



NASA's Software Architecture Review Board's (SARB) Findings from the Review of GSFC's "core Flight Executive/Core Flight Software" (cFE/CFS)

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NASA Software Architecture Review Board

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Background

Software Architecture Review Board

- SARB established in 2009 based on recommendation from FSW Complexity study to Office of Chief Engineer
- Funded as a NESC technical discipline team by Michael Aguilar
- Several reviews conducted, varying in duration and depth
- SARB Reviewed GSFC's cFE/CFS in October 2011
 - Reviewers: Michael Aguilar (NESC, NASA Software Tech Fellow), Dan Dvorak (JPL, SARB Lead), Lorraine Fesq (JPL, review chair), Robyn Lutz (Iowa State University) – Product Line expert, Michael Madden (LaRC), Pedro Martinez (JSC), Alex Murray (JPL), John Weir (MSFC), Steve Williams (APL)

SARB's website is a sub-Community of the Software Engineering Community of Practice

<https://nen.nasa.gov/web/software/sarb>

The screenshot shows the NASA Engineering Network website. At the top, there is a navigation bar with links for Sign In, Support, Feedback, Site Map, and About. Below this is a header with the NASA Engineering Network logo and a search bar. The main content area is titled "SOFTWARE ARCHITECTURE REVIEW BOARD" and includes a breadcrumb trail: Software Engineering » Software Architecture Review Board. On the left, there is a sidebar with "EXPLORE THE SUBCOMMUNITY" and links for Sub-Community Home, Conferences and Events, Contact List, Lessons Learned, Preparation for Review, Reading Room, Sample Architectures and Reviews, Forums, and FAQ. The main content area features "Upcoming SARB Reviews" by Lorraine Fesq at JPL, 10/20/11, listing reviews for Solar Probe Plus (SPP) Mission Definition Review (MDR) and Core Flight System (CFS)/core Flight Executive (cFE). Below this is a "TOP STORIES" section with announcements for IEEE Aerospace Conference, SEI Architecture Technology User Network (SATURN) 2011 Conference, and CNN Names Software Architect as Best Job. On the right, there is a "WELCOME" section with a photo of Dan Dvorak and a message from the SARB community. At the bottom, there is a "COMMUNITY LINKS" section with icons and text for Conferences and Events, Reading Room, Contact List, Sample Architectures and Reviews, Lessons Learned, Forums, Preparation for Review, and FAQ.

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Upcoming SARB Reviews

By Lorraine Fesq at JPL, 10/20/11

Upcoming SARB Reviews


- Solar Probe Plus (SPP) Mission Definition Review (MDR) (November 1-3 at APL)
- Core Flight System (CFS)/core Flight Executive (cFE) review (Delayed at TBA)
- [+ Read More](#)

TOP STORIES: ALL ANNOUNCEMENTS

- Call for Papers: IEEE Aerospace Conference, Collaborative Model-Driven Aerospace Engineering - 5/27/11
- SEI Architecture Technology User Network (SATURN) 2011 Conference - 3/3/11
- CNN Names Software Architect as Best Job - 1/19/11

WELCOME

Welcome to the Software Architecture Review Board (SARB) community! SARB is a NASA-wide board that engages with flight projects in the formative stages of software architecture. The objectives of SARB are to manage and/or reduce flight software complexity through better software architecture and help improve mission software reliability and save costs.











[SARB Charter](#)

[Why Review Software Architecture?](#)

Lead: Dan Dvorak (Bio)
Facilitator: Daria Topousis

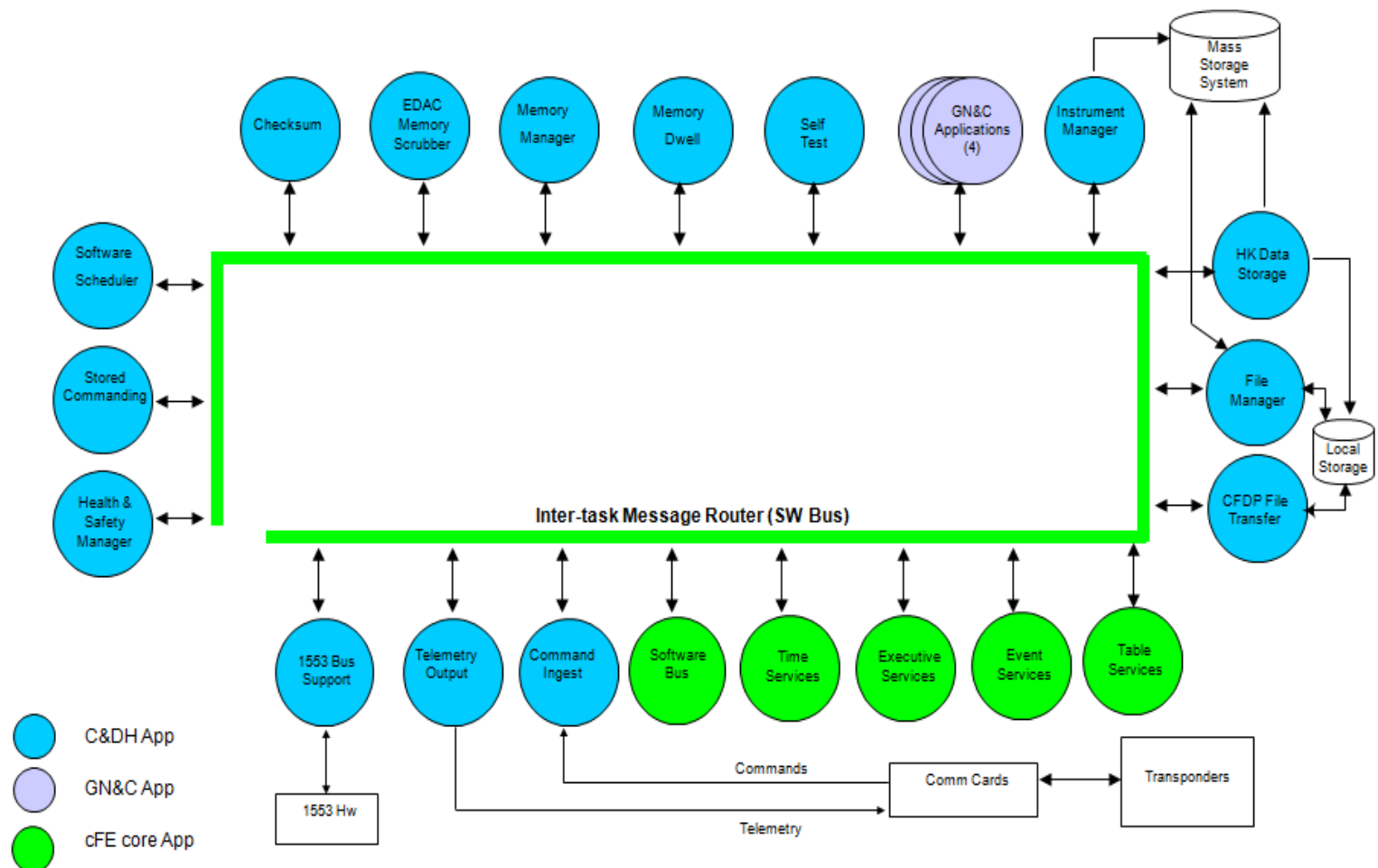
COMMUNITY LINKS

-  **Conferences and Events**
Software architecture conferences
-  **Reading Room**
SARB Reading Room
-  **Contact List**
SARB Contacts
-  **Sample Architectures and Reviews**
SARB Sample Architectures and Reviews
-  **Lessons Learned**
Software architecture lessons (coming soon)
-  **Forums**
Discuss software architecture
-  **Preparation for Review**
Supporting materials for architecture reviews
-  **FAQ**
Frequently asked questions

cFE/CFS Background

- Developed by GSFC Flight Software Systems Branch in response to growing costs and schedule for SW development due to increasing system complexity
- Project-independent FSW provides run-time environment and services for hosting applications
- Targeted for Class B FSW for Robotic s/c and instruments
- Domain: C&DH, GN&C, thermal, power, instrument control
- Users: ARC/LADEE, JSC/Morpheus, APL/RBSP

cFE/CFS Diagram



“Lollipop” Diagram shows cFE core applications and software bus (green), plus CFS applications that plug into the bus (blue and purple).

Review Objectives & Focus

- Objectives:
 - Help project identify architectural issues that may have been overlooked
 - Recommend actions to minimize downstream problems
- Focus on software *architecture*
 - not detailed design, not code, not avionics
- Engineering peer review
 - Tabletop review style, not primarily presentations to board
- Report:
 - Board report finalized January 2012
 - Report restricted to GSFC 582 management unless they permit broader release

Findings

- Well thought-out, perhaps partly due to systems engineers and FSW engineers in same organization, promoting collaboration
- Four categories of findings
 - Governance
 - Use on Projects
 - Architecture
 - Documentation

Findings: Governance

Meets a need across NASA, used by several projects at multiple Centers

- Has potential to become a dominant architecture framework for NASA FSW
- Lacks a business model - requires formal support for full benefit of product line to be realized

Findings: Use on Projects

Users at Multiple Centers were interviewed

- Technology viewed as mature – easy to build and test
- Promotes collaboration across Centers
- Code violates some standards
- Applications outside of original scope likely will require enhancements
- Could provide valuable training for pipelineing students – open-source availability

Findings: Architecture

Highly regarded by the Board

- Development guidelines for app layer exert a positive influence on architecture
- Use of pub/sub SW bus
 - allows for distributed development and easy integration
 - Well-encapsulated apps improve abstraction, flexibility, reuse, division of concerns
 - Could result in non-deterministic/non-repeatable execution

Findings: Architecture – cont.

- Modular components, well-defined I/Fs
- cFE shields apps from data structure formats
- OSAL allows easy use of different Operating Systems
- cFE can be used Stand-alone
- Message queue overflow handling
 - Drops newer messages
 - Subscriber not notified
- Seconds and sub-seconds derived from different sources, which could lead to timing issues

Findings: Documentation

SARB often find that the documentation doesn't describe all the key aspects that future users ought to know. Utility/longevity limited by quality, depth, maintenance of architectural description

- ADD incomplete
- ADD uses ad-hoc graphical notation
- Discrepancies in representation and terminology
- Document what has been used on projects
- ADD does not identify required vs optional cFE components

Findings: Documentation – cont.

- Distinction between cFE and CFS components not clear in ADD
- Need view of connections between publishers and subscribers
- Need description of dependencies among source packages
- Need rationales for design decision and underlying assumptions
- Need testing guidelines
- Conceived to meet GSFC's Earth-orbiter needs; no insight into architectural influences/limitations

Findings: Documentation – cont.

- QoS attributes not well documented
- Need guidance for complex, FT, autonomous control systems
- Need definition of FM philosophy – Limit Checker meets EO needs
- Need start-up procedures
- Need expanded time-services description
- Provide info to configure, execute, analyze performance data
- Document/analyze flight/ground division

Conclusions/Summary

- cFE/CFS Architecture highly regarded by the SARB
- Well-thought out – much potential
- Needs improved documentation
- Needs Governance and support to reach full potential
- Users outside of EO community should proceed with caution

Epilogue

- GSFC division management views the SARB review as value added and is executing a plan to address the SARB findings
- cFE/CFS use outside of EO has expanded after the SARB review – JSC Class A effort, APL use on DoD missions, GRC, KSC, KARI Lunar Lander
- cFE/CFS support for multicore, distributed, and partitioned systems in development
 - Prototyping has shown that these systems can be supported by the architecture
- Governance model remains undefined, but is currently being addressed
- For more information, contact Jonathan Wilmot -- 301-286-2623, Jonathan.J.Wilmot@NASA.gov