Advanced Exploration Systems (AES)
Core Flight Software (CFS) Project

- CFS Product Highlights
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CFS Product Highlights

• **Generic Command Ingest (CI) & Telemetry Output (TO) CFS applications**
  – Can be easily expanded and customized
  – Supports multiple channels
  – Supports multiple communication protocols: UDP, TCP & RS-422
  – Supports CCSDS Space-Data Link Protocols: TM-SDLP, TC-SDLP, COP-1
  – Works with CFDP (CF) application to do CFDP file transfers

• **Time-triggered scheduler (SCH_TT) CFS application**
  – Uses TTE network scheduling for scheduling messages
CFS Product Highlights (cont.)

- **Software Bus Network (SBN) CFS application**
  - A collaborative work with Ames Research Center (ARC)
  - Serves as a data bridge between cFS systems
  - Makes distributed network of cFS systems possible
  - Supports multiple communication protocols: UDP, TCP, serial

- **Protobetter tool**
  - Generates code for serializing/de-serializing CCSDS messages for transmission across the network
  - Generated code is compiled into its own CFS library
  - Works with CDD databases to access message definitions
  - Can run stand-alone if given message definitions
  - Is used by the SBN application, and eventually CI & TO applications
• **Command & Data Dictionary (CDD) Tool**
  – Is used to define system command & data definitions
  – Information is stored in a relational database, PostgreSQL
  – Provides a set of APIs for users to access the data via scripts
  – Provides a set of standard scripts that can be customized to generate output files like C headers, XTCE files, copy tables for HK application, and eventually, scheduling tables for SCH application.
  – Available at https://github.com/nasa/CCDD

• **CFS-101 Training**
  – A self-guided training package
  – Comes with a virtual machine as the tutorial workspace & a step-by-step tutorial guide
  – The virtual machine is equipped with the latest CFE, OSAL & PSP from https://sourceforge.net and all the necessary CentOS libraries.
  – Available at https://github.com/nasa/CFS-101
• **Orion Multi-Purpose Crewed Vehicle (MPCV)**
  – Class A, safety-critical FSW
  – Vision Processing Unit (VPU) Flight Computer
    • VxWorks on Leon3 SPARC processor
    • Backup Flight System (BFS) apps
  – Camera Controller Units
    • Ubuntu Linux on I5 Intel processor
    • Optical Navigation (OpNav) app

• **Orion Ascent & Abort 2 (AA2) Flight Test (May 2019)**
  – Class B, safety-critical FSW
  – VxWorks on SP0 PPC processors
• Advanced Extra-vehicular Mobility Unit (xEMU) Flight Experiment – Caution & Warning System (CWS)
  – Class A, safety-critical FSW
  – VxWorks on Leon3 SPARC processor
  – An advanced space suit

• Seeker Flight Experiment on ISS (July 2019)
  – Class C, non-safety-critical FSW
  – Wumbo GNU/Linux on CHREC space processor
  – An external, free-flying robotic inspector

• Certification of cFE on VxWorks ARINC-653
  – Class A, safety-critical FSW
  – VxWorks ARINC-653 on SP0 processor

• Avionics & Software Platform for Exploration Capabilities & Technologies (ASPECT) as ISS payload
  – Class C, non-safety-critical FSW
  – VxWorks on SP0-S processors
CFS Projects @ JSC (cont.)

- **AES integrated testing project**
  - A&S platforms for multi-center collaborations to integrate autonomous systems & operations in a distributed run-time environment

- **Next Space Technologies for Exploration Partnerships (NextSTEP) program**
  - Seeks commercial development of deep space exploration capabilities
  - Assists private companies in applying NASA-invested technologies to develop their capabilities
From SW development perspective,

- **Having a common SW framework increases SW productivity**
  - Modular application code with the same “look-n-feel”
    - Same code template
    - Same naming conventions
      - File names, function names, message ID names, command code names
    - Same build template
    - Same source directories
  - Minimal time to stand up an initial running system from scratch before any mission-specific capabilities are implemented
    - SW re-use actually works and with minimal effort!
  - Quicker to get up to speed with the new project for CFS-experienced developers, even when joining at a later phase of the development life cycle
    - Already familiar with the code setup
    - Can detect & fix application bugs in shorter time
    - Know where to look
  - Easier to pre-train newbies to become CFS-proficient before they join the project
Upshots of SW Development with CFS (cont.)

From SW development perspective (cont.),

• **Collaborations within the CFS user community**
  
  – Enable tool & code sharing
    • Increase the level of SW re-use at minimal cost
    • Open source SW makes this possible
  
  – Dissemination of lessons learned & best practices
    • The TODOs and the NOT-TODOs
    • Minimize development risks
  
  – Provide leverage for future projects with current & past projects
    • Emulate the existing system HW/SW configurations or tweak it to suit the new missions' needs
From project management perspective,

- **Making use of high quality flight software**
  - CFS has its pedigree in flight software!
    - CFS has been tested, certified & flown in space in numerous HW/SW configurations.

- **Better grip on SW development schedule & risk mitigation**
  - Using metrics, lessons learned & best practices from other CFS projects to help planning for new CFS projects

- **Increase in management buy-ins on new SW projects that use CFS framework**
  - Costs & schedules of past & current CFS projects show the productivity, benefits & effectiveness of the paradigm
  - Increasing number of CFS projects that are at various level of certifications