Army Cost Efficient Spaceflight Research, Experiments, & Demonstrations (ACES RED) SMDC-AR-001 ACES RED #1 (AR1): Attitude Determination and Control System (ADACS) Flyer

31st AIAA/USU Conference on Small Satellites

Flight Computer Architecture
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5-10 August 2017

Approved for Public Release

What is ACES RED #1: ADACS Flyer?

US Army Space and Missile Defense Command / Army Forces Strategic Command
Technical Center Army Cost Efficient Spaceflight Research Experiments and Demonstrations

ACES RED ADACS Flyer
Long duration space exposure of low cost COTS components for Army Small Satellite missions

MAI-400
The MAI-400 is utilized for attitude determination and life cycle testing. A novel star tracker design is also incorporated.

Xiphos Q7
The Q7 is used for the primary flight computer which enables robustness to radiation. It also allows for use of an Arch Linux operating system.

PicoZed
The PicoZed allows for redundant duplicate processing capability to the Q7, but at a much lower cost.

Raspberry Pi Compute
Multiple Rπs allow for a broad and unprecedented statistical analysis of space performance over the >12 month mission duration.

NovAtel OEM729
The OEM729 allows for Ethernet connectivity and GNSS capability utilizing the GPS, GLONASS, Galileo, BeiDou, and QZSS navigation constellations.

Memory Testing
An array of memory types is incorporated to allow testing on orbit.

Structure
A novel tray/slot-based mounting design is utilized for ease of integration into a modified 3U form factor. Also fully equipped with an integrated vehicle health monitoring system for power and environmental sensing.

GoPro Star Tracker
A consumer grade GoPro camera is used for image capture to be processed on-board for testing low cost star track algorithms.
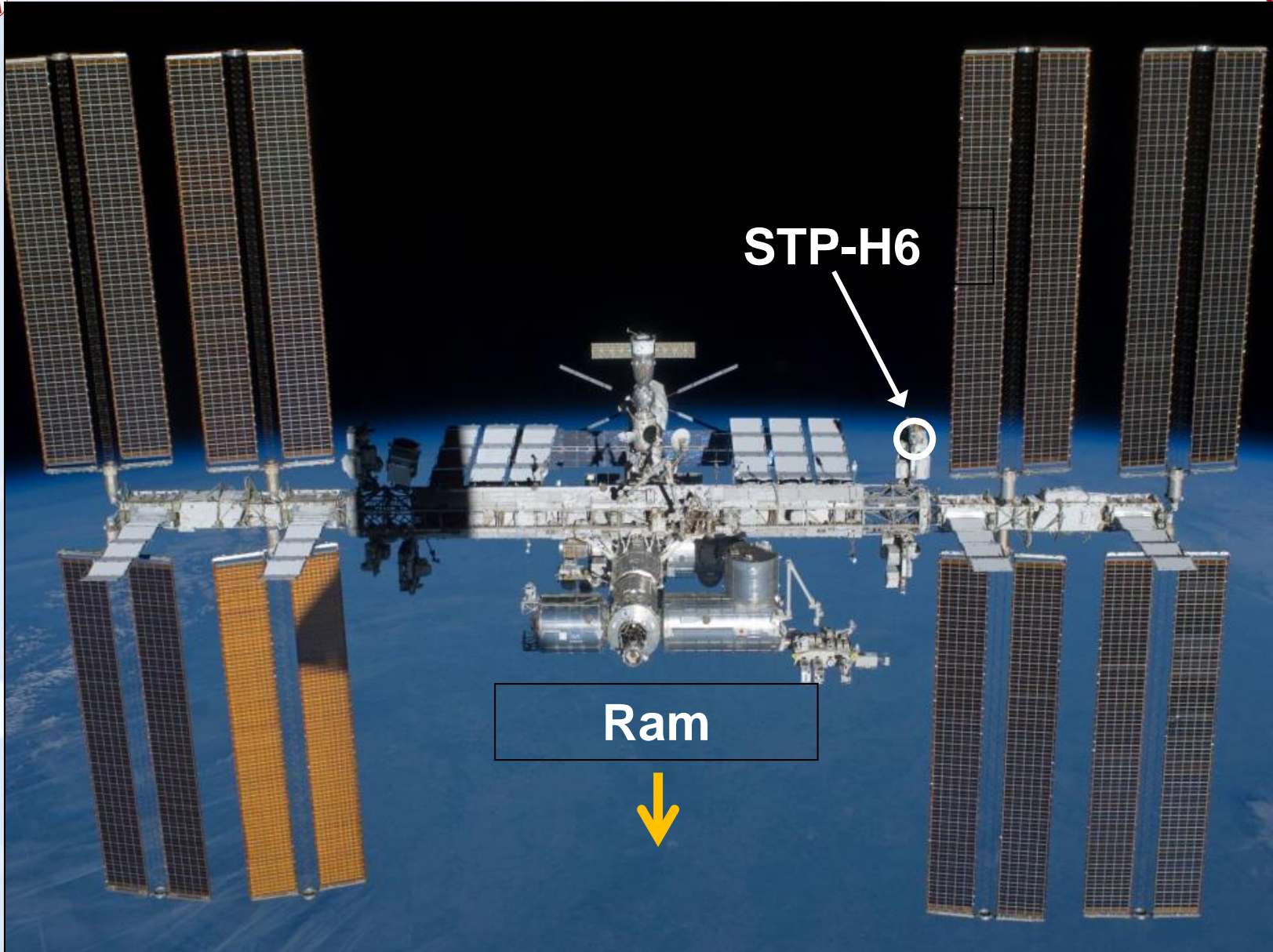
Distribution A. Approved for public release.

Program Technical Objectives:

1. Attitude Determination Evaluation

2. ADACS Fine-Control and Operational Evaluation

3. Observation of Vehicle Health

4. Assessment and Maturation of Components

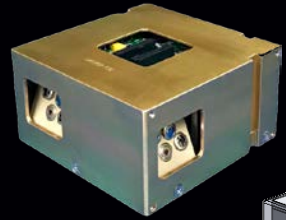5. GNSS Data Evaluation

6. Update Flight Software during Mission
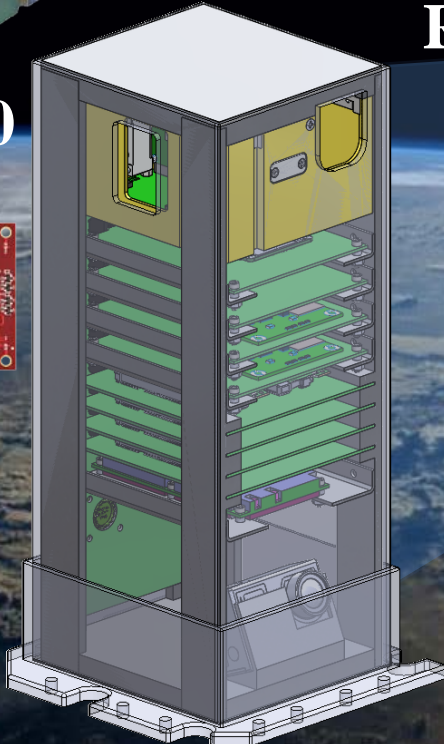
STP-H6 On-Orbit Location

ACES RED Experiment#1

MAI-400

Raspberry Pi

PicoZed

OEM729

Q7

GoPro

FPGA and Microcontrollers

Microcontrollers are…

❖ Fixed in Design

❖ (Typically) Serially Operated

❖ Outfitted with one or more CPUs

❖ Outfitted with Fixed Memory

❖ Outfitted with Fixed Number of Programmable GPIO

FPGAs offer…

❖ Reconfigurability

❖ Parallelization

❖ Built-in Triple Modular Redundancy Capable

❖ No PCB Redesign Required for Circuit Updates

❖ Adaptability for Data Interfacing

Xiphos Q7 and PicoZed…

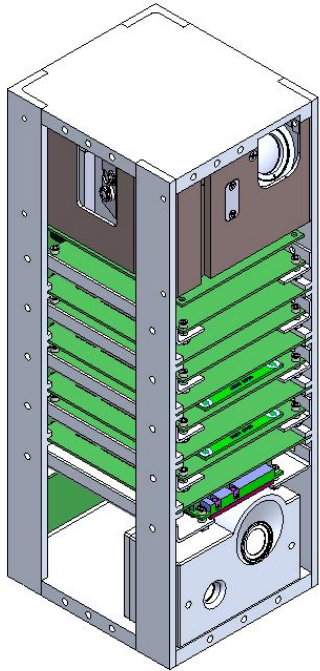Xilinx Zync 7000 – SoC - Best of Both Worlds

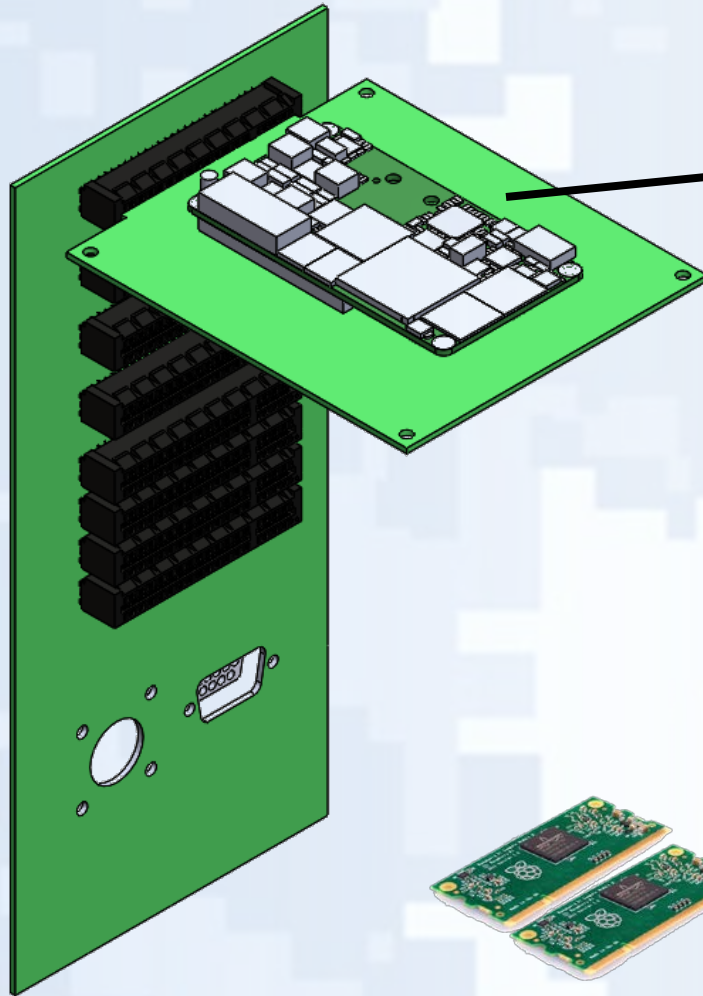– On-board ARM Cortex-A9

System Components

System Components

Primary Flight Computer

Physical Data Interface
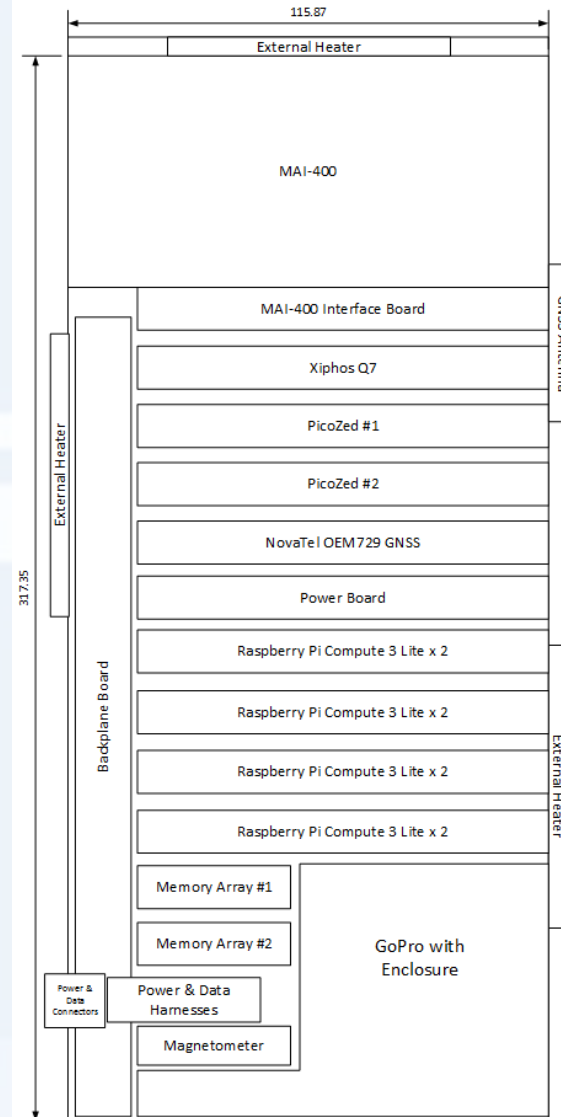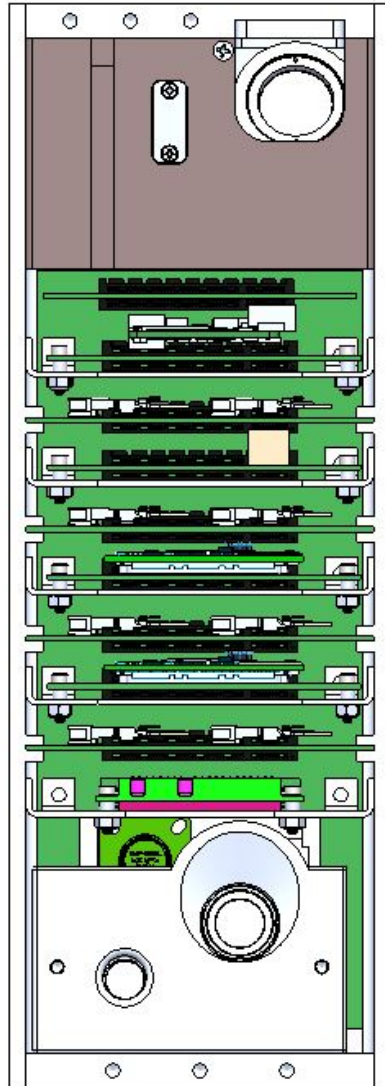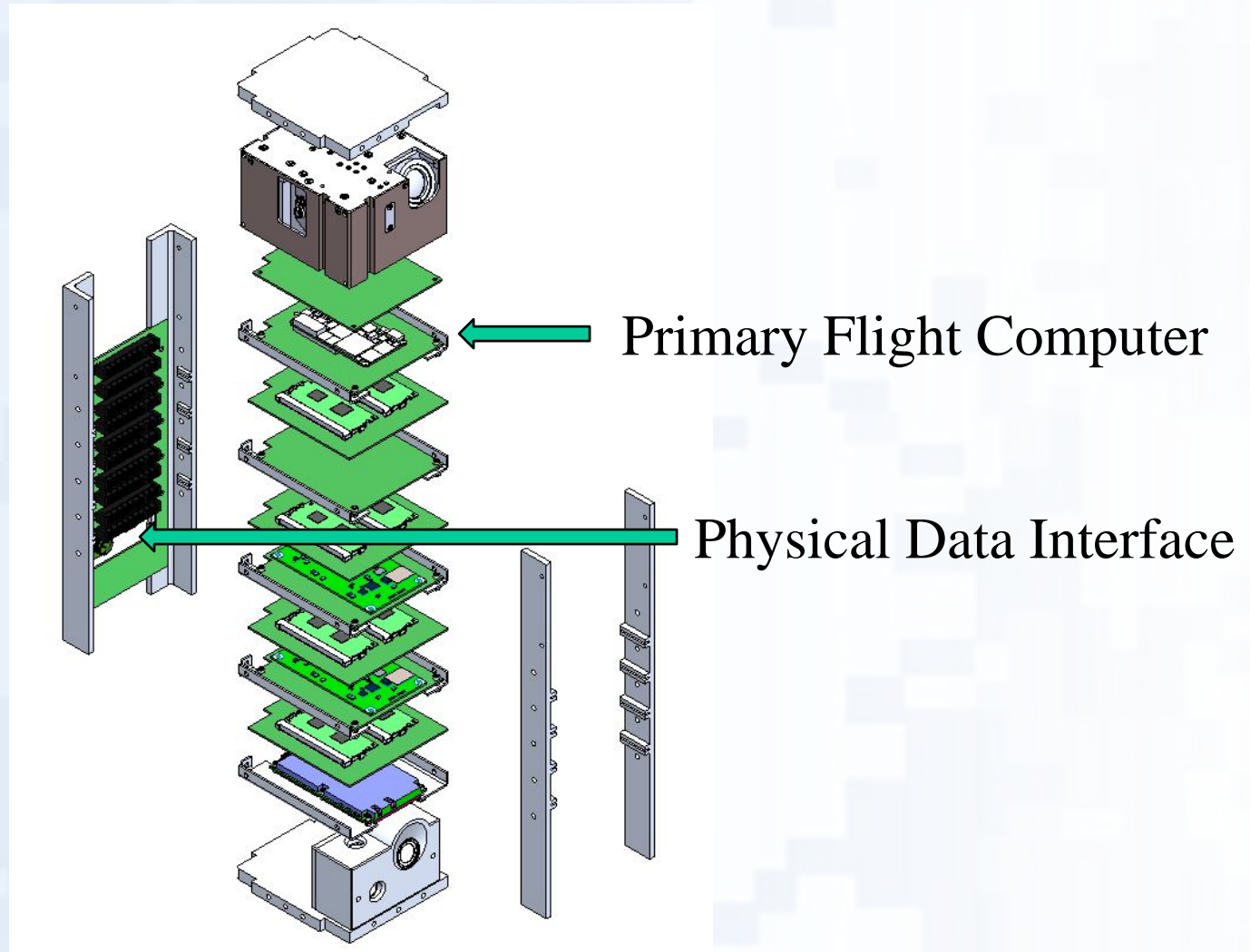
Processors
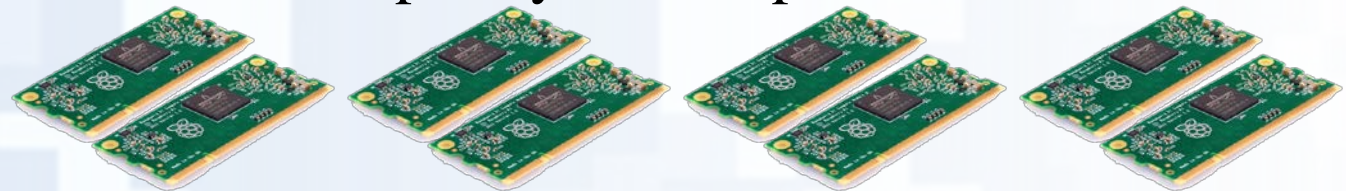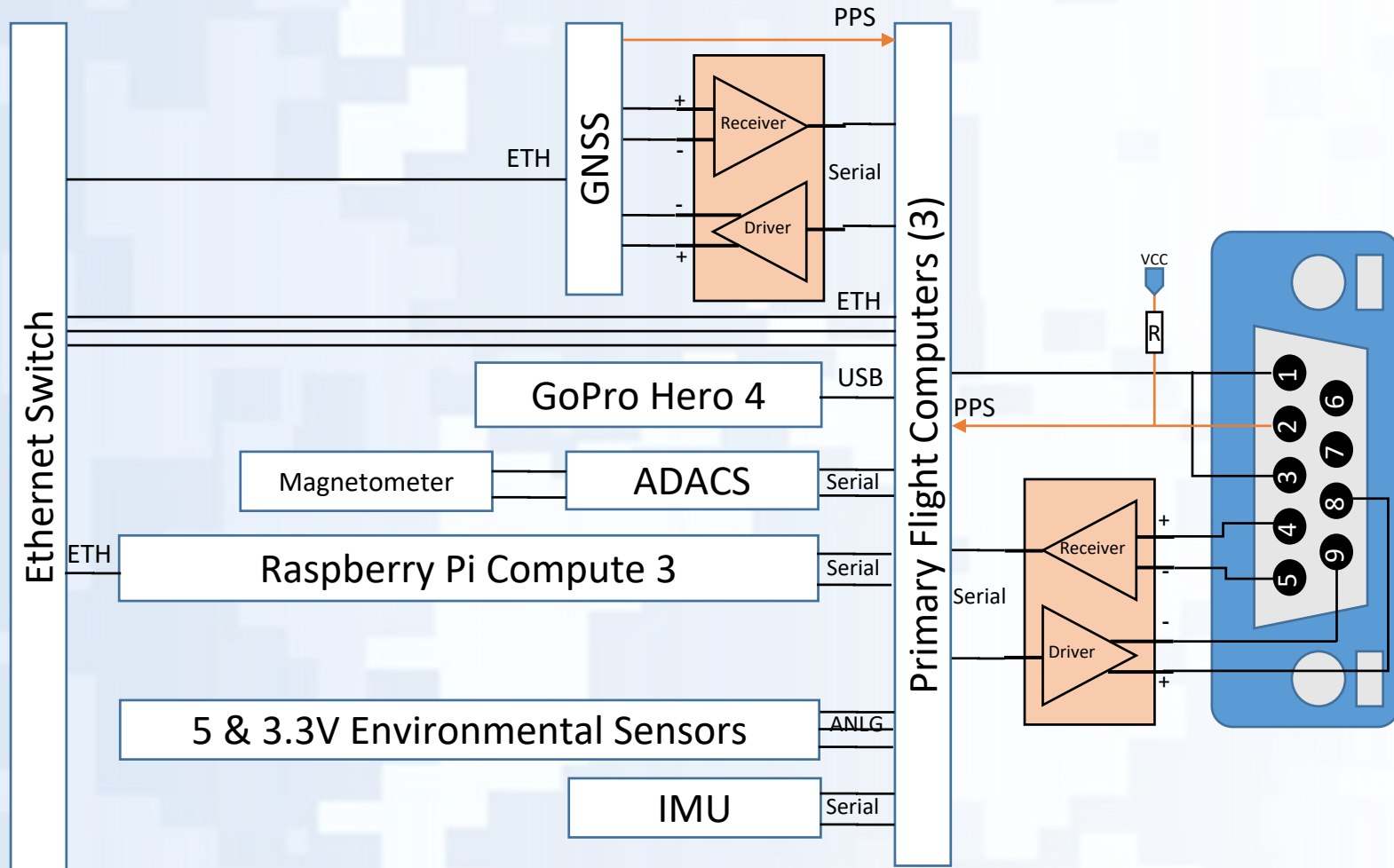
Xiphos Q7

PicoZed

Raspberry Pi Compute 3

Ground Interface

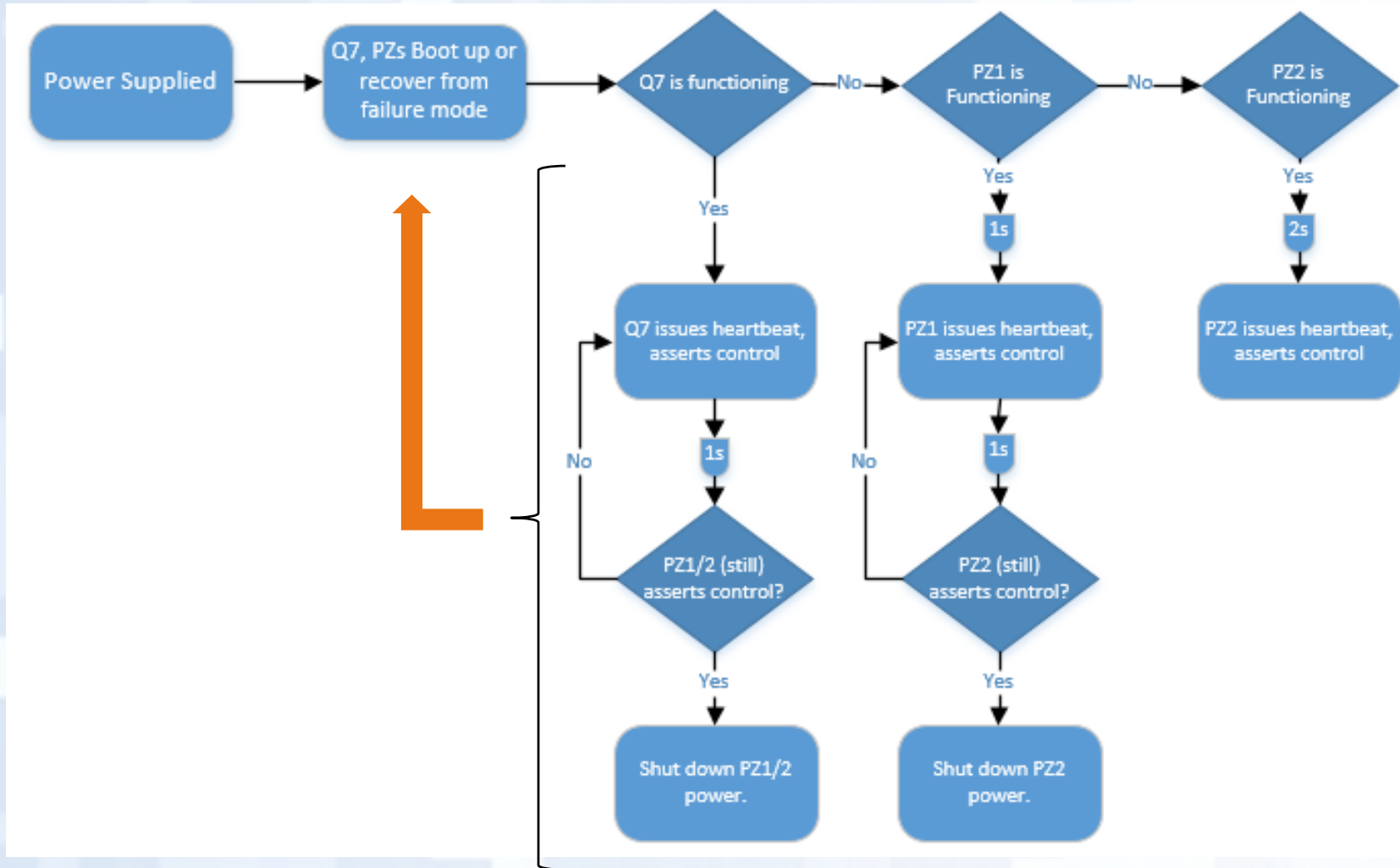# Failover Strategy

Hierarchical Redundant Failover

Q7

0x2B

0x2A

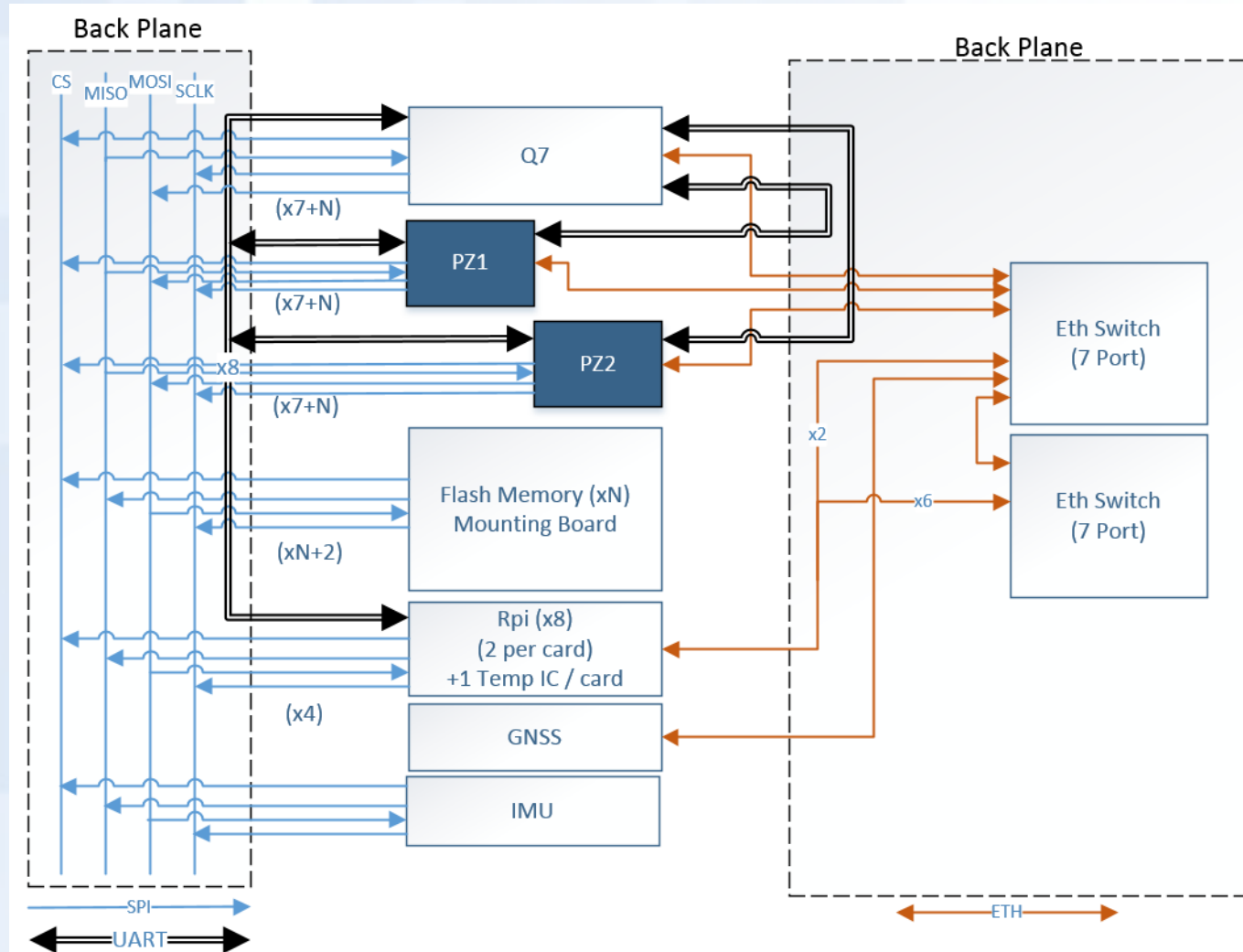PicoZed #1

0x2C
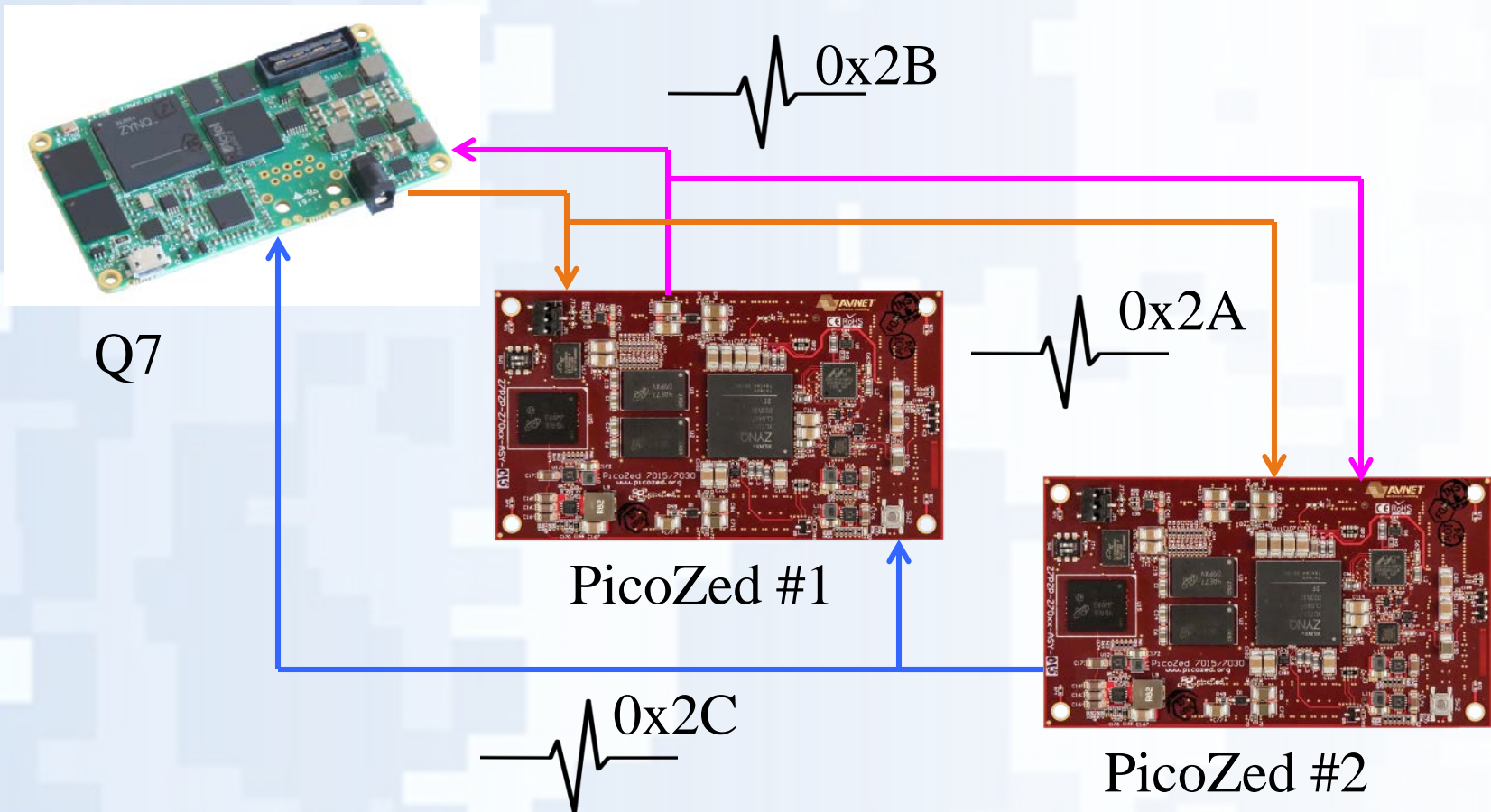
PicoZed #2

Failover Strategy

Data Connections

Dynamic Master Architecture

Desired Results

- Evaluate the performance of the PicoZeds and Raspberry Pi CM3s

- Evaluate the failover strategy

- Re-program/re-image from the ground

- Increase TRL of non-traditional and COTS components
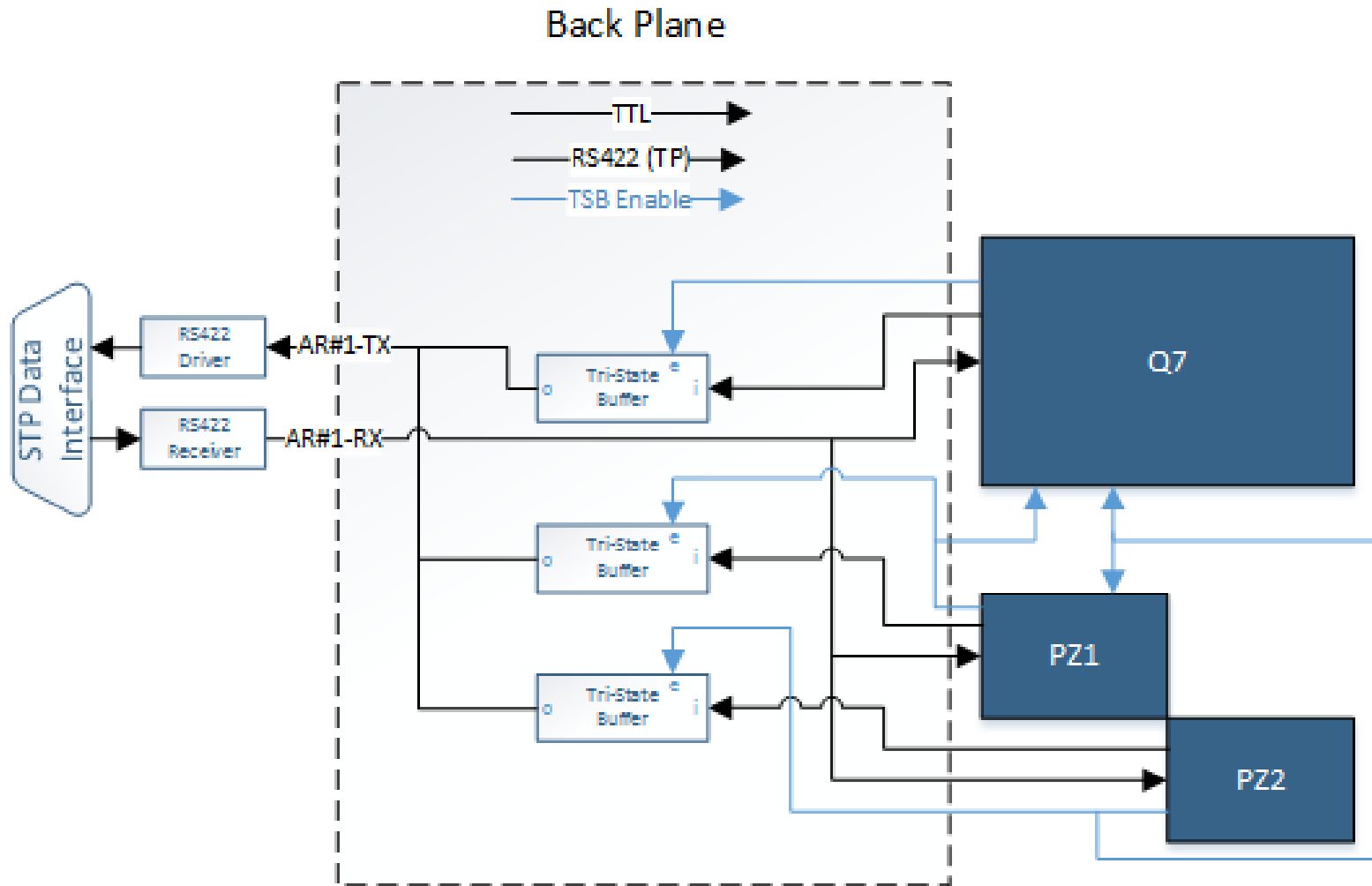
Questions/Comments?

BACKUP

Ground Interface

Telemetry Scheduling

- Collect continuous environmental, positional, and performance data

- Periodically Acquire Image via GoPro Camera, begin downlinking; acquisition frequency limited by downlink rate

- Position & environmental data to be correlated with collected imagery to assess quality of imagery and usability for star-field assessment

- Logging during idle periods will be downlinked when entering active states