Optimizing the Potential of Small Satellites:
Proximity Operations and Rapid Integration

Erin Beck
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Microscale satellites can perform complex technology demonstrations. How do you pack mission substance into a shoebox-sized spacecraft with minimal funding, facilities, and time?

Students are responsible for all project aspects.

Bandit/Akoya utilizes distributed subsystems with a plug-and-play platform to perform proximity operations and rapid integration of two microscale vehicles (<5 kg) and a host - all under 35 kg.
The Mission: Prox Ops and Rapid Integration

**Bandit**

- **3 kg, 12 x 12 x 18 cm**
- **Primary Mission**
  - Proximity operations; release and recapture of one vehicle
- **Extended Mission**
  - Repeatable docking
  - 6DOF control
  - Visual navigation
  - Autonomous flight

**Akoya**

- **29 kg, 40h x 42d cm**
- **Primary Mission**
  - Support Bandit
- **Secondary Mission**
  - Demonstrate RI&T using:
    - Modularized subsystems
    - Distributed C&DH
    - Standard power/data protocol

Bandit is capable of cutting-edge demonstrations in less volume than a triple CubeSat.
“We’re not Orbital Express, and we shouldn’t be.”

Heritage

Orbital Express: 700 kg, 2007
XSS-10: 31 kg, 2003
XSS-11: 100 kg, 2005
DART: 360 kg, 2005

SNAP-1: 6.5 kg, 2000
SPRINT AERCam: 16 kg, 1997
MINI AERCam: 5 kg
Long-term survival functions are distributed to Akoya. Bandit is dominated by **mission-specific subsystems**.

**Bandit**
- Short- to long-range, short-duration sorties
- Small (3 kg), inexpensive ($15,000)

**Akoya**
- Stationary, long-duration mission
- “Large” (29 kg), still inexpensive ($39,000)

By offloading subsystems, Bandit is **small, maneuverable, and expendable**.
80% of Bandit’s volume is dedicated to 
mission-specific subsystems.
Precision Sensing of a Slow-Moving, Low-Mass Object: Blended Navigation Sensing

**Primary Sensors:**
- Roll rate gyros
- MEMS 3-axis accelerometer

**Secondary Sensors:**
- Image processing
- IR range finder

*When you lack the brawn and the brain…*
- Bandit is too small and too slow for commercial accelerometers. (We require nano-g resolution for a 10 minute sortie.)
- Bandit’s processing is not fast enough for real-time video.

*Just throw everything you’ve got at it…*
- Slow/accurate secondary sensors refresh fast/inaccurate inertial sensors at 1/4 Hz and provide visual verification of position.

*Or get out fast.*
- Mission-critical sorties last only a couple minutes.

**Mission Success requires 10 seconds off dock.**
Bandit’s long-term needs are fractionated to Akoya. Bandit is structurally decoupled, but dependent on Akoya for survival and Mission Success.
Bandit’s Bed and Breakfast: Repeatable Soft-Docking and Power Charging

The Dock provides a long-term stable platform for Bandit to “stationkeep”, dump momentum, power down, and charge.

Bandit docks with **Velcro**!
Yes, it’s low-tech! It’s also:
- **Simple**
- **Strong**
- **Repeatable**
- **Soft**
- Extremely error tolerant

And did I mention it’s **electrically-conductive**…
- Bandit charges continuously and automatically while docked.
- Full charge in 2 hours, lasts 30 minutes
Akoya is a fully-customizable support bus, with modularized plug-and-play subsystems standardized by a common power/data protocol.
Bandit/Akoya demonstrates prox ops, repeatable docking, visual navigation, autonomous flight, and immediate integration - all under 35 kg and $70,000, and all student-built.

Capitalize on distributed subsystems and plug-and-play architecture:
- Consolidate long-term functions on a bus that supports multiple microscale payloads
- Distribute out functions such that payload subsystems are mission-dominated
- Seamlessly test, swap, or upgrade subsystems and payloads by utilizing standardized dCDH modules
- Ideal for rapid response and student missions.
Self-Propelling 6DOF Thrusters

The propulsion system is *half* of Bandit.

- Integrated with structure to save space
- R-134a cold gas propellant ("Dust Off")
- 8 control valves for uncoupled actuation about any axis

Bandit cannot refuel in orbit. How do you guarantee the mission?

1. A lot of propellant: 12 m/s deltaV
   (2,400 pulses at 5 mm/s deltaV per thrust)
2. An extra tank. **Bandit-2 is a complete on-orbit spare.**
Advanced Applications: Visual Inspection and Autonomous Flight

Visual Inspection
- Bandit photographs a pattern of LEDs on Akoya and determines its pose.
- Akoya Dockside camera confirms docking.
- Akoya Earthside camera confirms Nadir-pointing.

“Bandit Video Game”
- 3D computer simulator visualizes real-time or simulated telemetry.
- Includes disturbances like orbital drift and thruster imbalance
- Estimates future position to compensate for sensor lag
- Activates autonomous algorithms like “Return to Dock”

Autonomous Flight

Near-Dock Sorties
- Thrusters fire on timer
- Primary sensors

Complex Sorties
- Adaptable autonomous flying
- Primary and secondary sensors
Communications Hub

Akoya is the relay station between Ground and Bandit. Bandit only needs minimal cross-link chip radios/antennas.

Shared Processing

Complex computing - image processing, autonomous algorithms - is performed on Akoya.
Each subsystem is controlled by its own **microprocessor** and conforms to the **standard power/data** Emerald Data Protocol.

Not just “rapid,” but **immediate** plug-and-play integration…

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<th>Duration</th>
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* Because the imbedded systems engineer was distracted by