Space Mission Development Capabilities
Hawaii Space Flight Laboratory

HSFL Overview Presentation
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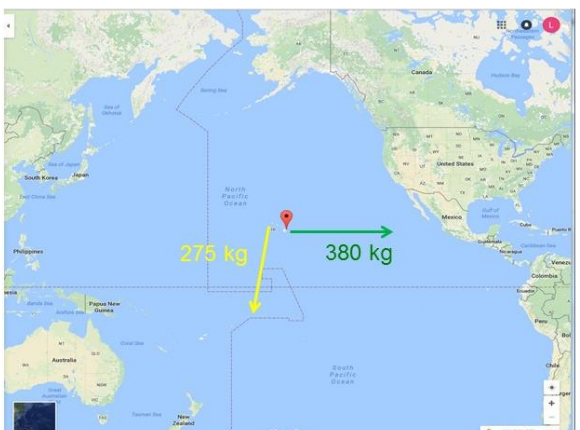
Demand for “Small Space”

August 26, 2016:
The Economist Technology Quarterly



- **In less than 60 years of space flight, the world has launched about 6500 satellites to space of which about 1000 are still operating…**
- **The Economist (08/26/16)**
  - OneWeb: 648 microsats for communications
  - SpaceX: 4425 microsats for communications
  - Google: microsats 20 for remote sensing
  - Spire: 44 microsats for observation
  - BlackSky: 60 microsats for remote sensing
- **Demand for space launch and small sats has shifted from Government to commercial groups.**
- **Hawaii positioned for small space**
  - Dedicated small launch facility possible
  - Greater payload to orbit from US site
  - UH/HSFL infrastructure support for small sats
- **HSFL Objectives**
  - Foster an aerospace economy in Hawaii.
  - Provide catalyst for microsatellite industry in Hawaii.
  - Enable small launch opportunities from Hawaii.
  - Enable creation of high-tech/high paying jobs for Hawaii citizens.

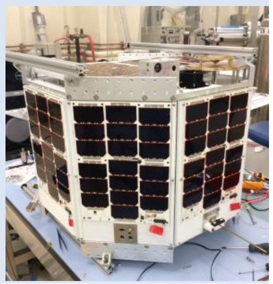
HSFL Overview: Vertical Integration

Spacecraft

• Partner with NASA Centers and others to advance small spacecraft design.

• Design, build, launch, and operate 1-100 kg small satellites for science and education tasks.

• Support technology validation missions as well as other University missions.



Integration and Test

• Clean rooms in UH/POST are used to assemble & test satellites
- Systems integration
- Thermal-vacuum testing
- Vibration/shock testing
- Payload spin balancing
- Attitude control testing

Instruments

• The HSFL can call on a diverse group of instrument-developing faculty from HIGP and SOEST.

• A number of businesses in Hawaii also develop a wide array of instrumentation. The HSFL will partner with these organizations to provide technology demonstration opportunities.

• NASA Centers (Ames and JPL) are interested in joint technology missions.

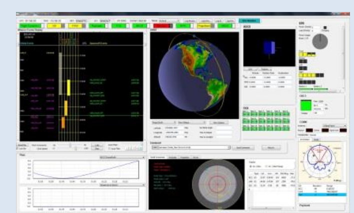
Launch Vehicle and Launch Support

Pacific Missile Range Facility (PMRF)
• Local launch facility and mission support
• Modify existing PMRF launch pad for rail-fitted and modified VAFB Scout launcher.

Kauai Test Facility (KTF)/ Sandia National Lab
• Experience with solid rockets and missile design. Use Super-Strypi launch vehicle.
• Can lift ~270 kg (594 pounds) to low-Earth orbit (400 km).
• Heritage working with PMRF as on-site vehicle integrator and launch agent.

Ground Station & Mission Operations

• UH/HSFL maintains UHF/VHF receiving stations with Kauai CC and Honolulu CC staff.
• Ground station provides command and control broadcast as well as data downlink capabilities.
• Mission Ops Center POST 5th floor using COSMOS software.



HSFL Facilities Usage



Test Facility	Thermal Vacuum Chamber	Vibration Table	ADCS Test Facility
Specs	1.6 x 2.25 m, 10^{-8} Torr, -70° - 70° C	Tests objects 1.2m x 1.2m 5-2200 Hz to 7000 kgf; 14000 kgf shock	Air-bearing platform, Magnetic Field, Sun, GPS simulations, up to 100 kg satellite
1-Week ROM Cost	$18k	$19k	$26k

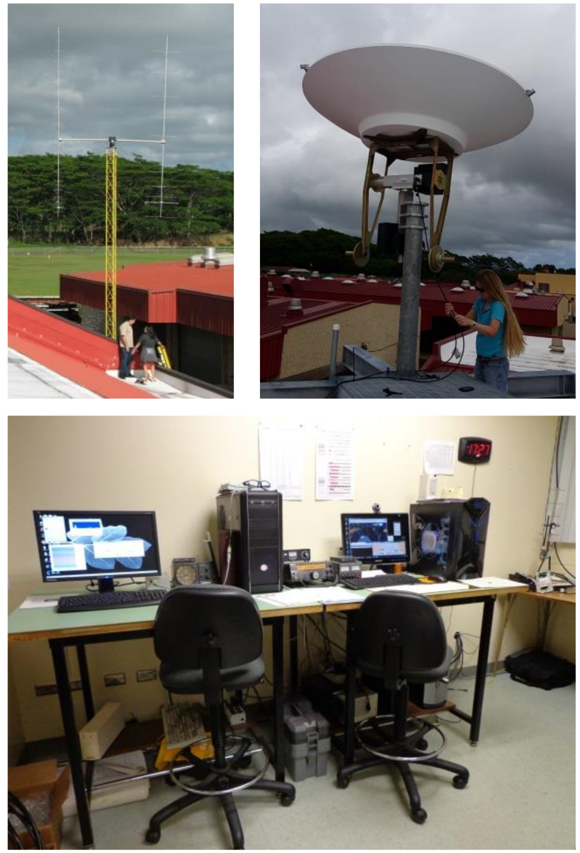
ROM cost includes engineering time to prepare the facility.

SUMMARY:

- HSFL provides access to its small satellite test facilities
- Support from HSFL engineers
- Custom projects with custom quotes

HSFL Ground Stations

Honolulu Community College
X-band



Kauai Community College
UHF/VHF/S-band

UH Manoa – NRL MC3 GS
UHF/S-band

Affiliated Ground Stations:

- Alaska Space Facility (S-band)
- Surrey Space Centre/SSTL (UHF/VHF/S-band)

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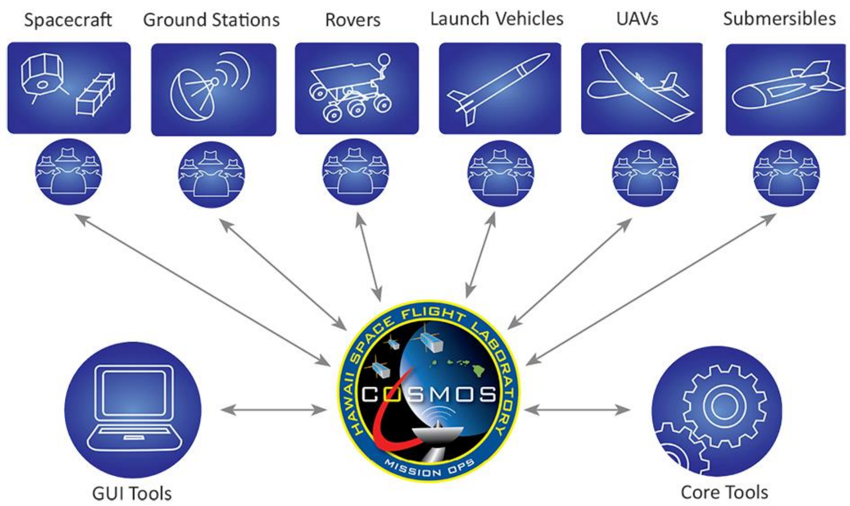
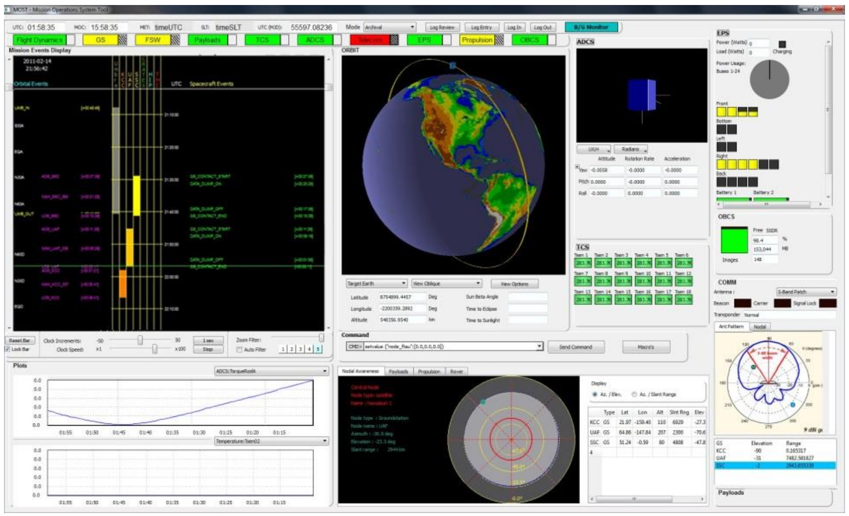
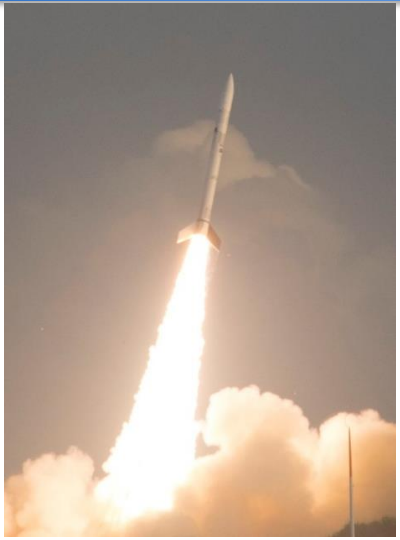
HSFL Mission Ops Software

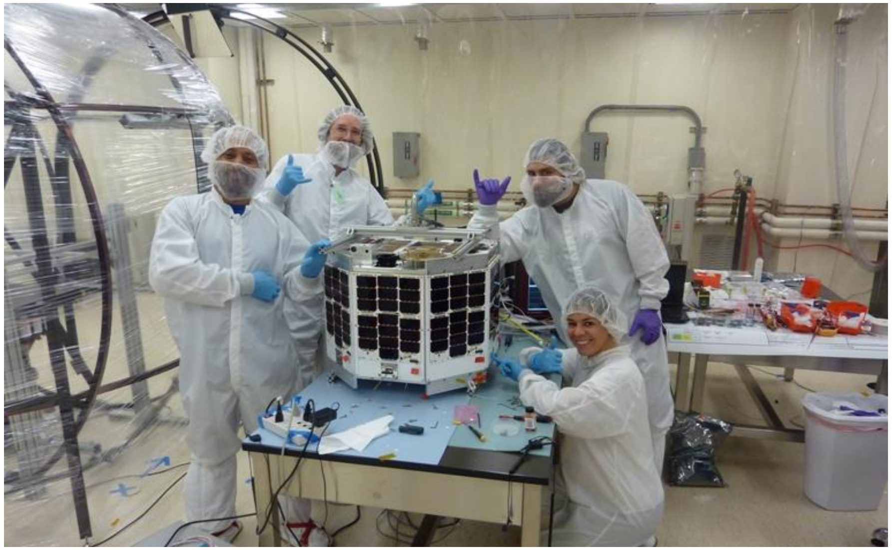




- Comprehensive Open-architecture Solution for Mission Operations Systems (**COSMOS**)
- Software framework to support spacecraft mission operations
- Set of tools:
  - Mission Planning & Scheduling Tool (MPST)
  - Mission Operations Support Tool (MOST)
  - Ground Segment Control Tool (GSCT)
  - Data Management Tool (DMT)
  - Flight Dynamics Tool (FDT)
  - Analysis Tools
  - Test Bed Control Tool (TBCT)
- Open architecture to enable modifications and adaptation to new missions and MOCs
- User-friendly interfaces and short learning curves for users and software integrators

ORS-4 Mission: November 3, 2015





- HSFL mission partner for rail and microsat development.
  - Largest rail launcher in the world built and successful
  - HiakaSat 50-kg microsat delivered by NASA and Air Force standards.
- ORS-4 terminates ~60 seconds into flight
  - 1st stage motor issue
- ORS-4 Takeaways:
  - 130 Hawaii students receive training/experience with HiakaSat
  - HSFL partnerships for future microsat work
  - X-Bow commercial follow-on missions

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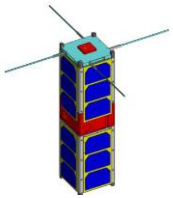
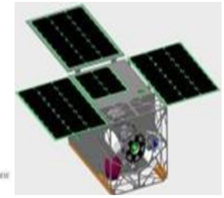
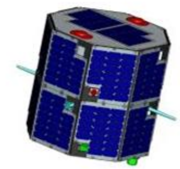
HSFL R&D Platforms







Size	3U	6U	12U	50 kg	100 kg
Pointing	1˚ - 5˚	<1˚	<1˚	<1˚	<1˚
Comm.	UHF, VHF, (S-Band, X-Band)	UHF, VHF, S-Band, X-Band	UHF, VHF, S-Band, X-Band	UHF, VHF, S-Band, X-Band	UHF, VHF, S-Band, X-Band
Payload	1 kg, 1W	2 kg, 5W	4 kg, 10W	10 kg, 10-20W	30 kg, 20-30W
S/C ROM	$0.7M	$1.3M	$2.5M	$3.5M	$6M
1-Year Mission ROM	$1.5M	$2.3M	$4.0M	$6.5M	$12M

Mission ROMs include US launch costs (Electron) plus 1 year Mission Ops

SUMMARY:

- HSFL microsat R&D missions for under $12M.
- HSFL accepts risk to test new space technologies while training workforce.
- HSFL Integration and Test Facility available to industry partners.
- HSFL tailored mission operations solutions with COSMOS.

Earth and Planetary Exploration Technology

1. History of solar system exploration (Existing course)

Why (the science) and how (the engineering and technology) humans have explored our planetary neighborhood

2. Cosmochemistry (Existing course)

What are the physical and chemical processes that formed the materials we now observe in our Solar System?

3. Hawai'i as a planetary analog (New Course)

Many processes that shaped the surfaces of Mars, the Moon, Mercury, and Venus, can be observed right here, in Hawai'i

4. Planetary surfaces and atmospheres (Existing course)

The physical and chemical processes that produce the surface geology and atmospheres of the planets

5. Planetary interiors (Existing course)

What can high pressure mineral physics experiments, conducted at HIGP, tell us about planetary interiors?

6. Extraterrestrial materials analysis (New Course)

HIGP has some of the best facilities in the world for analyzing extraterrestrial materials, such as meteorites, interplanetary dust particles and comet dust. Students will learn how our FEI Titan Transmission Electron Microscope and our Cameca ims 1280 ion microprobe are used to probe the origins of our Solar System

7. Remote sensing of planetary surfaces (Existing course)

We send satellites with imaging cameras to orbit the planets. How do they work, and how do we analyze the data collected?

8. Instrumentation for planetary exploration (New Course)

How do we design and build the instruments carried on board the satellites, landers, and rovers that we send into space?

9. Space mission design (New Course)

A space mission seeks to answer a science question using instruments carried onboard a satellite, and launched into space on a rocket. What elements of design, engineering, management, and budget are important to designing a successful mission?

10. Space mission operations (New Course)

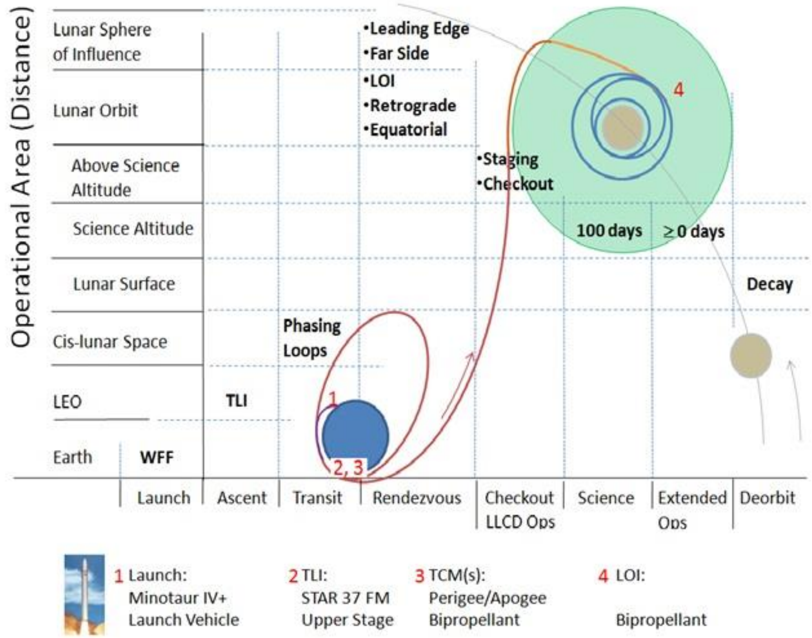
Once the satellite is in orbit, or the rover is on the surface, how do we control it? How do we communicate with it? How does it communicate with us? How does it send our data back? How do we get the data to scientists?

11. Senior Capstone Mission (New Course)

Interdisciplinary deep dive including science and technology students working on a mission concept.

Research: Moon Missions!!

- How to Get There: Lunar Atmosphere and Dust Environment Explorer (LADEE)
- Lunar orbit: RockSat mapper proposed
- Lunar Surface:
  - Mass limit of ~ 100 kg
  - Rover design and construction through national and international competitions
  - Rover testing on the Big Island
  - Lunar night limits missions to 12 days
  - HIGP can provide instrumentation package
  - All controlled by gaming interface – student exploration
- Cost of small launch delivery system ~$20-25M
- Total mission costs ~$40M



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HSFL Summary

- Increasing high technology aerospace workforce and infrastructure.
- Integrated small satellite ISR solutions for under $12M.
- 3-U Cubesats and larger satellites capable of accommodating rideshare payloads.
- HSFL Integration and Test Facility is fully functional and staffed to support testing and partnerships with commercial and government entities.
- Full mission support including ground station coverage and tailored mission operations solutions.


HAWAII SPACE FLIGHT LABORATORY
www.hsfl.hawaii.edu