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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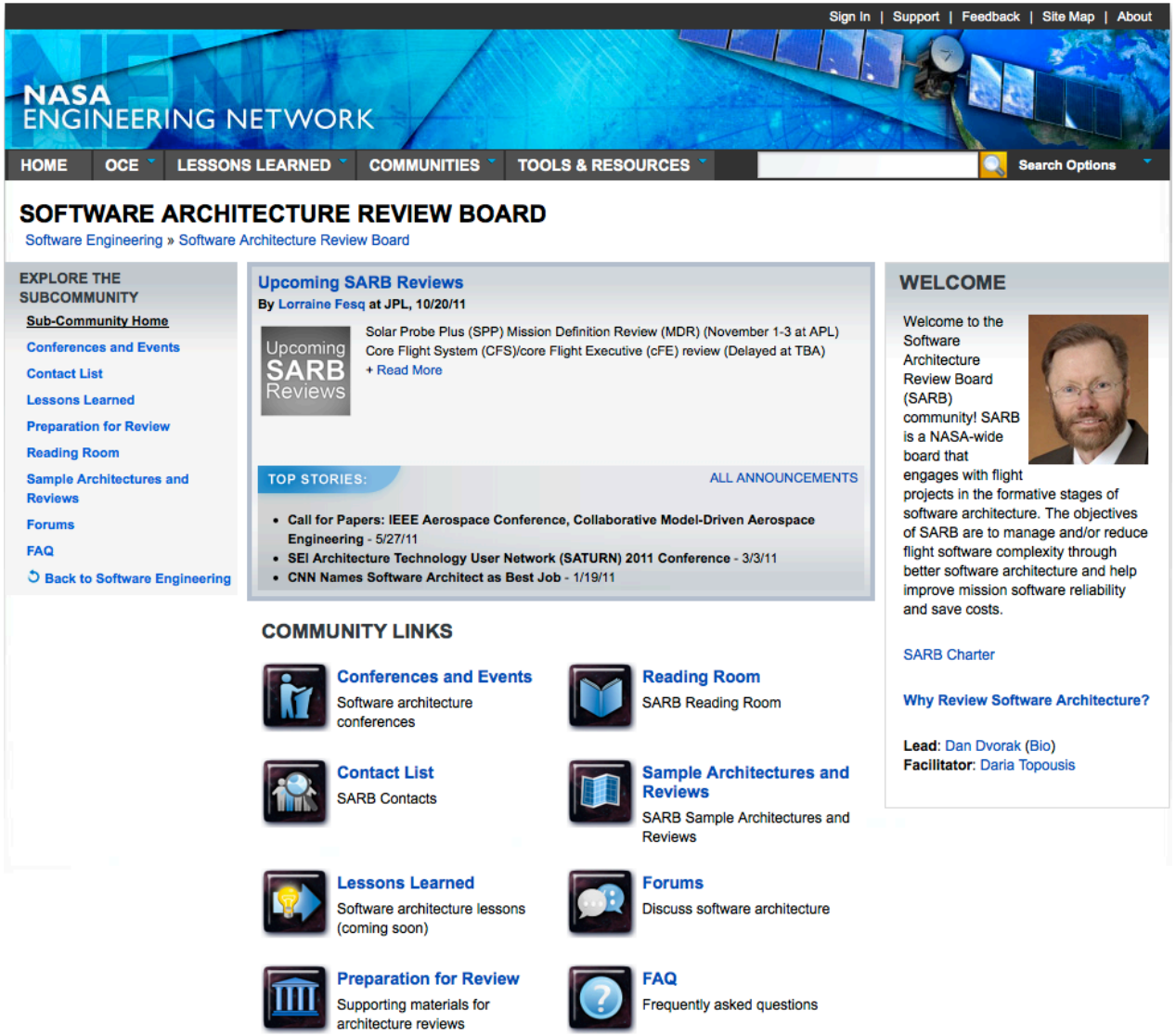
Background

Software Architecture Review Board

- SARB establish 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

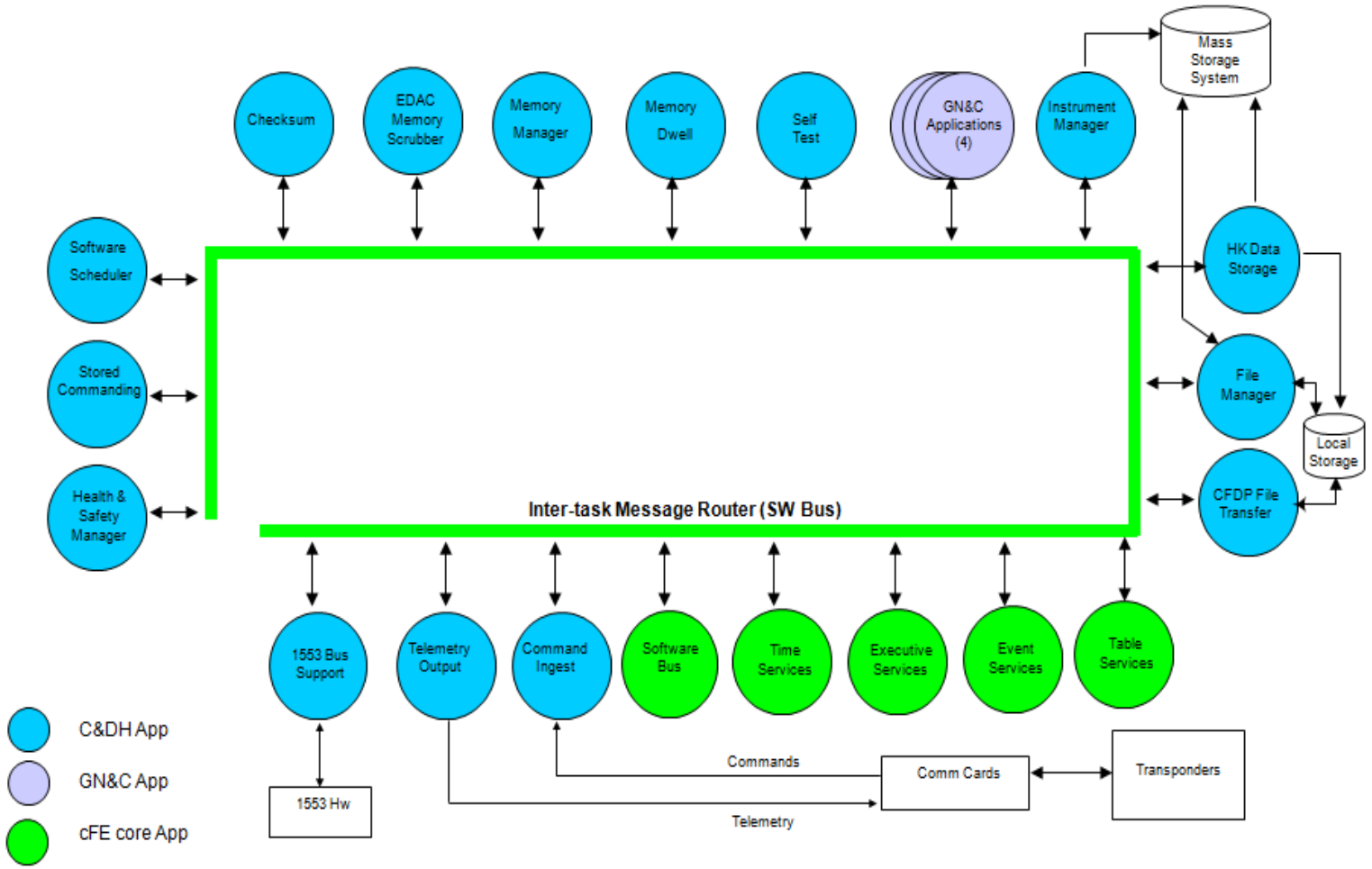
https://nen.nasa.gov/web/software/sarb



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
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