

## **Small Sat Exhibit Descriptions 2007**

### **4Links**

#### **Booth Space: 43**

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4Links, distributed in North America by Aeroflex Colorado Springs, are leaders in SpaceWire.

The 4Links EtherSpaceLink family extends from virtual interfaces for software development, through bridges, routing switches, monitor/analyzers and validation tools. Precise time tags, record and relay, waveform capture, simple API with source ..., all enable users to detect and quickly correct bugs that other validation techniques have missed. The family interfaces to Gbit Ethernet and Internet Protocols, enabling concepts such as virtual satellite integration and testing from almost any computer, any operating system, from anywhere, at any stage of the project, and long into the future. The products are based on modular, reconfigurable building-block platforms, minimizing bugs, risk, time and cost throughout the project.

4Links have supported SpaceWire since 1993, are acclaimed for their promotion of SpaceWire, for their support of Plug and Play, for the maturity and usefulness of their SpaceWire EGSE, and for their customer response.

### **Advanced Cooling Technologies, Inc.**

#### **Booth Space: 55**

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Advanced Cooling Technologies Inc. develops innovative thermal technologies and provides technology based thermal products to customers in electronics, energy systems, aerospace, military and government sectors. ACT specializes in custom thermal product design and fabrication, two-phase flow heat transfer, heat pipes and advanced thermal systems are particular areas of expertise.

Engineering Services and Products: Heat Pipe, Vapor chambers, Custom Assemblies, and Complete Thermal Engineering Services- Design, Analysis, Optimization, Prototyping and Testing.

Aerospace Products: Aluminum / Ammonia Constant and Variable Conductance Heat Pipes.

Technology Development: Hybrid Two Phase Loops, Pumped Two Phase Loops, Metal Hydride Thermal Storage.

### **AeroAstro, Inc.**

#### **Booth Space: 77**

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AeroAstro, founded in 1988, is a leader in innovative microsatellite systems, components, and advanced communications technologies.

AeroAstro's experience spans a range of capabilities – from ultra-low-cost R&D programs using commercial components, to high-reliability programs using space-qualified components. Our heritage is one of engineering innovation, simplicity of design, reliability, and rapid space-readiness. The launch of STPSat-1 demonstrates AeroAstro's ability to combine technical innovation with reliability. STPSat-1's elegant design incorporated both proven technical design from previous missions and advanced technologies. The satellite construction was tailored for the highly constrained ESPA environment and included advances in electronics packaging, space materials and manufacturing techniques. AeroAstro was the prime contractor for STPSat-1 responsible for spacecraft design and fabrication, integration of all experiments, space vehicle testing, launch integration support, launch and early orbit operations support, and post-launch mission operations support.

STPSat-1 was recently launched by the U.S. Air Force.

### **Aeroflex Colorado Springs**

#### **Booth Space: 29**

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Aeroflex Colorado Springs is a supplier of integrated circuits and custom circuit card assemblies. We supply a broad range of standard products for space applications including RadHard microcontrollers, logic, programmable logic, FPGAs, 4M and 16M RadHard-by-Design memory, 4M, 8M and 16M QCOTS™ memory, serial communication interfaces for MIL-STD-1553, 1773, RadClock™, an LVDS family of products and our new SpaceWire products. Our RadHard-by-Design ASICs handle design complexities up to 3,000,000 usable gates, offers advanced technologies down to 0.25um and are RadHard to 1 Mega rad. Aeroflex offers Circuit Card Assembly capabilities, which consists of full assembly, test and coat in a high mix/low to medium volume operation.

### **Aeroflex Motion Controls**

#### **Booth Space: 27**

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Aeroflex Motion Controls offers a wide range of capabilities in the design and manufacture of components and systems for the space market. Our products include rotary and linear actuators, brushless DC motors, gimbals,

scanners and electronic controllers. Wherever precision, power and packaging goals need to be manufactured in a design-to-cost environment, Aeroflex is globally competitive.

Aeroflex has been providing motion control products since the early 1940's. Aeroflex entered the motor business in the early 1950's to fulfill internal needs for higher performance motors for gimballed applications. Aeroflex provides stepper (both hybrid and permanent magnet), brushless, full and limited-angle torquers, arc segment, zero-cogging, solenoid and voice coil motors.

Precision gimbals for pointing and tracking, stabilized platforms and pedestals are a core of the Aeroflex Motion Control division. Coupled with our electronic motion controllers and adaptive software, Aeroflex can provide a complete turn-key multi-axis system to meet your requirements.

### **Aeroflex Plainview**

#### **Booth Space: 25**

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Aeroflex Plainview is a manufacturer of advanced microelectronic Multi-Chip Modules (MCMs) for airborne, space, shipboard, ground based avionics. Our full breadth of space related products include Mil-STD-1553, high speed low power PWM controller, Motor Driver, Resolver-to-digital converter, Analog Multiplexer modules, Solid State Relays, and Voltage Regulators. DC-DC converter MCMs using Chip-on-Board technology for Military and space applications.

Our latest product release is a Battery Electronics Unit (BEU), a 24 cell Li-Ion battery balancer and cell telemetry electronics unit. It performs autonomous cell balancing, high cell limit indication and low cell limit indication. A 1553 bus is used for individual cell telemetry and commands including closure of a cell bypass relay in the eventuality of a cell failure, and connecting the battery's reconditioning load. The BEU system has fully redundant telemetry, control and balance functions.

Aeroflex also offers a variety of Broadband, RF and Microwave products for aerospace and space applications.

### **Aerostar International**

#### **Booth Spaces: 78 & 80**

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Over 60 years of experience, makes Aerostar the world leader in the design and fabrication of high altitude scientific balloons and high altitude airships for near space applications. Strategic partnerships with the foremost scientific research facilities allow us to expand our expertise allowing us to manufacture applications which accomplish our customer's goals.

Scientific balloons and high altitude airships are used for applications altitudes higher than aircraft can fly and lower than a satellites orbit and enabling long duration flights lasting from hours to days. Some potential

applications include scientific data collection, communications and intelligence gathering. Our high altitude research balloons carry payloads from a few pounds to up 6000 pounds and can reach altitudes up to 45 kilometers. Our products can successfully fly your payloads.

**Alliance Spacesystems, LLC**

**Booth Space: 30**

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Alliance Spacesystems, LLC provides robotics, structures, mechanisms, and engineering services for spacecraft and instruments. Formed through the merger of Vision Composites and Alliance Spacesystems, Inc., Alliance provides end-to-end product development not only for electromechanical products but also composite structures. Currently Alliance's most notable products are the robotic arms that continue to function flawlessly on JPL's Mars Exploration Rovers after over three years of service. Key competencies include system engineering, controls, electromechanical and structural design, dynamic and stress analysis, complex machining, precision assembly, and composites manufacturing. Our Pasadena, CA facility houses engineering and electromechanical manufacturing and includes a precision CNC machine shop, Class 10,000 clean room, and test facilities including thermal/vacuum. The nearby Signal Hill, CA facility has extensive composite manufacturing capabilities including large autoclaves, ovens and platens; a CNC machine shop geared to panel and composite processing; and in-house capabilities for static testing and mechanical property/fiber volume evaluations.

**Applied Technology Associates**

**Booth Space: 63**

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Applied Technology Associates (ATA) is a world leader in precision sensing, measurement and control, pointing and tracking and line-of-sight stabilization. ATA produces space qualified inertial sensors, optical inertial measurement units, and high performance fast steering mirrors from 1 to 12 inches with 1 kHz and higher bandwidths. Inertial measurement units offer low power and small size with sensor fusion of GPS, inertial sensors, and star trackers. We supply satellite subsystems for vibration measurement & analysis and jitter mitigation in imaging and laser com systems. ATA services include integration, test and qualification of satellites and subsystems including EMI/EMC, thermo-vac, temperature cycling, life testing, shock & vibration, and space qualification for aerospace and defense customers, classified and unclassified. ATA develops imaging technologies for ISR and multi-spectral polarimetric imaging. ATA Aerospace is our joint venture providing research, engineering, integration and testing services in support of space vehicles, payloads and systems.

**ATK**

**Booth Spaces: 65, 67 & 69**

Lee Rulis

UT40-PUBS/Thiokol

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ATK is a \$3.5 billion advanced weapon and space systems company. We are a world-class provider of composite structures for space and launch applications (optical benches, dimensionally stable satellite assemblies, and launch system structures) and proven propulsion systems such as the space shuttle RSRM, GEM, CASTOR®, Orion, and STAR™. From aerospace to defense, we are committed to the exploration of new markets and the expansion of our role as a systems-level prime contractor.

### **ATK Space**

#### **Booth Spaces: 4, 6 & 8**

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ATK Space Division is headquartered in Beltsville, MD and led by Mike Cerneck. ATK Space is a division of the ATK Mission Systems Group led by Jack Cronin out of Baltimore, MD. ATK Space is comprised of several product lanes including Space Systems, Precision Structures, Panels and Bus Structures, Thermal Management Solutions, Propulsion Tanks, Solar Arrays, Deployables, Mechanisms, Ceramics and Space Services. We partner with several major government customers as well as major primes such as Lockheed Martin, Northrop Grumman, Orbital, and Boeing. Our goal is to remain the Partner of Choice through outstanding service, products and capabilities and deliver affordable and effective mission critical solutions on time, every time.

### **Ball Aerospace**

#### **Booth Space: 13**

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Ball Aerospace & Technologies Corp. supports critical missions for important national agencies such as the Department of Defense, NASA, NOAA and other U.S. government and commercial entities. The company develops and manufactures spacecraft, advanced instruments and sensors, components, data exploitation systems and RF solutions for strategic, tactical and scientific applications. Over the past 50 years, Ball Aerospace has been responsible for numerous technological and scientific 'firsts' and now acts as a technology innovator for the aerospace market.

### **Broad Reach Engineering**

#### **Booth Space: 31**

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Broad Reach Engineering is a leading provider of modern Rad-Hard, and Rad-Tolerant high performance, high reliability miniature avionics and real time software. Our new GPS receivers are called 'Pyxis' and are tri-frequency L1/L2/L5/(E5a) compatible with Galileo. These GNSS receivers are designed to work in LEO, GEO & HEO orbits, and available to perform radio occultations for atmospheric soundings. Our new 400MIP class PowerPC Rad-Hard processor is nearing completion with commercial prototypes available now.

Most of our avionics are designed for 3U cPCI compatible digital interface cards, processor boards, DSPs, solid state memory, motor controllers, power control and peripheral cards with common interfaces, as well as specialized I/O for unique payload requirements. Delivered avionics include missions such as: COSMIC, XSS-11, AMS, TACSAT-2, TerraSAR-X, Kompsat-5, Tandem-X, SMART-2/ST-7, SUMO, LRO and others.

Our goal is to facilitate the success of scientists and experimentalists through high performance avionics and embedded software systems that directly improve the mission and scientific bottom line.

**Busek Co. Inc.**

**Booth Space: 28**

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Electric propulsion systems is Busek Co. Inc. core business. We are the leading source for Hall thruster and micropropulsion technologies. Our principal products include: Hall effect thrusters (200W to 20kW), colloid thrusters, micro-pulsed plasma thrusters, thermionic cathodes and carbon nanotube field emission cathodes. We also provide customized power electronic systems and depending on customer requirements can deliver fully integrated propulsion systems. Other advanced devices under development at Busek include micro-ion engines, micro-resistojets and air-breathing Hall thrusters. Busek also has extensive vacuum test chambers equipped with state-of-the-art diagnostic, performance measuring and plume instrumentation to support thruster development and customer sponsored testing.

Busek's 200W Hall effect thruster for the TacSat-2 mission was successfully launched and operated. Other missions involving Busek thrusters are the micro-PPT on the Air Force Academy's FalconSat-3 mission, scheduled to launch on March 9th, 2007, and the colloid micro-Newton thruster for NASA's New Millennium ST-7 Disturbance Reduction System.

**Canyon Composites**

**Booth Space: 49**

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Canyon Composites is a leading supplier of complex aerospace structures and an expanding aerospace fabrication and assembly company involved in all levels of prime spacecraft and aircraft manufacture. Our Anaheim, CA facility is 31,500 sq ft., divided functionally to provide optimal environments for different processes. We have fabricated and assembled hardware on spacecraft using state of the art materials and processes.

We are a full complimentary machine shop to suit many versatile machining needs. We are a job shop with (14) CNC machines meaning we manufacture custom precision-machined parts to our customer's specifications on computer controlled machine tools.

Canyon Composites has strong heritage in all aspects of manufacture and assembly. We are continually improving our processes to be one of the elite fabricators and assembly companies of composite parts.

### **Clyde Space Limited**

#### **Booth Space: 87**

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Clyde Space is dedicated to providing reliable, high performance, yet cost-effective, power subsystem solutions for small satellites. We are a power systems specialist company and are located in Glasgow, Scotland. Our product portfolio of power system products can reliably support missions with power requirements from 1W to over 2.5kW; and each of our products demonstrate significant heritage.

The Clyde Space team contains a number of ex-Surrey Satellite Technology Ltd Power Team members, including the ex-Head of Power Systems. Clyde Space also boasts some of the best analogue and power electronics expertise in Europe, as well as impressive systems design ability. This combination of detailed design, systems design and hands-on mission experience means that our customers are provided with a complete and appropriate solution for their programme.

We pride ourselves in providing quality, affordable products with excellent customer service and will support our customers throughout the duration their mission.

### **Colorado Satellite Services**

#### **Booth Space: 71**

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Eyassat™ (patent pending) is a modular, working satellite for the classroom. Colorado Satellite Services markets the Eyassat and works with universities all over the country to give their students hands-on experience with reusable, low-cost hardware that is carefully designed to mimic the subsystems of flying spacecraft. The included Eyassat curriculum material gives students of any level the chance to touch and feel power, communications, data handling, ADCS, and experiment modules without fear of damaging space-rated components. The U.S. Air Force uses Eyassat to help their satellite operations personnel gain a practical understanding of the spacecraft they work with every day. The CSS engineering team has a half dozen spacecraft on orbit to its credit, and has used this experience to bring satellite technology into the classroom. Stop by and see how you can use Eyassat semester after semester to give your students the practical experience that cements their theoretical knowledge.

## **Center for Robotic Exploration and Space Technologies (CREST)**

### **Booth Space: 81**

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<http://crestnrp.org>

The Silicon Valley Center for Robotic Exploration and Space Technologies (CREST) is a consortium of universities with a common interest in developing student-centered satellite and robotic systems for supporting hands-on engineering education, advanced technology demonstration, and scientific discovery. These systems are typically low-cost and are capable of supporting high-risk experimental studies. CREST members include a regional cadre of academic institutions, to include Santa Clara University, Stanford University, San Jose State University, California Polytechnic State University San Luis Obispo, and Mills College. Additional non-local partners include Northeastern University, Washington University in St. Louis, and Montana State University. CREST partners jointly lease lab and office space in a dedicated facility in the NASA Research Park at Moffett Field, CA. CREST partners have expertise ranging from small satellites to underwater robotic systems and routinely conduct world-class experiments and research with a wide variety of governmental, industrial and non-profit partners.

## **CSA Engineering**

### **Booth Space: 72**

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CSA Engineering provides products and services in vibration suppression and precision motion control including launch load attenuation systems, secondary payload adapters, ground test equipment including very low frequency suspension/isolation systems, vibration generators, and hexapod positioners, finite element analysis, vibration damping, control systems and dynamic testing.

CSA's patented SoftRide launch load alleviation systems are available for multiple launch vehicles. They reduce vibration and shock loads on whole satellites without a large mass penalty.

The EELV Secondary Payload Adapter (ESPA) flew on an Atlas V supporting the Air Force STP-1 mission in March 2007. ESPA allows up to six secondary payloads to be launched with a larger primary on Atlas V or Delta IV.

CSA recently installed a large vacuum-compatible vibration-isolated optical bench in a new space simulation facility. CSA's product comprises vibration isolation mounts, an automatic leveling, monitoring and control system, and a clean 240-ton bench structure.

## **Design\_Net Engineering**

### **Booth Space: 11**

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Design\_Net Engineering specializes in the design, development and manufacture of custom electronics and associated software for aerospace instrumentation and avionics. Our systems design approach with supporting disciplines including FMECA, Structural, Radiation, and Thermal analyses, consistently meets the demanding life cycle needs of our customers. Our instrumentation and electronics designs supported NASA missions such as the Floating Potential Probe (ISS), FUSE (APL), COS (GSFC Hubble), LTMPF (JPL), NPP (GSFC) as well as DoD programs such as TacSat .

DNet's core strengths in instrumentation and the supporting avionics hardware and high reliability software are coupled with an exceptional record for meeting aggressive schedules. Our internal "R & D" programs support the DoD responsive space initiative and the Operationally Responsive Space program resulting in development of highly modular and configurable Plug and Play architectures that reduce cost and increase reliability.

Design\_Net is ISO 9001-2000 compliant and fully qualified for space flight hardware manufacturing.

### **Digital Solid State Propulsion LLC**

#### **Booth Space: 50T**

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Digital Solid State Propulsion LLC is introducing a first-of-its-kind energetic material: Electrically Controlled Extinguishable Solid Propellant (ESP). The no-moving-parts ESP grains: throttle, allow variable pulse widths, and on-off cycles, all controlled digitally.

ESPs provide higher impulse at lower power levels than PPTs for spacecraft maneuvering applications. ESP igniters use higher power levels to enhance electrochemical burning for gas ionization and hard-to-ignite materials. ESP grain clusters also balance electrically for more demanding applications. ESPs have a low chance of accidental ignition, making it extremely safe for secondary payloads. ESP energetic systems offer flexible mounting options for nano-spacecraft ACS and even on extended booms and tethers.

Change your perception of solid propellants for small spacecraft applications. Pending approvals, daily demonstrations will be conducted; check booth for times and location.

### **Ecliptic Enterprises Corporation**

#### **Booth Space: 36**

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Ecliptic provides systems for accessing and experiencing space and other extreme environments.

Our popular RocketCam™ imaging systems and related data-transport systems are used routinely on launch vehicles, spacecraft and other remote platforms to provide dramatic engineering- and PR-quality color video. Ecliptic is the world's leading supplier of such systems.

Our new RocketPod™ secondary payload launch system (derived from the RocketCam integration architecture) promises to dramatically reduce the cost of getting CubeSat-class payloads into space.

Ecliptic pursues and supports other special projects involving aerospace avionics, small space payloads and instrumentation, and ground systems.

Stop by our booth to see samples of RocketCam and RocketPod hardware, view recent RocketCam video clips and discuss your project with our engineers. And stop by to pick up your copy of the newest version of our popular DVD, *RocketCam Greatest Hits: 1997-2005*.

RocketCam video clips and Ecliptic company information can be found at our website, [www.eclipticenterprises.com](http://www.eclipticenterprises.com).

### **Florida Space Institute**

#### **Booth Space: 73**

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The Florida Space Institute was created to support Florida's space industry through university education in space-related fields. This is accomplished by offering university courses at the undergraduate and graduate level in relevant disciplines, providing technical training through practice based, hands-on teaching, and by providing opportunities for basic and applied research.

FSI is a multi-school institute, formed to provide university students, military, NASA, and Kennedy Space Center / Cape Canaveral Air Force Station contractor personnel with a unique, practice based, space technology relevant curriculum. FSI is located at the Cape Canaveral Spaceport, bringing the curriculum within easy access to the majority of the potential students. This location also affords access to various space processing facilities, enabling the practice based, hands-on teaching which is at the core of the program, and which is virtually unavailable anywhere else in the world.

Contracts and grants also provide students opportunities for hands-on, relevant work experience.

### **General Dynamics**

#### **Booth Spaces: 40 & 41**

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General Dynamics C4 Systems is a Lead Systems Integrator offering engineering and management expertise for the design, manufacture, integration, test, and on-orbit support of high performance space systems. Our products include satellites and advanced technology components for applications such as ballistic missile

defense, planetary exploration, space science, imaging, and communications. In addition, our modeling and simulation capability is used to predict and improve performance of system-level designs. The company manufactures spacecraft based upon a modular open architecture that allows the spacecraft to be tailored to a specific payload or mission through a timely and cost-effective process. This approach has yielded a 100% on-orbit success rate for the missions performed to date.

Through our commitment to innovation, we are striving to develop the technologies needed to transform the next generation of space systems, while providing the most affordable and timely solutions from core to edge.

### **IAC 2008/The British Interplanetary Society**

#### **Booth Space: 51T**

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The 59th International Astronautical Congress and Exhibition (IAC 2008), hosted by British Interplanetary Society, will be held in Glasgow, Scotland, 29 September - 3 October 2008.

IAC 2008 will be the most comprehensive “must attend” space event of the year. It will provide an international focus for the global space industry, academic researchers and students worldwide through the presentation of the latest ideas, current activities and future ambitions across a diverse range of space-related topics. Highlights include: attendance by industry leaders & politicians; covers key topics relevant to today’s space-age environment; influencing decision makers; and ensuring constructive media coverage.

Delegates will enjoy free access to the major space exhibition which extends over 10,000m<sup>2</sup>. Exhibitors attending include aeronautical engineering; government and space-related agencies; satellite manufacturers; space tourism; meteorology; environmental; R&D; space science and research; technology and communications and many more.

Further information can be obtained at [www.iac2008.co.uk](http://www.iac2008.co.uk) or email [info@iac2008.co.uk](mailto:info@iac2008.co.uk)

### **Instarsat, LLC**

#### **Booth Space: 48**

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Instarsat, LLC is a privately held high technology company that specializes in the development and manufacture of reliable, cost-effective and high performance satellites for academic, science, civil space, military, and commercial markets. To meet the growing demand for a new generation of smaller space platforms, Instarsat is developing ExpressBus™. First in a family of privately developed small satellite products, ExpressBus™ is intended for use in academic and research missions. ExpressBus™ is a microsatellite class platform that offers customers greater mission planning flexibility, responsive operations, higher return on mission investments and a lower cost access to space. Other product families under development include ScienceBus™ (minisatellite class spacecraft), CommercialBus™ (small class spacecraft), and DefenseBus™ (large class

spacecraft). These innovative space platforms afford a broader range of product choices for mission planners and encompass breakthrough improvements in cost, reliability, and performance not available in the 21st Century space marketplace.

### **Jackson and Tull**

#### **Booth Space: 32**

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Jackson and Tull (J&T) provides a full range of Aerospace and Information Technology engineering and management services for civilian and military customers. A hallmark of J&T specialized services is support for one-of-kind and few-of-kind small satellite vehicles and payloads operated in near-space and space flight applications. J&T's expertise in advanced system technologies include: systems engineering, propulsion technology, fabrication and assembly, integration and test, development of flight and ground hardware systems, mission planning and operations, facility operations and maintenance, and configuration management.

### **L-3 Communications – Telemetry & RF Products**

#### **Booth Space: 76**

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Today, L-3 Telemetry & RF Products serves commercial, military, and civilian customers worldwide, with a product offering that includes TT&C satellite transponders, high data rate satellite transmitters, high-power amplifiers, high-reliability receivers/transmitters, encryption/decryption units, video compression/decompression units, tactical intelligence radios, tactical HF/SSB and microwave radios, telemetry ground system components and solutions, and specialized telemetry and surveillance products.

All Telemetry & RF Products solutions are offered with complete systems engineering and integration services and are backed by a global customer support organization. The company has more than 50 years of experience in telemetry, data acquisition and RF technology and serves virtually every major aerospace organization in the world.

### **Lockheed Martin**

#### **Booth Spaces: 3 & 5**

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www.lockheedmartin.com

Lockheed Martin Space Systems Company, a major operating unit of Lockheed Martin Corporation, designs, develops, tests, manufactures and operates a full spectrum of advanced-technology systems for national

security, civil and commercial customers. Chief products include human space flight systems; a full range of remote sensing, navigation, meteorological and communications satellites and instruments; space observatories and interplanetary spacecraft; laser radar; fleet ballistic missiles; and missile defense systems.

## **MDA**

### **Booth Space: 68**

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MDA is a space contractor with more than 40 years of experience in the development of innovative space systems. The Company delivers turnkey, fixed-price Earth observation, space surveillance, space science, and information delivery satellite missions. Complementing its mission capability is its heritage in the design, development and supply of spacecraft payloads and subsystems, including optical, radar and communication payloads, antennas, digital, microwave, and power equipment for communications. Employing state-of-the-art test and integration facilities supported by extensive engineering expertise and state-of-the-art design tools, MDA solutions define mission success.

Building on experience gained successfully delivering complex space systems, MDA has extended its capabilities into the development of operationally responsive small satellite missions and payloads that combine value and responsiveness with end-to-end functionality. The Company offers a suite of low cost, highly capable payloads compatible with emerging affordable platforms and launchers that meet tomorrow's requirements for rapid and affordable access to space today.

## **Mechanical & Aerospace Engineering**

### **Booth Space: 18**

Utah State University

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Mechanical and Aerospace Engineering (MAE) at Utah State University (USU) continues to build a strong reputation in the Aerospace arena. Faculty research continues to grow and expand, providing students valuable experience while they complete their degrees. Several agencies sponsoring research at USU are Lockheed, NASA, ONR, SDL, AFRL, and others. This funding provides students with research opportunities to help prepare them for an exciting career in Aerospace Engineering. Advanced aerospace topics taught at USU include Spacecraft Attitude Control, Space Navigation, Astrodynamics, and Satellite and Propulsion Systems. Students benefit from these quality classes and continue to learn from hands-on experience with design project/contests like the Chimaera Hybrid Rocket project. In addition, USU students send more experiments into space than any other university in the world. *Think aerospace career--Think Utah State!*

## **Microcosm Astronautics Books**

### **Booth Space: 61**

Pam Esquinca

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Hawthorne, CA 90250

Phone: (310) 219-2700 or (866)-ASTROBK

Email: bookstore@smad.com

www.astrobooks.com

Our unique bookstore carries a huge selection of astronautics books, over 250 titles! These include our world renowned *Space Mission Analysis and Design* and *Reducing Space Mission Cost*. We pride ourselves on supplying the space industry with high quality books at very low prices, and providing our professional assistance in finding the right book for your astronautical needs. It's easy to order on-line, by phone, or by email or visit us from 8am-5pm PST, Monday through Thursday at our near-to-LAX location. Our goal is to make access to our books and services incomparable. We also have wholesale prices for retailers and institutes of higher learning. This year we will be introducing a couple of new editions to our Space Technology Library Series, and plan to use this conference to showcase them.

**MicroSat Systems, Inc.**

**Booth Spaces: 82, 84 & 86**

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MicroSat Systems, Inc. offers high performance microsatellites and spacecraft subsystems including; space power systems, advanced miniaturized avionics and lightweight composite structures, to government and commercial customers. Our heritage, innovation and modular bus approach allows us to provide reliable, lower cost spacecraft for distinct mission applications.

**Mid-Atlantic Regional Spaceport**

**Booth Space: 60**

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The Mid-Atlantic Regional Spaceport (MARS) is an FAA licensed, operational spaceport located at the NASA Wallops Flight Facility on the mid-Atlantic coast. MARS is a cooperative venture of Virginia and Maryland administered by the Virginia Commercial Space Flight Authority. MARS provides low cost access to mid-inclination orbits for ELVs, and supports sub-orbital launches, RLV launch and landing, and payload recovery. Its location provides unobstructed access to the ISS for cargo/re-supply missions. MARS offers two FAA licensed launch pads, sub-orbital launch rails, vehicle/payload storage and processing facilities, co-located airport, flexible mission support, and an accommodating schedule for commercial and government aerospace customers. Its unique location, capabilities, and cost advantages make it the test, demonstration, and operational launch site of choice for ELV/RLV programs by government and industry alike. The December 2006 launch of the TACSAT 2 mission on a Minotaur I exemplifies MARS commitment to responsive, cost efficient small satellite deployment.

**NASA-Ames Research Center Small Spacecraft Office (SSO)**

**Booth Space: 83**

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The NASA-Ames Research Center Small Spacecraft Office (SSO) is charged with the development of small, low-cost, fast response spacecraft and missions in support of NASA Exploration, Science, and space infrastructure objectives. This "Venture Class" of spacecraft and missions, range from 5-200 Kg and are envisioned to cost in the neighborhood of \$100M, for the larger sizes. NASA Ames hopes to enable the capability for frequent access to space, and demonstrate innovative, higher risk technologies, and development and operations approaches. A further goal is to provide venues and projects to train future spacecraft and mission professionals, by enabling applied, goal-oriented collaboration and innovative teaming approaches. To support these objectives, NASA-Ames has established an advanced Mission Design Center, a Center for Engineering Innovation, and a Multi-Mission Operations Center. These and other facilities and resources are being utilized to provide a tightly integrated, full space mission life cycle development and utilization environment.

### **NASA MicroSat Free Flyer ( $\mu$ Sat-FF) Project**

#### **Booth Space: 85**

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The NASA MicroSat Free Flyer ( $\mu$ Sat-FF) Project is a progressive, 4 mission, 5 year effort that is targeted towards developing and demonstrating autonomous nanosatellite space platforms and technologies to support multidisciplinary science investigations. The  $\mu$ Sat-FF project is enabled by the GeneSat-1 and GeneBox projects, in which 5 Kg Nanosatellites, organized in the 3U Cubesat configuration, were flown in 2006 in both the autonomous satellite and attached payload configurations, aboard the USAF Minotaur (TacSat-2) and Bigelow Aerospace Genesis missions, respectively. The overall goal of the initial  $\mu$ Sat-FF Mission, PharmaSat-1, is to test and validate autonomous, in-situ bioanalytical and sample management technologies to implement a Principal Investigator defined science experiment to evaluate the efficacy of an antifungal drug agent on a biological specimen. The  $\mu$ Sat FF project is managed from the NASA-Ames Small Spacecraft Office, and is composed of a multidisciplinary technology development team including government, industry, and academic participants.

### **National Aeronautics & Space Administration**

#### **Booth Space: 62**

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NASA's Wallops Flight Facility (WFF), located on Virginia's Eastern Shore, provides low-cost, responsive suborbital and orbital flight project services to government, industry, and academia customers. As WFF is dedicated to furthering science, technology, and commercial responsive access to space, WFF provides facilities and expertise to enable frequent flight opportunities worldwide. WFF manages an array of research carriers, including sounding rockets, scientific balloons, science aircraft, unmanned aerial vehicles, and small

spacecraft systems. WFF provides operational support through its launch range, mobile range, research airport, and orbital tracking station. In addition to flight projects, WFF is also home to Earth Science researchers as well as engineers responsible for developing flight systems and advanced technologies. WFF possesses highly capable flight hardware fabrication and testing capabilities used to support both its NASA and non-NASA customers.

**NEA Electronics, Inc**

**Booth Space: 26**

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NEA is an innovative company specializing in the design, development, qualification and production of non-explosive Separation Mechanisms, Battery Cell Isolation Switches, Electrical Interconnect Devices and Non-Pyrotechnic Valves for the aerospace and satellite industries.

NEA has successfully addressed a need expressed by NASA to find an alternative to the traditional explosive actuator by developing a reliable, fast-acting, sure release, low shock output, non-explosive separation mechanism with redundant release features. NEA mechanisms eliminate the residue and shock produced by explosive devices and are factory refurbishable for extended use.

Our Battery Cell Isolation Switches were developed to facilitate the isolation of a failed battery pack or a failed battery cell within a battery pack, thereby eliminating the need to shut down the entire pack if a failure occurs.

Our Electrical Interconnect Devices satisfy a need for zero separation force between the plug and receptacle connectors and incorporates contact arrangements based on military specifications.

**Orbital Sciences Corp.**

**Booth Spaces: 17 & 19**

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Orbital Sciences Corporation is one of the industry's leading providers of small space and rocket systems. Orbital supplies low Earth orbit (LEO) spacecraft, geosynchronous Earth orbit (GEO) satellites, and planetary spacecraft for Earth and space science, communications, national security, remote-sensing, and technology demonstration missions. Orbital also develops and manufactures launch vehicles for boosting small- to medium-class satellites into low-Earth orbit, and missile defense interceptor and target launch vehicles. In addition, Orbital also provides a wide range of space-related technical services, including specialized analytical, engineering and production services. Since its founding in 1982, Orbital has developed, built and delivered 538 satellites, launch vehicles and other space systems with an additional 204 systems under contract through 2014. Throughout 2007 the company is celebrating 25 years of providing innovative and flight-proven space systems to civil, government, military, commercial and international customers. Orbital. Innovation You Can Count On.

**Planetary Systems Corp.**

**Booth Space: 59**



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Planetary Systems Corporation (PSC) designs, manufactures and tests staging and payload separation systems for the aerospace industry. The Lightband separation system is the lightest, lowest shock, test-verified system available. PSC was founded in 1998 by Walter Holemans and is located in Silver Spring, MD. Please visit our website [www.planetarysystemscorp.com](http://www.planetarysystemscorp.com).

**Pumpkin, Inc.**

**Booth Space: 74**

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Pumpkin provides off-the-shelf hardware and software solutions for CubeSat and other picosatellite missions. Our affordable CubeSat Kit(TM) family of products provides a thoroughly engineered foundation upon which to build your CubeSat. Each CubeSat Kit contains everything you need to get started right away, as well as a fully conforming CubeSat Flight Model. The high-strength, low-mass CubeSat Kit structure is modular and is easily scaled to satisfy mission requirements. The ultra low-power on-board electronics and Salvo(TM) RTOS software are designed to handle a variety of mission tasks (C&DH, COM, etc.). A wide range of transceivers is supported.

CubeSat Kits are used around the world by a variety of educational, governmental and commercial organizations.

We also offer CubeSat Kit customization and other engineering services. Our technical expertise includes systems engineering, fabrication, software design and programming. Please visit our SmallSat booth and <http://www.cubesatkit.com> to learn more.

**Raytheon Company**

**Booth Space: 15**

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Raytheon Company is a space systems provider with global space sales ranking number four in 2005. The combined strength of Missile Systems, Space and Airborne Systems, Network Centric Systems, Intelligence and Information Systems, Integrated Defense Systems and the Raytheon Technical Services Company provides a vast array of innovative full system solutions for the space community including the emerging Operationally Responsive Space and growing Space Control markets.

Raytheon offers leading technologies in areas including satellite command and control, mission and resource management, end-to-end information and network management, modeling and simulation, systems engineering, producibility and space sensors.

Other areas of expertise include space packaging and quality, radar and communication technologies, directed energy, plug-and-play designs, networking technologies, missile/space vehicle and avionics design, mission assurance and manufacturing.

Raytheon's focus on low-cost, versatile products and programs allows our customers to expand the envelope of space capabilities.

### **Reagan Test Site - Kwajalein**

#### **Booth Space: 33**

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“WORLD CLASS” RANGE..... Ronald Reagan Ballistic Missile Defense Test Site (RTS) has a successful launch history to include a recent ground launched LEO mission. The immeasurable value of RTS is based on its geographical equatorial location, unique radars, instrumentation, support of deep space operations and surveillance, launch facilities, and extensive flexibility for test scenarios.

The four RTS mission areas are: Space Control, Space Support, Missile Defense T&E and Emerging Technologies. These elements are supported by dedicated expertise, capabilities (assets & location) and flexibility to rapidly change to meet customer requirements.

Launch sites allow for flight trajectories in virtually all azimuths for LEO and Geo synchronous orbits. Future connectivity (FY07) will allow for Mission Control and data flow to the Huntsville Range Operations Control Center (ROCC).

### **Rockwell Collins Deutschland GmbH**

#### **Booth Space: 42**

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Rockwell Collins is a world leader in the production of momentum and reaction wheels for spacecraft applications and the European market leader in airborne data processing for tactical military aircraft.

Our standard wheels feature lightweight design, 15 year life time, and ITAR-free electronics. Delivery time is less than 12 months for off the shelf products.

Rockwell Collins TELDIX<sup>®</sup> Space Wheels are available in five different sizes with an angular momentum storage capacity spanning a range between 0.04 Nms and 68 Nms. The wheels accommodate the requirements of attitude control systems for satellites weighing less than 65 kg as well as for geostationary satellites reaching a mass of three tons or more.

To date, 714 wheels installed in 276 satellites have been launched representing nearly 3,000 years of in-orbit operation (as of May 2007).

### **Routes AstroEngineering**

#### **Booth Space: 66**

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ROUTES AstroEngineering develops scientific instruments and payload/bus equipment, including solar panels, power control & distribution units (PCDUs), and spacecraft solid-state mass memory products. Founded in 1988, Routes has developed equipment for LEO satellites, Space Shuttle, International Space Station, and suborbital rocket payloads. Our clients include the Canadian Space Agency, NASA, Swedish Space Corporation, European Space Agency, and several commercial aerospace companies.

Our scientific instruments operate in the UV, visible, and IR wavelengths and are used for astronomy, atmospheric, auroral, and life sciences research.

Our payload & bus products include space solar panels offering state-of-the-art performance, PCDUs for smallsat/microsat class satellites, and on-board data storage systems providing Terrabit capacities using non-volatile FLASH technology.

Our facility & personnel are fully qualified for space manufacturing with ISO 9001-2000 compliance and NASA certified personnel.

### **Rutherford Appleton Laboratory**

#### **Booth Space: 70**

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At the forefront of UK space science research the Rutherford Appleton Laboratory operates one of the largest space research centres in Europe. Working with universities, research institutes, and industry and government agencies around the world, providing management, satellite and ground based instruments, testing and data handling for international space science and EO missions. In particular RAL has developed a number of

instruments specifically for small satellite missions. It has a number of ground stations that are able to support such missions from both its RAL and Chilbolton sites covering S and X band reception and a TT&C capability.

**Saab Space AB**

**Booth Space: 23**

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Saab Space – part of your mission! Saab Space is an independent supplier of space qualified equipment to satellite and payload primes and launcher operators worldwide within the product niches: command and data handling systems; microwave electronics; antennas; payload adapters & separation systems; satellite structures; ground support equipment; thermal isolation; and sounding rocket guidance systems.

Saab Space is a leading supplier of adapters and separation systems for launchers offering modular designs with low-shock separation system technology and multiple spacecraft launch solutions.

Saab Space computer systems and signal processing know-how contributes to a large number of scientific, earth observation and navigation missions.

Saab Space frequency converters are used in several major operators telecom payloads.

Our family of wide coverage antennas, well-known since 30 years, covers frequencies from L-band up to and including Ka-band. They are used in TT&C, data downlink and array applications.

**San Diego Composites**

**Booth Space: 57**

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San Diego Composites, Inc provides advanced-composite product development, technology transition, testing services and production capability to the aerospace community. An ISO 9001 certified corporation, SDC has a proven track record of providing composite products and assemblies which have been successfully transitioned to production programs. Focus markets include space structures and optical benches, missile and aircraft composite structures, missile defense structures, lightweight mirrors and telescopes, electronic enclosures and electronics thermal management. San Diego Composites' staff has extensive experience with polymer matrix (including high-temp), carbon-carbon and metallic structures design, analysis, and fabrication. Additionally, SDC has ISO 17025 accreditation to perform material and component testing services.

**Satellite Services Ltd**

**Booth Space: 9**

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Satellite Services Ltd designs and manufactures satellite sub-systems for supply to the small satellite market and to the European Space Agency programmes. They also design and manufacture electronics for spaceborne scientific instruments. Satellite Services is a 'One Stop Shop' for the complete suite of sub-systems including sensors, actuators, power systems, computer systems and communications equipment. Satellite Services business model offers the delivery of 'semi-standardised' sub-systems where the core circuitry has flight heritage, but the electrical and mechanical interfaces can be adapted to suit the customer's satellite system architecture reducing overall costs and increasing platform efficiency.

Satellite Services is part of the SSBV Group which owns, or has major shareholding in, companies in The Netherlands, UK, Portugal and Australia.

### **SEAKR Engineering, Inc.**

#### **Booth Space: 10**

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SEAKR Engineering is a world-leading provider of advanced state-of-the-art electronic avionics for space and airborne applications. Since our inception in 1982, SEAKR has delivered over one hundred flight units. More than sixty of these units have launched with all having met or exceeded mission objectives. This 100% success rate establishes a track record simply unsurpassed in the industry. SEAKR leading edge space avionics include CISCO System IP Routers, Software Defined Radios, High Performance Payload Processors, modular Command & Data Handling systems, and Solid State Recorders. SEAKR is a small business proud to serve our customers and our country.

### **SIMULIA**

#### **Booth Space: 7**

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SIMULIA is the Dassault Systemes brand that is developing an open platform for multidisciplinary analysis as well as a scalable portfolio of realistic simulation solutions including ABAQUS and CATIA Analysis applications. ABAQUS is the world's leader in advanced Finite Element Analysis providing complete and powerful solutions for routine and sophisticated linear and nonlinear engineering problems. Aerospace companies the world over rely on ABAQUS to make realistic simulation an integral business practice to improve product performance, reduce physical prototypes, and drive innovation. From launch event vibration analyses to failure analyses of composite layups to impact events, ABAQUS software can provide effective, high-performance solutions using the latest state-of-the-art techniques. For the growing aerospace composite industry, ABAQUS provides time saving tools to enable users to define complicated composite layups and windings for axisymmetric, 2D and 3D simulations and analyze typical loading situations as well as extreme conditions such as impact and fracture.

## **Sinclair Interplanetary**

### **Booth Space: 34**

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Sinclair Interplanetary exemplifies the cottage-industry nature of modern microsatellites. Eight spacecraft launched in the past five years have carried equipment from this one-man shop. Qualified off-the-shelf products include nanosatellite reaction wheels and digital sun sensors. Custom avionics such as power supplies, actuator drives and C&DH components are available on extremely aggressive schedules.

Whether you are getting ready to start phase A of your satellite project, or you are in a last-minute panic as the launch looms, Sinclair Interplanetary can lend a hand. Please take a moment to visit the booth, say 'hello,' and see if I can solve your problems.

## **Southwest Research Institute**

### **Booth Space: 16**

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Southwest Research Institute (SwRI) was founded in 1947 as a public service scientific corporation to provide contract R&D to both industrial and government clients. The Institute provides extraordinarily technical capabilities through 11 technical operating divisions, with approximately 3300 staff members and gross annual revenue of \$380 million.

SwRI's Department of Space Systems has a long and distinguished track record of producing high quality, high reliability spacecraft computers for NASA, DoD, ESA, and commercial space missions. Since the first SC-1 spaceflight computer was developed in 1979, SwRI has developed hardware for over 50 space flight missions without a single on-orbit failure. The track record of the last 26 years is a product of a strong commitment to support the current and future needs of the space community. SwRI is recognized as one of the leaders in space instrument design and development, command and data handling (C&DH) systems and mission management.

## **Space Development and Test Wing**

### **Booth Spaces: 56 & 58**

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The Space Development and Test Wing develops, tests and evaluates Air Force space systems, executes advanced space development and demonstration projects, and rapidly transitions capabilities to the warfighter. The wing is comprised of two groups, The Space Test Group and the Space Development Group.

## **Space Dynamics Laboratory**

### **Booth Spaces: 38 & 39**

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www.spacedynamics.org

The Space Dynamics Laboratory (SDL), a nonprofit research corporation owned by Utah State University, has over five decades of experience in developing innovative solutions for complex science and military sensing needs. SDL's expertise includes ground-, air- and space-based IR, visible, and UV sensors; hyperspectral, polarimetric, and hypertemporal systems; small satellites and supporting technologies; rapid, experimental development of prototype hardware and associated software; concept validation studies and demonstrations; real-time intelligence, surveillance and reconnaissance data compression, visualization, and exploitation systems; contamination control and stray light analysis; and cryogenic and thermal management systems. SDL is a recognized international leader in sensor system characterization and calibration, and hosts the Annual Conference on Characterization and Radiometric Calibration for Remote Sensing. Headquartered in a 200,000 ft<sup>2</sup> research complex in Logan, Utah, SDL also operates facilities in Boston, Albuquerque, and Washington DC, and employs over 300 professional and technical personnel.

**Space Micro, Inc.**

**Booth Space: 44**

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Space Micro specializes in innovative high-performance computing and electronics solutions that meet the unique requirements of space, military, and domestic security. By leveraging technologies from the commercial sector with innovative and patent-protected design approaches, Space Micro offers radiation-hardened products that achieve levels of performance that surpass other offerings in a similar class of size, weight, and power utilization.

The Proton 200k single-board computer performs at levels up to 900 MFLOPS or 4,000 MIPS while using only 5-7W of power, at an SEU rate of <1E-4/day using Space Micro's TTMR™ (Time Triple Modular Redundancy) techniques. Using H-Core™ (Hardened Core) technology, each computer is immune from unrecoverable SEFI events.

Other products that are useful for Space applications include transponders, FLASH Memory, Solid State Buffers, Valve Drivers, and a Space Radiation Dosimeter Card.

This same level of innovation is applied to offerings in its sensor, microwave, and computing security products as well.

**SpaceDev/Starsys**

**Booth Spaces: 1 & 2**

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www.starsys.com

Starsys has developed a reputation for delivering extraordinary results in spacecraft mechanisms ranging from complex sub-systems to complex restraint devices. Starsys has extensive experience and expertise in engineering, manufacturing, and testing that enables us to meet the most demanding requirements through innovative designs. Core technologies include docking/servicing systems, deployable structures, cover systems, electro-magnetic and phase-change actuators, low shock separation, battery switches, and passive thermal control.

**Spacelink Co. Ltd.**

**Booth Space: 47**

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The Saito laboratory of JAXA developed GPS receiver (IGPS-1) for the space satellite. IGPS-1 was installed in small satellite "Reimei" and the operation was proven. This GPS receiver is the one having improved to adjust to the space environment by using the commercial-off-the-shelf component. It is what improved from the vehicle GPS receiver, and to install it in the satellite making the best use of the advantage of a micro vehicle GPS receiver. Spacelink Ltd. in Japan will manufacture, and came to be able to supply for the world wide users.

Outline of performance: The cold start time is within 30 minutes. Ranging accuracy is within 0.9 m. Position measurement accuracy is within 17m. Power consumption is about 5V160mA. Number of channels is 8 channels. Size is 11mmx36mmx56mm. Mass is about 39g. Operating temperature range is -30°C to +70°C. Random vibration is 26 Grms.

**SpaceX**

**Booth Spaces: 35 & 37**

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[www.spacex.com](http://www.spacex.com)

The SpaceX family of launch vehicles are intended to reduce the cost and increase the reliability of space transportation. The Falcon I, Falcon IV, and Falcon IV Heavy can deliver light, medium and heavy payloads to any inclination and altitude. The Falcon IV and Falcon IV Heavy have true engine out reliability and are the world's first fully reusable launch vehicles. Initiated internally, SpaceX's Dragon spacecraft is designed for Earth to LEO transport of pressurized cargo, unpressurized cargo, and/or crew members, and it will be utilized to fulfill the NASA COTS contract for demonstration of ISS cargo re-supply.

SpaceX was established in 2002 by Elon Musk, the founder of PayPal and the Zip2 Corporation. Since then, they have developed two brand new launch vehicles, established an impressive launch manifest, and been awarded the COTS contract by NASA to demonstrate cargo delivery/return to the ISS. For more information, visit [www.spacex.com](http://www.spacex.com).



## **Sun Advanced Product Testing**

### **Booth Space: 24**

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www.aptesting.com

Sun Advanced Product Testing (Sun APT) is a commercial test lab department of Sun Microsystems located in Longmont, Colorado. Sun APT specializes in environmental testing for the aerospace industry in the areas of shock, vibration, temperature & humidity, altitude and other MIL Spec and DO-160 dynamic and climatic testing requirements.

## **Surrey Satellite Technology Limited**

### **Booth Spaces: 12 & 14**

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Surrey Satellite Technology Ltd (SSTL) is a privately-owned British company, specializing in the design, manufacture and operation of high performance small satellites. SSTL has launched 27 small satellite missions for international customers and employs 230 staff working on LEO, GEO and interplanetary missions, all of which exploit the cost-effective technologies and techniques that are the hallmarks of Surrey's work. In 2005 SSTL launched the 600kg GIOVE-A minisatellite into MEO, the first satellite in the European Galileo navigation system. SSTL's most recent launch, March 2007, was CFESat, a microsatellite for the US Department of Energy Los Alamos Laboratory. Nine satellites are currently under construction and test at SSTL's facilities for customers in Germany, Spain and Nigeria, including a follow-on contract from the European Space Agency for a second navigation satellite, GIOVE-A2.

## **Universal Space Network, Inc**

### **Booth Space: 75**

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Universal Space Network, Inc. (USN) along with the Swedish Space Corporation (SSC) provides satellite tracking and communications services from a global network of remote ground stations called PrioraNet. PrioraNet offers worldwide satellite tracking, telemetry and control (TT&C) and data downlink services on a lease 'by the pass' basis. Subscribers gain access to PrioraNet services through Network Management Center (NMC) facilities in Pennsylvania, California and Sweden. Through this single point of interface a subscriber gains access to satellite ground stations in strategically selected locations around the world.

**Carlo Gavazzi Space SpA**

**CANCELLED 7/19/07**

**Booth Spaces: 77 & 79**

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Carlo Gavazzi Space is the first small satellite integrator in Italy and one of the main companies developing space projects in Europe.

The company develops turn-key systems for: science, earth observation, technology demonstration and telecommunications missions, based on platforms ranging from 30 up to 800 kg for LEO orbits. A small GEO platform is currently under study. The company offers flexible, reliable and competitive solutions for demanding missions. CGS has 25 years experience in space systems and it has know-how and technologies to support customer's needs from design to post-launch operations.

CGS main customers are space agencies (e.g. European Space Agency ESA, Italian Space Agency ASI) and commercial customers. The company works in close cooperation with the main research institutes. Main current projects are: AGILE satellite for high-energy astrophysics, commercial satellites for telecommunications and observation, relevant parts of the German SAR-LUPE constellation.