Build and Run cFS Tutorial

Objectives

- Describe Basecamp's core Flight System (cFS) build and runtime environments
- Introduce Application Specifications and describe how they are used in the build and runtime environments
- Application Specifications include Electronic Data Sheet (EDS) interface definitions and JSON application integration parameter definitions

Basecamp supports cFS application related activities and does not address porting the cFS to different processor/operating system platforms.

- https://github.com/cfs-tools/cfs-platform-list provides a list of community supported cFS ports

Lesson 1

Objectives

- Describe Basecamp’s build environment
- Introduce the startup and runtime environment

Important Host Platform Configurations (1 of 2)

1. **Set the host platform's memory endian setting in to match your processor's memory type ****

   – The configuration is in cfs-basecamp/cfe-eds-framework/basecamp_defs/eds/config.xml

   – `Set DATA_BYTE_ORDER to either "littleEndian" or "bigEndian"(default)` **

** There's a bug in Basecamp's version of the EDS Toolchain that causes issues with cFE file header reads/writes. Big endian seems to work even on little endian Intel machines so big endian is the default. See Basecamp issue #121.

Important Host Platform Configurations (2 of 2)

2. **Set whether the cFS runs in privilege mode****

   – The configuration settings are is in cfs-basecamp/gnd-sys/app/basecamp.ini
   - `In [CFS_TARGET] section set SUDO_START_CFS to True or False(default)`
   - `In [APP] section set PASSWORD = <your Linux user account password>; only required if SUDO_START_CFS is set to True`

** See Build and Run the cFS Lesson 2 for details .

Key cFS Build Directories

- Below are some of the important top-level directories and files used when building the cFS
  - Other directories and files will be introduced as needed

```
cfs-basecamp
├-apps/  . . . . . . . . .  Preinstalled Basecamp apps that provide essential functionality
├-cfe-eds-framework/
│ ├-apps/  . . . . . . . .  cfe-eds 'lab' apps, all but Command Ingest are replaced by Basecamp apps
│ ├-build/ . . . . . . . .  Output directory containing the artifacts produced by the build process
│ ├-cfe/ . . . . . . . . .  core Flight Executive, includes Electronic Data (EDS) Sheet base type definitions
│ ├-basecamp_defs/ . . . .  Top-level cmake files that define the cFS target
│ │ └-eds/ . . . . . . . .  EDS configurations and Topic ID definitions
│ ├-libs/
│ ├-osal/
│ ├-psp/
│ └-tools/ . . . . . . . .  Electronic Data Sheet build tools
└-usr/
  └-apps/  . . . . . . . .  User apps added to Basecamp
```

Key Build Files

```
cfs-basecamp
├-apps/
├-cfe-eds-framework/
│  ├-apps/
│  ├-build/
│  │  ├- exe/cpu1/core-cpu1 . . . . . .  Core Flight Executive (cFE) executable
│  │  └- exe/cpu1/cf/*.*  . . . . . . .  "Compact Flash (CF)" contains app/lib object files, app default table files
│  ├-cfe/
│  ├-basecamp_defs/
│  │  ├-global_build_options.cmake  . .  Defines app source search path
│  │  ├-mission_build_custom.cmake  . .  Defines compiler options
│  │  ├-targets.cmake   . . . . . . . .  Defines the target name cpu1, the apps/libs in the cpu1 target, and
│  │  │                                  files to copy from basecamp_defs/ to build/exe/cpu1/cf/
│  │  └-cpu1_cfe_es_startup.scr . . . .  Defines the apps/libs that are loaded when core-cpu1 runs
│  ├-libs/
│  ├-Makefile  . . . . . . . . . . . .  Controls the build process; GNU-make wrapper that calls the CMake tools
│  ├-osal/
│  ├-psp/
│  └-tools/
└-usr/
   └-apps/
```

There are multiple Electronic Data Sheet files used during the build process that are described in Lesson 2

Cmake Structure

cFS Mission

- Top-level context/scope that includes everything that is being built
- Includes development tools (not crossed compiled) that are built within this context
- Includes one or more cFS "**target**" CPUs that are built using an architectural (**"arch")** specification

basecamp_defs/targets.cmake

- Defines one or more cFS targets that is identified as cpu1, cpu2, etc.
- Each target is built using an "arch" cmake specification
- See targets.cmake file prologue comments for more information
- Basecamp defaults to cpu1 being built for a Linux platform

Custom cmake configurations in basecamp_defs directory:

- The following files allow you to call "add_compile_options" or "add_definitions" as necessary for your use case
    - global_build_options.cmake
    - mission_build_custom.cmake
    - arch_build_custom.cmake
- The difference is scope - global applies globally, mission applies only to mission (host) build, and arch applies only to target build. The latter can also be broken down per-arch.

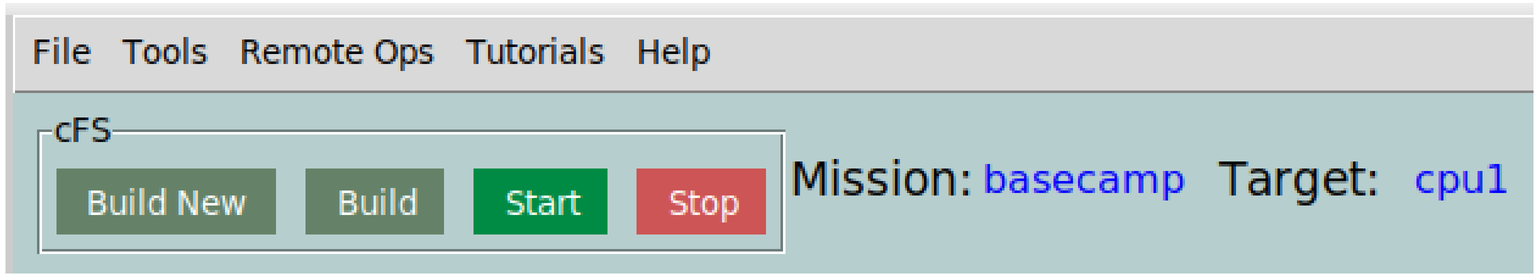
cfe-eds-framework/Makefile

- Single access point to manage build process
- Basecamp's custom "**topicids**" make target runs a tool to resolve EDS Topic IDs in app initialization JSON file (described in lesson 2)

Basecamp’s target.cmake

- **Target.cmake defines configurations for a mission’s cFS targets**
- **Basecamp defines one mission with a single target using the following commands and these names are shown on the main window**

```
SET(MISSION_NAME “Basecamp")
SET(MISSION_CPUNAMES cpu1)
```



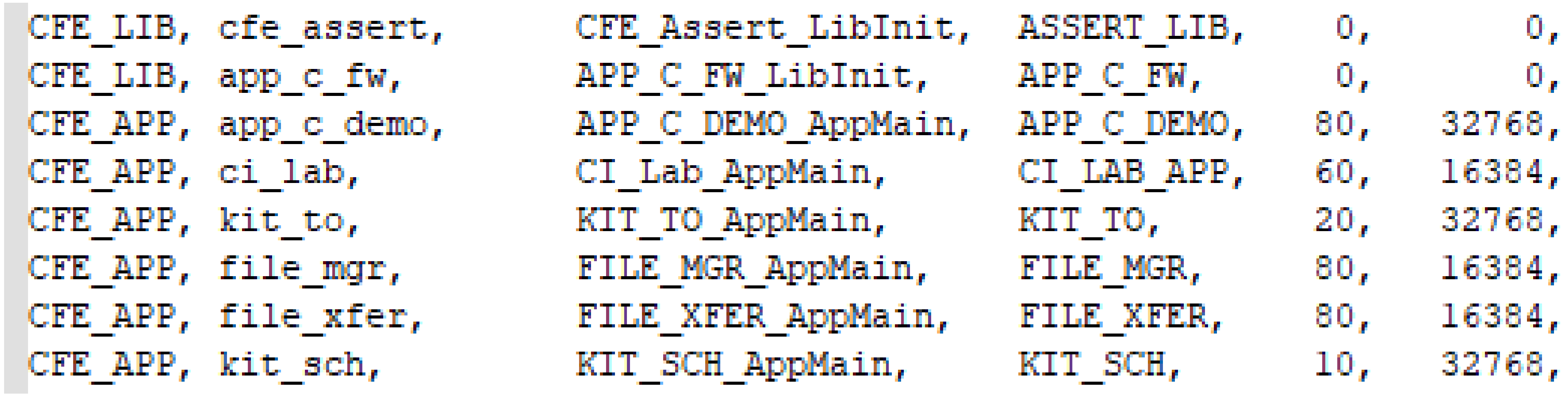
- **The following configurations define Basecamp’s cpu1 target contents**

```
list(APPEND MISSION_GLOBAL_APPLIST app_c_fw)
SET(cpu1_APPLIST ci_lab kit_to kit_sch file_mgr file_xfer app_c_demo)
SET(cpu1_FILELIST cfe_es_startup.scr file_mgr_ini.json file_xfer_ini.json . . .
```

- The term ‘app’ refers to both libraries and applications
- Basecamp’s application framework, app_c_fw, is defined globally so it is accessible to all targets if new targets are added
- New libraries and applications are added to *cpu1_APPLIST*
- *cpu1_FILELIST* defines which files are copied from the basecamp_defs directory to the build/exe/cpu1/cf

cfe_es_startup.scr

- cfe_es_startup.scr defines which libraries and apps are loaded during initialization
- The filename in basecamp_defs is cpu1_cfe_es_startup.scr to associate it with target cpu1 and the cpu1_ prefix is removed when the file is copied to the build/exe/cf directory



Object Type	Path/Filename	Entry Symbol	cFE Name	Priority	Stack Size
CFE_LIB,	cfe_assert,	CFE_Assert_LibInit,	ASSERT_LIB,	0,	0,
CFE_LIB,	app_c_fw,	APP_C_FW_LibInit,	APP_C_FW,	0,	0,
CFE_APP,	app_c_demo,	APP_C_DEMO_AppMain,	APP_C_DEMO,	80,	32768,
CFE_APP,	ci_lab,	CI_Lab_AppMain,	CI_LAB_APP,	60,	16384,
CFE_APP,	kit_to,	KIT_TO_AppMain,	KIT_TO,	20,	32768,
CFE_APP,	file_mgr,	FILE_MGR_AppMain,	FILE_MGR,	80,	16384,
CFE_APP,	file_xfer,	FILE_XFER_AppMain,	FILE_XFER,	80,	16384,
CFE_APP,	kit_sch,	KIT_SCH_AppMain,	KIT_SCH,	10,	32768,

- On a Linux system the core Flight Executive executes as a process and each app is a thread

Runtime Applications

- Basecamp's **Scheduler** and **Telemetry Output** apps provide functionality that support apps to run as part of a cFS target
- The Scheduler app send messages on the Software Bus at fixed intervals to signal apps to perform a particular function
- Telemetry Output receives messages from the Software Bus and sends them to an external destination
- The Basecamp Application Developer's Guide and each app's documentation provide complete details on these two app's tables

Scheduler App Tables

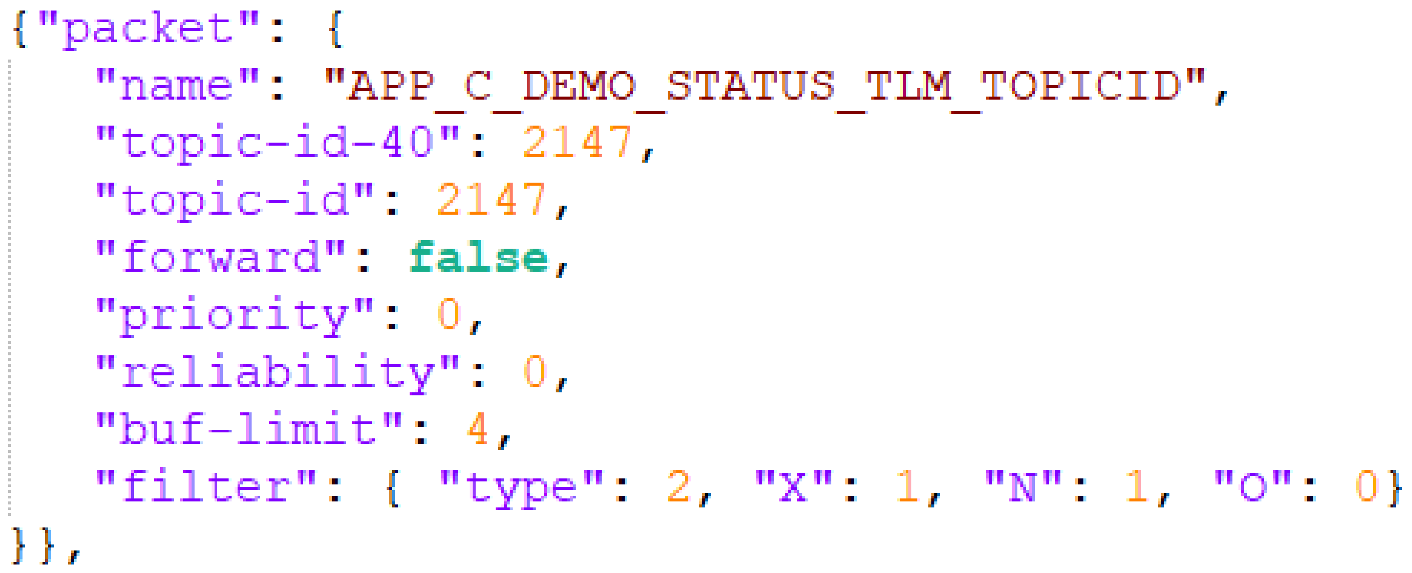
- **The kit scheduler (KIT_SCH) app uses a scheduler table defined in cpu1_kit_sch_schtbl.json to determine when to send messages on the software bus**
- **Apps use these messages to perform periodic functions**
  - Apps are not required to use KIT_SCH
  - An app's JSON initialization table defines which messages (EDS topic IDs) are used by the app (Details in Lesson 2)
- **Basecamp's default scheduler table divides a second into four 250ms slots and each slot can have up to 15 messages sent**
- **The following periodic messages are provided by Basecamp and available for apps to use**
  - BC_SCH_1_HZ_TOPICID
  - BC_SCH_2_HZ_TOPICID
  - BC_SCH_4_HZ_TOPICID
  - BC_SCH_2_SEC_TOPICID
  - BC_SCH_4_SEC_TOPICID
  - BC_SCH_8_SEC_TOPICID

Telemetry Output Table

- **The kit telemetry output (KIT_TO) app uses a packet filter table defined in cpu1_kit_so_pkt_tbl.json to determine which telemetry messages are read from the software bus and sent to an external systems over a UDP port**

- **Apps define telemetry message topic IDs in their EDS definitions**

- **AP_C_DEMO's status telemetry packet definition** (See Basecamp Application Developer's Guide for details)



```
{"packet": {
   "name": "APP_C_DEMO_STATUS_TLM_TOPICID",
   "topic-id-40": 2147,
   "topic-id": 2147,
   "forward": false,
   "priority": 0,
   "reliability": 0,
   "buf-limit": 4,
   "filter": { "type": 2, "X": 1, "N": 1, "O": 0}
}},
```