



## **Developing Lunar Flashlight and Near-Earth Asteroid Scout Flight Software Concurrently using Open-Source F Prime Flight Software Framework**

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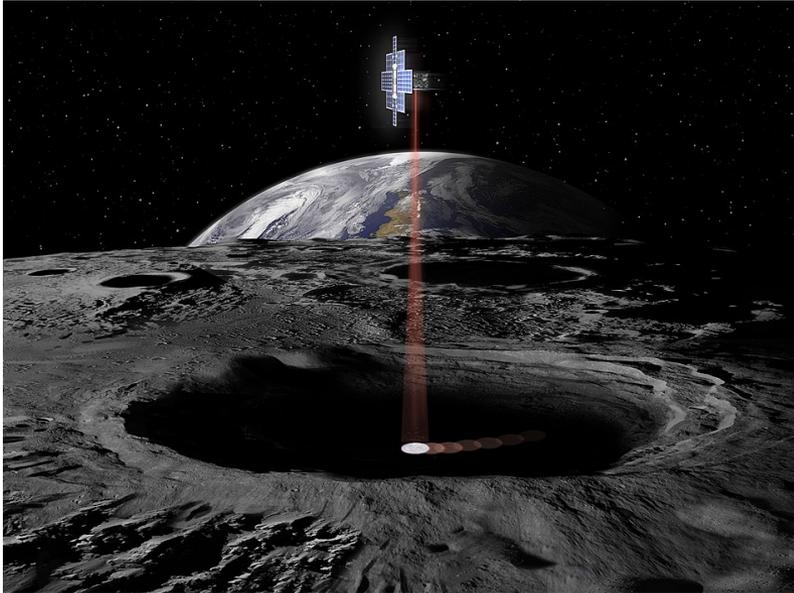


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California Institute of Technology

**This document has been reviewed and determined not to contain export controlled technical data.**

# Introduction

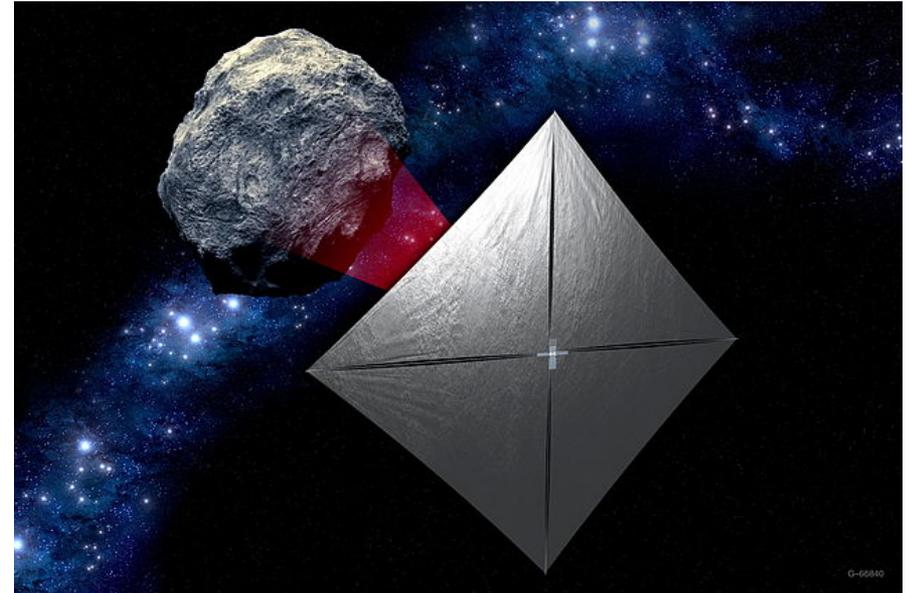
## Lunar Flashlight CubeSat



Illuminate permanently-shadowed regions and detect water ice absorption bands in the near-infrared.

Expected launch: early 2023

## NEA Scout CubeSat

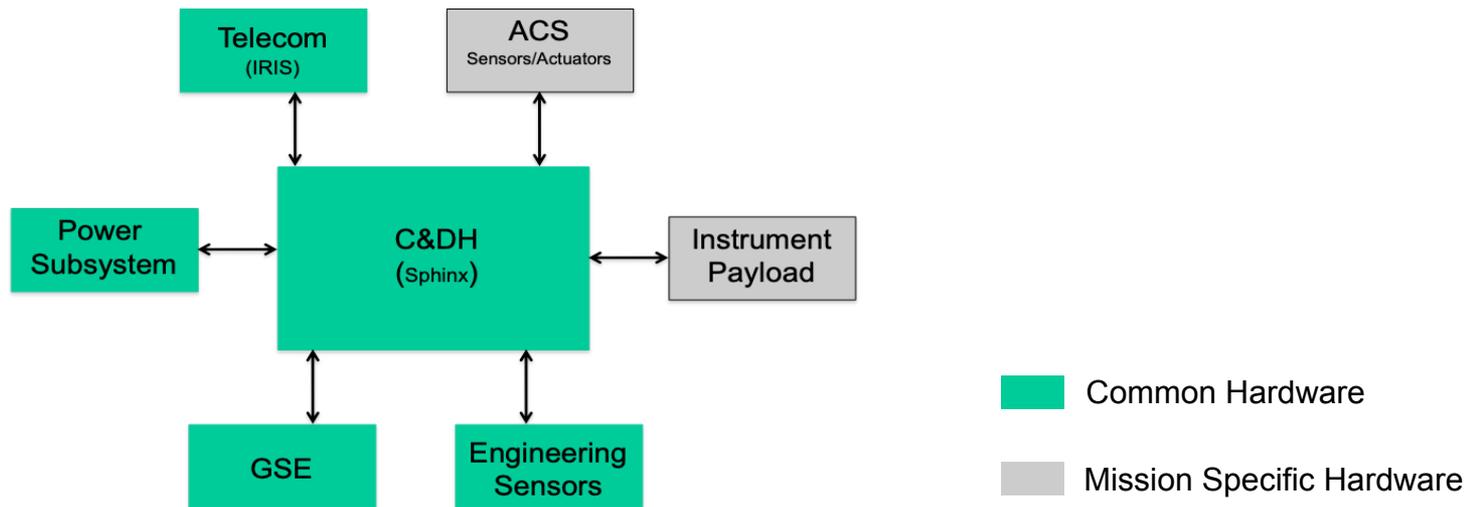


Rendezvous with an asteroid using solar sail and gather detailed imagery.

Expected launch: Aug/Sep. 2022

# Lunar Flashlight and NEA Scout Commonalities

- Same avionics hardware
- Same software architecture
- Same teams (C&DH, software, comm, power)

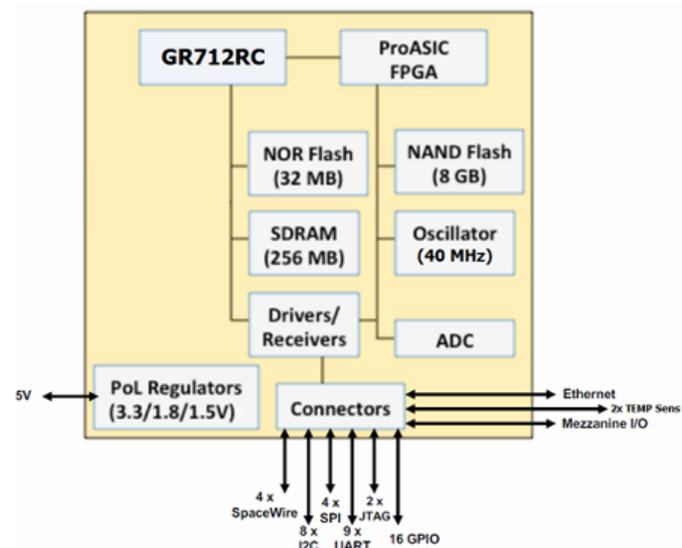


# Sphinx C&DH Board

Avionics platform used on Lunar Flashlight and NEA Scout



Category	Design Features
Memory (EDAC protected)	256 MB SDRAM 32 MB NOR Flash 8GB NAND Flash
Data Interfaces	2x SpaceWire with RMAP 7x UART (4x RS-422) 2x UART RS232 for GSE 4x SPI (10 available slaves) 8x I2C (masters) 2x 32-bit GPIOs 2x JTAGs (processor and FPGA) 1x Ethernet PHY RMII (for GSE) 8x analog channels
System Features	External watchdog with boot-bank swapping Supports up to 4 software image selections

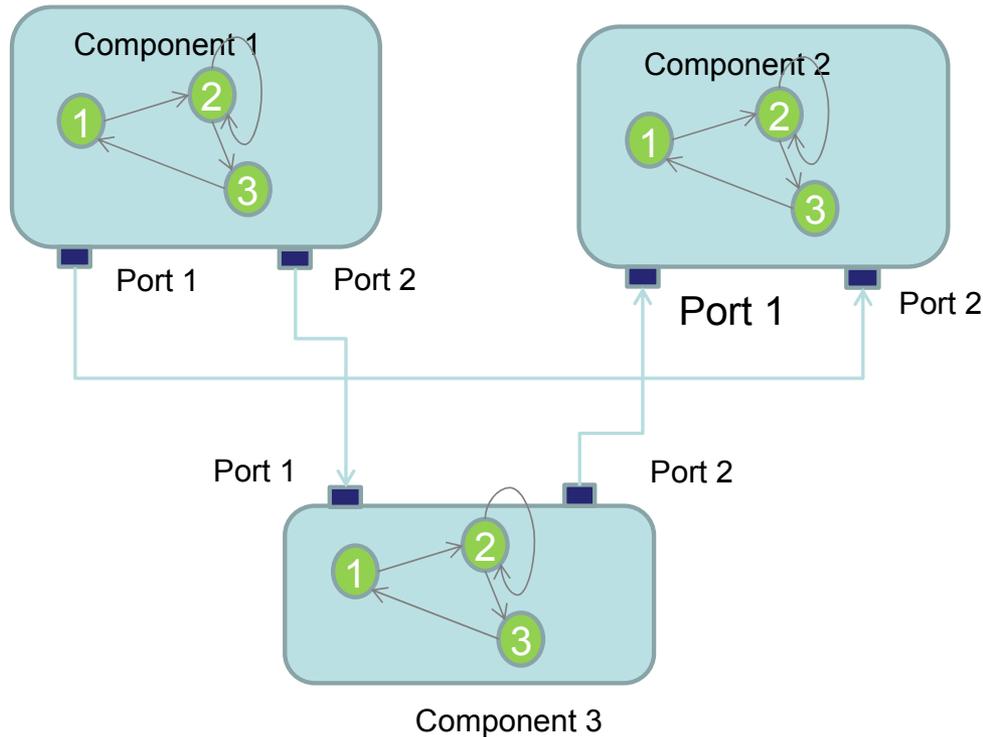


# F Prime Product Line

<https://github.com/nasa/fprime>



Open-source software framework for the rapid development and deployment of embedded systems and spaceflight applications



# Mission Specific Software Deployments

## Lunar Flashlight and NEA Scout Software Deployments

Lunar Flashlight Deployment

Cmd	Tlm	Events	Seq	Prm
Poly	Rate Grp	Health	File Mgr	Fault Protection Mgr
Com Logger	Buffer Mgr	Sphinx Time	File Worker	Buffer Writer
AMPCS File Up	AMPCS File Down	AMPCS EVR Conv.	AMPCS EHA Conv.	AMPCS APID Conv.
SPI Driver	GPIO Driver	NOR Driver	FPGA Driver	Space Wire Driver
FPGA SPI Driver	FPGA GPIO Driver	NOR Mgr	NOR Mgr Worker	Space Wire Mgr
ADC	UART Driver	FSW Image Mgr	Util	Patch
IFB ADC	Eng. Unit Conv	Gen Monitor	Fatal Handler	FSW Info
Iris Radio	Key Tlm	Idle Task	EPS Mgr	Power Switch Mgr
Space Packet	File System	FP State Mgr	RCS Mgr	LF FP State Mgr
Payload Mgr	XACT	Mode Mgr		

F Prime Common
Sphinx Shared
LF Specific

NEA Scout Deployment

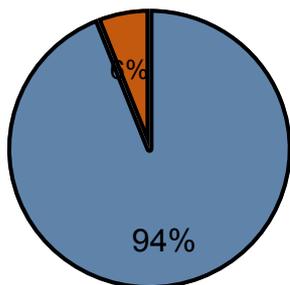
Cmd	Tlm	Events	Seq	Prm
Poly	Rate Grp	Health	File Mgr	Fault Protection Mgr
Com Logger	Buffer Mgr	Sphinx Time	File Worker	Buffer Writer
AMPCS File Up	AMPCS File Down	AMPCS EVR Conv.	AMPCS EHA Conv.	AMPCS APID Conv.
SPI Driver	GPIO Driver	NOR Driver	FPGA Driver	Space Wire Driver
FPGA SPI Driver	FPGA GPIO Driver	NOR Mgr	NOR Mgr Worker	Space Wire Mgr
ADC	UART Driver	FSW Image Mgr	Util	Patch
IFB ADC	Eng. Unit Conv	Gen Monitor	Fatal Handler	FSW Info
Iris Radio	Key Tlm	Idle Task	EPS Mgr	Power Switch Mgr
Space Packet	File System	FP State Mgr	RCS Mgr	NEA FP State Mgr
IMU Mgr	SS-AMT Mgr	G&C Mgr	Cam Mgr	Science
XACT	Mode Mgr			

F Prime Common
Sphinx Shared
NEASc Specific

# Software Metrics

## Deployment SLOC (Source Lines of Code) Metrics Comparison

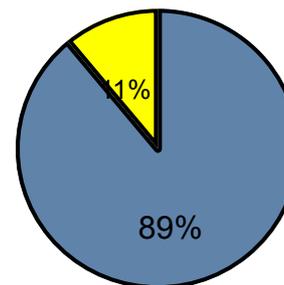
**Lunar  
Flashlight  
FSW SLOC  
Metrics**



- F Prime, Sphinx Common and Auto-coded Software
- LF Specific Hand Coded Software

Total SLOC = 320,985

**NEA Scout  
FSW SLOC  
Metrics**



- F Prime, Sphinx Common and Auto-coded Software
- NEASc Specific Hand Coded Software

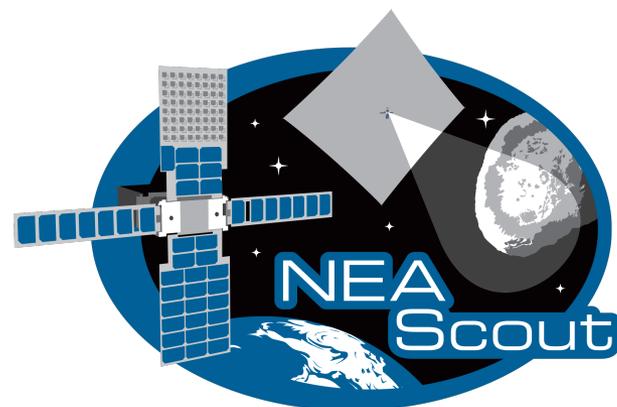
Total SLOC = 355,793

# Sphinx Common Deployment

- Lunar Flashlight and NEA Scout leveraged the use of Sphinx common deployment to develop mission specific applications enabled by F Prime Product Line's reusability and modularity
- A version of the Sphinx common deployment has been released as open-source: <https://github.com/fprime-community/fprime-sphinx>
- The open-source Sphinx common deployment can be used as a starting point for a future project using the Sphinx platform

# Conclusion

- Reusability and modularity of F Prime enabled concurrent development of flight software for both Lunar Flashlight and NEA Scout CubeSats
- Components developed using F Prime were deployed on both CubeSats resulting in significant software commonality between the two CubeSats





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