Simple Satellite Overview

September 29, 2019

Simple Sat (SimSat) Objectives

- **SimSat is a fictional spacecraft that provides a reference mission context**

- **Provide a complete application suite illustrating**
  - What apps are required to meet a mission's requirements
  - How they are configured and integrated as a system

- **Provide example scripts**
  - Integration test script
  - Operational script

- **Provide context for training exercises**

This slide deck does not cover OSK or the cFS.
See OSK Quick Start Guide or User's Guide for OSK and cFS descriptions.

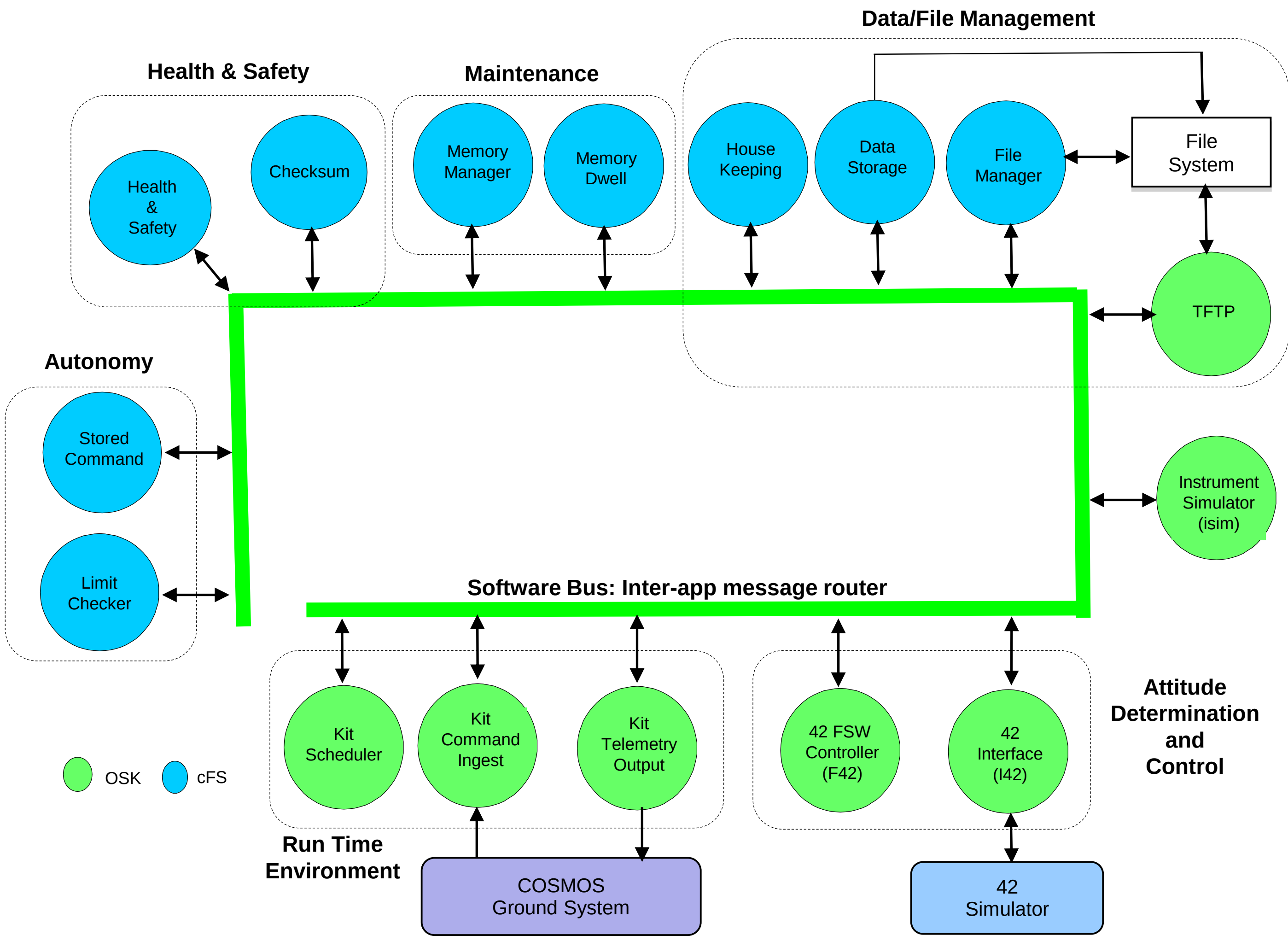
SimSat

- **Low Earth Orbit (LEO)**
  - 90 minute orbit
  - One 15 minute ground contact per orbit with bi-directional comm
- **One science instrument, iSim**
  - Detector's 1Hz scan produces 10 bytes of data
  - Power on sequence
    - Apply power, wait for instrument warm up (~20s), then enable science
  - Power off sequence
    - Disable power

SimSat Ops Concepts & Requirements

- **Science team requires**
  - A 1Hz auxiliary spacecraft data containing time, attitude, orbit data, and instrument status
  - Start science during a ground contact. Can be automated but ops prefers to monitor instrument health.
- **Ground contact resources/schedule are preplanned**
  - Implies autonomous operations can be loaded on board using stored commands
- **Each pass can either be a low or high downlink rate**
- **FSW must autonomously monitor instrument health and power off the instrument in the event of a fault**

SimSat Applications



SimSat Applications (1 of 3)

- **The previous slide shows a cFS "bubble" chart where each app is a bubble and they communicate via messages on the software bus.**
  - The blue cFS apps are reusable open source apps that are available on https://github.com/nasa/xx where 'xx' is the abbreviated app name
  - The green OSK apps were written specifically for OSK
  - The external COSMOS and 42 interfaces use UDP and TCP respectively
- **Apps are designed to perform a dedicated function with clear interfaces and they operate in groups to achieve higher level mission objectives**

- **Runtime Environment Apps**
  - Kit Command Ingest (KIT_CI) receives CCSDS command packets from COSMOS and sends them on the Software Bus
  - Kit Telemetry Output (KIT_TO) reads CCSDS telemetry packets from the Software Bus and sends them to COSMOS
  - Kit Scheduler (KIT_SCH) contains tables that define when to send messages on the Software Bus
    - Apps can use these messages to perform synchronous activities, e.g. sending their housekeeping status packet

SimSat Applications (2 of 3)

- **Data/File Management**
  - File Manager (FM) provides a ground interface for performing common directory and file operations
  - Data Storage (DS) reads packets from the software bus and writes them to files according to table-defined
  - Housekeeping (HK) creates new telemetry packets from pieces of other telemetry packets. The new packets are written to the SB and can be stored and/or telemetered.
  - Trivial File Transfer Protocol (TFTP) transfers files between the flight and ground COSMOS. There’s an open source CCSDS File Delivery Protocol (CFDP) app that will be added in a future release.

- **Autonomy**
  - Limit Checker (LC) monitors one or more telemetry values and start stored command relative time sequences (RTSs) in response to limit violations
  - Stored Command (SC) Provides services to execute preloaded, table-defined command sequences at predetermined absolute or relative time intervals

SimSat Applications (3 of 3)

- **Attitude Determination and Control Apps**
  - 42 Interface (I42) manages a TCP/IP connection to 42 and transfers actuators/sensor packets to/from 42
  - 42 FSW (F42) Implements the “ThreeAxisFsw” attitude control algorithm defined in 42

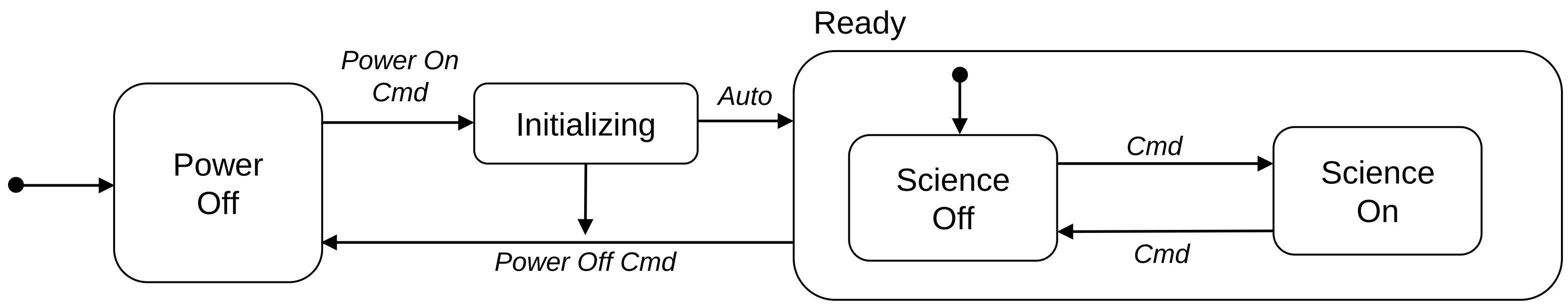
- **Maintenance**
  - Memory Dwell (MD) creates telemetry packets containing contents of memory location specified in dwell tables
  - Memory Manager (MM) provides read/write access to memory

- **Health & Safety**
  - Checksum (CS) monitors checksums across table-defined static code/data regions and reports errors
  - Health & Safety (HS) monitors table-defined application check-in and event messages and reporting errors and/or starting a RTS to address the issue

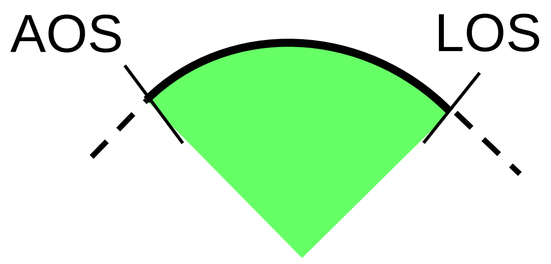
SimSat App Solution (1 of 5)

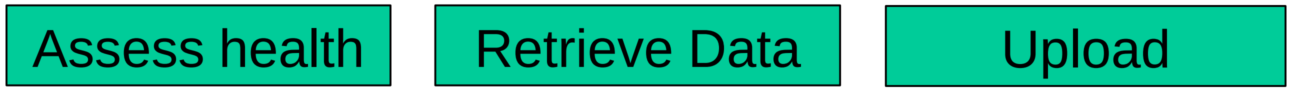
- **iSim App**
  - Simulate science instrument data
  - Creates science data files and moves them to downlink directory
  - Commands
    - Power instrument on/off
    - Start/stop science data
    - Set/clear fault
  - Telemetry
    - Instrument status: Off, Initializing, Ready
    - Science data: Enabled, disabled
    - Fault: True, False
  - Use informational events to trace behavior.

SimSat App Solution (1 of 5)



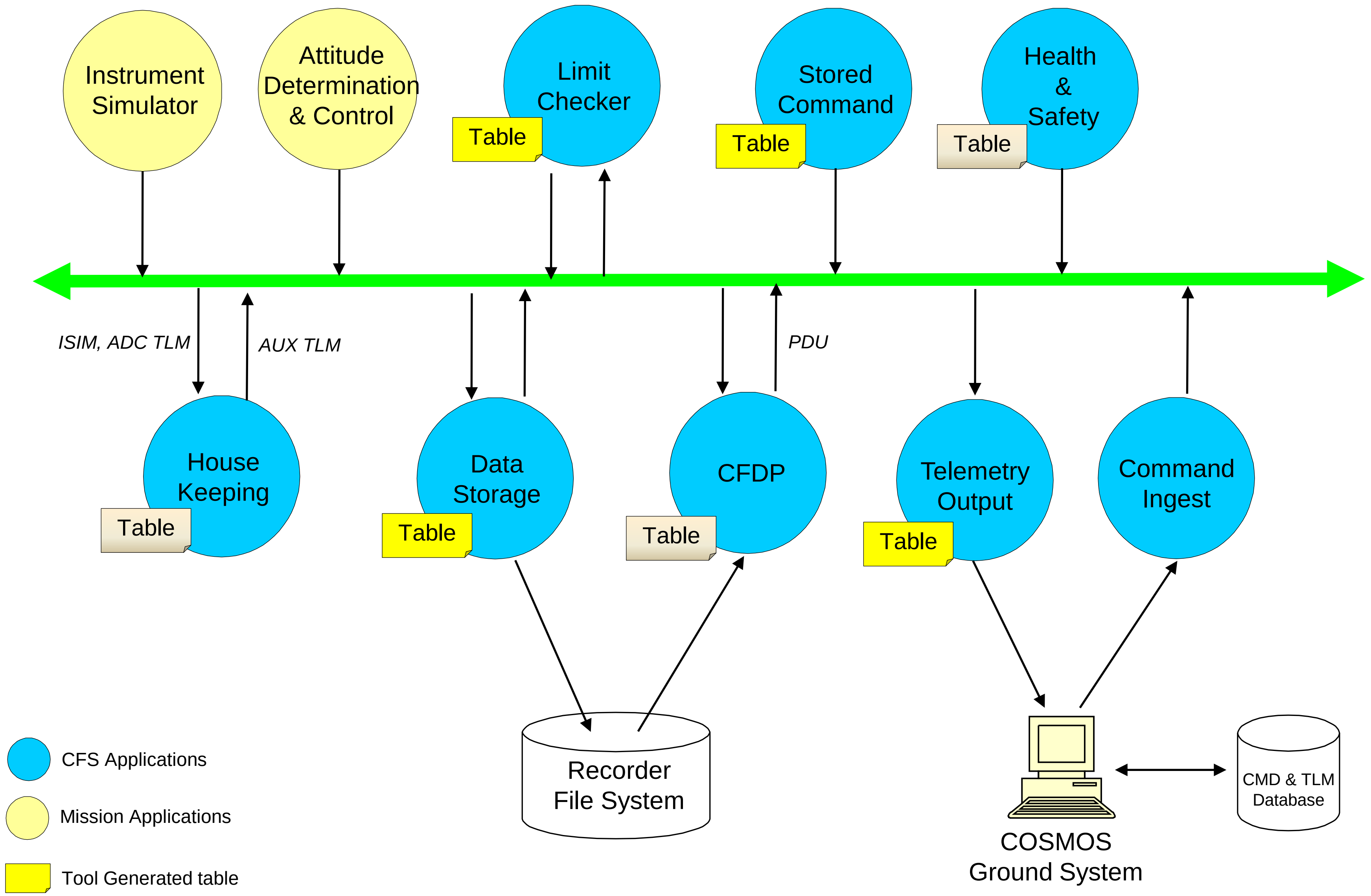
Contact Activities





- **Create and load stored command sequences to run a demo**
- **Use OpenSatKit exercises to work through an example**

SimSat Application Configuration



SimSat Application Configuration (1 of 4)

- **Housekeeping (HK)**
  - HK Combo packet 1 (0x089C) comes predefined with HK and contains HK data from each cFE app
    - Scheduler Slot 6, Activity 6
  - Create a new auxiliary science data packet using HK combo packet 2 (0x089D) that combines instrument status telemetry and ADC data
    - Scheduler Slot 6, Activity

- **Data Storage (DS)**
  - Configure file & filter tables to create:
    - Event message file: DS filter 6, file 0
    - Auxiliary data file: DS filter 15, file 6

SimSat Application Configuration (2 of 4)

- **Telemetry Output (KIT_TO)**
  - Doesn't support filter tables
  - Create low/high tables that define which packets will be output for each scenario
  - Load low/high rate tables using stored commands

- **Limit Checker**
  - Monitor instrument status for the ready state and start RTS to enable science
  - Monitor instrument for a fault and start RTS to power off instrument if a fault persists for 3 seconds
    - WP #12 – Monitor ISIM fault
    - AP #2 – Start RTS 6 to stop science and power off the instrument

SimSat Application Configuration (3 of 4)

- **Stored Command (SC)**
  - Create Relative Time Sequences (RTS) to perform specific operational functions
  - RTS Definitions

    6 - Power off science instrument

    TODO

    - Load KIT_TO low rate table
    - Load KIT_TO high rate table
    - Power on science instrument
    - Start science
    - Stop science
    - Start pass
    - End pass
  - Absolute Time Sequence (ATS)
    - Create an ATS to manage 24 hours of operations
    - For periodic operations such as bSat the duration of an ATS should be much longer than the ATS upload frequency to account for contingencies

SimSat Application Configuration (4 of 4)

- **File Manager (FM) & Trivial File Transfer Protocol (TFTP)**
  - Use FM to perform directory listing of files to downlink
  - Transfer files from flight to ground using TFTP
- **Checksum**
  - Configure checksum to monitor the stored command table checksums
- **CCSDS File Delivery Protocol (CF)**
  - Currently not in the kit
  - CF could significantly change the operational scenarios. Most of the file transfer and onboard file deletion activities could be automated if CF's "hot directory" and Class 2 mode are used

Contact Planning

- **For each ground contact**

1. Assess health of spacecraft
   a. Take action if needed

2. Manage onboard data files

3. Uplink new ATS if needed

Assess Health of Spacecraft

- **Verify expected spacecraft state**
  - This is mission specific, includes items such as
    - Expected control mode, clear LC flags, etc.
- **Dump, transfer, and display event log**
  - Event log should not fill up with informational events if you're judicious on how you define events. See cFE training module for guidelines
  - Clear log after log transferred to the ground

Manage Onboard Data Files

1. **Use FM to list directory to a file**
2. **Transfer directory file to the ground**
3. **Sort files in priority order**
4. **Transfer files in priority order**
    a. Delete each file after successful transfer

Reference