Applying F Prime Flight Software Framework for Lunar Flashlight and Near-Earth Asteroid (NEA) Scout CubeSats

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What is F’?

- F’ facilitates the development of software for embedded applications.

- The Product Line consists of several elements:
  - An architectural approach that decomposes an embedded software system into discrete components with well-defined interfaces that communicate over ports interconnected in a topology
  - A C++ framework that provides basic features such as message queues, threading and an OS abstraction layer
  - A suite of tools for specifying components and their connections and automatically generating a partial implementation from the specification
  - A growing collection of generic components for basic features such as command dispatch, event logging, and memory management that can be incorporated without modification into new software projects
  - A suite of tools for testing software at the unit and integration levels

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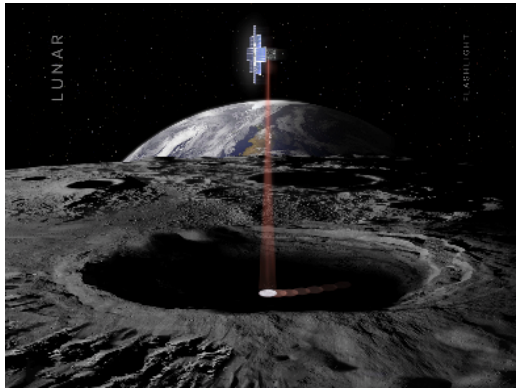
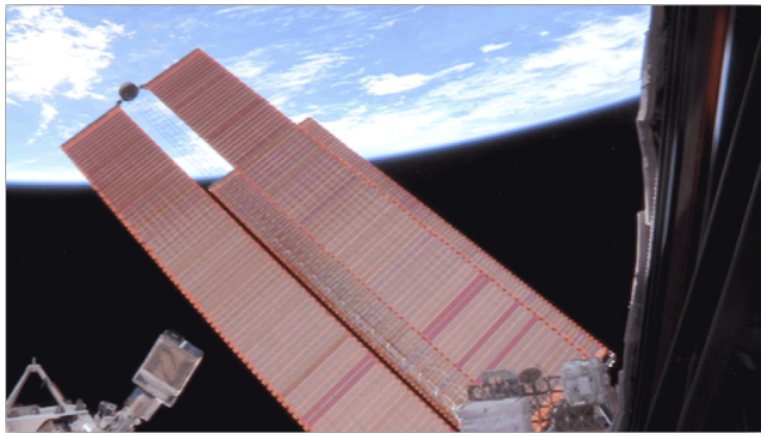
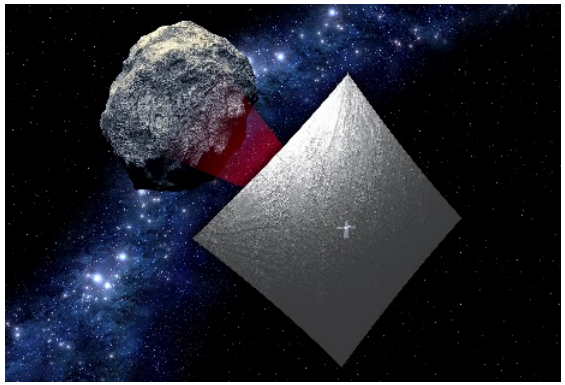
Where is it being used?

- Developed under a JPL technology exploration task (2013)
- Flown on RapidScat – radar scattermometer on ISS (2014-2016)
- Baselined flight software deployments in development for:
  - Mars Helicopter Technology Development
  - Lunar Flashlight (Cubesat)
  - Near Earth Asteroid Scout (Cubesat)
  - Autonomy R&TD task

- Currently in operations on the Asteria Cubesat (Deployed Nov 20, 2017)







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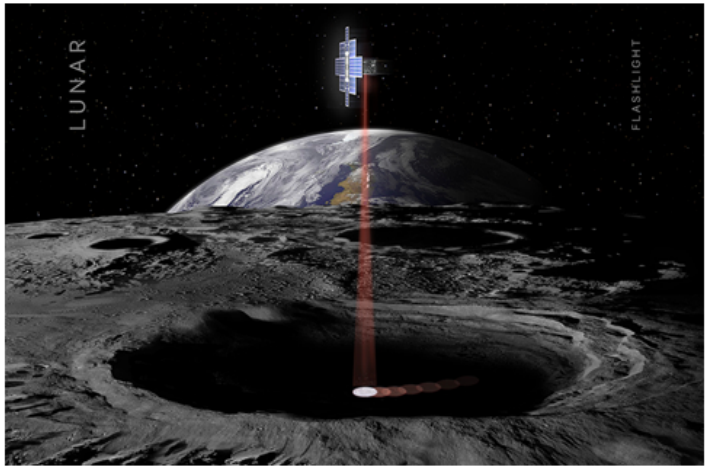
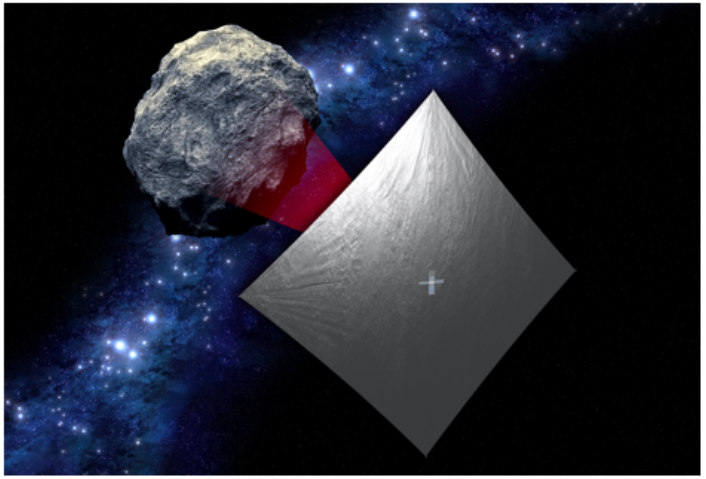
Lunar Flashlight and Near Earth Asteroid (NEA) Scout Missions



Lunar Flashlight

- 6U cubesat mission to explore, locate and estimate size and composition of ice deposits on the Moon
- Lunar polar orbit
- Uses lasers and spectrometer to measure surface reflection and composition



NEA Scout

- 6U cubesat mission to fly by and return data from an asteroid representative of NEAs that may one day be human destinations.
- Robotic reconnaissance mission
- Uses a science-grade multispectral camera for imaging

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2 Missions 1 Team

- Lunar Flashlight and NEA Scout are 2 separate deep space missions
- 1 FSW development team (2-3 developers for majority of the development timeline)
- Aggressive schedule
- Little margin for bug fixes and errors
- Leverage existing software proven to work
- Work as a single team to deliver multiple deployments rather than working as separate teams on different missions

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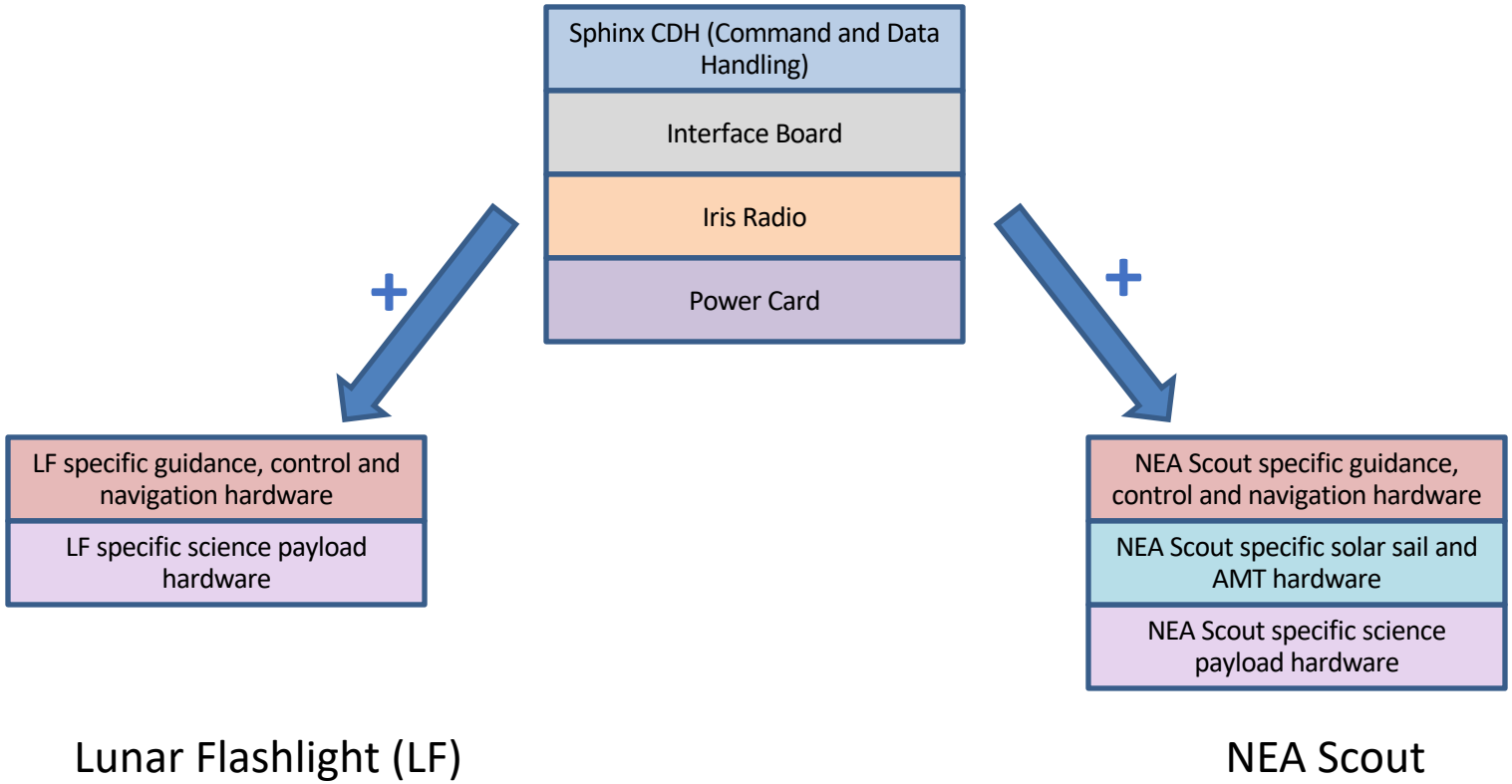
Hardware Configurations



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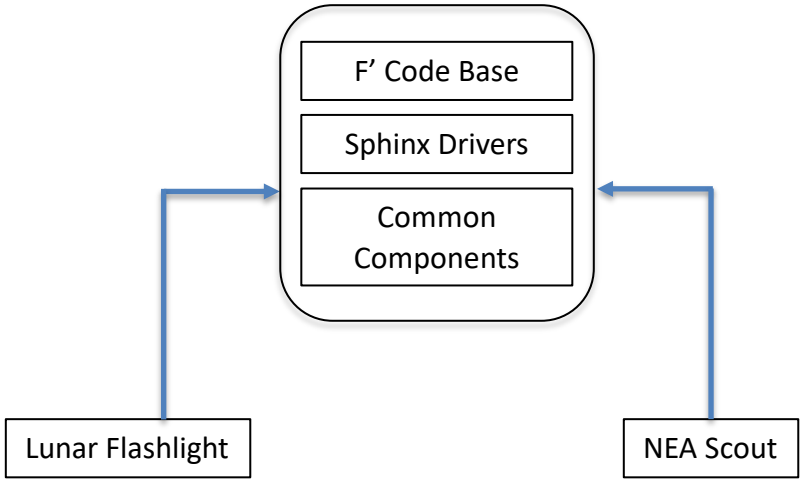
Software Deployments and Code Re-Use



- Code base shared across multiple deployments
  - Lunar Flashlight deployment
  - NEA Scout deployment

- Software reusability and modularity at the component level
  - Inherited components from ASTERIA

- Components developed for Lunar Flashlight and NEA Scout deployments can be re-used for other mission deployments
  - Adds to F' component library

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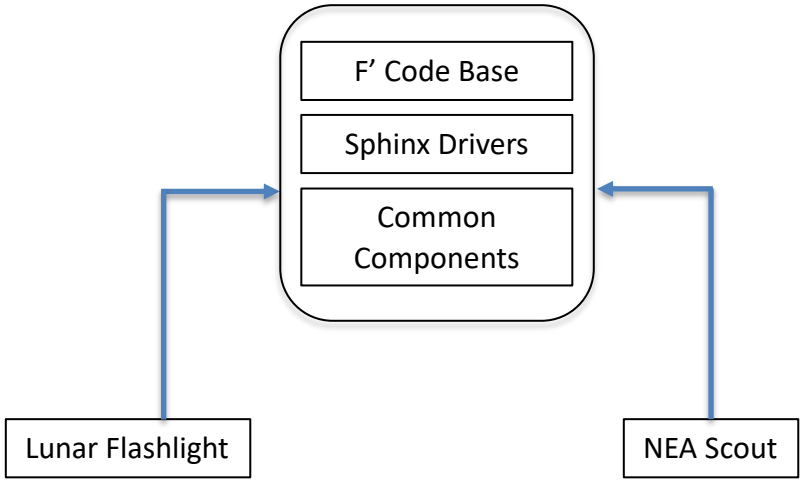
Software Metrics



	Hand	AC	XML	Total
Common	63,627	173,224	8,167	245,018
Lunar Flashlight	18,949	49,132	1,174	69,255
NEA Scout	55,227	68,376	3,274	126,877
NEA Scout (excl. delivered software for G&C and science)	33,125	65,524	3,241	101,890

Lunar Flashlight and NEA Scout FSW have 59% identical developed code base

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F’ Tools for Rapid Development

- Component Modeling
  - Formal specification in XML that can be auto-generated
- Component Auto-coding
  - F’ auto-coding tools generate component base classes and interfaces
- Deployment Modeling
  - Component ports can be connected to form a topology
  - F’ auto-coding tools generate base application code
- Testing
  - Unit test framework
  - Allows for random scenario based testing
  - Integrated testing framework

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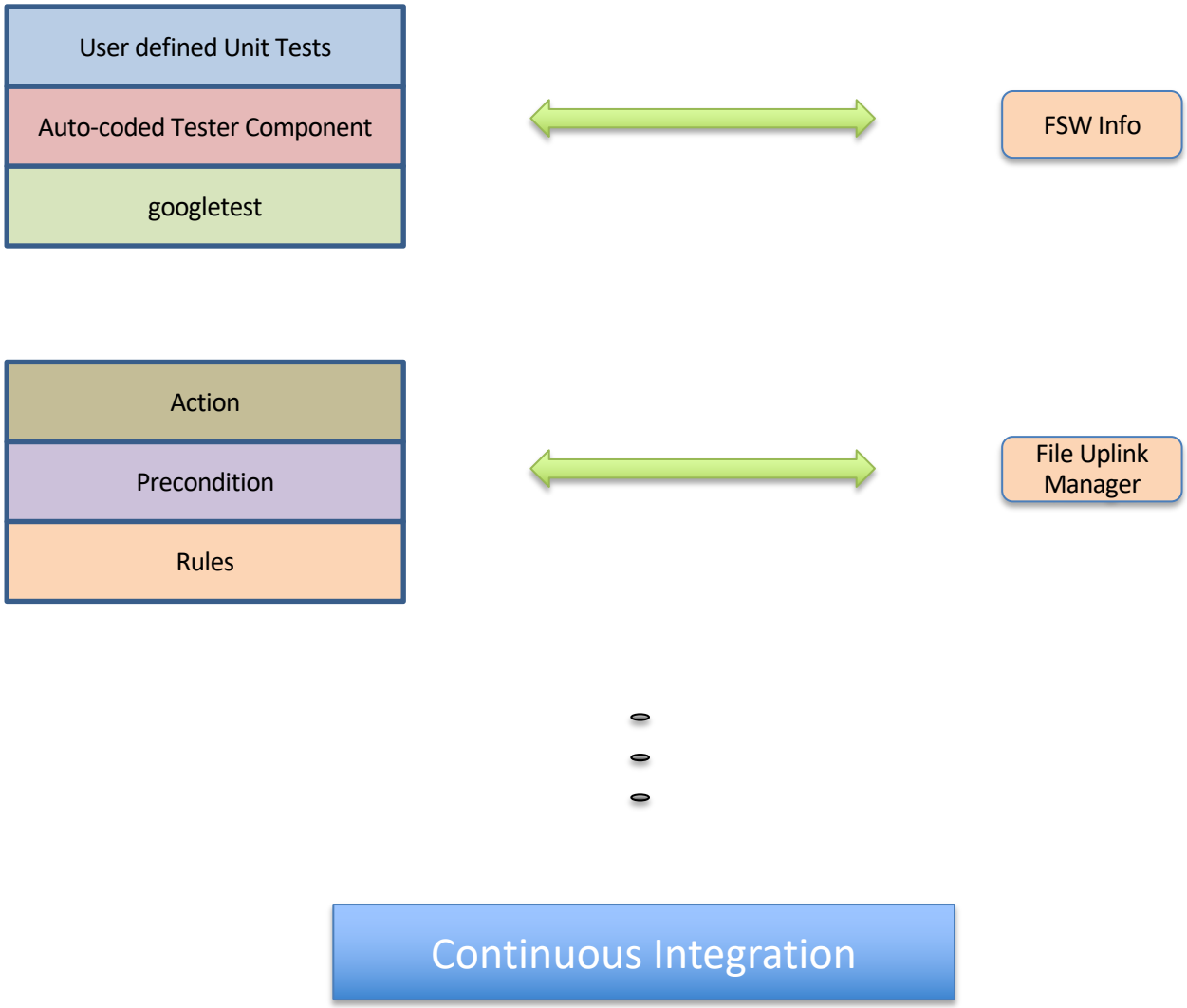
Random Scenario Based Unit Testing



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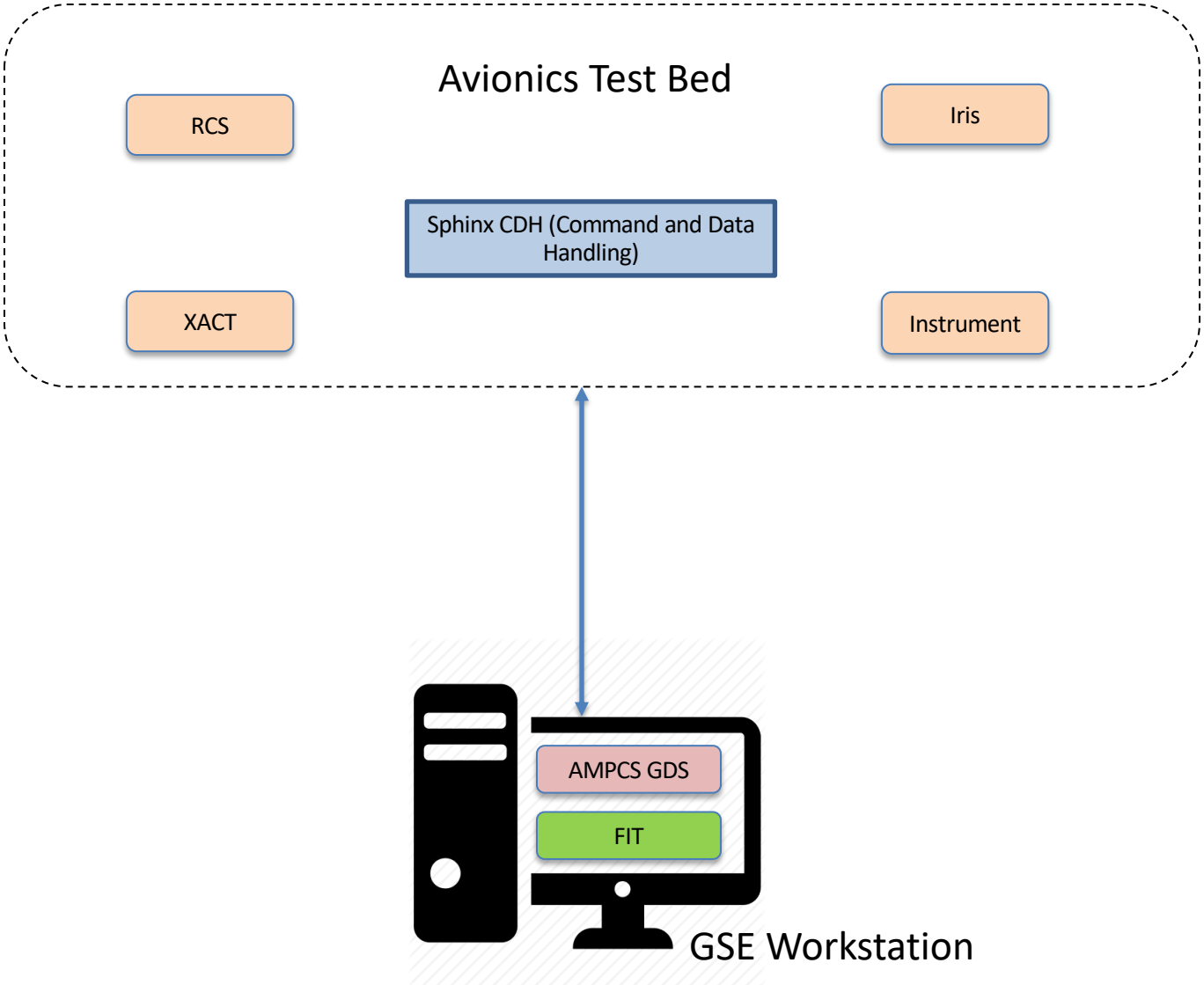
FSW Integrated Testing



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F’ Open Source Repository

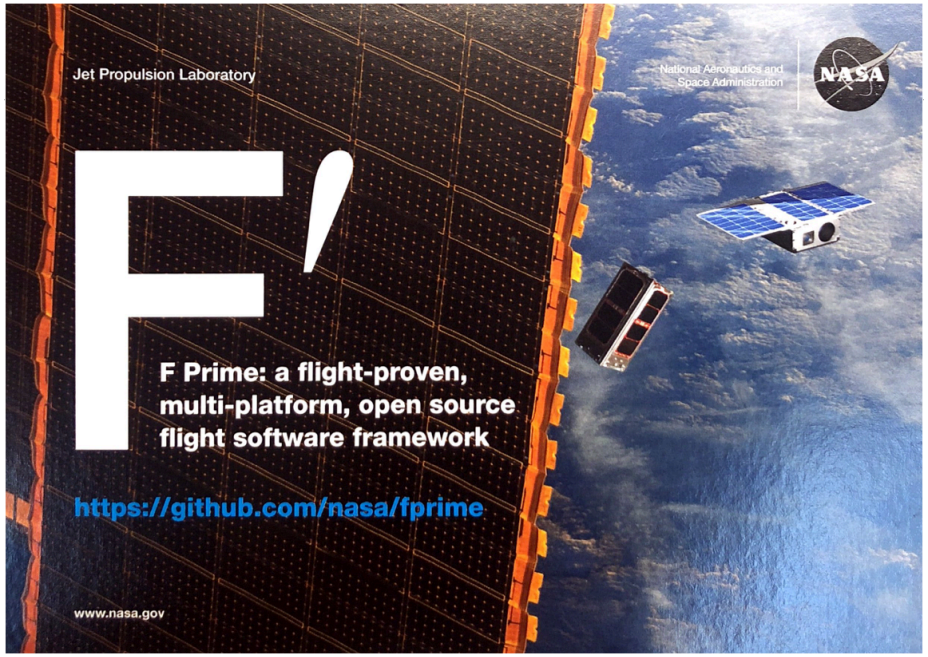
Open Source: Release of F’ base repository in July 2017

Available on GitHub at https://github.com/nasa/fprime

Includes reference example that can be run in multiple environments

F’ SmallSat Conference Paper:

https://digitalcommons.usu.edu/smallsat/2018/all2018/328/



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Summary

- Cubesat flight software development poses technical as well as schedule challenges
- Rapid development and deployment of software is required to meet project deadlines
- A componentized framework enabling modularity, reusability and testability helps address project schedule needs
  - F' Framework equipped Lunar Flashlight and NEA Scout FSW team with tools to address these issues
- Collaborative FSW development across multiple mission deployments is crucial in gaining success with a small development team

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Questions

Lunar Flashlight and NEA Scout Avionics Testbeds

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