# Combinatorial Optimization of Unit Tests in NASA's Core Flight System (cFS)

Dimitris E. Simos, Manuel Leithner, William M. Stanton, Rick Kuhn, Raghu Kacker

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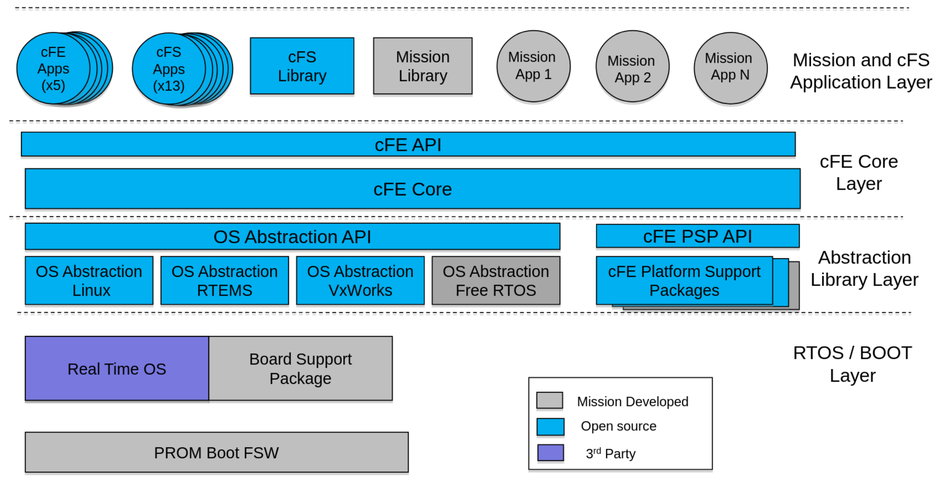
## NASA Core Flight System (cFS)

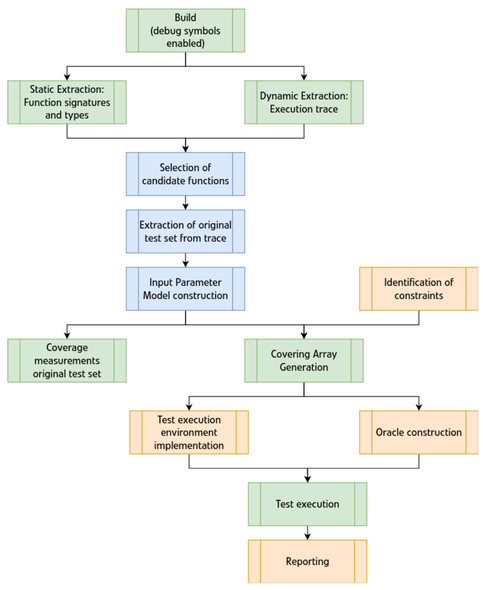
- Common software for spaceflight missions.
- Focus on mission-specific applications instead of reinventing the wheel.
- Layered architecture allows development on desktop systems and later integration on actual flight hardware.
- Provides unit tests for cFS.
- Mission-specific apps supply their own tests.

### Research Questions

- How much combinatorial coverage do current tests provide?
- Can we add Covering Arrays to improve it?




## Workflow




- Extract function signatures and execution trace using `gdb`.
- Create Input Parameter Model from signatures, traces and constants.
- Measure combinatorial coverage using `CAmetrics`.
- Create Covering Array from Input Parameter Model using `CAgen`.

### Additional Variations

- Covering Arrays that extend existing tests.
- Input Structure Model based on manual partitioning.
- Combined model for `CFE_SB_SubscribeFull()` and `CFE_SB_UnsubscribeFull()`.

### Next Steps

- Identify additional constraints.
- Construct oracle and test bed.
- Execute tests as part of continuous integration.

## Figures

```
Test_Subscribe_API ()
  Test_Subscribe_SubscribeEx ()
    SB_ResetUnitTest ()
    CFE_SB_CreatePipe (PipeIdPtr = 0x7fffffffd8f3 "", Depth = 10, PipeName = 0x55555559a3c9 "TestPipe")
    CFE_SB_SubscribeEx (MsgId = 6145, PipeId = 0 '\000', Quality = {Priority = 0 '\000', Reliability = 0 '\000'}, MsgLim = 8)
    UT_GetNumEventsSent ()
    UT_EventIsInHistory (EventIDToSearchFor = 5)
```

*Figure 1:* Excerpt of execution trace


*Figure 2:* Coverage of (a) existing unit tests, (b) generated $\boldsymbol{MCA}(19596; 3, 6, \{272, 18, 3, 2, 4, 3\})$ for `CFE_SB_SubscribeFull()` function

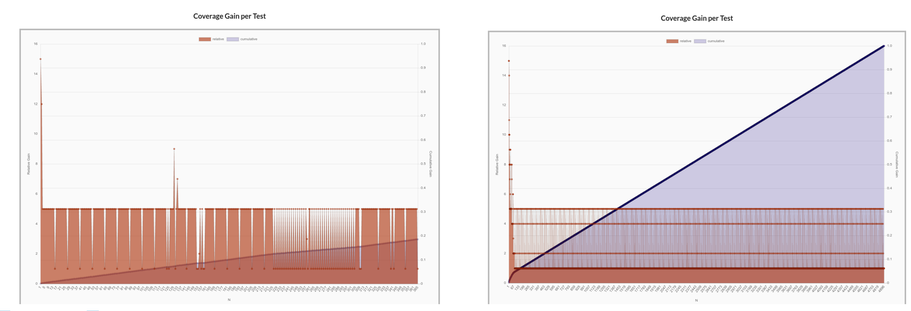



*Figure 3:* Per-test and cumulative coverage of (a) existing unit tests, (b) generated $\boldsymbol{MCA}(19596; 3, 6, \{272, 18, 3, 2, 4, 3\})$ for `CFE_SB_SubscribeFull()` function

## Conclusion

### Summary

- Model extraction of unit tests feasible with dynamic analysis.
- Existing unit tests do not provide much combinatorial coverage.
- Combination of unit and combinatorial testing yields high assurance.

### Challenges

- Unit tests may not use defined values.
- Identifying constraints requires domain knowledge.
- Testbed and oracle necessary for execution.

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