Time Services

Basecamp

August 2025

Audience & Prerequisites

- **Objectives**
  - Provide a comprehensive description of the cFS Framework Executive Service
- **Intended audience**
  - Software engineers developing with the cFS
- **Prerequisites**
  - cFS Framework Introduction
- **Refer to the Executive Services module for a list of topics covered in each cFE service training module**

Blue screens contain hands on cFS Basecamp exercises

- Basecamp is a lightweight environment with built-in tutorials for learning the cFS
- https://github.com/cfs-tools/cfs-basecamp

Time Services Overview

- cFE Time Services provides time correlation, distribution and synchronization services
- Provides a user interface for correlation of Spacecraft Time to the ground reference time (epoch)
- Provides calculation of spacecraft time, derived from mission elapsed time (MET), a spacecraft time correlation factor (STCF), and optionally, leap seconds
- Provides a functional API for cFE applications to query the time
- Distributes a “time at the tone” command packet, containing the correct time at the moment of the 1Hz tone signal
- Distributes a “1Hz wakeup” command packet
- Forwards tone and time-at-the-tone packets
- Designing and configuring time is tightly coupled with the mission avionics design

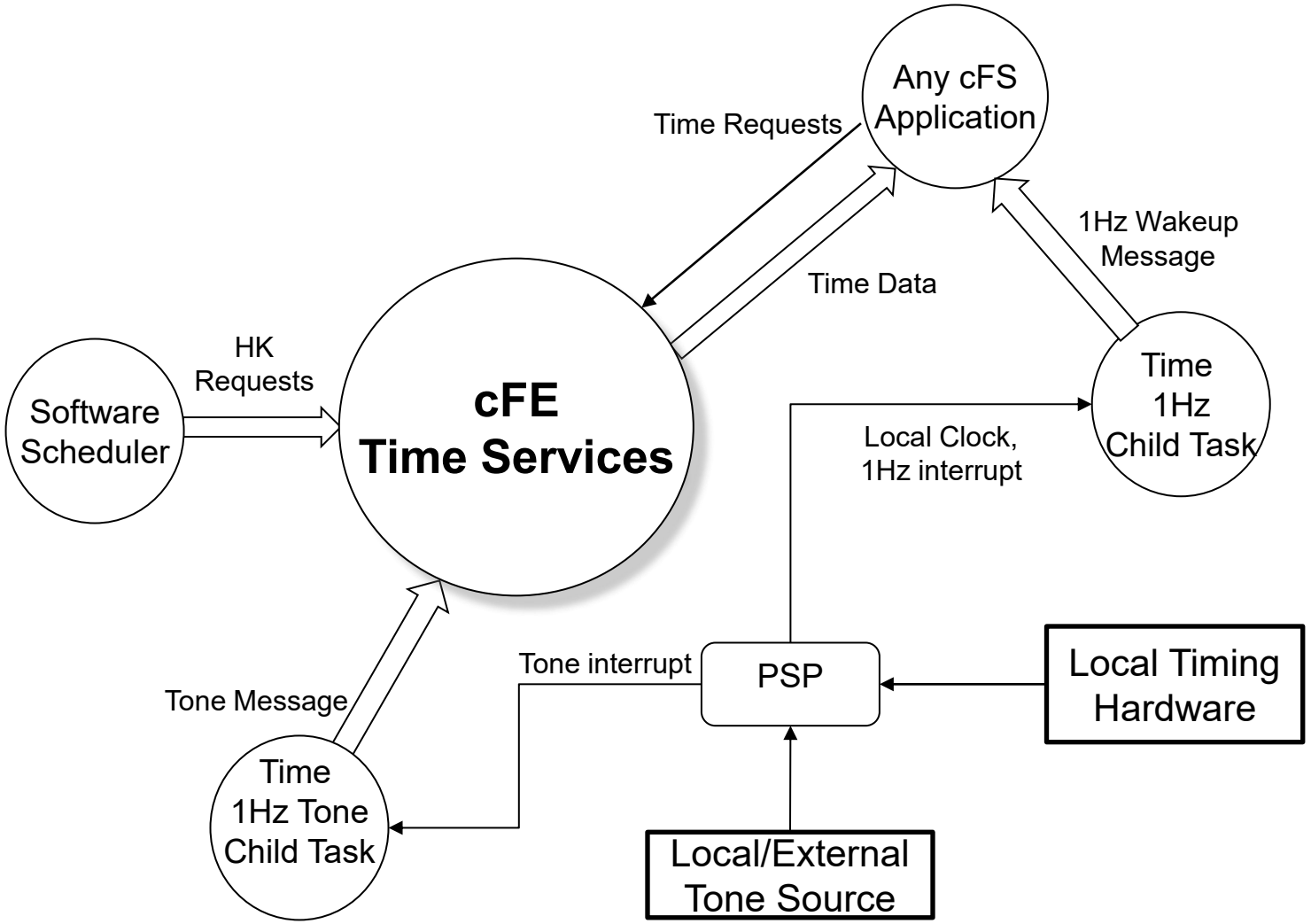
Concepts and Terminology

- Split up previous slide
- See cFS online users guide
- Update cFE Framework overview slides

Time Formats

- **Supports two formats**
- **International Atomic Time (TAI)**
  - Number of seconds and sub-seconds elapsed since the ground epoch
  - TAI = MET + STCF
    - Mission Elapsed Counter (MET) time since powering on the hardware containing the counter
    - Spacecraft Time Correlation Factor (STCF) set by ground ops
    - Note STCF can correlate MET to any time epoch so TAI is mandated
- **Coordinated Universal Time (UTC)**
  - Synchronizes time with astronomical observations
  - UTC = TAI – Leap Seconds
  - Leap Seconds account for earth's slowing rotation

Time Services Context



“Flywheeling”

- ***Flywheeling*** **occurs when TIME is not getting a valid tone signal or external "time at the tone" message. While this has minimal impact on internal operations, it can result in the drifting apart of times being stored by different spacecraft systems.**

- **Flywheeling occurs when at least one of the following conditions is true:**
  - loss of tone signal
  - loss of "time at the tone" data packet
  - signal and packet not within valid window
  - commanded into fly-wheel mode

Reset Behavior

- **Power-On-Reset**
  - Initializes all counters in housekeeping telemetry
  - Validity state set to Invalid
  - STCF, Leap Seconds, and 1 Hz Adjustment to zero set to zero

- **Processor reset, preserves:**
  - MET
  - STCF
  - Leap Seconds
  - Clock Signal Selection
  - Current Time Client Delay (if applicable)
  - Uses ‘signature’ to determine validity of saved time. If signature fails then power-on-reset initialization is performed

Retrieving Onboard State

- **Housekeeping Telemetry**
  - Clock state, Leap Seconds, MET, STCF 1Hz Adjust
- **Telemetry packets generated by command**
  - Diagnostic Packet
- **Files generated by command**
  - None

System Design : Configuration Considerations

- What is your time format?
- Are you setting time or receiving time?
- Is your MET provided by local hardware?
- Is time coming from an external source?
- How long can you go without synchronizing time?

System Design : TBD

- **TODO**
  - Packet time stamps

- **List parameters that with higher probability of being tuned**
- System time is TAI or UTC

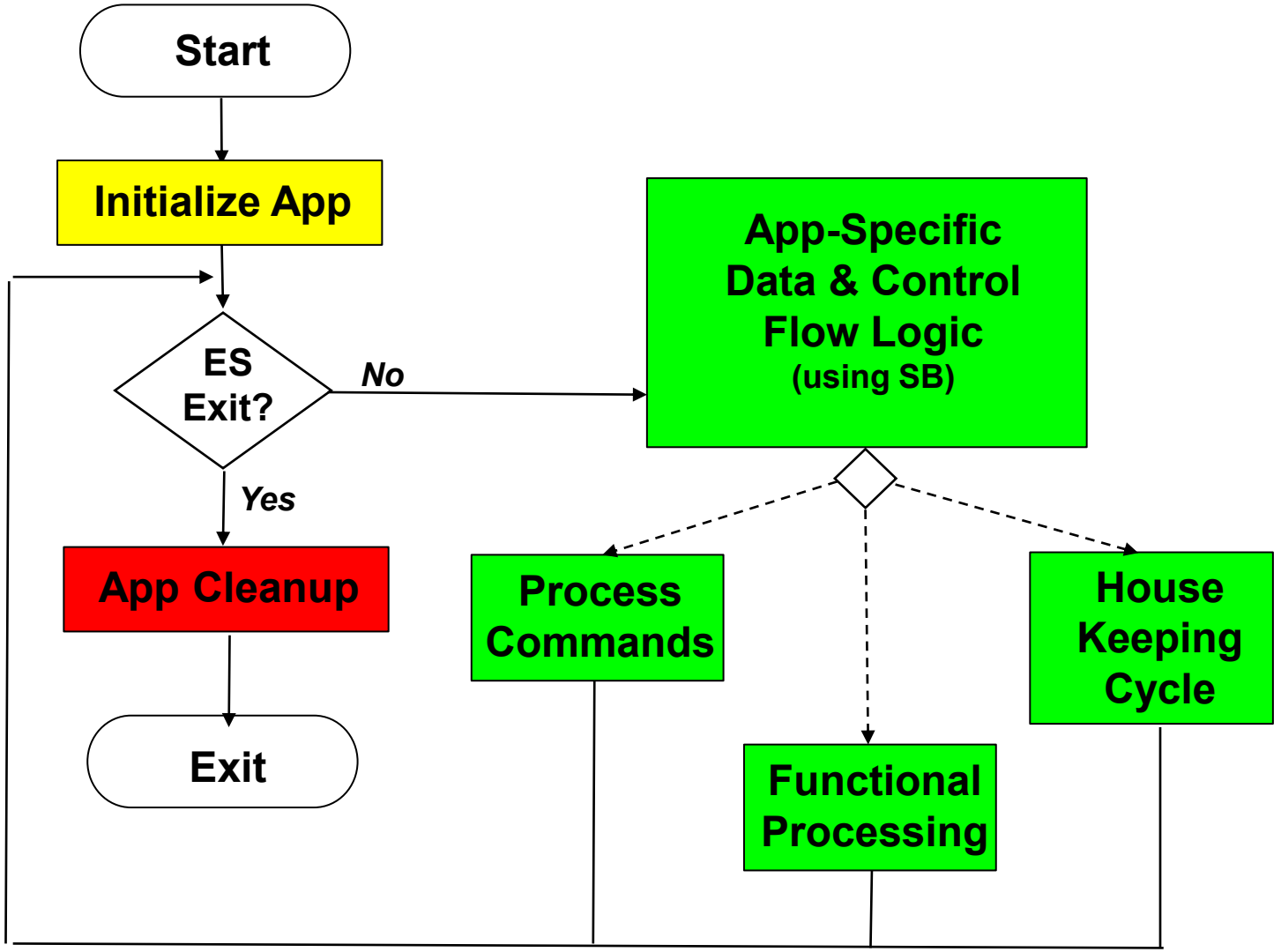
MET – Hardware register or software variable

GPS and a Time Manager App (GPM Design)

Application Development: Guidelines

- **Many apps don't need to directly use Time's API directly**
  - The most common app use of time is to time stamp telemetry messages and this is provided by the Software Bus service
- **App's requiring execution synchronized with the 1Hz using CFE_TIME_RegisterSynchCallback()**
  - For examples, see NASA's Health & Safety (HS) app and Basecamp's Kit Scheduler (KIT_SCH) app
- **Time stamp events and compute delta time between events**
  - For examples, see NASA's Limit Checker (LC) & Stored Command (SC) apps and Basecamp's Kit Scheduler (KIT_SCH) app

App Development: Example Control Flow



App Development: Example Control Flow TIME Calls

Initialize App

CFE_TIME_RegisterSynchCallback()

- Register a function to be called during a CFE_TIME synchronization event which is typically a 1Hz pulse

App-Specific Data & Control Flow Logic (using SB)

CFE_TIME_GetTime(), CFE_TIME_Add(), CFE_TIME_Subtract(), CFE_TIME_Compare()

- Time stamps events
- Compute time between events

APIs (1 of 2)

Get Current Time APIs	Purpose
CFE_TIME_GetTime	Get the current spacecraft time
CFE_TIME_GetTAI	Get the current TAI (MET + SCTF) time
CFE_TIME_GetUTC	Get the current UTC (MET + SCTF - Leap Seconds) time
CFE_TIME_GetMET	Get the current value of the Mission Elapsed Time (MET)
CFE_TIME_GetMETseconds	Get the current seconds count of the mission-elapsed time
CFE_TIME_GetMETsubsecs	Get the current sub-seconds count of the mission-elapsed time

Get Time Information APIs	Purpose
CFE_TIME_GetSTCF	Get the current value of the spacecraft time correction factor (STCF)
CFE_TIME_GetLeapSeconds	Get the current value of the leap seconds counter
CFE_TIME_GetClockState	Get the current state of the spacecraft clock
CFE_TIME_GetClockInfo	Provides information about the spacecraft clock

Time Arithmetic APIs	Purpose
CFE_TIME_Add	Adds two time values
CFE_TIME_Subtract	Subtracts two time values
CFE_TIME_Compare	Compares two time values

APIs (2 of 2)

Time Conversion APIs	Purpose
CFE_TIME_MET2SCTime	Convert specified MET into Spacecraft Time
CFE_TIME_Sub2MicroSecs	Converts a sub-seconds count to an equivalent number of microseconds
CFE_TIME_Micro2SubSecs	Converts a number of microseconds to an equivalent sub-seconds count

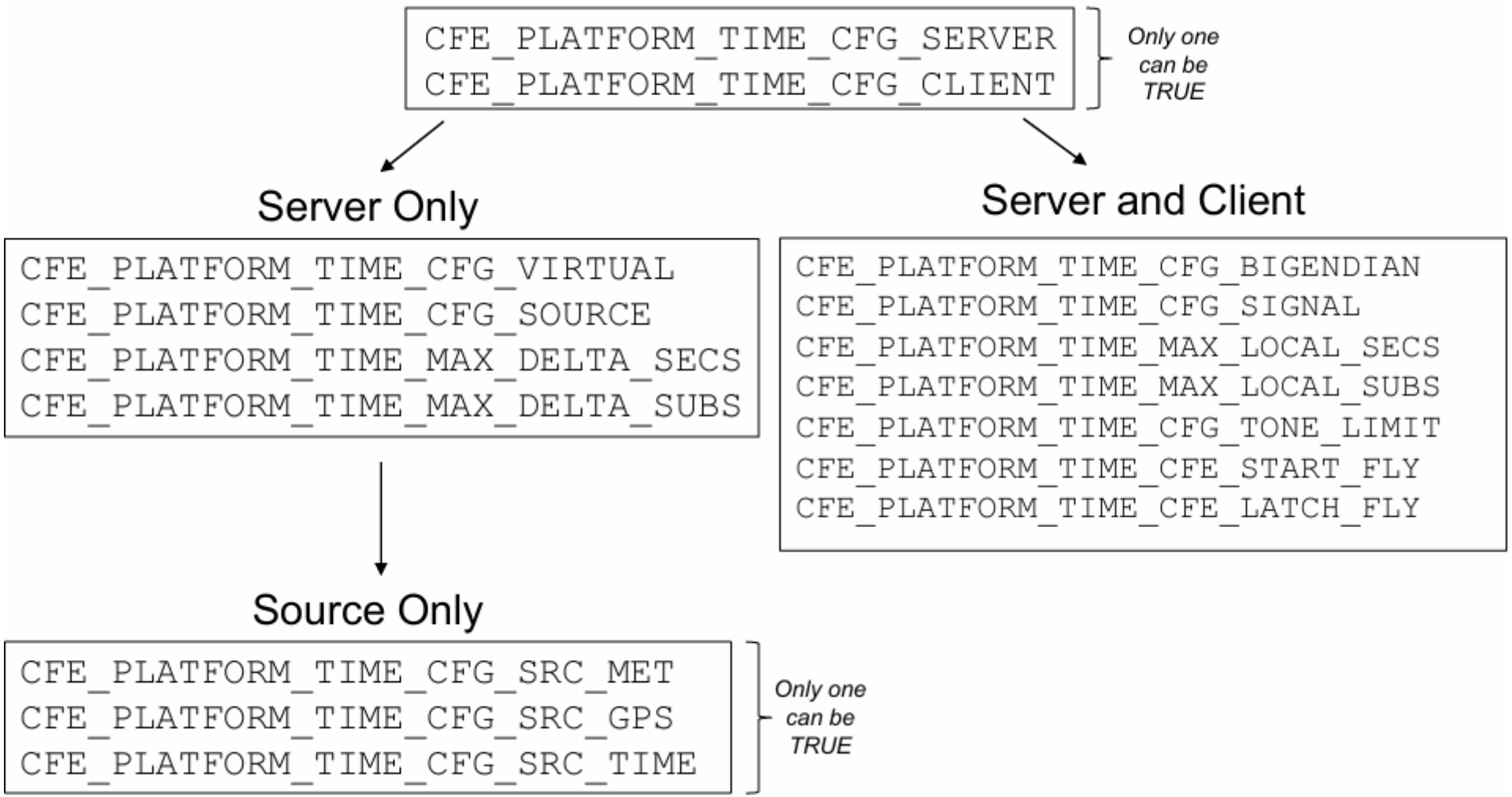
External Time Source APIs	Purpose
CFE_TIME_ExternalTone	Provides the 1 Hz signal from an external source
CFE_TIME_ExternalMET	Provides the Mission Elapsed Time from an external source
CFE_TIME_ExternalGPS	Provide the time from an external source that has data common to GPS receivers
CFE_TIME_ExternalTime	Provide the time from an external source that measures time relative to a known epoch
CFE_TIME_RegisterSynchCallback	Registers a callback function that is called whenever time synchronization occurs
CFE_TIME_UnregisterSynchCallback	Unregisters a callback function that is called whenever time synchronization occurs

Miscellaneous Time APIs	Purpose
CFE_TIME_Print	Print a time value as a string
CFE_TIME_Local1HzISR	Drives the time processing logic from the system PSP layer.

Command List

Command Functions	Purpose
CFE_TIME_Add1HZAdjustmentCmd	Add Delta to Spacecraft Time Correlation Factor each 1Hz
CFE_TIME_AddAdjustCmd	Add Delta to Spacecraft Time Correlation Factor
CFE_TIME_AddDelayCmd	Add Time to Tone Time Delay
CFE_TIME_SendDiagnosticTlm	Request TIME Diagnostic Telemetry
CFE_TIME_NoopCmd	Time No-Op
CFE_TIME_ResetCountersCmd	Resets counters within the housekeeping telemetry
CFE_TIME_SetLeapSecondsCmd	Set Leap Seconds
CFE_TIME_SetMETCmd	Set Mission Elapsed Time
CFE_TIME_SetSignalCmd	Set Tone Signal Source
CFE_TIME_SetSourceCmd	Set Time Source
CFE_TIME_SetStateCmd	Set Time State
CFE_TIME_SetSTCFCmd	Set Spacecraft Time Correlation Factor
CFE_TIME_SetTimeCmd	Set Spacecraft Time
CFE_TIME_Sub1HZAdjustmentCmd	Subtract Delta from Spacecraft Time Correlation Factor each 1Hz
CFE_TIME_SubAdjustCmd	Subtract Delta from Spacecraft Time Correlation Factor
CFE_TIME_SubDelayCmd	Subtract Time from Tone Time Delay

Platform Configuration Parameters (1 of 3)



Platform Configuration Parameters (2 of 3)

Parameter	Purpose
CFE_PLATFORM_TIME_CFG_[SERVER/CLIENT]	Time Server or Time Client Selection
CFE_PLATFORM_TIME_CFG_BIGENDIAN	Time Tone In Big-Endian Order
CFE_PLATFORM_TIME_CFG_VIRTUAL	Local MET or Virtual MET Selection for Time Servers
CFE_PLATFORM_TIME_CFG_SIGNAL	Include or Exclude the Primary/Redundant Tone Selection Cmd
CFE_PLATFORM_TIME_CFG_SOURCE	Include or Exclude the Internal/External Time Source Selection Cmd
CFE_PLATFORM_TIME_CFG_SRC_[MET/GPS/TIME]	Choose the External Time Source for Server only
CFE_PLATFORM_TIME_MAX_DELTA_[SECS/SUBS]	Define the Max Delta Limits for Time Servers using an Ext Time Source
CFE_PLATFORM_TIME_MAX_LOCAL_[SECS/SUBS]	Define the Local Clock Rollover Value in seconds and subseconds
CFE_PLATFORM_TIME_CFG_TONE_LIMIT	Define Timing Limits From One Tone To The Next
CFE_PLATFORM_TIME_CFG_START_FLY	Define Time to Start Flywheel Since Last Tone
CFE_PLATFORM_TIME_CFG_LATCH_FLY	Define Periodic Time to Update Local Clock Tone Latch
CFE_PLATFORM_TIME_START_TASK_PRIORITY	Defines the cFE_TIME Task priority.
CFE_PLATFORM_TIME_TONE_TASK_PRIORITY	Defines the cFE_TIME Tone Task priority.
CFE_PLATFORM_TIME_1HZ_TASK_PRIORITY	Defines the cFE_TIME 1HZ Task priority.

Platform Configuration Parameters (3 of 3)

Parameter	Purpose
CFE_PLATFORM_TIME_START_TASK_STACK_SIZE	Defines the cFE_TIME Main Task Stack Size
CFE_PLATFORM_TIME_TONE_TASK_STACK_SIZE	Defines the cFE_TIME Tone Task Stack Size
CFE_PLATFORM_TIME_1HZ_TASK_STACK_SIZE	Defines the cFE_TIME 1HZ Task Stack Size

Mission Configuration Parameters

Parameter	Purpose
CFE_MISSION_TIME_CFG_DEFAULT_[TAI/UTC]	Select either UTC or TAI as the default (mission specific) time format.
CFE_MISSION_TIME_CFG_FAKE_TONE	Default Time Format
CFE_MISSION_TIME_AT_TONE_[WAS/WILL_BE]	Default Time and Tone Order
CFE_MISSION_TIME_MIN_ELAPSED	Min Time Elapsed
CFE_MISSION_TIME_MAX_ELAPSED	Max Time Elapsed
CFE_MISSION_TIME_DEF_MET_[SECS/SUBS]	Default Time Values
CFE_MISSION_TIME_DEF_STCF_[SECS/SUBS]	Default Time Values
CFE_MISSION_TIME_DEF_DELAY_[SECS/SUBS]	Default Time Values
CFE_MISSION_TIME_DEF_LEAPS	Default Time Values
CFE_MISSION_TIME_EPOCH_YEAR	Default ground time epoch values
CFE_MISSION_TIME_EPOCH_DAY	Default ground time epoch values
CFE_MISSION_TIME_EPOCH_HOUR	Default ground time epoch values
CFE_MISSION_TIME_EPOCH_MINUTE	Default ground time epoch values
CFE_MISSION_TIME_EPOCH_SECOND	Default ground time epoch values
CFE_MISSION_TIME_FS_FACTOR	Define the s/c vs file system time conversion constant

Time Services Exercises - 1

1. TODO: Investigate and stop synch message?

2. TODO