Phase I Project Summary

Firm: nScrypt, Inc.
Contract Number: 10-1 S4.02-8566
Project Title: 3D Print and Play Payload (P3) Systems

Identification and Significance of Innovation: (Limit 200 words or 2,000 characters whichever is less)
A 3D sensor system was demonstrated, the fabrication of which could revolutionize the manner in which spacecraft and satellites are constructed in the future on Earth or *in situ* in Space. This effort has proven the possibility of fabricating an entire system with both electrical and mechanical content through on-demand 3D printing. In this new manufacturing paradigm, conformal and complex shapes with a diversity of materials in spatial gradients can be built layer-by-layer using a combined fabrication technology that includes 1) Additive Manufacturing (AM) – also known as **3D Printing –** combined with 2) micro-dispensing and 3) robotic pick-and-place. A design can be conceived in Computer Aided Design (CAD) and printed on-demand – **even in zero gravity**. This new integrated approach enables the fabrication of sophisticated electronics in mechanical structures by avoiding the restrictions of traditional electronic packaging methods. The integration of the three manufacturing technologies can 1) provide the capability of print-on-demand fabrication – literally anywhere; 2) enable the use of micron-resolution cavities for press fitting electronic components including micro-systems; and 3) integrate conductive traces for electrical interconnect between components.

Technical Objectives and Work Plan: (Limit 200 words or 2,000 characters whichever is less)
The ultimate goal of the nScrypt/UTEP team for Phase I and Phase II is to establish a process to create working 3D Print and Play space electronics and structures, initially targeting CubeSat applications and later general space exploration applications as well. The electronic circuits will range from sensing circuits to RF transmit and receive circuits. All of these must be radiation hardened or the process must include a radiation-hardened step to ensure properly functioning circuits in space. Functional electronic circuits are not necessarily anything new with regard to functionality; however, the 3D Print and Play is a novel approach, not only to packaging but to system integration as well. 3D Print and Play will significantly enhance operations through reduced weight, and it will truly fabricate three dimensional freedom and increased durability.

Phase 1 Workplan:

- Fabricate a 3D AT90USB device demonstration as a SPA1 ASIM sensor interface;
- Evaluate outgassing of materials used in Structural Electronics;
- Direct Print a variety of components including:
    - Passives
    - Conductors
    - To connect unpackaged die
- Explore the ability to make electronics that truly benefit from the fabrication within a structure for which complexity is for free based on the 3D Printing techniques

Technical Accomplishments: (Limit 200 words or 2,000 characters whichever is less)

Outgassing Results - Qualitative results show under the worst case scenario for vacuum, the FDM materials showed less than 1% outgassing, making these substrates an excellent choice for space flight as the outgassing is insignificant. As a general standard, the total mass loss screening level for materials is 1.00%, as specified in the Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials used by NASA. The devices performed beyond the rating of NASA requirements, leading to the potential of these devices to be fabricated for general space missions.

Leveraging collaboration with COSMIAC, a research center affiliated with the University of New Mexico, the team has built a device including an SPA-1 ready Atmel Chip AT90USB1287 capable of communicating through I2C to an external data module, set to launch in 2012. The circuit included the Atmel AT90 microprocessor as well as an external oscillator, and included connections to the I2C channel needed for communication. The device was built as a single straight 3D printed substrate and interconnect including embedded components as well as a serpentine line to test the behavior of ink within the vacuum.

NASA Application(s): (Limit 100 words or 1,000 characters whichever is less)

CubeSats provide a key benefit to NASA due to the extremely minimized SWAT of this platform. This translates into an easily deployable space platform, creating the opportunity to expand and accelerate experimentation with self-healing networking, swarming, and sensor suites. 3D printing structural electronic devices in the SPA platform with highly integrated sensor payloads will further accelerate these experiments. The ability to design and fabricate items in 3D that are form factor and function agnostic opens the door to any application, be it small CubeSats or a large TDRS. Total freedom in 3D also opens up new exploration and platform opportunities.

Non-NASA Commercial Application(s): (Limit 200 words or 2,000 characters whichever is less)

CubeSats also fill a need in the DoD and commercial sectors. The NRO is exploring networked CubeSat “constellations” as the next generation of satellites that provide redundancy as well as a smaller target for adversary countries to hit. Additionally, CubeSats provide a great opportunity for expanding educational support in Science, Technology, Engineering, and Mathematics for Universities and High/Middle Schools. The ability to 3D print CubeSats from a 3D graphic also pulls in an artistic skill set that will bring in a new thought process for CubeSats as well as other functional devices. This aesthetic also pulls in a potential new breed of designer or engineer from youth that operate in the cyber 3D world through gaming and graphic software like Adobe Illustrator. Any 3D object that can incorporate aesthetics with structure and with electronic function opens the door to many applications as well as those yet to be imagined.

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