

The Colorado Student Space Weather Experiment (CSSWE)

Command & Data Handling

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Logan, Utah

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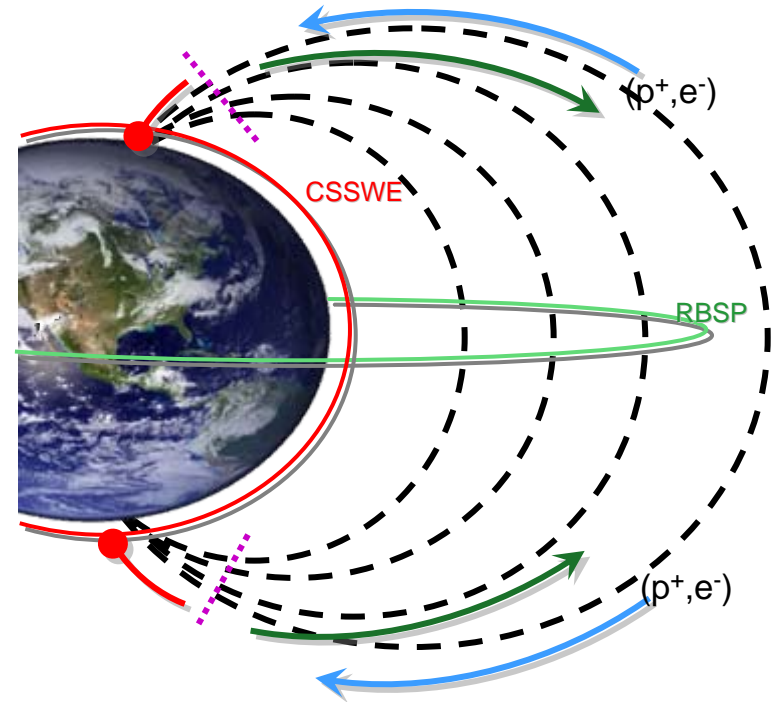
Objectives

■ Science Objectives

- Understand the relationships between solar energetic protons (SEPs), flares, and coronal mass ejections (CMEs)
- Characterize the variations in Earth's radiation belt electrons

■ High energy solar particles (p^+ , e^-) travel along magnetic field lines

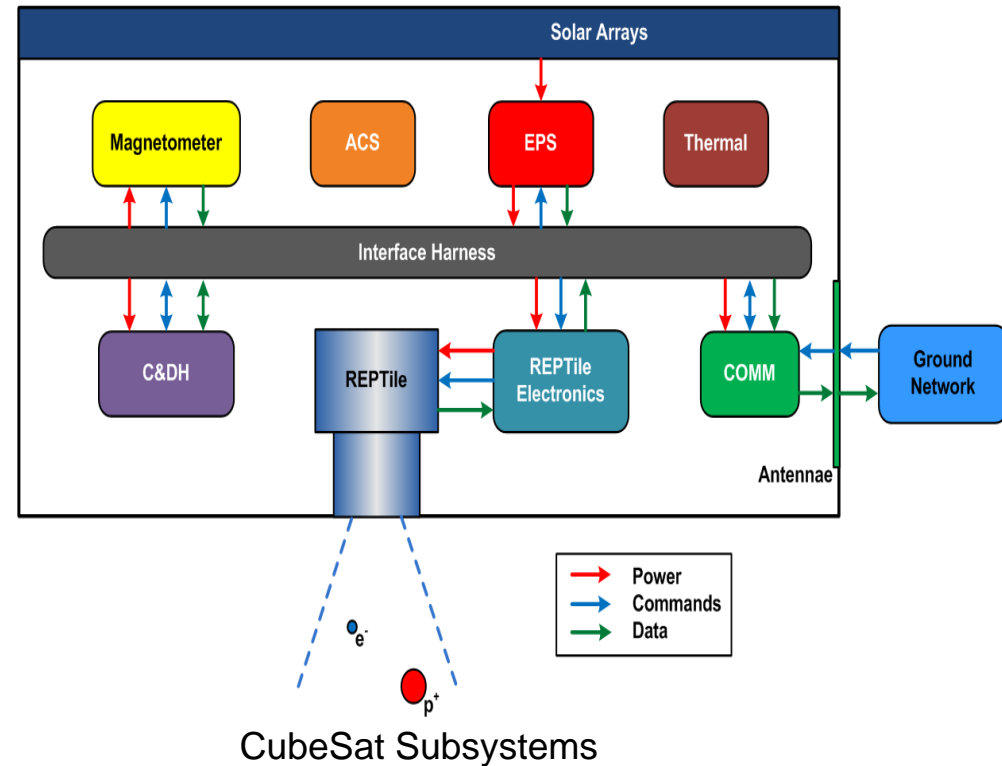
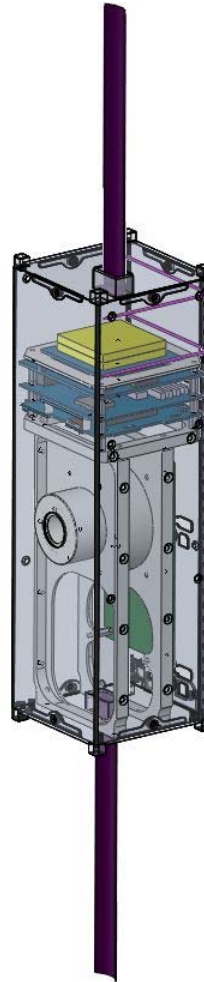
- Oscillate between N and S magnetic pole



CubeSat Overview

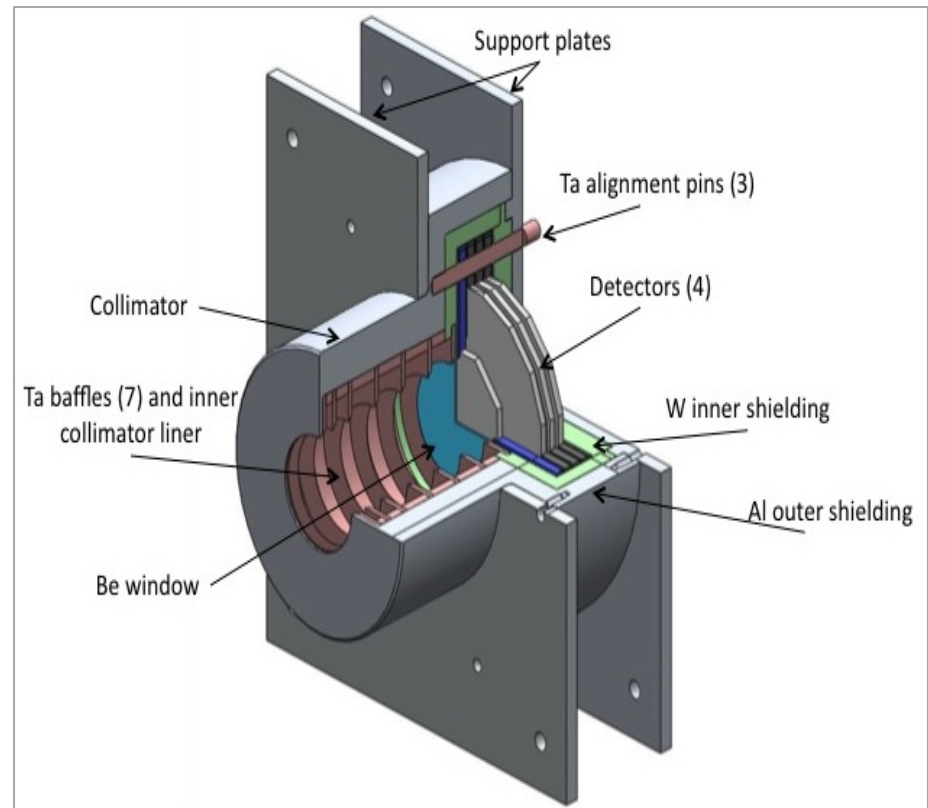
■ Subsystems

- EPS
- C&DH
- REPTile
- Structures
- ADCS
- Systems
- COMM
- INTF
- Thermal



REPTile

- Relativistic Electron and Proton Telescope integrated little experiment (REPTile) to measure dangerous energetic electrons and protons
- Motivation
 - Potentially fatal to spacecraft and astronauts
 - April 5, 2010 - Intelsat Galaxy 15 fails due to unexpected particle flux increase



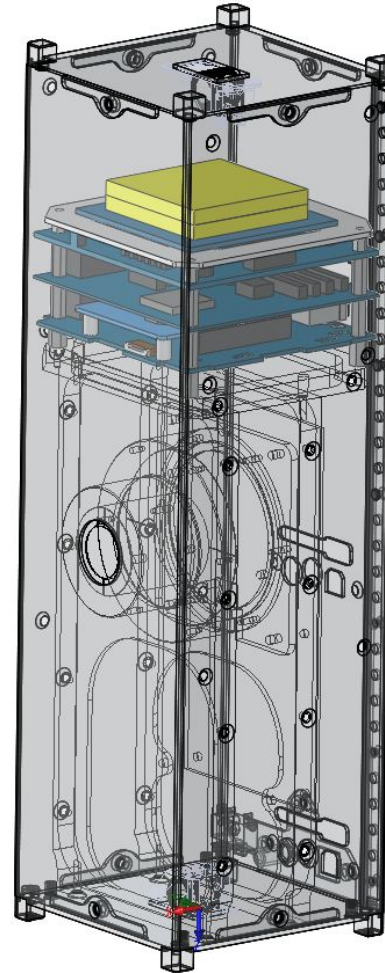
REPTile



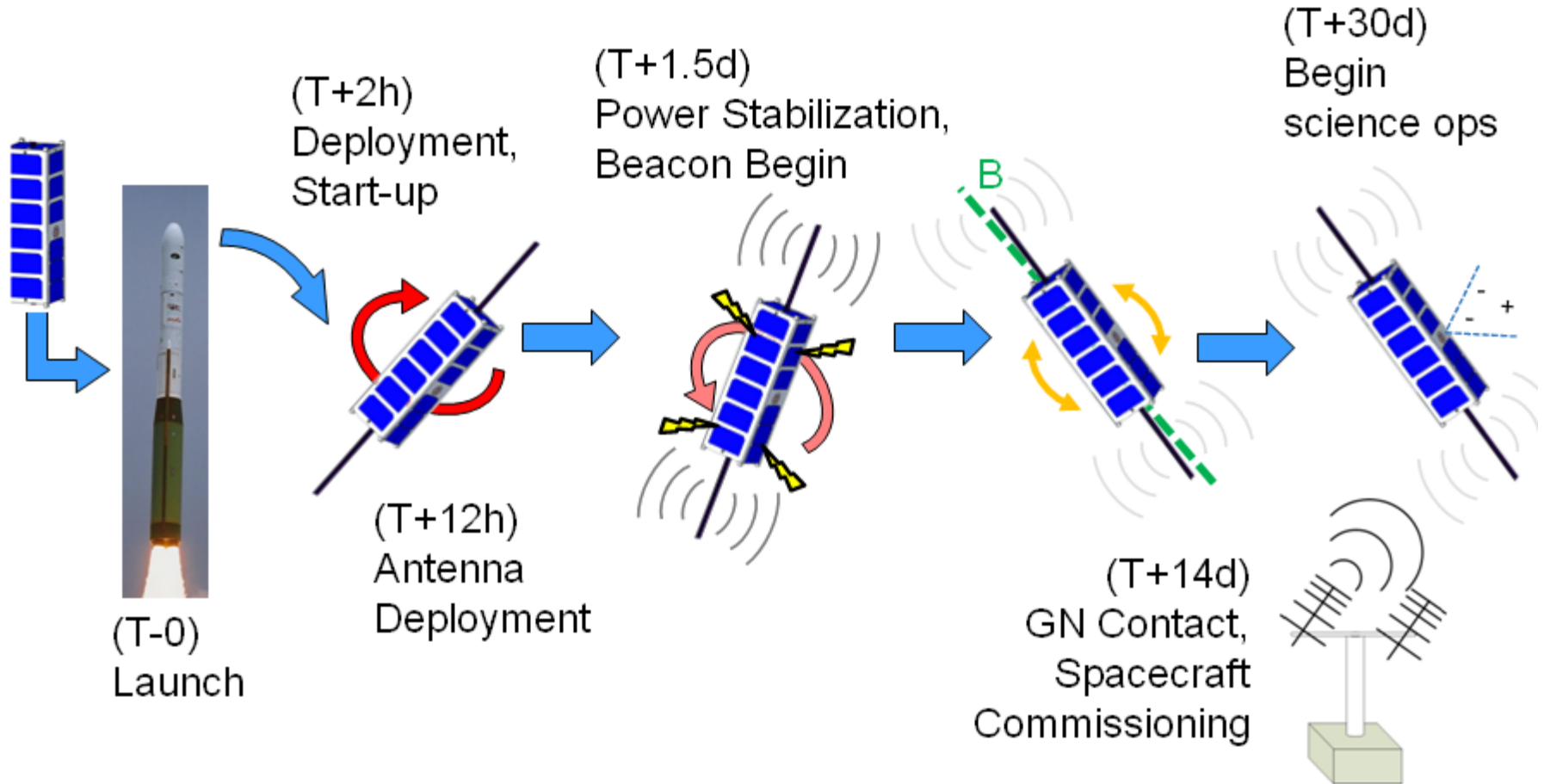
C&DH Overview

■ Requirements

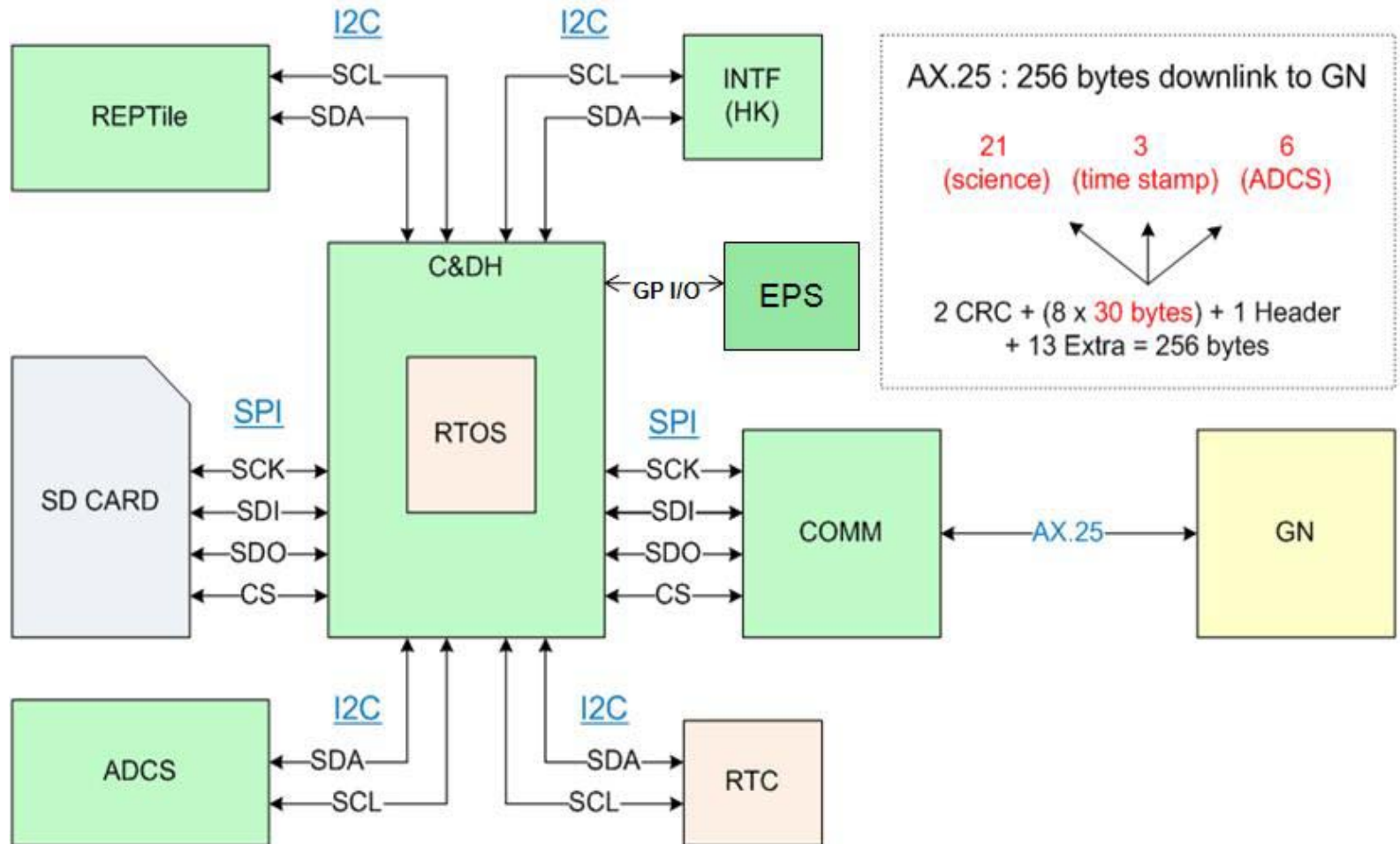
- Command REPTile to take science data
- Gather HK data from the CubeSat subsystems
- Perform fault detection and correction (FDC)
- Send science and housekeeping data to COMM
- Receive commands from ground station
- Provide a single-wire reset to all powered subsystems



Mission Timeline



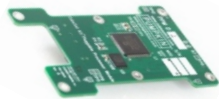
C&DH Block Diagram



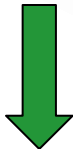
C&DH Hardware - Pumpkin

- The flight module has two components
 - Motherboard
 - PPM A3 – MSP430F2618
- Both are provided by Pumpkin

- SD Card – SanDisk 2GB
- Pumpkin development board – Pumpkin Inc.
- TI MSP430F2618 64 pin target board + debug tools



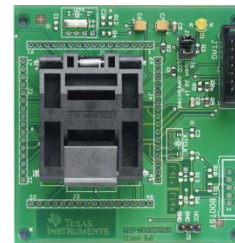
PPM



Motherboard



Pumpkin Dev. Board



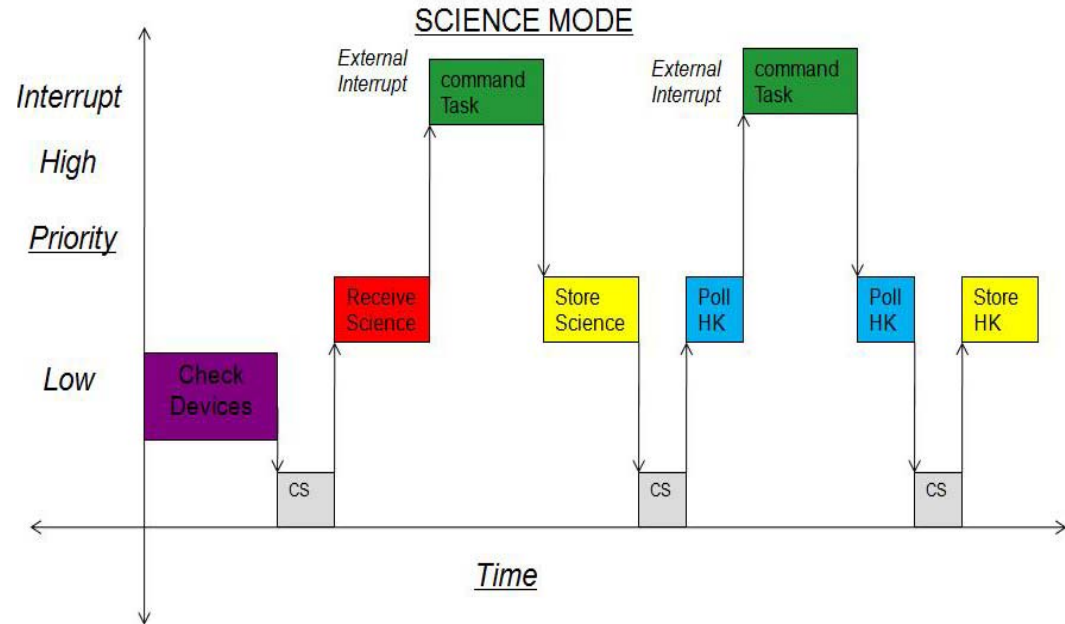
TI MSP430 64 pin target board



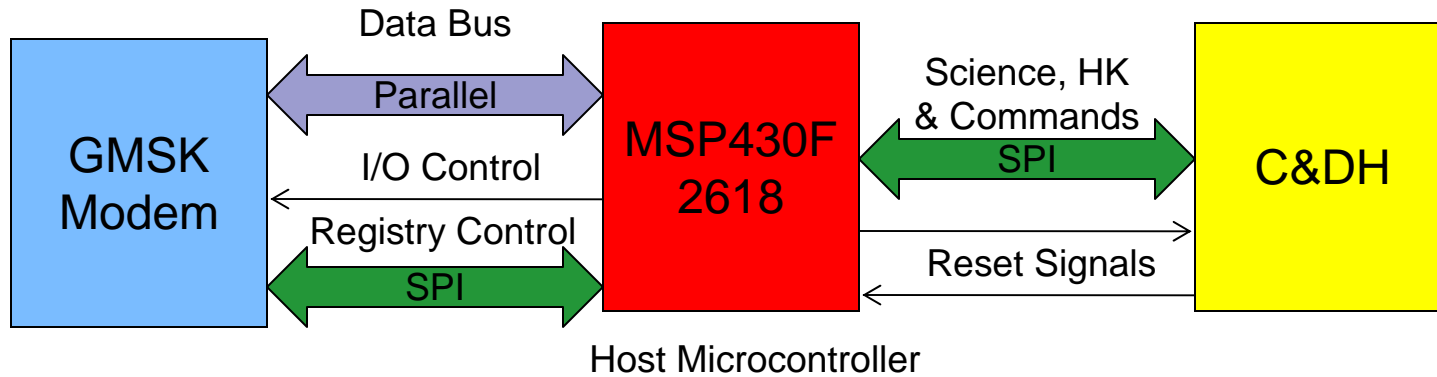
C&DH Software

- Salvo Real-time Operating System (RTOS)
 - Co-operative RTOS
 - Works with CrossWorks IDE (Rowley Associates)

- EFFS-THIN Library – HCC Embedded
 - API for accessing file-system on SD-Card
 - Library only available



C&DH- COMM Interface

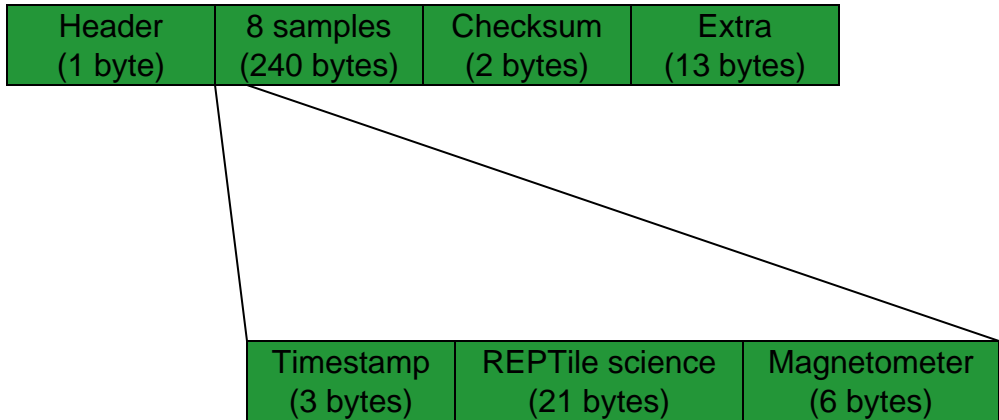


REPTile Data – C&DH

- C&DH collects REPTile data
 - Every 6 seconds (top most priority – receiveTask)
 - Useful Science Data at high latitudes
- Data dumped based on Two Timestamps
 - Timestamps resistant to C&DH reset
- REPTile
 - Magnetometer
 - Timestamp
 - Housekeeping
 - Packet Margin – 13.2%
- 545,642 bytes of data every day



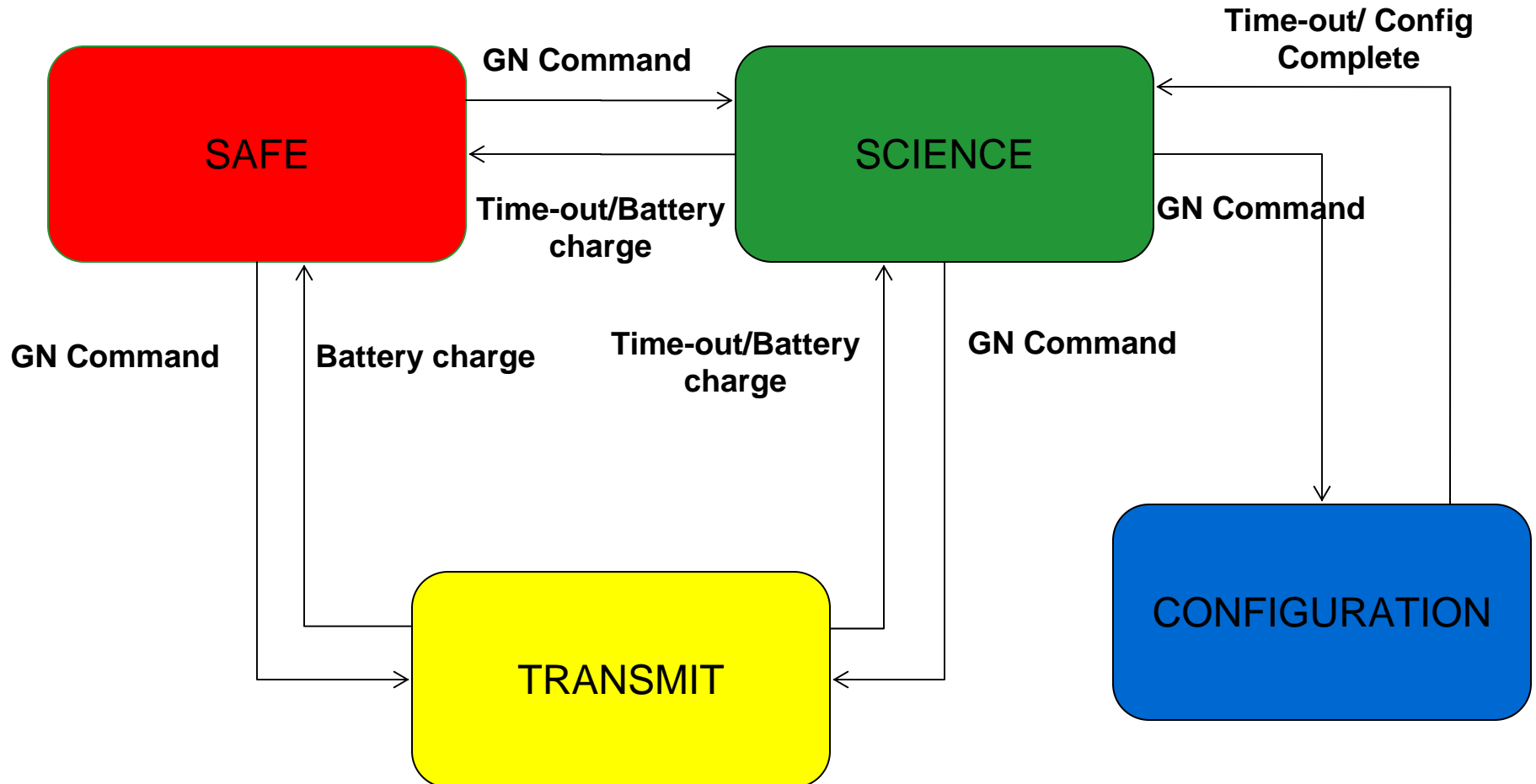
Science Data Packet Format



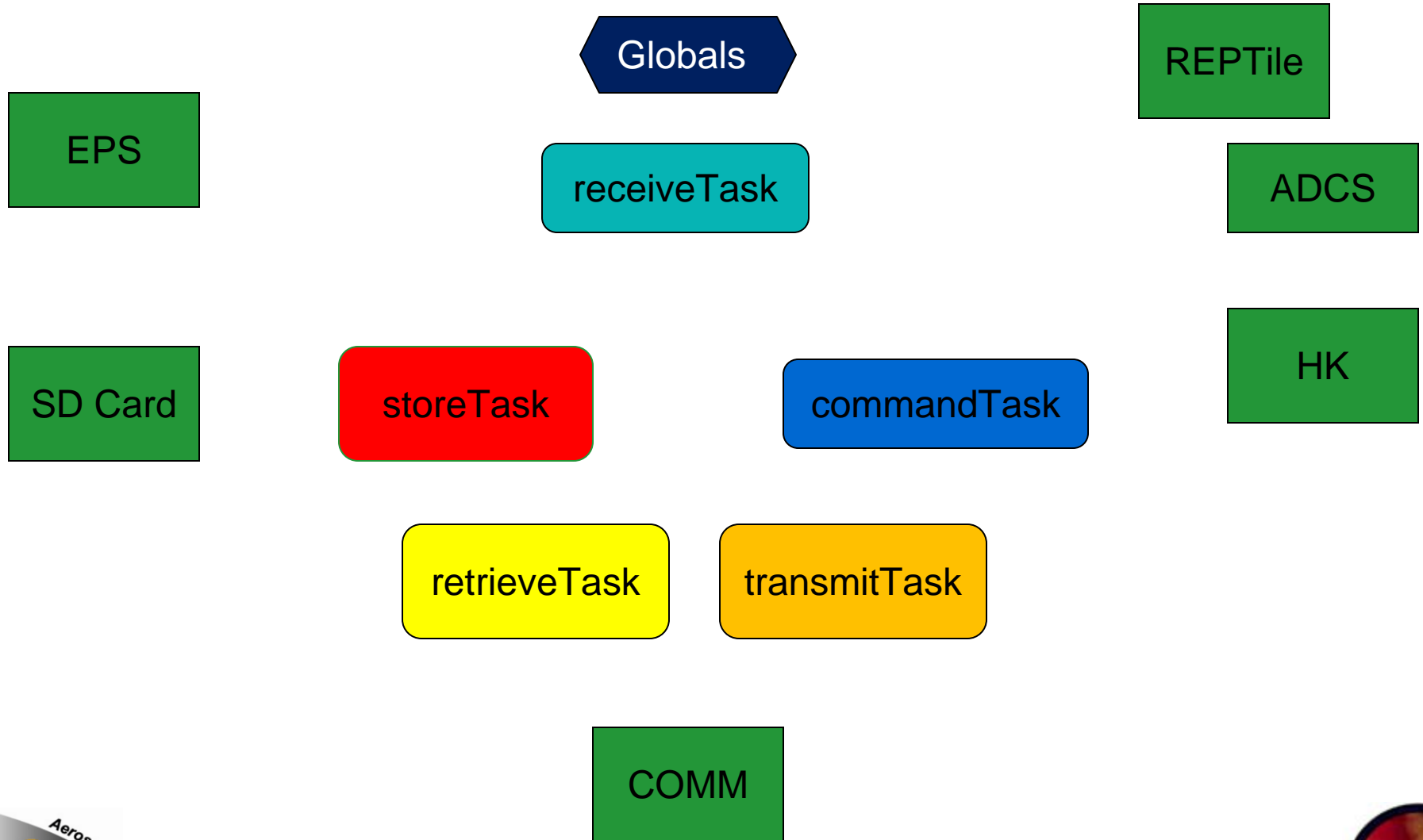
- Science data stored on SD card in samples (30 bytes)
- Science data - packetized in 256 byte chunks (AX.25)
 - 1 packet per 48 seconds = 461 KB/day
 - Note, not all of the science data will be down-linked
- 3 byte timestamps allows for 6 months with 1 second resolution



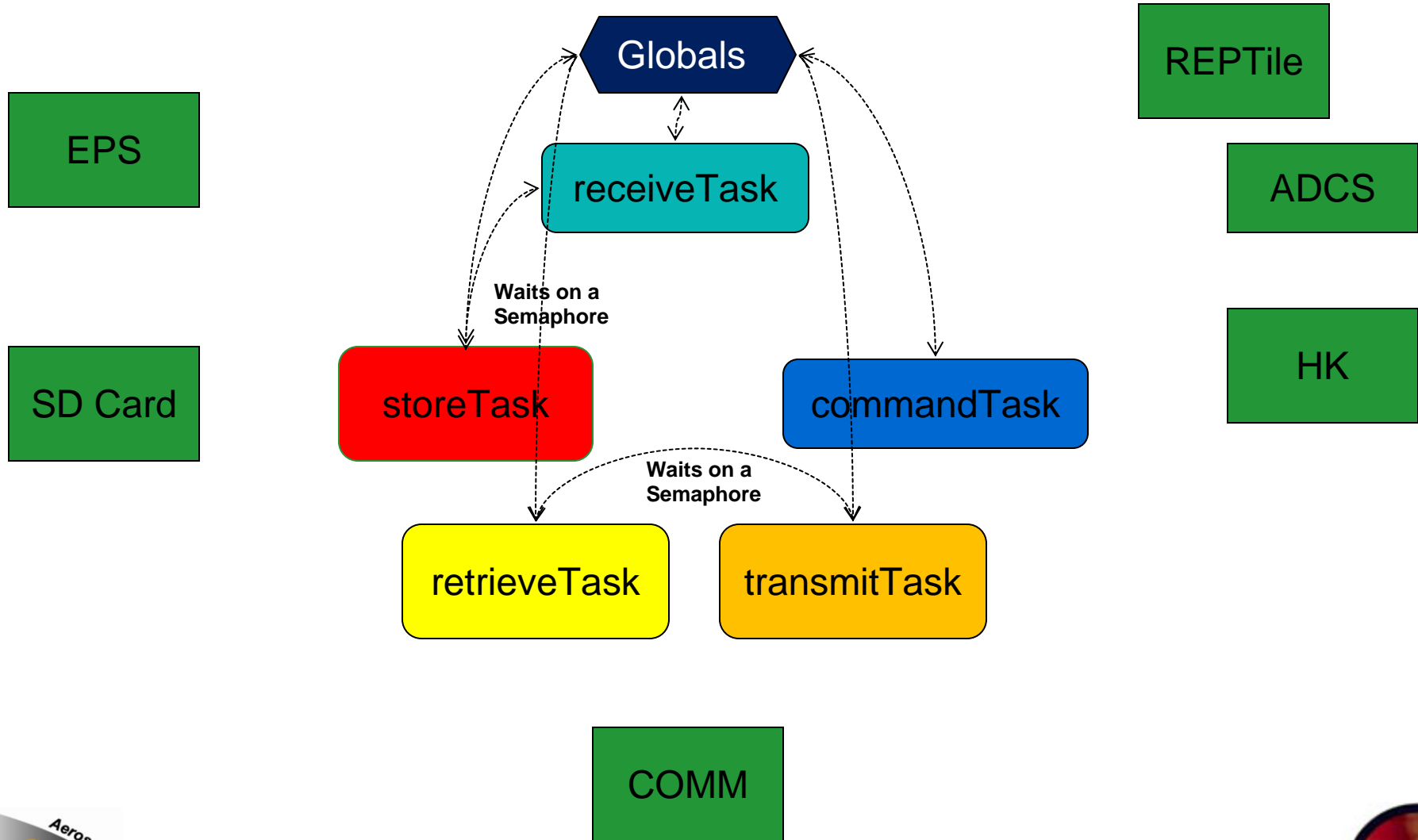
C&DH Architecture – Operational Modes



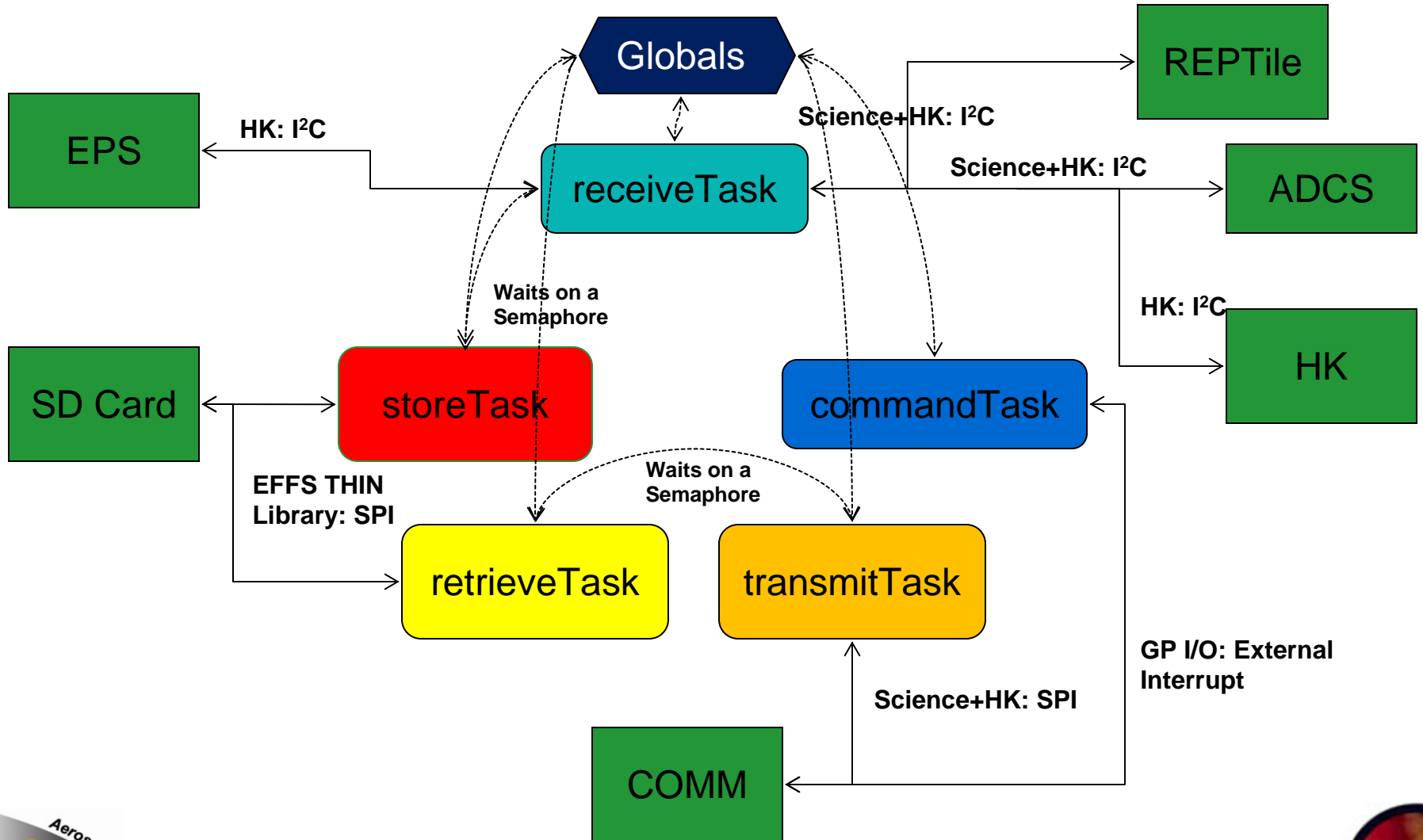
Tasks



Tasks



Tasks



Summary

- C&DH Operational Modes
- RTOS vs Infinite Loop
 - Decision should be based on a thorough study of requirements
- Communication Interfaces – SPI, I²C
 - SD Card
 - SPI – faster throughput than I²C



Thank You !!

Questions ?



BACKUP SLIDES



C&DH Architecture – Operational Modes

■ SAFE

- Beacon 0 – Lowest Power Mode (C&DH+COMM)
 - Battery 25% charge, Lowest Beacon Rate
- Beacon Min – C&DH + COMM + EPS HK
 - Battery 40% charge, Min. Beacon Rate
- Beacon Max – C&DH + COMM + All HK, Max. Beacon Rate
 - Battery 80% charge, Max. Beacon Rate

■ SCIENCE

- scienceTake – Turn on REPTile, I²C Ready
 - Poll EPS HK, Turn on Reptile, USCI_B0 Ready
- scienceReceive – dedicated I²C (USCI_B0 Module), shared I²C (USCI_B1 Module)
 - Receive REPTile, ADCS science data
- RTCReceive – shared I²C (USCI_B1 Module)
 - Receive Time-stamp data from RTC
- scienceStore – dedicated SPI (USCI_A1 Module)
 - Store Science Data Sample in SDCard
- HKReceive - shared I²C (USCI_B1 Module)
 - Receive HK data
- HKStore - dedicated SPI (USCI_A1 Module)
 - Store HK Data Sample in SDCard



C&DH Architecture – Operational Modes

■ Transmit

- scienceRetrieve - dedicated SPI (USCI_A1 Module)
 - Retrieve relevant time-stamp science data from SD Card
- HKRetrieve - dedicated SPI (USCI_A1 Module)
 - Retrieve relevant time-stamp HK data from SD Card
- sendData - dedicated SPI (USCI_A0 Module)
 - Send Science, HK data samples to COMM via USCI_A0

■ Configuration

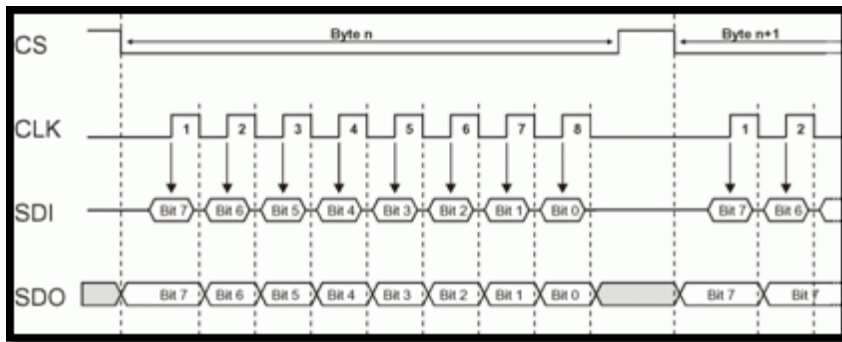
- Default
 - Configuration parameters, change mode



Communication Interfaces

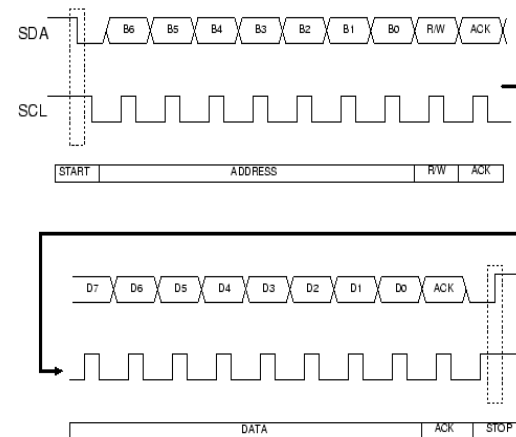
■ SPI

- Full duplex communication
- Higher throughput than I²C

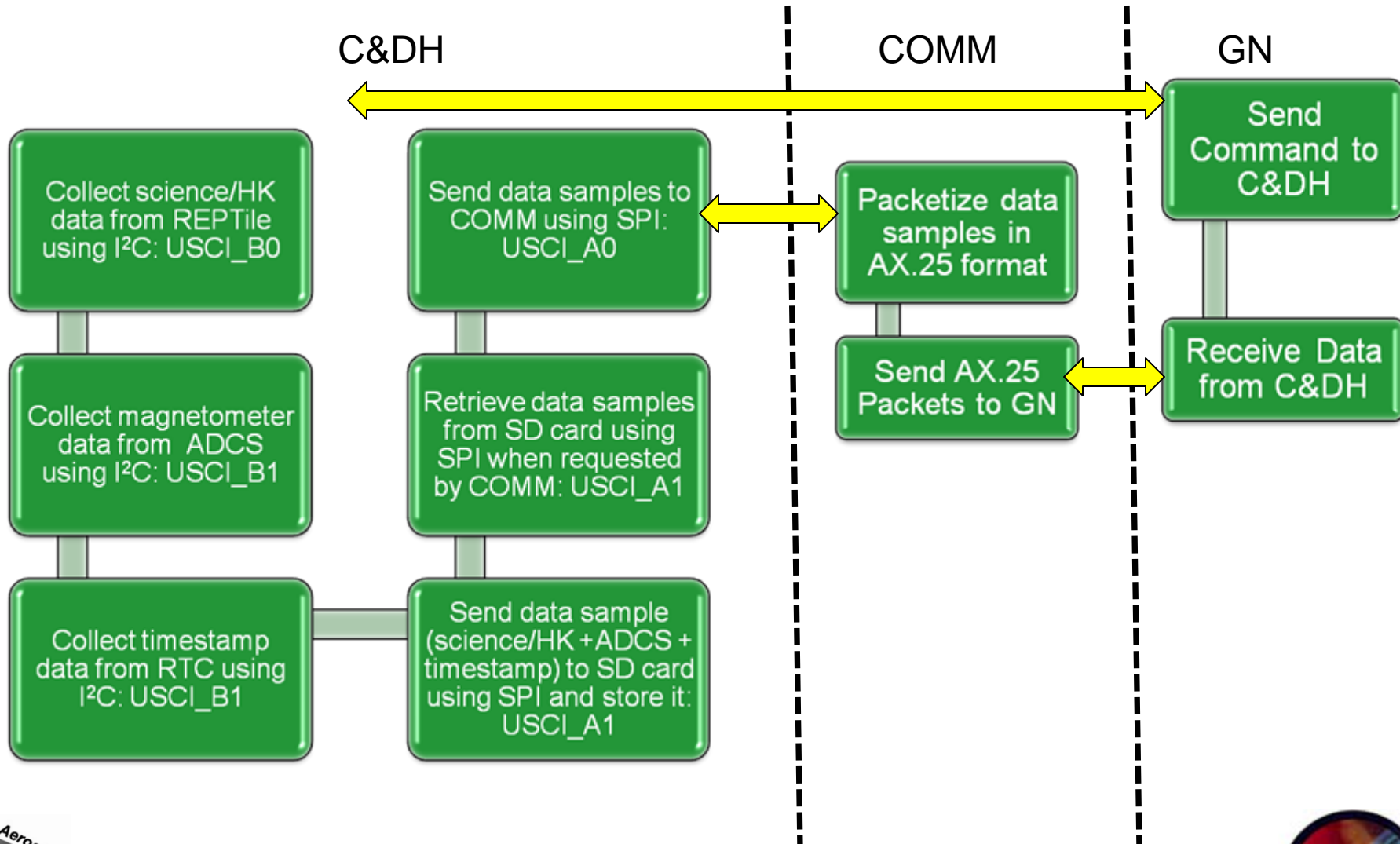


■ I²C

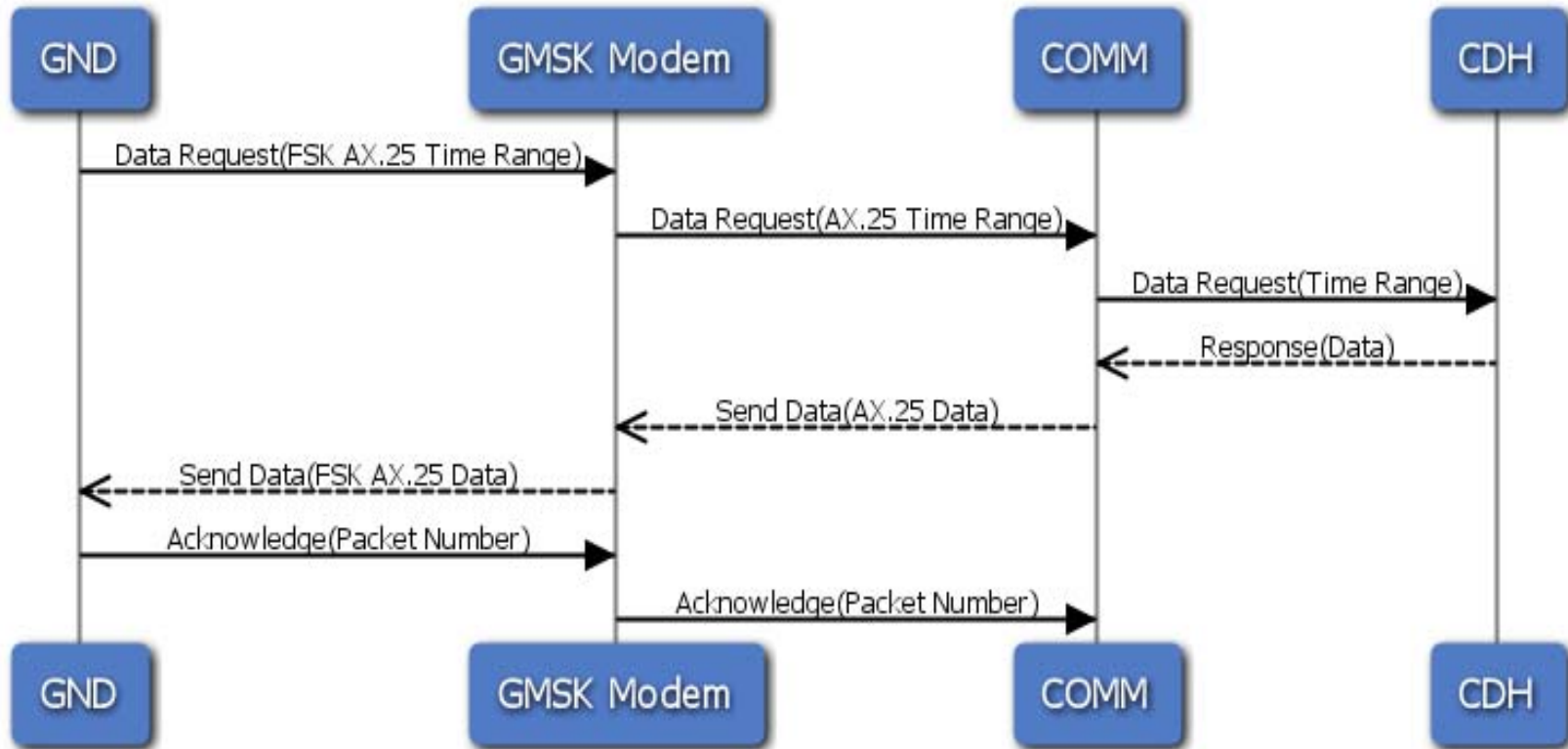
- Half duplex communication
- 100 kbit/s (upto 3.4 Mbit/s)



C&DH-GN Task Flow - Science



C&DH – GN Task Flow



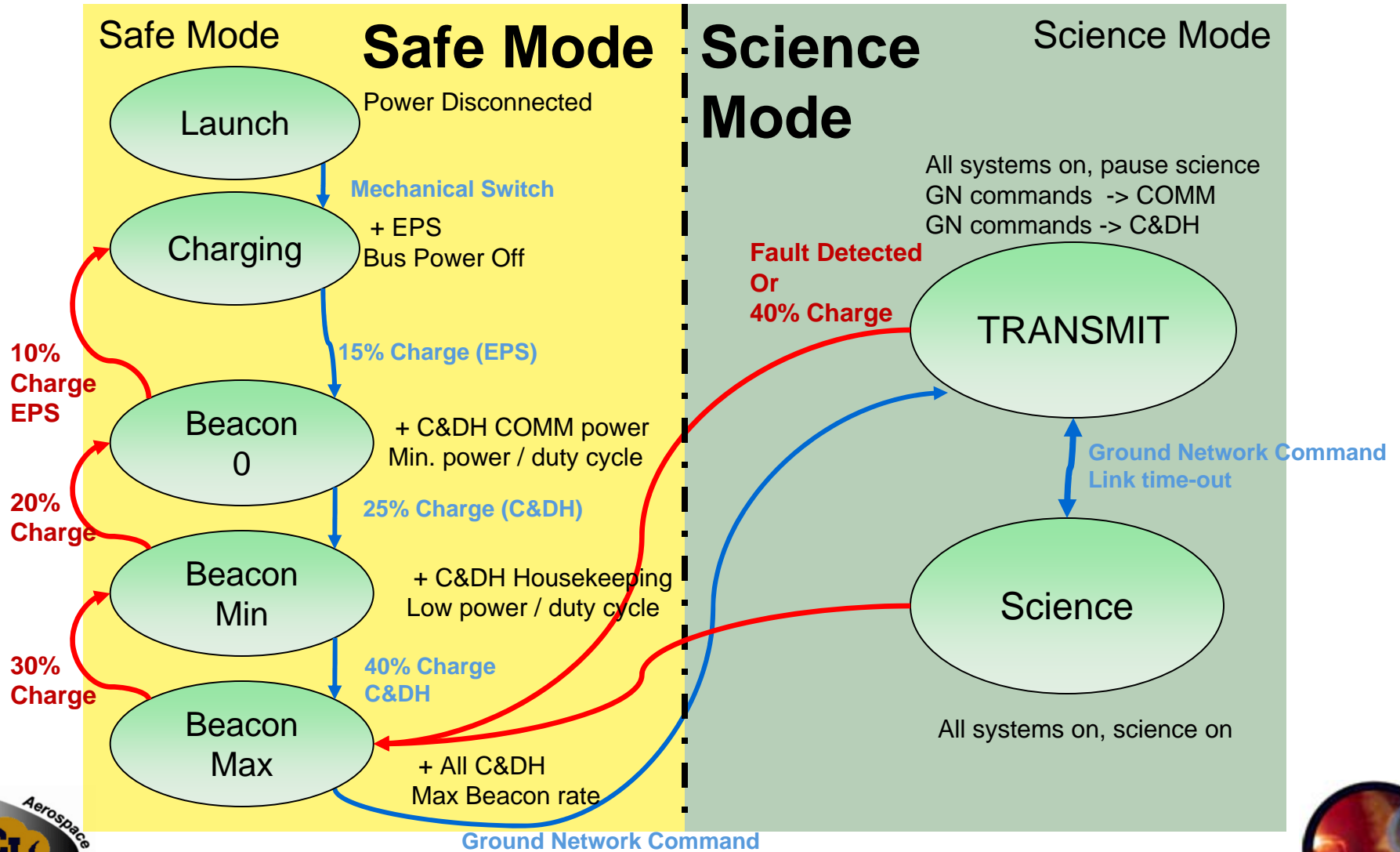
Command Data Packet Format

Header (1 byte)	Sectional Header (optional) (2 bytes)	Function Op-code (2 bytes)	Parameters (n bytes)	Extra (256-(n+5) bytes)
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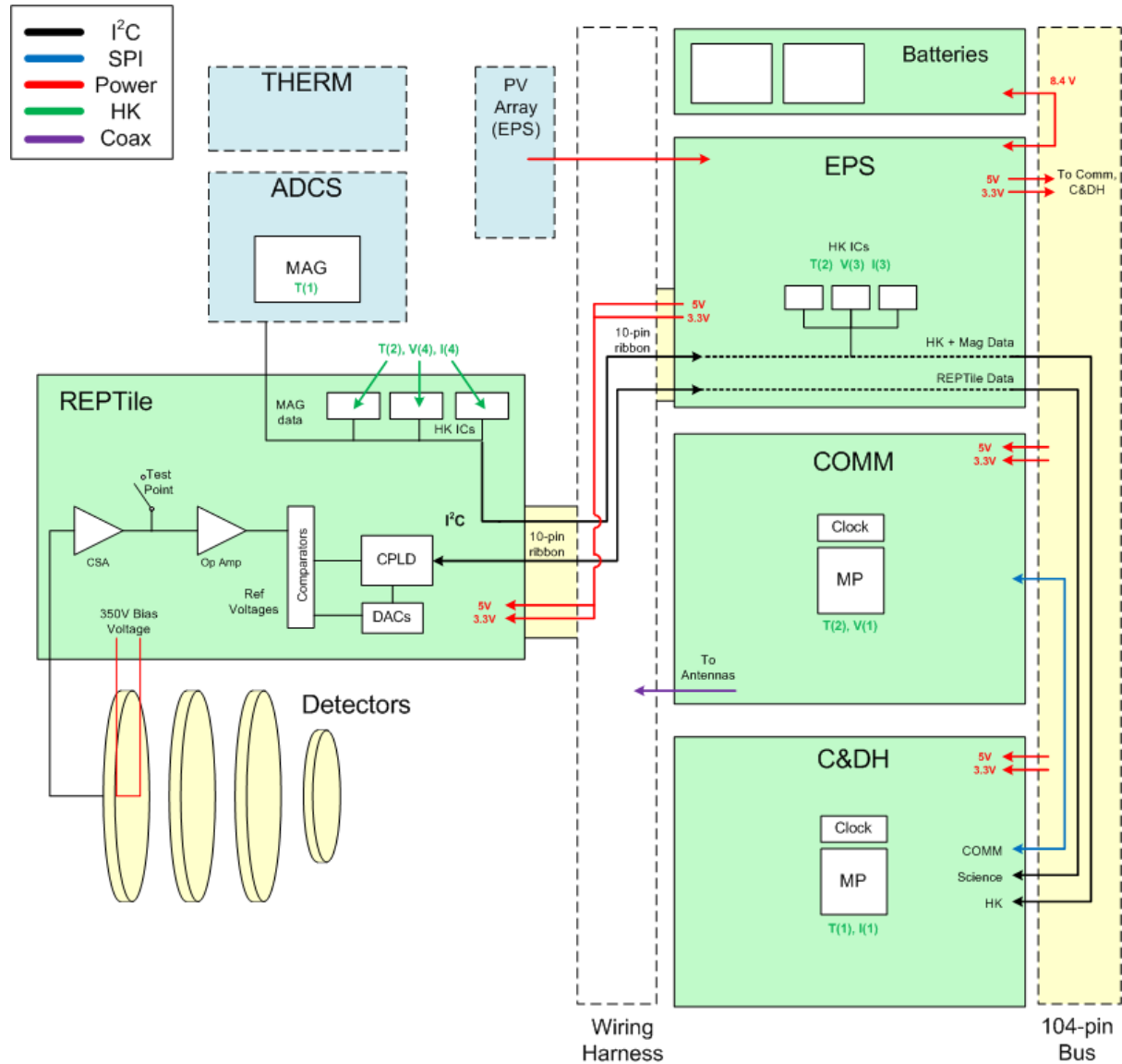
- Command Data Packet routed by COMM to C&DH
- Data packet size follows AX.25 format– 256 bytes
- Functional op-code identifies configuration parameters – Beacon period, HK Data collection frequency, depth of discharge for safe mode, ignore HK data, time-out, turn off specific detectors, C&DH reset (by COMM)



Operational Modes



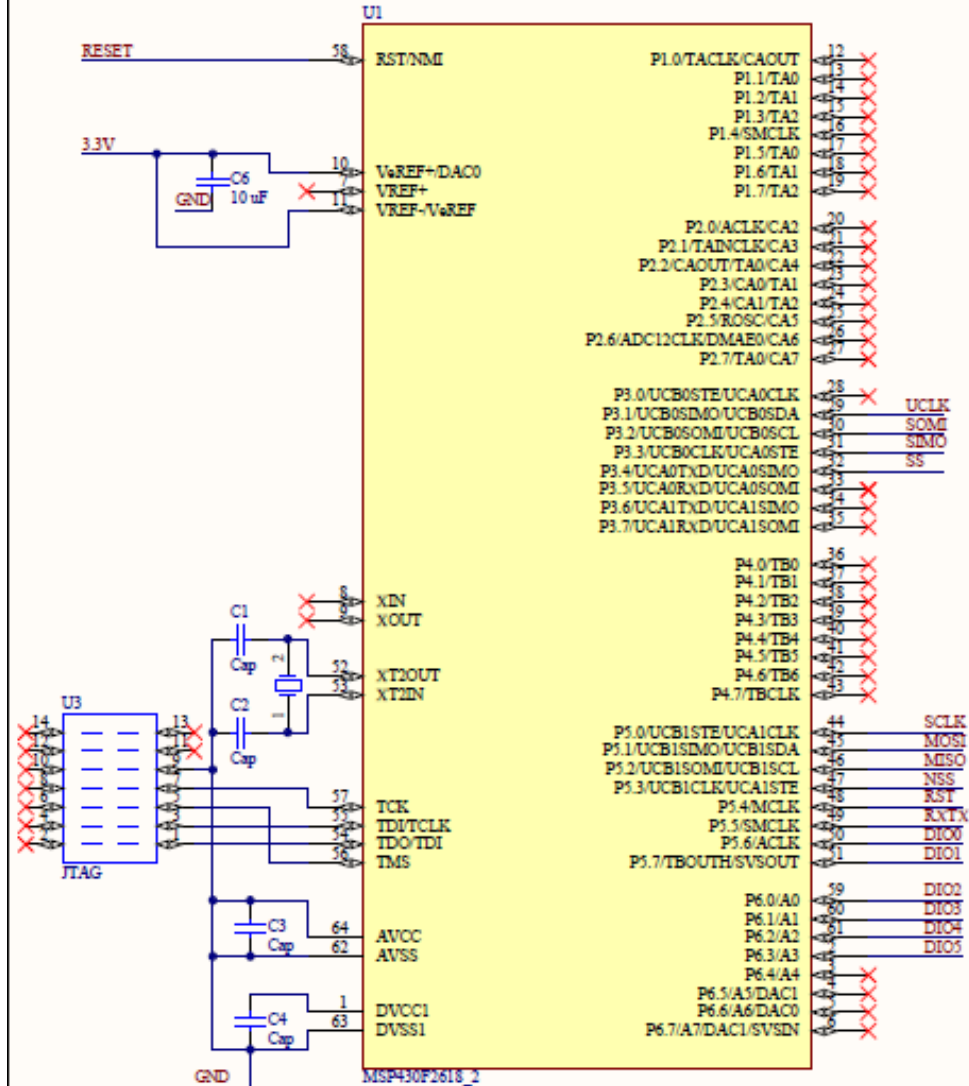
INTF Block Diagram



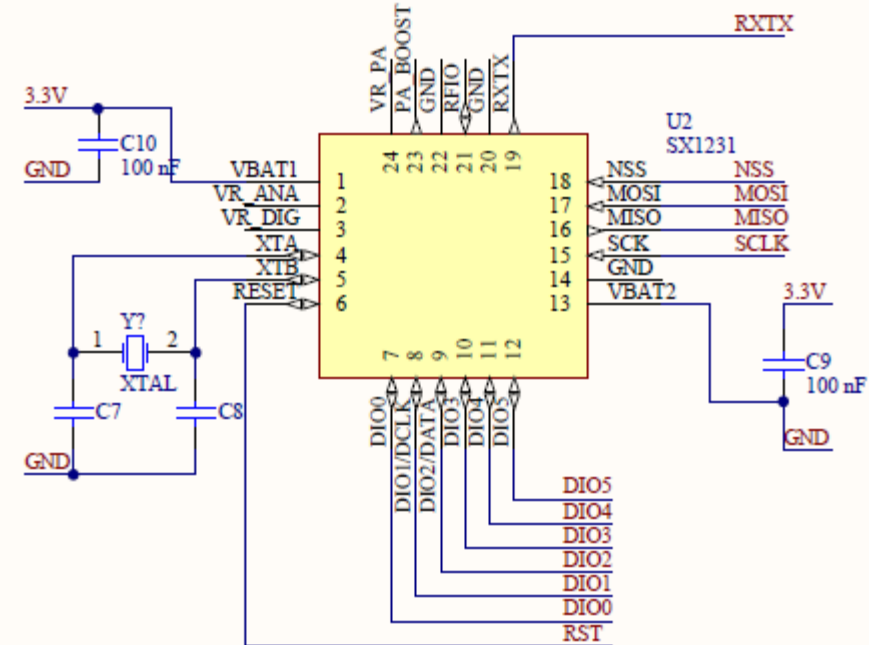
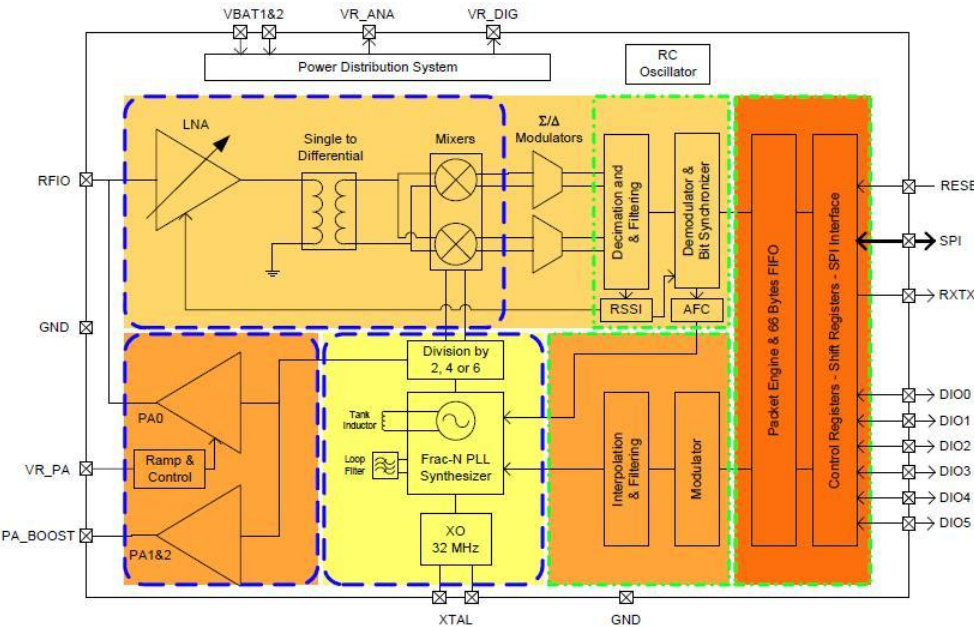
Microcontroller Unit

MSP430F2618 MCU

- Low power
- Shared design and programming environment with C&DH
- Shared learning curve with C&DH
- Relatively few external components required



GMSK Modem

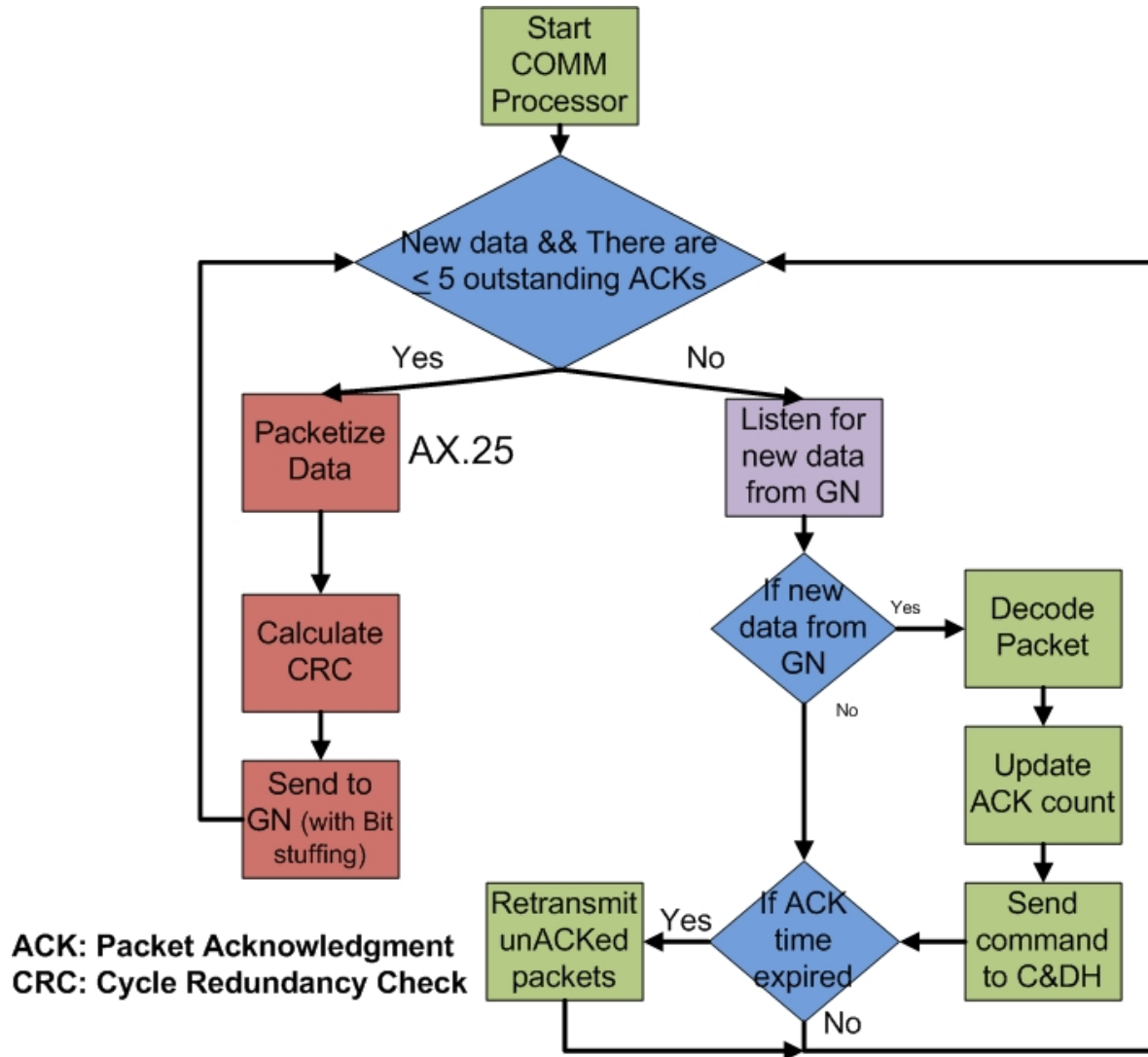


SX1231 UHF Modem Transceiver

- GMSK Modulation
- Provides majority of Front End
- Requires few external components
- Low power consumption
- Variable transmit power



Software Flow Diagram



C&DH - Tasks Interaction

