THE RANGING AND NANOSATELLITE GUIDANCE EXPERIMENT (RANGE)

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Space Systems Design Laboratory
• Two 1.5U satellite formation
• Selected for a launch opportunity through the Terra Bella (formerly Skybox) University Cubesat Partnership
  – Satellite delivery due in 2016
• Mission objectives
  – Improve absolute and relative positioning capabilities of nanosats
  – Explore propulsion-less formation control techniques
  – Transmit low-rate optical (laser) communications
• Innovations
  – Demonstrate m to cm level POD for cubesats
  – Demonstrate mm-level inter-satellite ranging
  – Demonstrate inter-satellite laser comm from a nanosat platform
  – Evaluate performance of miniaturized atomic clock
Satellite Laser Ranging (SLR)
• Satellites will have no propulsion system
• Intersatellite distance (in plane) will be controlled through differential drag
  – Change in drag ratio (orientation) between the two satellites causes a relative motion
  – Well described in the literature, but few mission examples (Planet Labs, Aerospace AC6)
• Current mission plan will vary distance from hundreds to thousands of meters
• Primary payloads
  – Novatel OEM628 Receiver (L1/L2)
  – Chip Scale Atomic Clock (CSAC)
    • $< 2.5e^{-11}$ ADEV over 10s

• Orbit validation through ground-based satellite laser ranging (SLR)
  – Service provided by the NLR/ILRS
  – Cm-level accuracy
• Laser Rx/Tx System
  – Made by Voxtel
  – 25 kW, 4 ns pulses
  – APD sensitive to nW
  – Custom optics design (GTRI)
  – 2.5° beam divergence to account for coarse s/c pointing
  – Class 1 (eye-safe), 1535nm

• Est. one-way detections to 500 km, dual-way detections < 1km

• Same system will also be tested as a low-rate laser communications
**RANGE – S/C DESIGN**

- **GPS antenna** (Antcom)
- **GPS receiver** (Novatel)
- **ADCS** (GT, CubeSpace, SolarMEMS)
- **OBC/COMMS/CDH** (Gomspace)
- **Laser Rx/Tx** (Voxtel)
- **CSAC** (Microsemi, Jackson Labs)
- **Solar panels** (Pumpkin)
- **UHF/VHF antenna** (Gomspace)
- **EPS** (Gomspace)
- **Corner cube reflectors**
• Custom structure
• Custom solar panels (Pumpkin)
HARDWARE

- Ruggedized electronics
- Custom Torque rods
- Reaction wheels (CubeSpace)
- Integration and Testing
- ADCS

ReacEon wheels (CubeSpace)
CHALLENGES AND NEXT STEPS

• Complete RANGE integration and testing
  – Flight software maturity
  – Environmental testing (thermal vacuum, vibration, antenna characterization)

• Controlling inter-satellite distance
  – Differential drag techniques still experimental
  – Want to avoid fast/out-of-plane separation of satellites
  – Refining simulations using advanced models (rarefied flow)

• Maintaining sufficient pointing control for laser Rx/Tx
  – 3-axis S/C pointing control expected to be 3-5°
  – With 2.5° laser beam divergence, continuous Rx/Tx not guaranteed
  – With only one reaction wheel, precise rotation only possible for one-axis
  – May require random attitude “search” until alignment achieved
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  – Georgia Tech Research Institute (GTRI)
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