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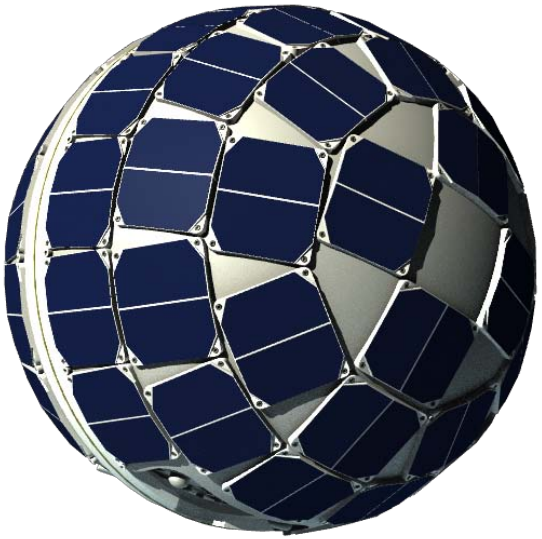
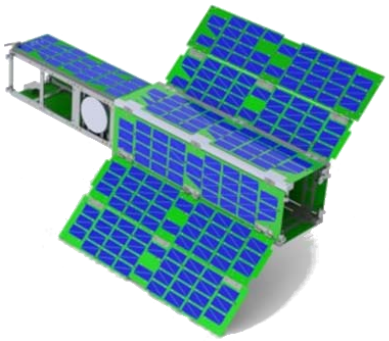




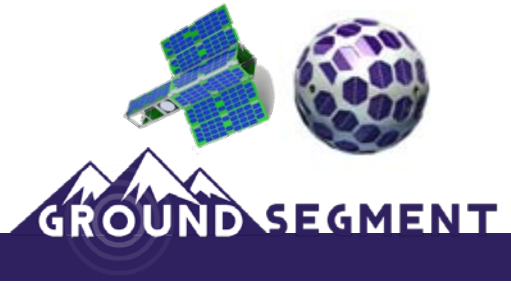
STRATEGIES FOR RAPID DESIGN AND DEVELOPMENT OF ALLSTAR-1 GROUND SEGMENT

GROUND SEGMENT

COSGC

Vignesh Muralidharan, Michael Trowbridge, Quinn McGehan, Bill Irelan, Logan Smith

Agenda



- Background
- Modular Design and Re-Usable Architecture
- Leveraging open source software and pre-existing protcols
- Design and deployment practices

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Background

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Colorado Space Grant Consortium

- NASA sponsored network of higher education institutions and a foundation in Colorado charged with inspiring students to work in the space industry
- Students design, build and operate spacecraft

Our Ground System

- Heterogeneous: more than one type of satellite
- Hub-spoke architecture
  - Remote sites link to central station

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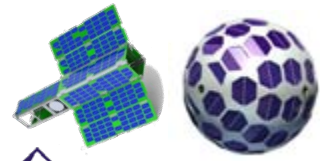
Capital Expenditure DANDE



GROUND SEGMENT

Terminals (x4)	$500 (ea)
InControl	No cost educational Demonstration License
Radio, Antenna, etc	$10,300
Server (x2)	$500 (ea)
Total	$13,300

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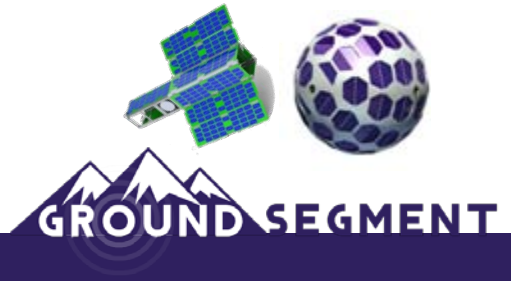
ALLSTAR



- 3U CubeSat
- ALLSTAR-1 will carry imaging payload (Lots of data, low com time).

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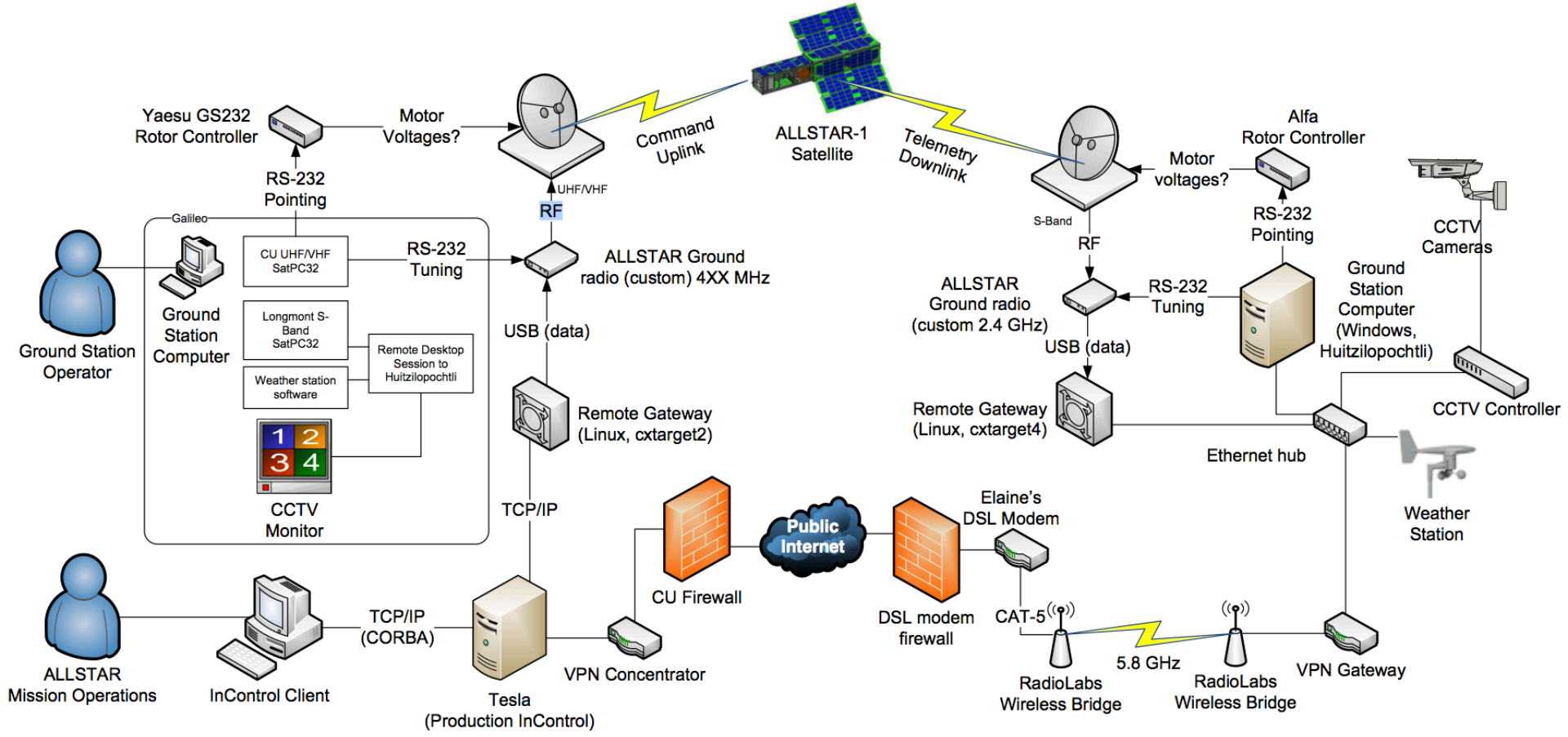
ALLSTAR-1 Architecture

GROUND SEGMENT



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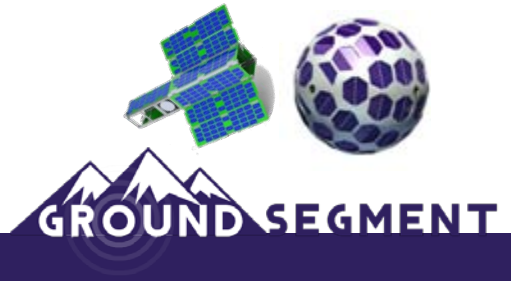
ALLSTAR Constraints



- Low integration time (less then one year of development).
- Low personnel (2-3 students working 10 hours a week).
- Capex for ALLSTAR ground segment projected to be in low thousands.
- Due to University building code geography, ground station is far away.

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Modular and Reusable Architecture

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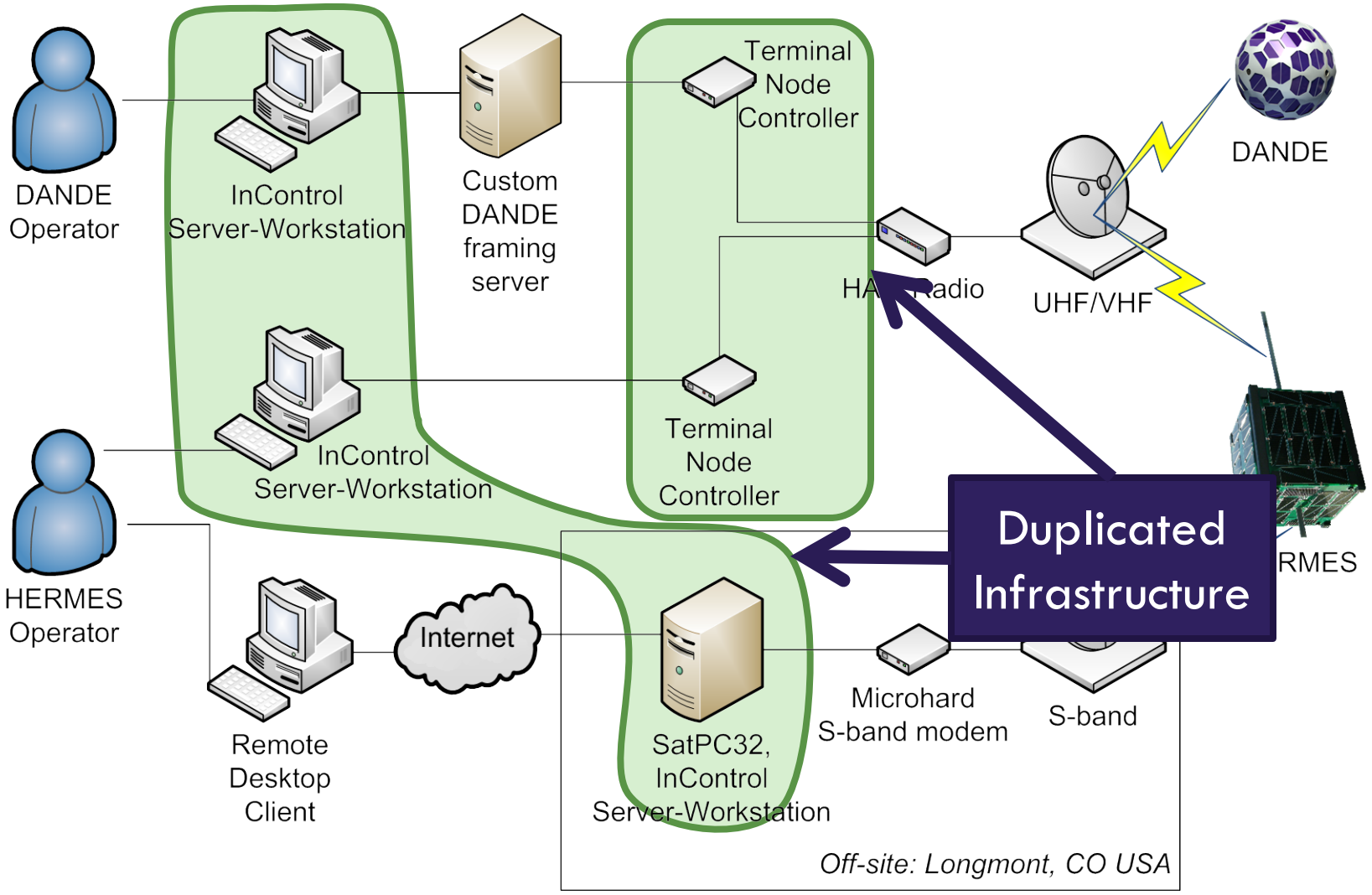
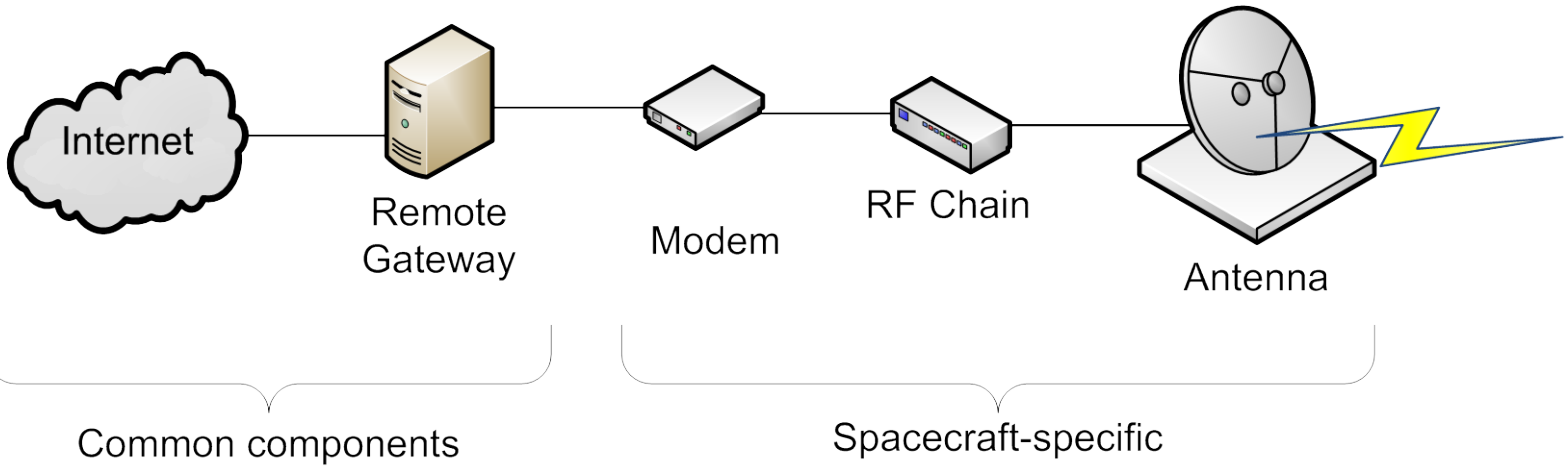
Architecture: Fall 2009



Ground Station Pattern



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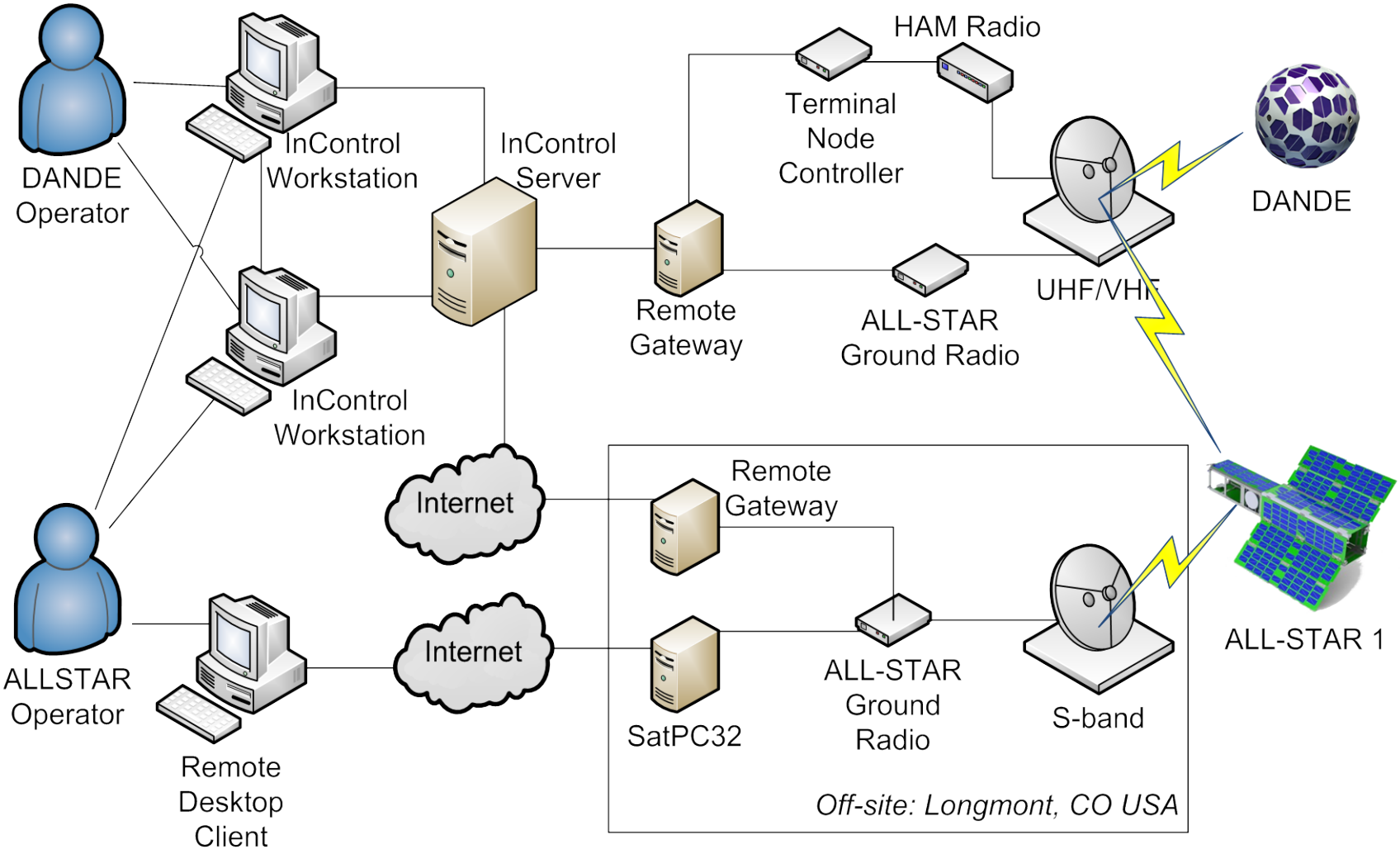
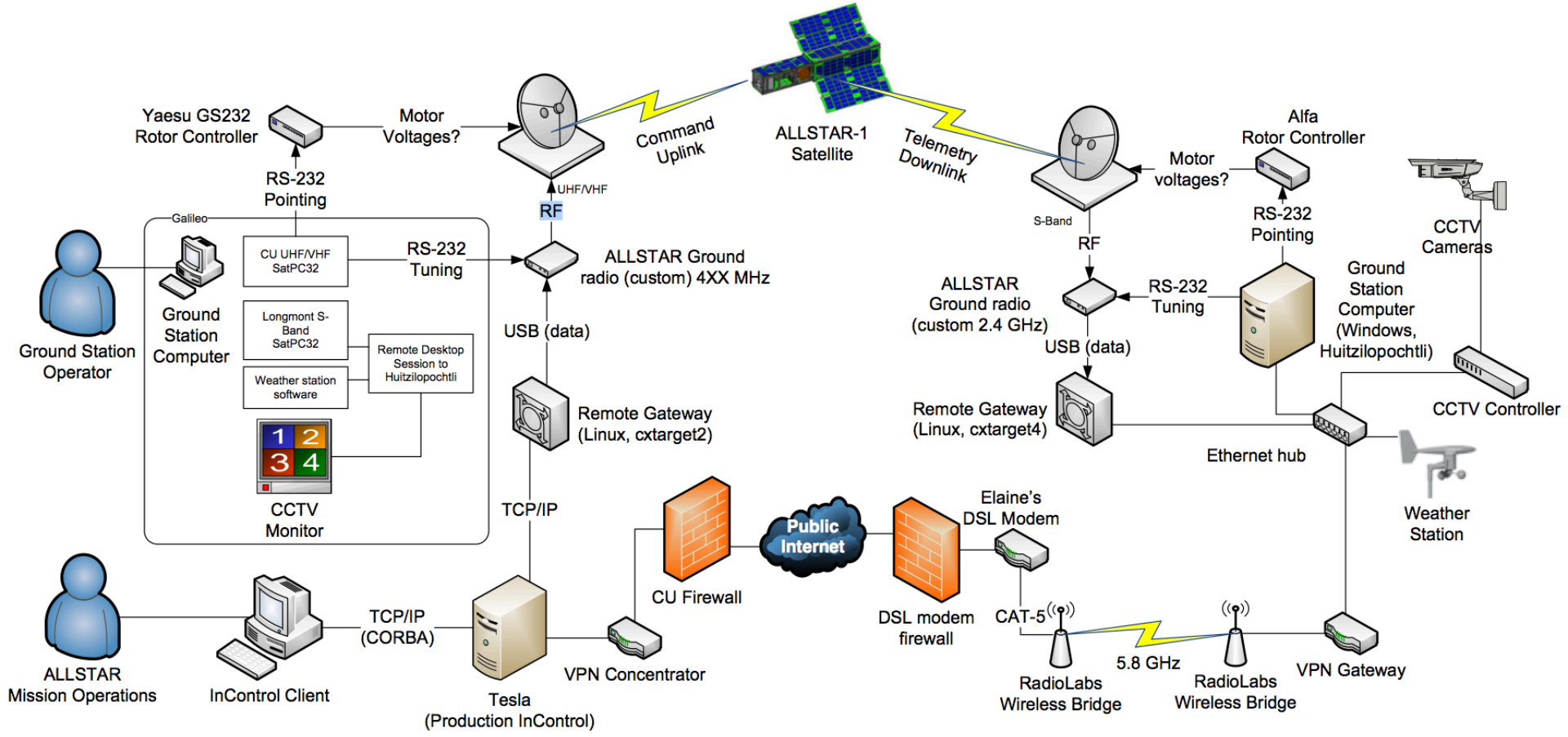
Overall Architecture



ALLSTAR-1 Architecture

GROUND SEGMENT



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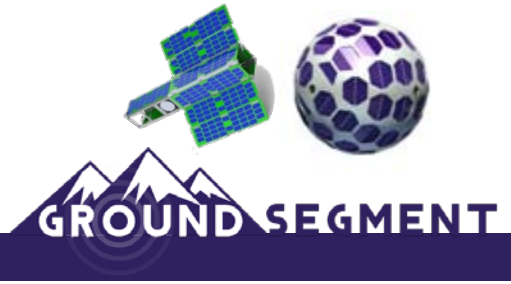
How to simplify ALLSTAR



- Re-use existing ground station
- Re-use existing server infrastructure
- Re-use existing MOPS team
- Build custom Remote Gateway

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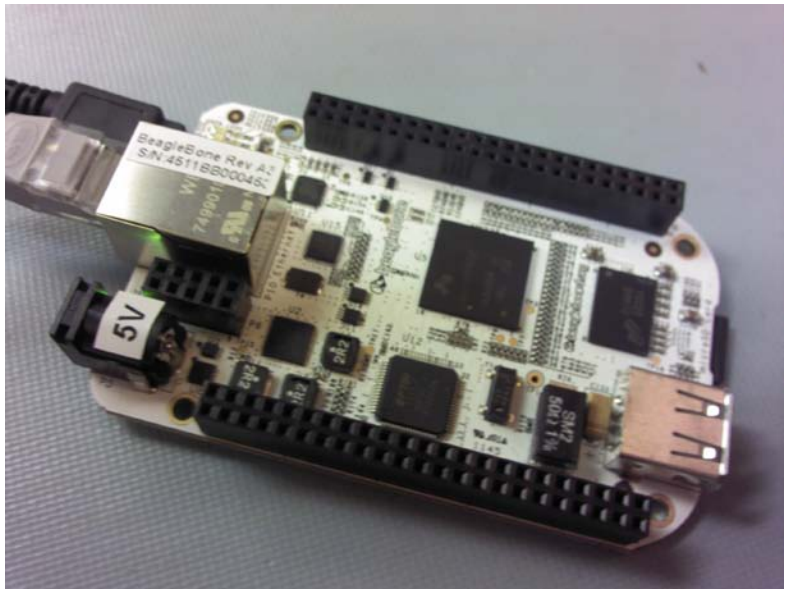
Beaglebone

- Serves role of Remote Gateway for ALLSTAR-1
- Low cost ($45).
- Runs Ubuntu Linux (simplifies development)



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Beaglebone Deployment

- Install Tomcat/Socat with apt-get
- Enable SPI Dev
- Develop custom class to interface with ALLSTAR

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Using Existing Technologies

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Commercial Internet

- Cheap
- Easy to setup and use
- Wide area of coverage
  - Easy to integrate new ground stations
- Interchangeable module

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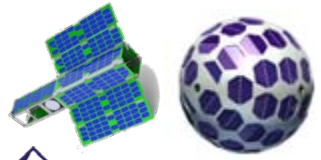
Security & Commercial Internet



- 2 layers to ground digital board: VPN/IPSEC encryption, ssh AES encryption
- 2 layers of firewalls to ground digital board: Router firewall, VPN gateway
- Farm side VPN gateway does not accept incoming connections – only makes outgoing connections to Campus VPN concentrator

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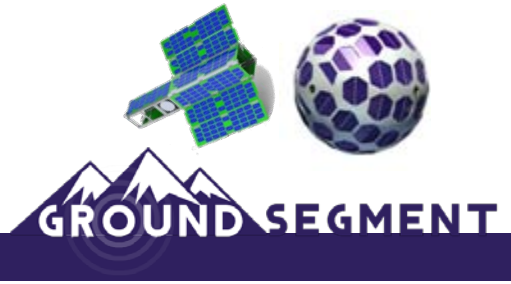
ALLSTAR COM



- Distributed System (Multiple hardware, software players).
- Very complex

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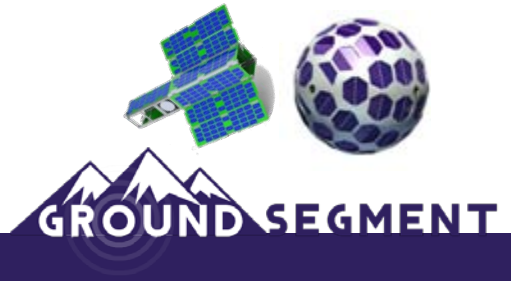
TCP/IP



- Pre-existing, well tested communications protocol.

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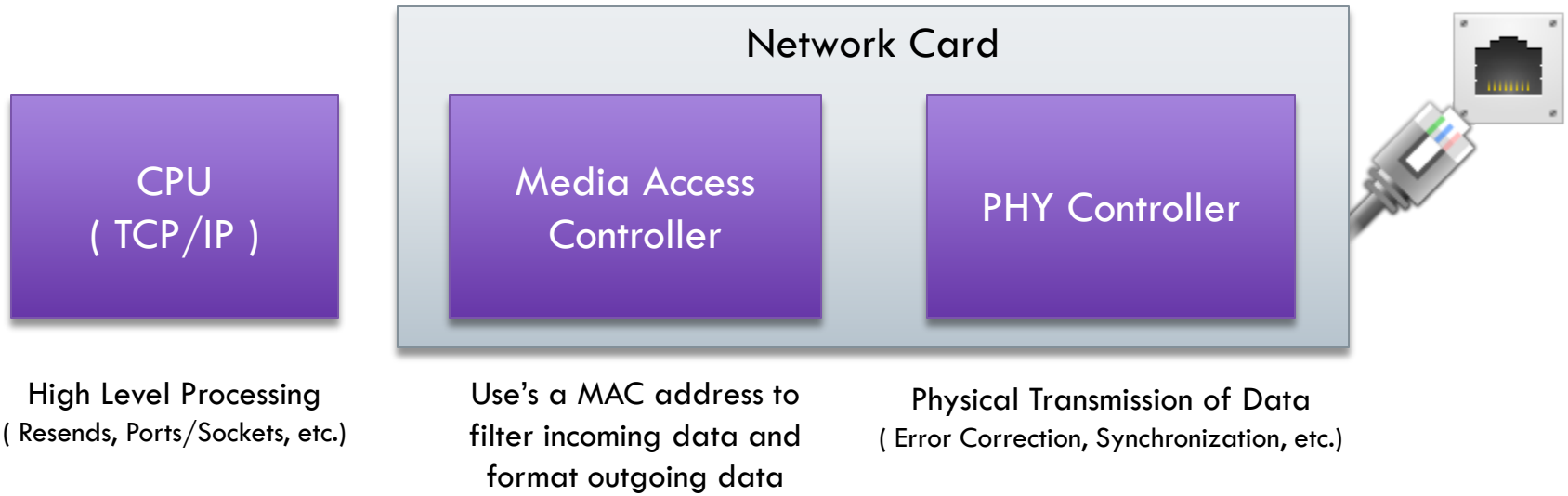
Typical Ethernet Setup



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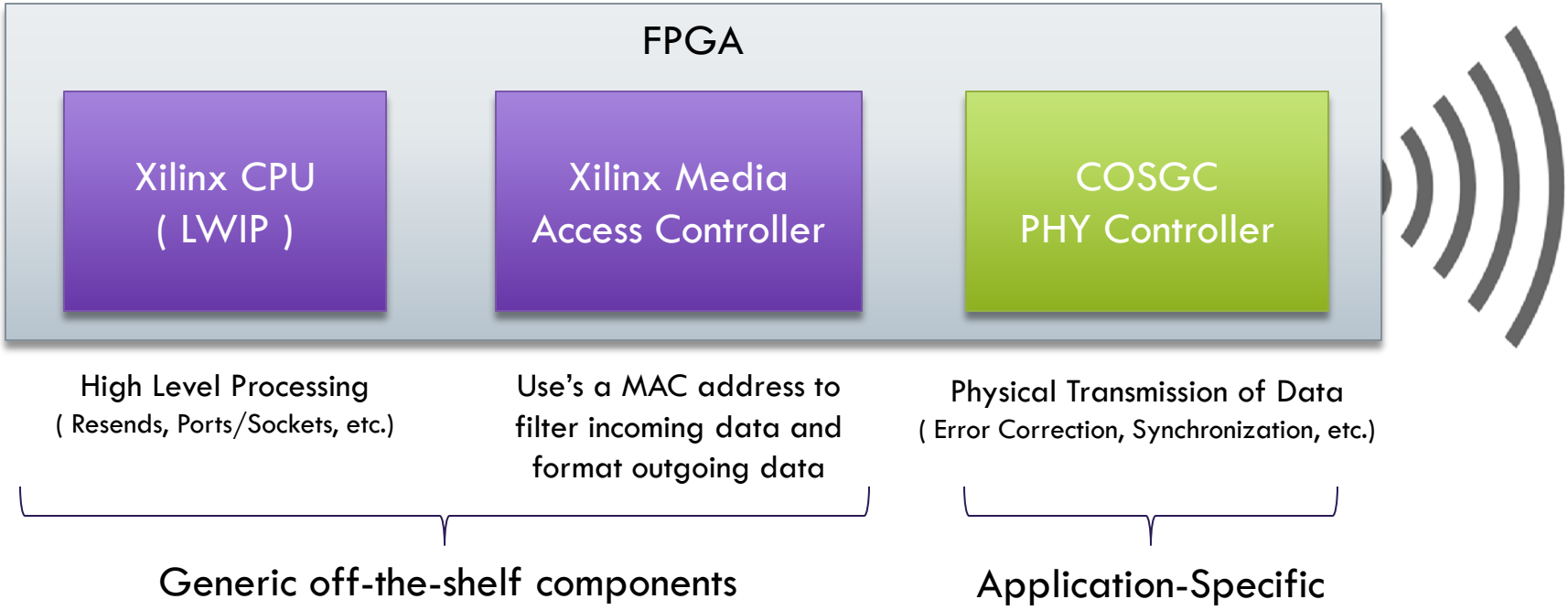
ALL-STAR Setup



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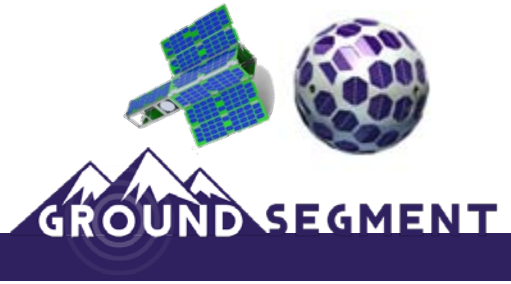
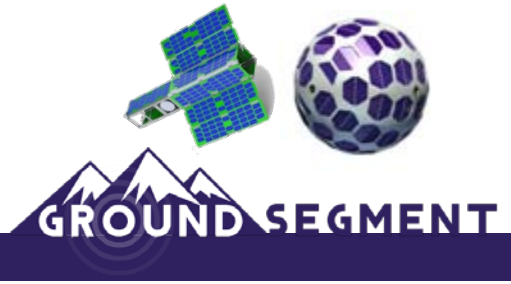
Transport Layer



- LWIP – Lightweight IP
  - Popular Software Library
- TCP – Transmission Control Protocol
  - Ensures data is correct and in order
- Media Access Controller (MAC)
  - Link Layer (Software and Hardware Bridge)
  - Manages data as 802.3 compliant frames
- PHY Controller
  - Interface between MAC and RF

Efficiency



- Worst Case Efficiency (42 bytes) ≈ 61%
- Best Case Efficiency (1500 bytes) ≈ 98%

Design, Development, Deployment

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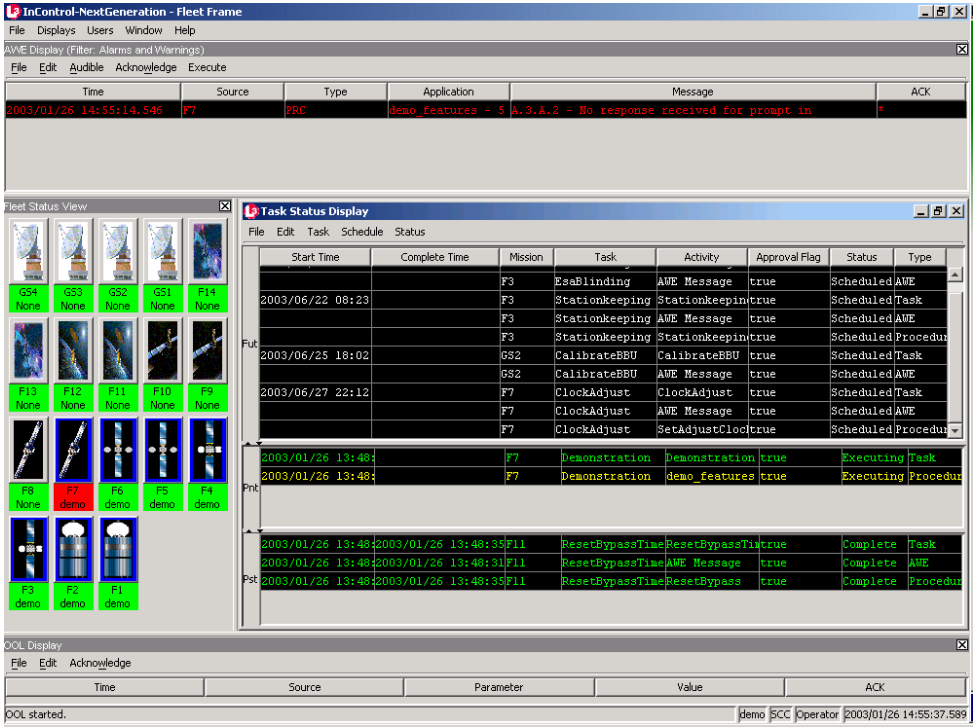
Starting with InControl

- Includes user interface
- Developers focus on mission-specific plugin



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Roles of the Plug-in

- Parses satellite-specific telemetry and beacons
- Puts telemetry into InControl
- Homogeneous interface to heterogeneous missions
- Generic plugin: We add a few things to ALLSTAR to our pre-existing interface.

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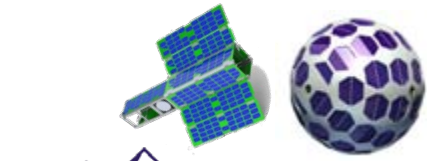
Strategy Design Pattern



- Based on the Strategy design pattern
- Encapsulates key software behaviors
  - Easy to add new missions and behaviors
- Using Strategy paid off – two late-cycle discoveries
  - Only minor code changes
  - Minimal regression testing needed

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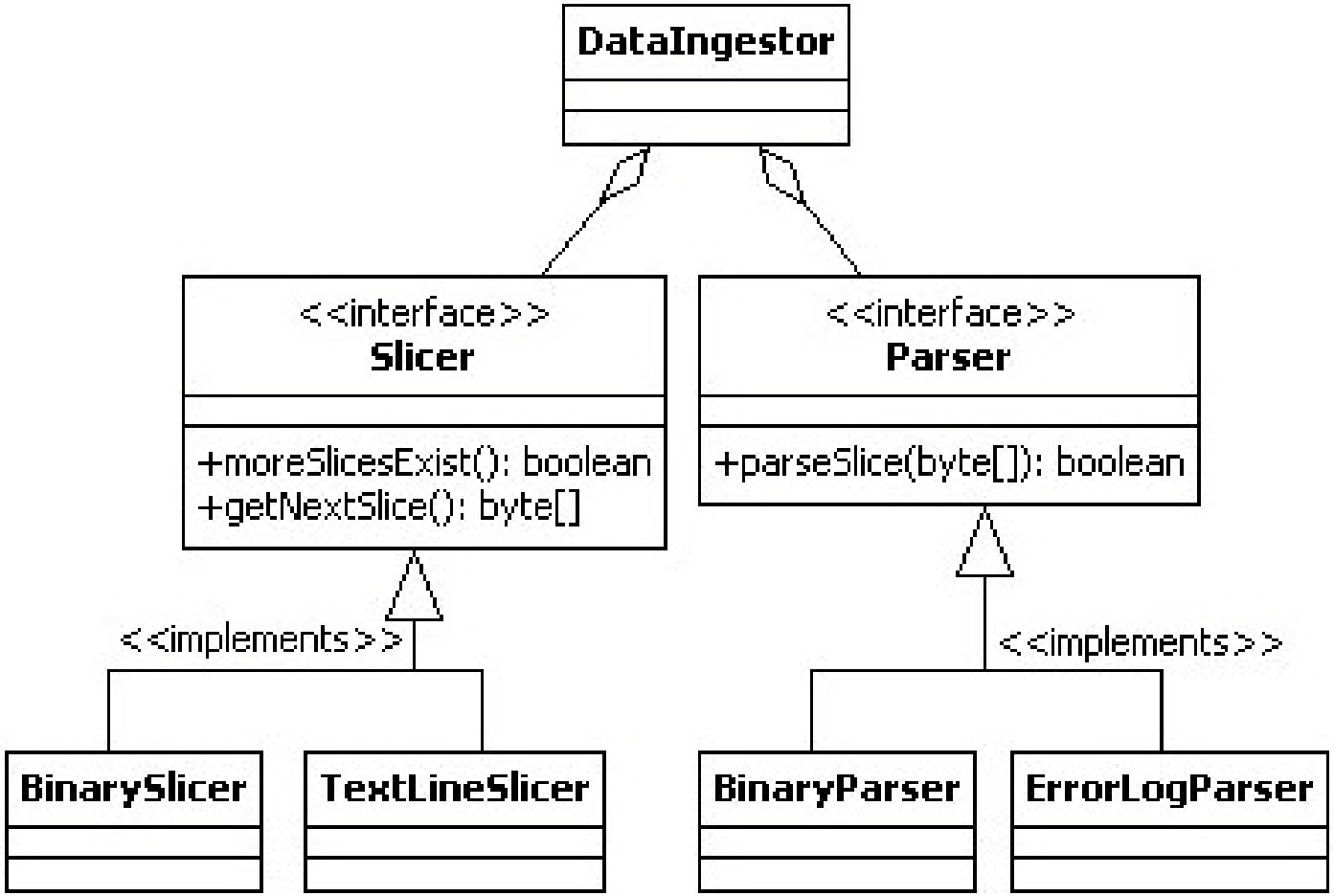
Implementation of Strategy



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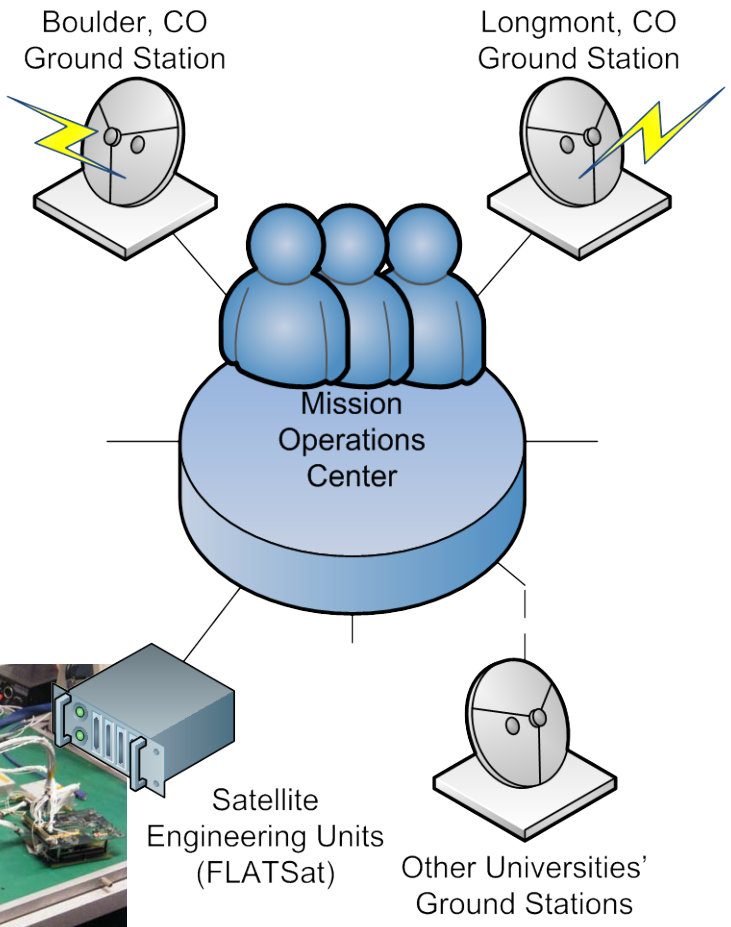
Centralization

- All mission operations are at one facility
  - 1/3 personnel needed
  - Easier training, policy coordination
- Remote sites: on-call maintenance crew



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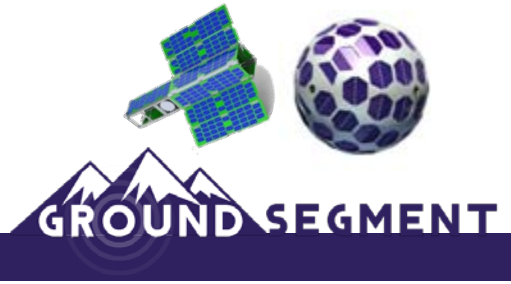
Recap



- Modular architecture and re-usable architecture allows quick integration of new systems.
- Using existing technologies such as TCP/IP to allow rapid development and reduce testing.
- Strategy Design pattern, anticipating changes

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Acknowledgements

- The Ground Segment team would like to thank:
  - Paul Blanchard of L-3 Telemetry West for the No cost Educational Demonstration InControl license
  - Mitch Seybold of L-3 Telemetry West for debugging/troubleshooting assistance
  - Kathryn Trowbridge for graphic design and the ground segment logo

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Questions?

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Backup Slides

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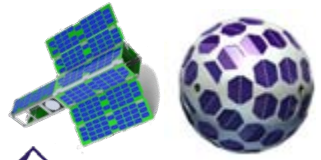
Fallacies of Distributed Systems



- 1. The network is reliable.
- 2. Latency is zero.
- 3. Bandwidth is infinite.
- 4. The network is secure.
- 5. Topology doesn't change.
- 6. There is one administrator.
- 7. Transport cost is zero.
- 8. The network is homogeneous.

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System Architecture