The Sprite system can accommodate extended launch hold times and launch abort/recycle times without significant difficulty. The Jet-A kerosene fuel can remain in the fuel tank essentially indefinitely, while the liquid oxygen is continually topped-off from remote storage tanks. The Tridyne is maintained at a chilled condition by circulation through a cooler. The first stage ignition system uses ground-based torch ignitors, which can remain in phase for extended periods and accommodate shutdown and launch recycle without deleterious effects. The electrical power system uses rechargeable batteries which can be trickle charged on the pad during an extended launch hold.

The primary basing mode planned for the Sprite or other Scorpius® vehicles is land-based with dedicated propellant and pressurant storage facilities located a safe distance from the launch pad. This approach provides the fastest times for vehicle and payload integration, system setup/teardown, and turnaround times for relaunch. The simple launch pad allows basing at multiple sites and multiple pads per site. The Scorpius® system components are road, air, and rail transportable to accommodate launch from a remote, minimally improved site with a short setup time. This approach would also lend itself to launching from a barge, assuming propellants and pressurants are transported and stored separately from the launch platform.

CONCLUSIONS

Microcosm's Scorpius® family of launch vehicles have been designed to provide Operationally Responsive Spacelift (ORS) capability and meet the need for an ever-growing demand for lower cost, more responsive launch to space. The vehicle has been designed from the outset to achieve these goals by manufacturability, ease of operation, and low infrastructure cost. By incorporating robust design and design for operations, Microcosm has created a system that easily meets an 8-hour launch period from payload arrival to launch and a two-day period between launches. Two successful flights with smaller single-stage suborbital development test vehicles have demonstrated that the cost and operability goals, though challenging, are achievable. Technologies, specifically required for the Sprite and other larger Scorpius® vehicles, i.e., the 20-klbf engine, the High Performance Pressurization System, all-composite propellant tank upper stage, and the separation system are all in the final stages of design and development as part of our goal to support the DT&E flight of the Sprite SLV in 2006 and the first production flights soon thereafter.

ACKNOWLEDGMENTS

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The substantial team effort has allowed us to put together a successful rocket program, ranging from funding and administrative efforts, innovative design, development, fabrication, integration, and test, to the launch campaign itself. With continuing effort, and perseverance, we will strive to make the program succeed, drive down cost, and improve responsiveness.

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