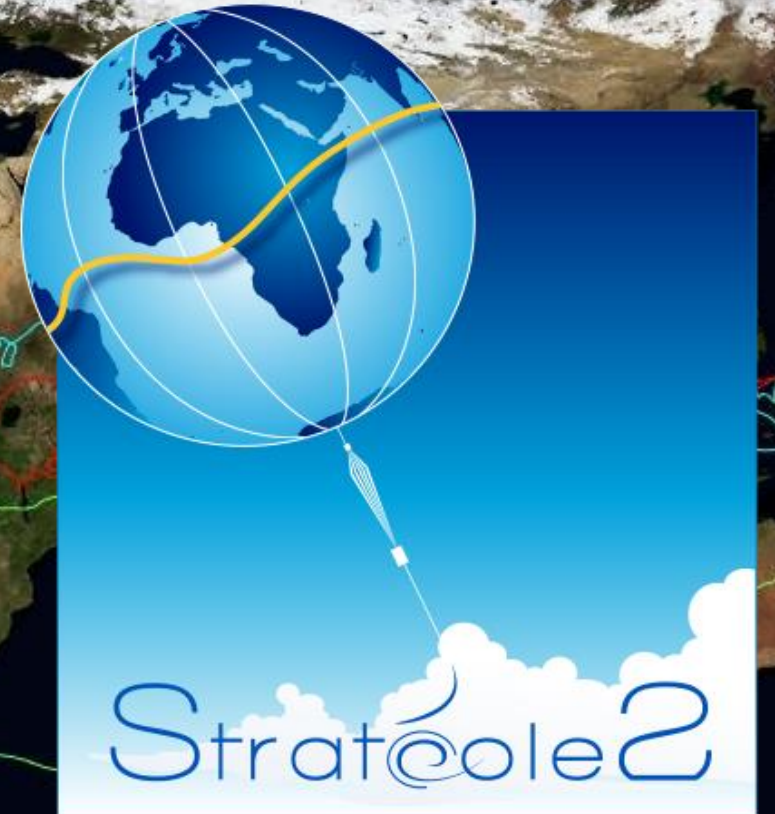


StratoCore

Developed for LASP Stratéole 2 instruments by Alex St. Clair

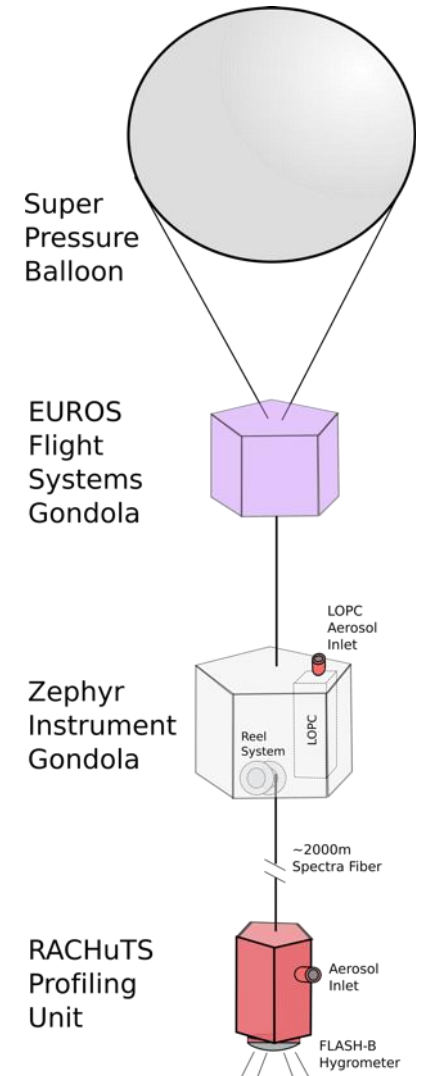
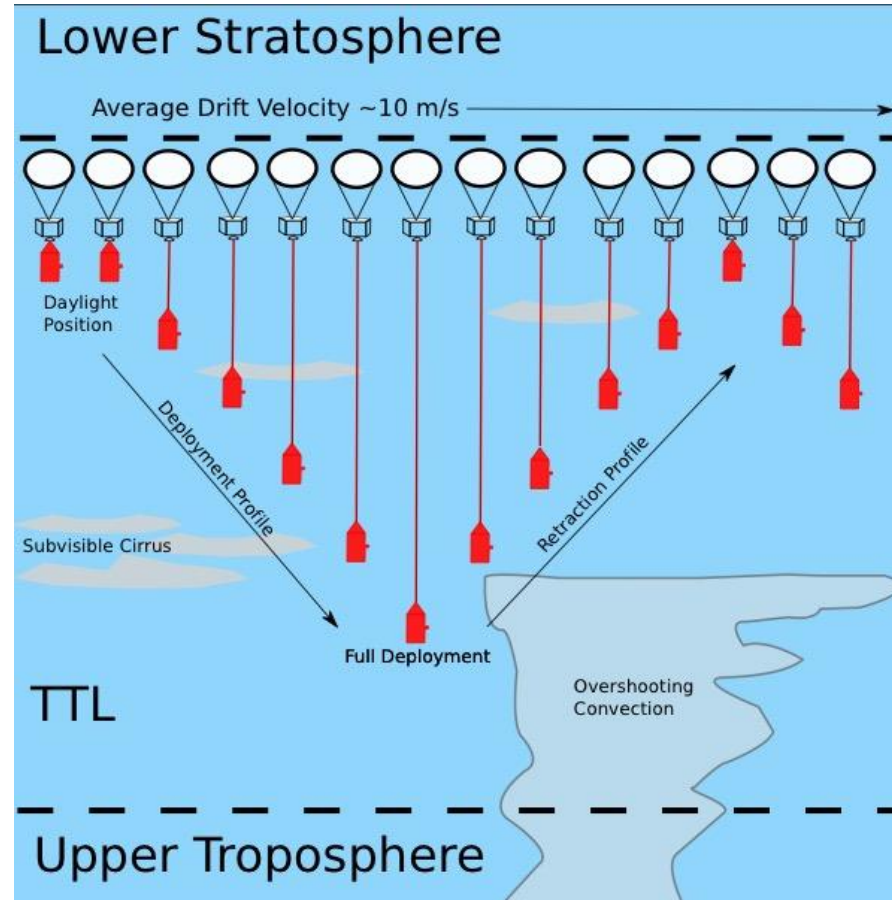
Stratéole 2 Campaign Overview

- CNES-led long-duration super-pressure balloon campaign in the Tropical Tropopause Layer with 10 international instruments
- Engineering validation flights from the Seychelles, Nov. 2019
- Two 20-balloon science flights 2021-2024

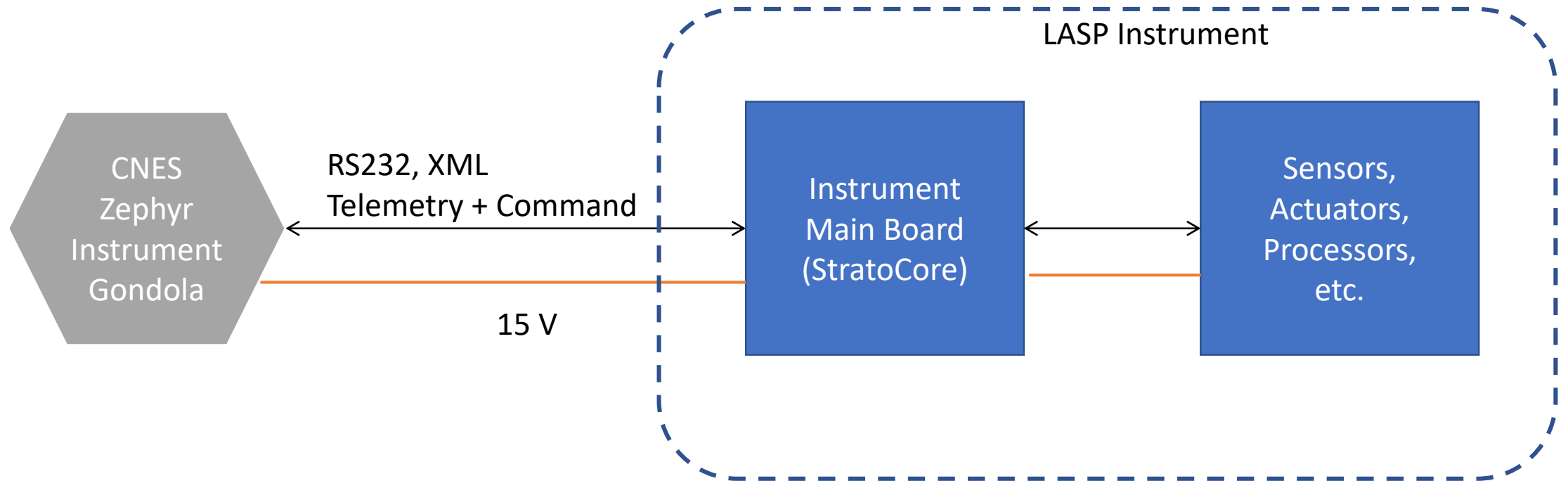


LASP Stratéole 2 Instruments

- Three instruments with common computing architecture
- Two with common reel system

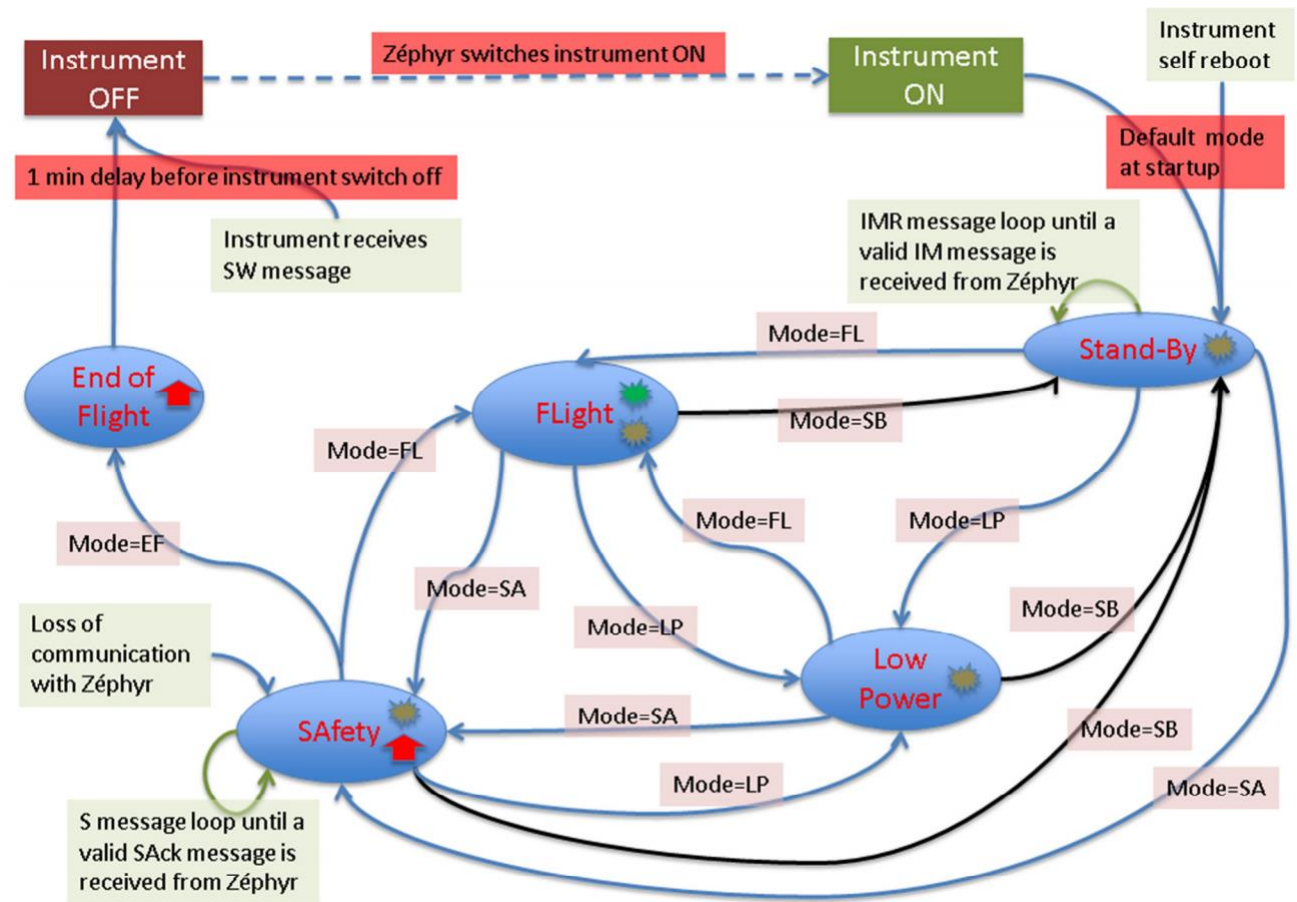


Generic LASP Stratéole 2 Instrument



Design Constraint: CNES Interface

- XML over RS-232
 - With binary command and telemetry
 - GPS messages every minute
- Strictly defined modes and message requirements
- Must respond to messages within 5 seconds
- 1-minute shutdown warning
- Go to Safety if no comms for 2 hours
- Iridium comms: expected 10 minute command latency



Design Goal: Maintainability

- The duration of the project is 5+ more years—it will far outlast my time with LASP
 - The code will need to be maintained by students/scientists
 - Requirements will inevitably change
 - Lessons will be learned after the flight leading to operational and hardware changes
- It should be easy to implement the CNES interface and required modes
- It should be easy to implement and change complex instrument CONOPS

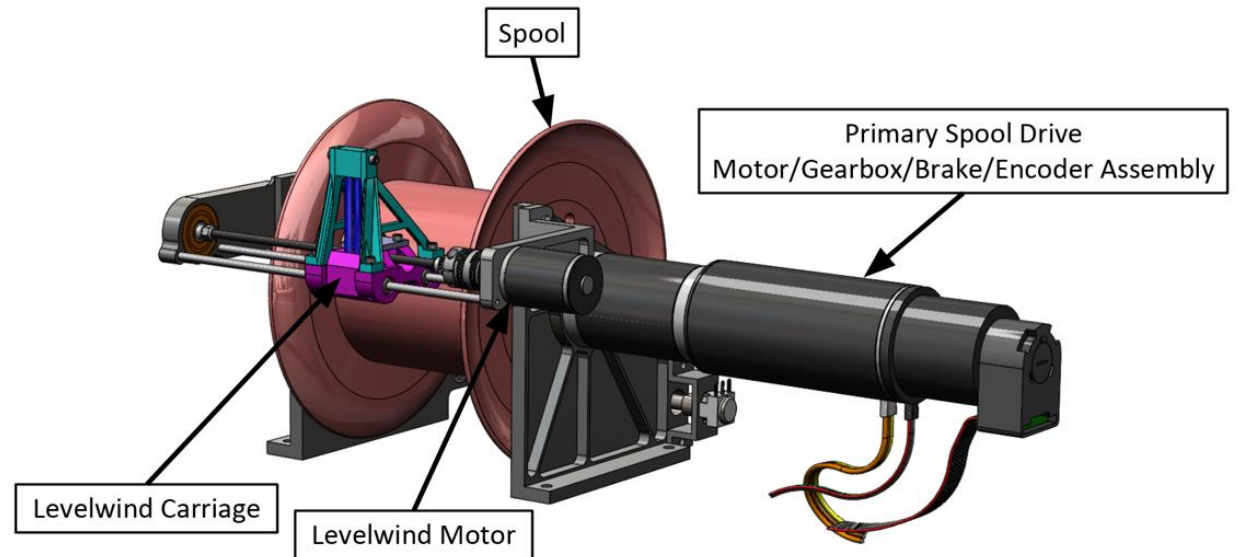
Design Constraint: Hardware and Tools

- Teensy 3.6 Arduino-compatible NXP MCU dev board
 - ARM Cortex-M4F @180MHz w/ 1M Flash, 256K RAM, 4K EEPROM
 - Standard peripherals: UART, SPI, I2C, ADC, PWM
 - MicroSD slot
 - Embedded in custom electronics for each instrument
- Arduino development environment
 - Based on C++
 - IDE w/ compiler and USB programmer (*no debugger!*)
 - Extensive libraries for hardware interface
 - *Can be limiting, no access to serial interrupts for example*

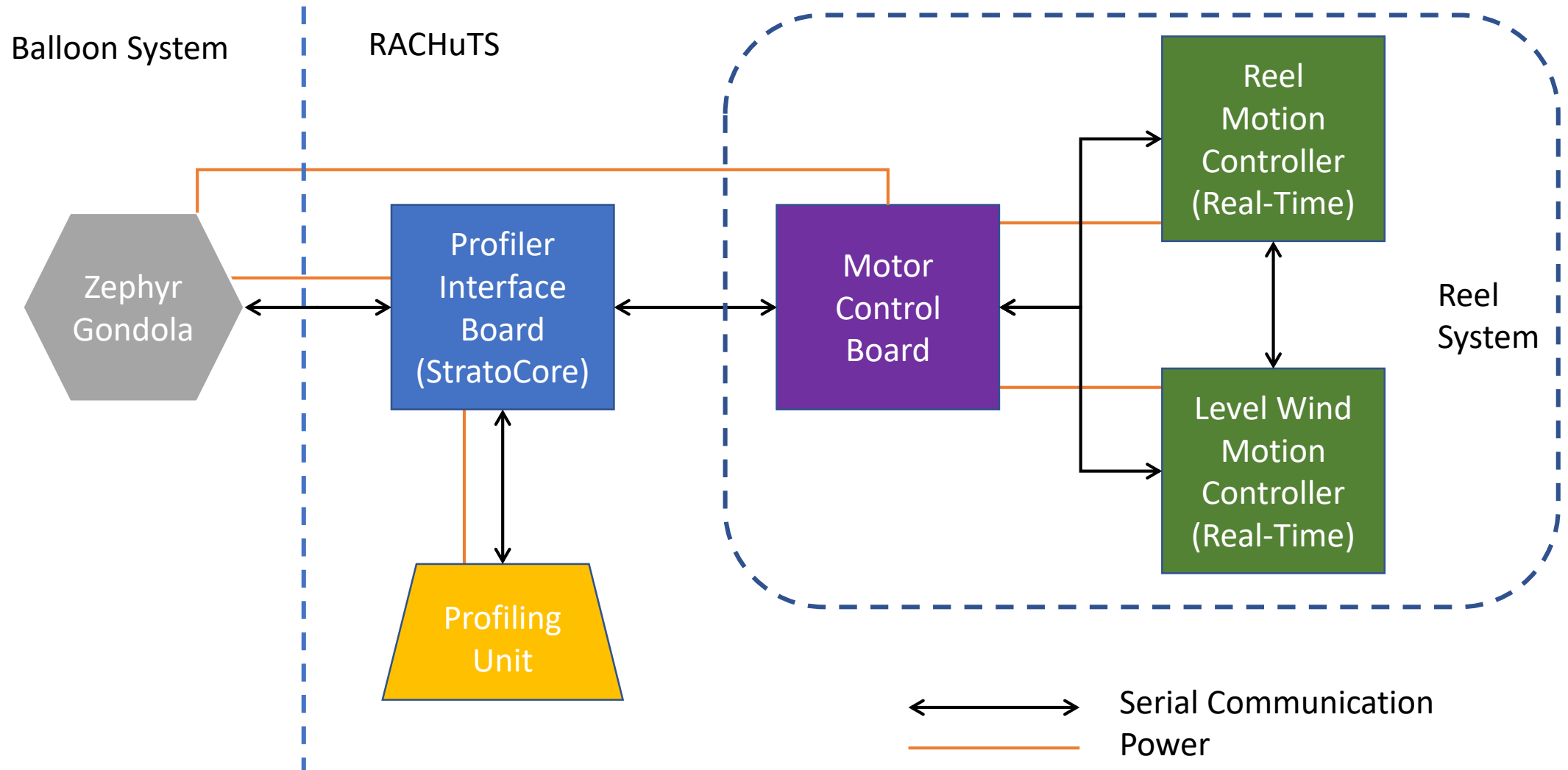


RACHuTS: Instrument Overview

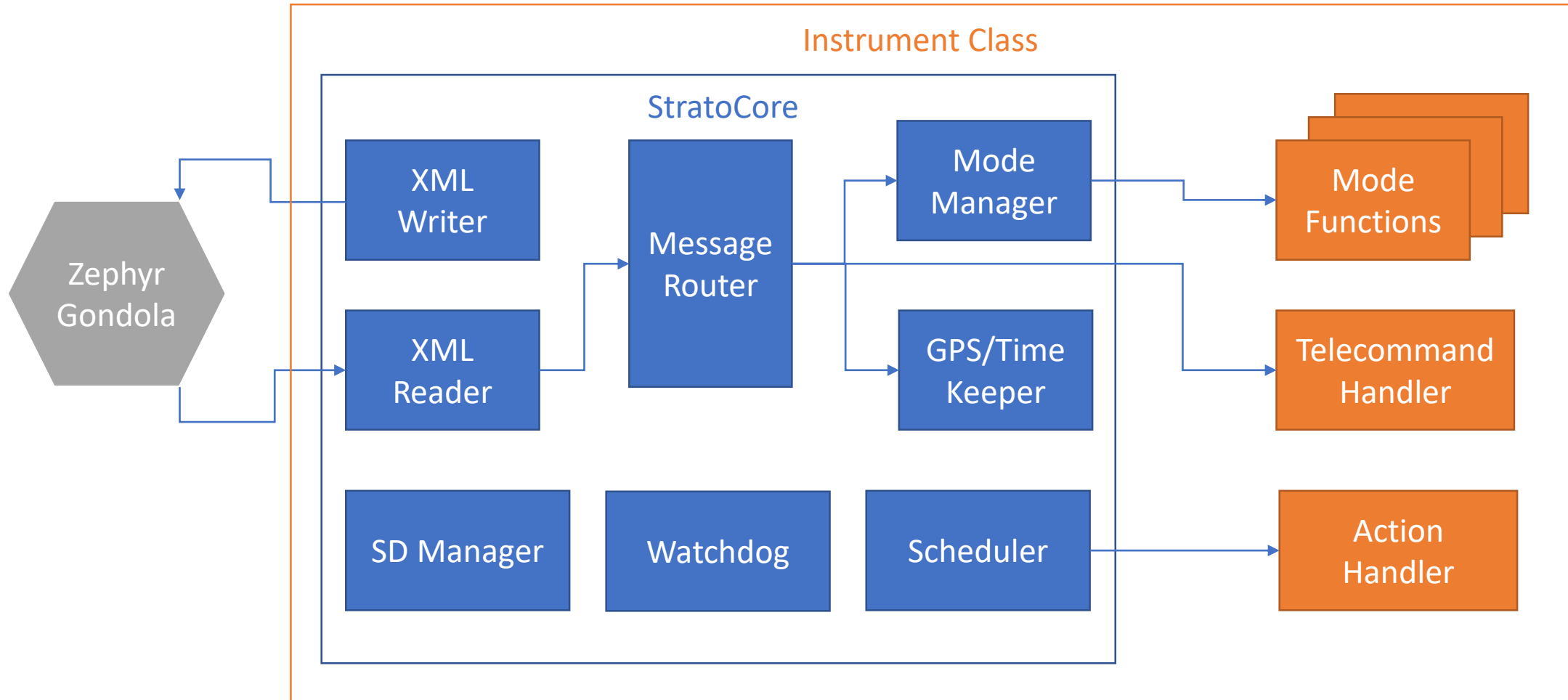
- Reeldown Aerosol Cloud Humidity and Temperature Sensor
- Reels down a sensor package on high strength fishing line to take tropical tropopause layer profiles
 - ~1800 meter profiles
 - Up to five profiles per night



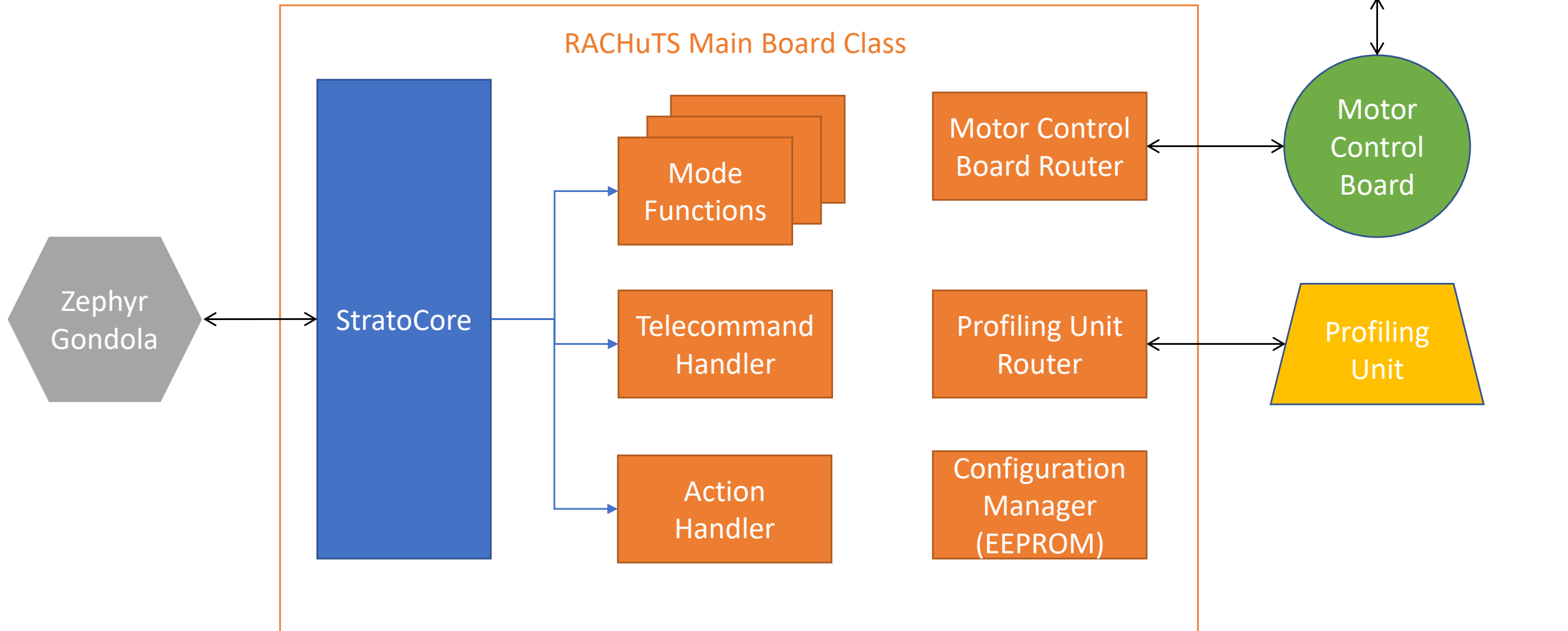
RACHuTS: Electronics FBD



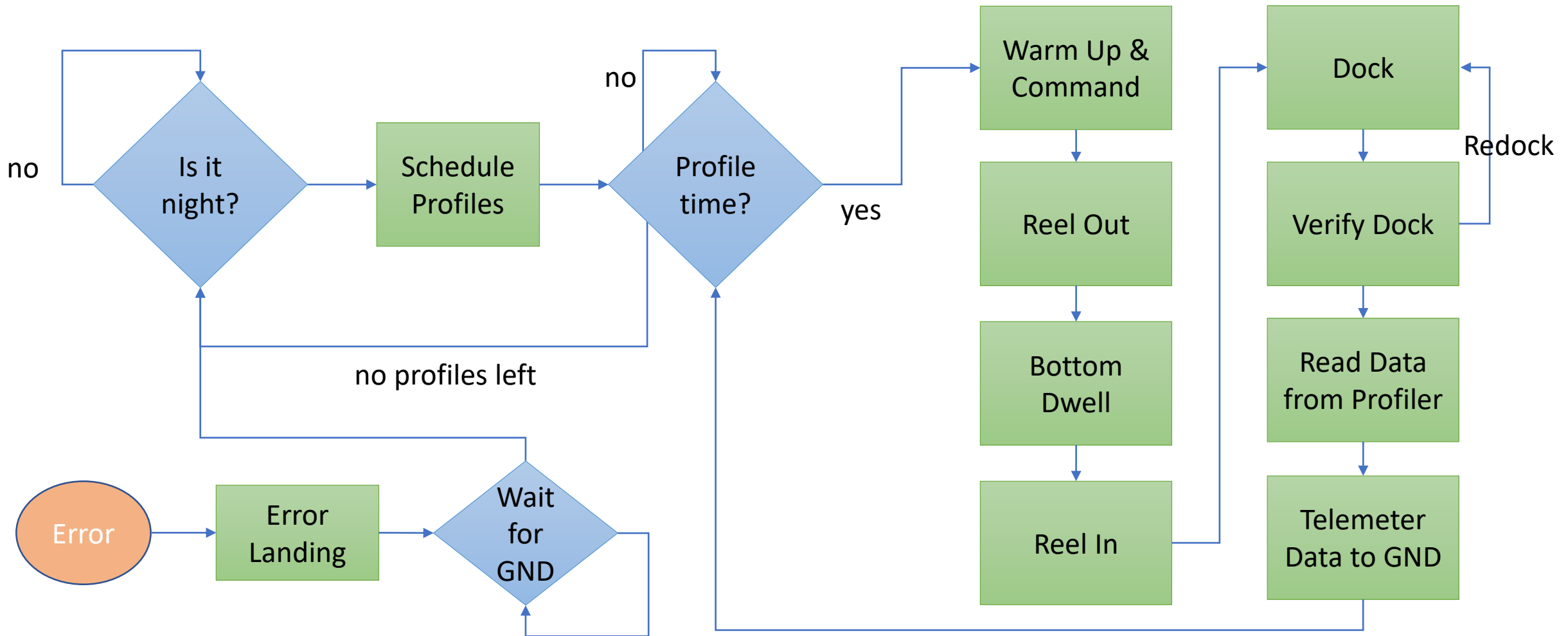
Design: StratoCore Component Diagram



RACHuTS: Components

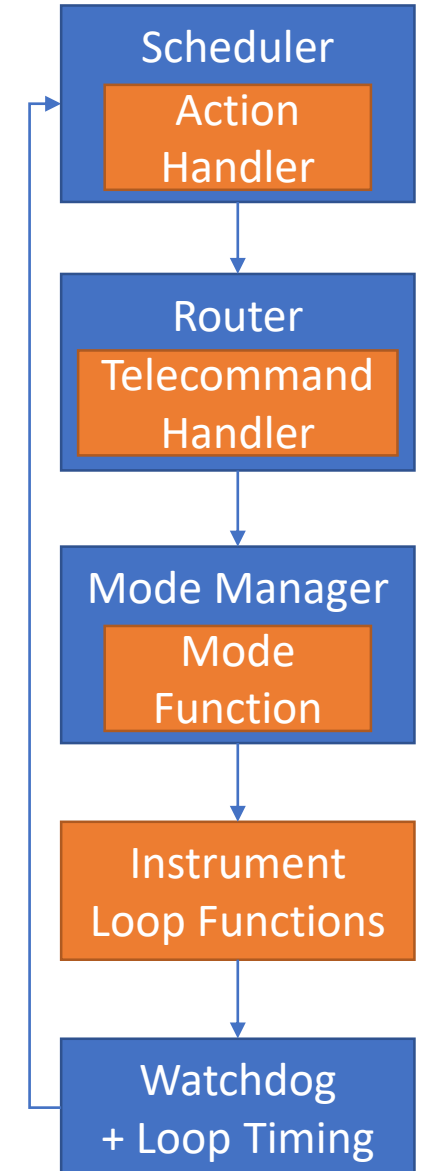


RACHuTS: Simplified Autonomous Mode



Design: Control Structure

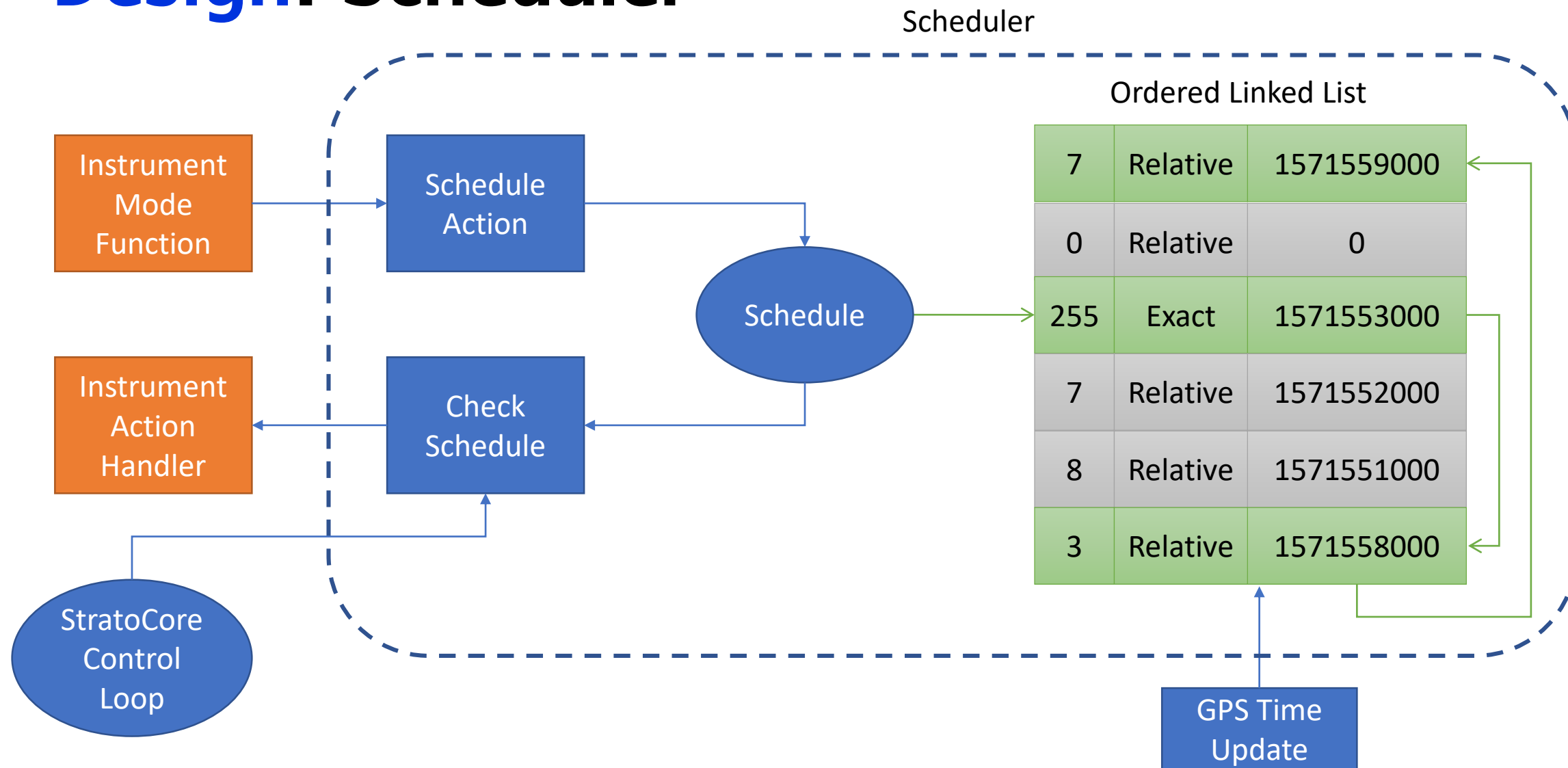
- Cyclic executive loop at 1 Hz with best effort timing
- Enumerated states in each mode expected by StratoCore maintained in protected variable
 - Entry
 - Shutdown
 - Error
 - Exit
- Mode switch
 - Previous Mode -> Exit
 - New Mode -> Entry



RACHuTS: Challenges With Docking

- Fiber generates lift—even in the stratosphere—due to wind shear
 - Profiling unit could swing while coming in
- Drag-induced variable load has stalled the level wind motor in tethered balloon testing
 - The level wind must “home” every time the controller restarts
 - Docking procedure altered so that the level wind never moves without the reel

Design: Scheduler



RACHuTS: Action Handler

