Mission Assurance For Smallsat Payloads

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February 15, 2017

PERICLE COMMUNICATIONS COMPANY

Company Background

- **Wireless Engineering Firm Founded in 1992**
  - Headquartered in Colorado Springs, CO
  - Development team of 10 employees & contractors
- **Started Company with SBIRs from NSF**
- **First DoD Near Space Payloads Delivered 2004**
- **First DoD Cubesat Payload Delivered 2009**
- **Pericle Payloads Have Flown on 10 U.S. Army Cubesats on 4 Launches**
- **Currently Delivering Our 3rd Generation Software Defined Radio (SDR)**

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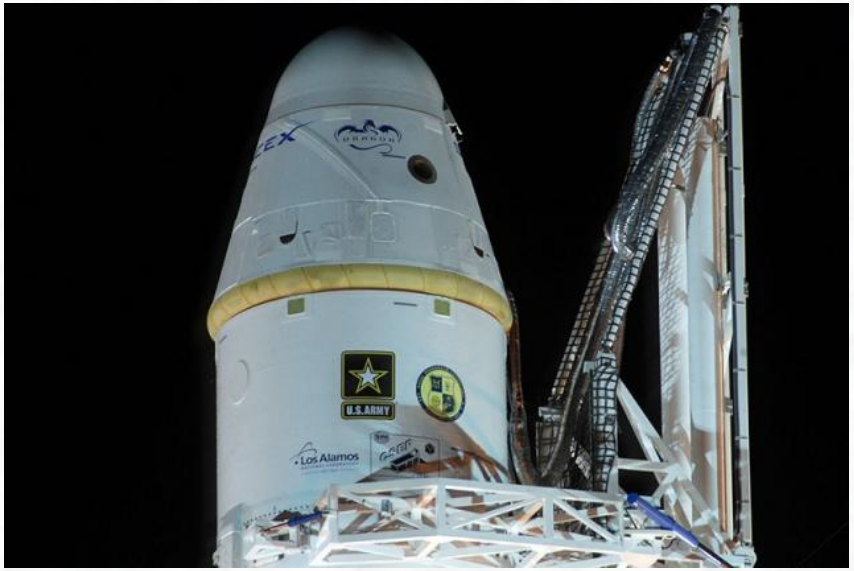
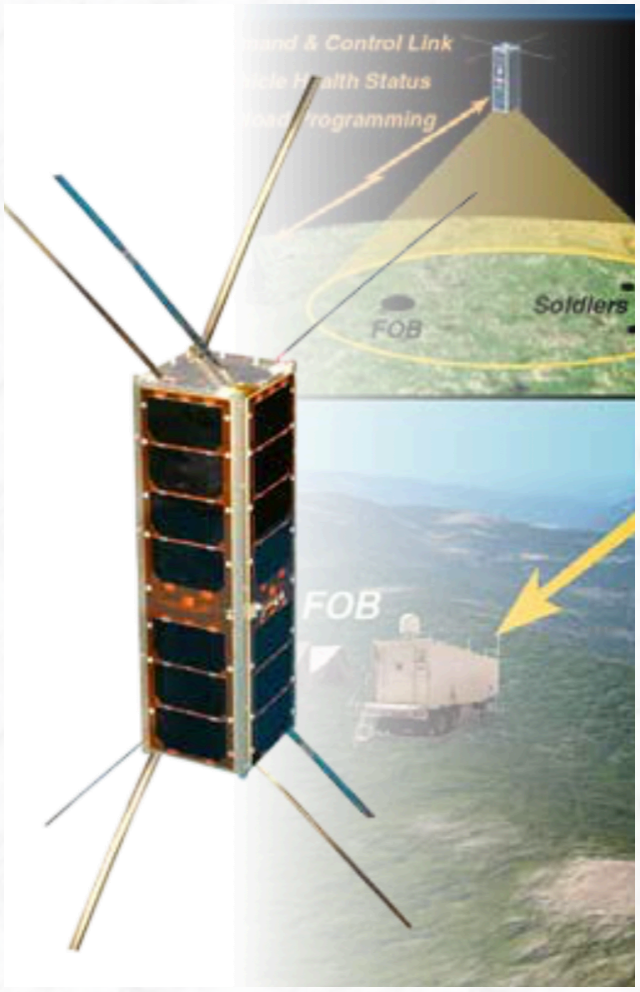
Payload/Launch 1

- **SMDC-ONE: UHF UGS Store & Forward**
  - Prime: Miltec Missiles and Space (now General Atomics)
  - Customer: U.S. Army SMDC
  - Launch Vehicle: Space X Falcon 9
  - Launch: December 8, 2010 from Cape





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**SMDC-Orbital Nanosatellite Effect Technology Demonstration*

Payloads/Launch 2

- **SMDC-ONE: Able and Baker (3U)**
  - Prime: Miltec Missiles and Space (now General Atomics)
  - Customer: U.S. Army SMDC
  - Launch Vehicle: Atlas 5
  - Launch: September, 2012 from Vandenberg AFB
- **Modified SMDC-ONE to Pass UHF Voice**

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Payloads/Launch 3

- **SNaP-3, Tacsat-6, SMDC-ONE Charlie & David (3U)**
  - Prime: Miltec Missiles and Space (now General Atomics)
  - Customer: U.S. Army SMDC
  - Launch Vehicle: Atlas 5
  - Launch: December, 2013 from Vandenberg AFB (NROL-39)
- **SNaP-3 is Software Defined Radio**
  - UHF transponder for tactical man-pack radios (e.g., PRC-117G)
  - Several Mil-Std 188-181B waveforms implemented
  - Backward compatible with SMDC-ONE
- **Combatant Command Sponsor = USSOUTHCOM**
  - Addresses triple canopy coverage problem

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Payloads/Launch 4

- **SNaP-3 Alice, Eddie, Jimi (3U)**
  - Prime: Miltec Missiles and Space (now General Atomics)
  - Customer: U.S. Army SMDC
  - Launch Vehicle: Atlas 5
  - Launch: October, 2015 from Vandenberg AFB
- **SNaP-3 Bus Innovations**
  - Type 1 Encryption (Gryphon Module)
  - Propulsion (Aerojet)
  - New ADCS (Maryland Aerospace)
  - New Flight Computer (Miltec)
  - New UHF Antenna (Haigh-Farr)

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Other Payloads

- **Two New Payloads to Be Delivered in 2017**
  - Both use our third generation SDR
  - Hardware Platform is Xilinx Zynq 7035 System on a Chip (SOC)
    - FPGA & ARM processor on one IC
- **Launches To Be Determined**

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Mission Assurance Approach

- **Engineering Best Practices**
  - Including EMI design techniques
  - Good heat conduction & radiation design
  - Skilled and experienced RF circuit designer is essential
- **Flight Heritage**
- **ULA Requirements**
- **Selective Use of NASA Standards**
- **Apply Lessons Learned (ours and others)**
- **In Keeping with Nanosat Philosophy,**
  - No radiation hardened parts
  - Radiation effects mitigated primarily through software

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Mission Assurance Techniques

- **Functional Testing**
  - Bench & field testing
  - Including high altitude balloon testing (budget permitting)
- **EMI Testing**
  - We always provide a receiver and EMI tests are essential
- **Environmental Testing**
  - Temperature, temperature cycling testing in-house
  - Vibe, TVAC and radiation performed by bus provider
- **Heat is the Enemy of Reliability**
  - Good heat conduction & radiation design are essential
- **Radiation Effects Mitigation (e.g., SEU)**
  - Primarily through software

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Software Mitigation

- **Redundant Storage**
- **File CRC (Error Detection Code)**
- **CPU/MMU Protection**
- **Watchdogs**
  - Watchdog timers
  - Interrupt handlers
  - Memory access timeouts
- **Interrupt Handlers**
- **Code Insertion**
- **Current Monitoring**

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What Keeps Us Up at Night

- **Did We Do Enough Testing?**
- **Will ULA Range Safety Requirements Cause Payload to Fail to Turn On at All?**
- **Did Everyone Else Do Their Job?**
- **We're Using State-of-the-Art FPGA, Will This Come Back to Bite Us?**
- **Do We Really Understand the Radiation Problem and Did We Do Enough to Mitigate It?**

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Questions?

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