FalconSAT-2 Launched (and Recovered)

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In the Fall of 2000, the Academy’s Space Systems Research Center, part of the Department of Astronautics, started FalconSAT-2. Learning many valuable lessons from the FalconSAT-1 experience, the emphasis shifted to building a solid, continuing program rather than focusing on a single mission. The Center focused on cadets “learn space by doing space.” A commercial-off-the-shelf set of spacecraft bus components consisting of power, communications, and data handling was adopted to provide an out-of-the-box solution for critical components, freeing cadets and faculty to focus on payload, structure, and attitude control development. Working with the Academy Physics Department, an important space environment experiment was developed called MESA (Miniature Electrostatic Analyzer). MESA’s mission was to investigate the morphology of plasma depletions in the ionosphere that effect GPS and other military satellite communications. Cadets briefed this experiment to the DoD Space Experiments Review Board in November 2000 where it was impressively ranked 21 of 34 among all space experiments DoD-wide. In parallel, full-scale systems engineering efforts began on FalconSAT-2.

Cadets initiated the FalconSAT Avionics & Simulation Testbed (FAST) in Fall 2000 and began software development and payload integration. The faculty also decided to follow the Russian approach of building three satellites per mission: engineering model; qualification model; and flight model. There were several reasons to do this. First, it would give each cadet class a significant deliverable/milestone every year with a plan of completing a new mission every 3 years. Next, it would allow the cadets to experience a “hands-on” assembly, integration and test. It would also reinforce the importance of documentation, since each cadet class must pass their work to the next class – approximately 30 senior class cadets take the course each year. Finally, this approach reduces program risk by avoiding last minute integration and testing issues which lead to scheduling and budget woes for many space programs.

In Spring 2001, cadets built a full scale Engineering Model (EM) of FalconSAT-2 including a cadet-built solar panel. A team of cadets traveled to Kirtland AFB, NM for two weeks in April of that year to conduct complete EM environmental testing, including temperature cycling in a thermal/vacuum chamber and vibration testing to many times expected launch g-levels. The results validated the basic structural and systems design for the satellite and final negotiations with the Air Force Space & Missile Center’s Space Test Program (SMC/STP) were conducted, aiming for the launch of the MESA–equipped FalconSAT-2 on the Space Shuttle in early 2003. Starting in Fall 2001, cadets built a full-scale Qualification Model (QM) of FalconSAT-2, followed by the Flight Model which was ready for delivery to NASA with the MESA payload in Summer 2002.

FalconSAT-2 was originally scheduled to launch on the Space Shuttle in early 2003. Unfortunately, the Columbia accident in February 2003 put the launch date on hold until the Shuttle fleet was back in service. In the interim, a storage container was designed to keep the satellite protected while allowing cadets and faculty to monitor its health (mainly charging of the batteries). Software and complete checklists were also written so cadets and faculty could be certified as ground station operators. Using the qualification model of the

satellite and the ground station, 12 cadets and 5 faculty members were then able to commission and put the satellite into the correct operational mode.

In March 2004, the cadets passed their flight readiness review with NASA and Air Force officials at the NASA Johnson Space Flight Center with flying colors. However, the cadets began investigating alternative launch vehicles when it looked like the Shuttle opportunity was fading. Most of this research focused on finding an adaptor ring that could integrate to FalconSAT and other possible launch vehicles. The cadets' aggressive research and marketing campaign paid off! In December 2004, DARPA announced that FalconSAT-2 was manifested to fly on the maiden launch of the Space Exploration (SpaceX) Corporation's Falcon I launch vehicle. FalconSAT-2's rapid response capability and ease of integration were primary factors in this decision.

SpaceX planned to launch the vehicle from Omelek Island, part of the Kwajalein Atoll in the Republic of the Marshall Islands, and home of the U.S. Army's Reagan Test Site in the Central Pacific. Omelek—an island of only about 7 acres—is situated approximately 30 miles north of the atoll's namesake island, on the atoll's eastern rim. SpaceX constructed a bare-bones launch site on Omelek that included an integration hangar, storage areas, temporary lodging for crew, and propellant storage facilities. The cadets redesigned the antennas to give the satellite a stronger signal, qualified over 20 cadets and faculty in the commissioning and operation of the satellite from the USAFA ground station, completed two separation tests with the SpaceX hardware using the NASA Goddard payload ejection system, conducted a "fit check" with the SpaceX launch vehicle, and prepared four interface control documents ensuring they would be ready for the challenges posed by remote launch. In October 2005, the cadets presented a successful pre-ship review to representatives from DARPA, SMC, Air Force Research Laboratory, and SpaceX.

Cadets and faculty deployed to Kwajalein in five waves. Due to its remote location, the cadets experienced conditions not unlike deployments that they will see in their Air Force careers. The first waves conducted satellite functionality tests to prepare it for launch, and then worked with SpaceX to integrate FalconSAT-2 to the launch vehicle's payload separation system. The remaining waves supported launch operations.

After four aborted attempts from November 2005 through February 2006, Falcon I lifted-off from the island of Omelek, 30 miles north of Kwajalein on Friday, 24 March 2006. Shortly after lift-off, the launch vehicle failed, impacting the shallow reef on the ocean side of Omelek. Amazingly, the satellite was blown free from the launch vehicle on impact and discovered in a storage shed on Omelek, having crashed through the roof of the shed, coming to rest just a few feet from the shipping container used to deliver it from Colorado to the launch site!

Although the cadets are disappointed in the failure, they realize that life goes on. They finished FalconSAT-3 flight model on 14 April and conducted thermal/vacuum and vibration tests at Kirtland AFB from 17- 26 April. Though some follow-up tests and adjustments will be accomplished this summer, launch is scheduled aboard a Lockheed Martin Atlas V launch vehicle as a secondary payload in October 2006.

Definition and design of FalconSAT-4 began in January 2005 with a symposium at which 25 different possible payloads were presented. They will finish the conceptual design in May 2006 and start engineering model construction the following academic year (Fall 2006).

Cadets are also investigating the possibility of controlling existing satellites to gain space operations experience while await FalconSAT-3's launch.

Since the launch failure, many former cadets from the FalconSAT program have sent e-mails expressing their disappointment at the result, but also relaying many glowing comments on how much they learned in the program and how it has made them better officers. Over the past six years, approximately 180 cadets and 20 faculty members have had a unique space experience. Their comments have been amplified by many former faculty, staff, and friends of the Academy, who feel our loss, but also understand the importance of the valuable lessons FalconSAT teaches every day to every cadet involved in the program.

The Space Systems Research Center would like to thank th Association of Graduates, for their financial support of our program.

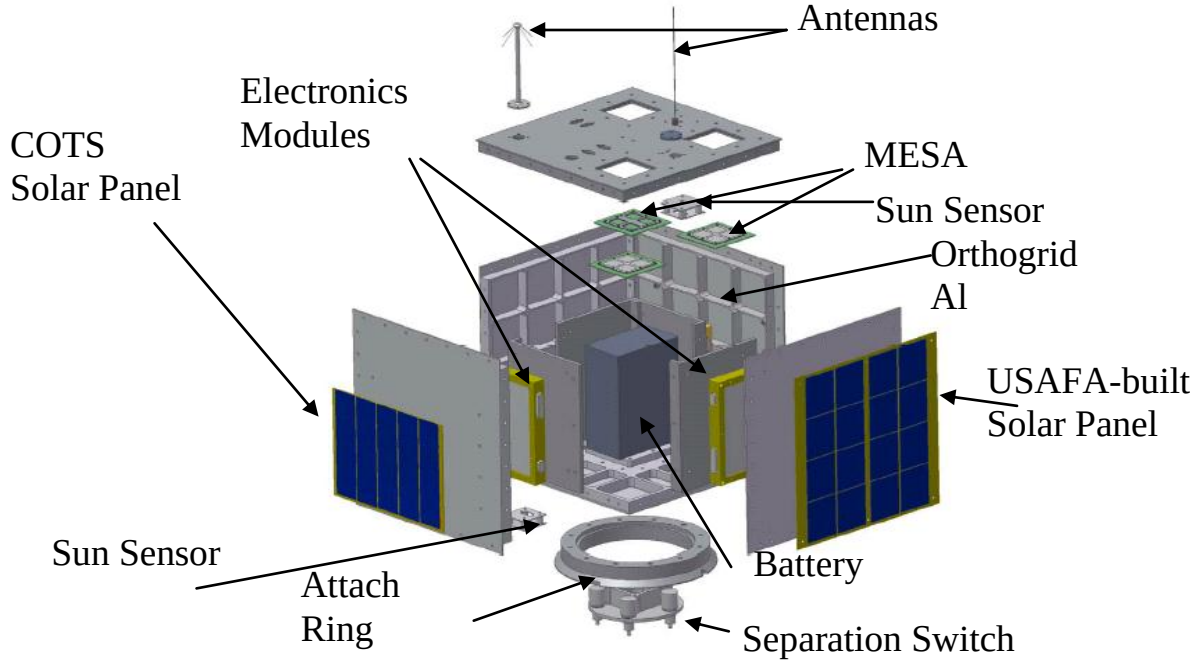


Figure 1: Exploded View of FalconSAT-2, the satellite is a "tumbler"; Mesa required no active Attitude Determination and Control. It is a 12.5" cube and weighs 43 lbs. It has a VHF uplink and S band downlink. Control was planned from the cadet built USAFA ground station.

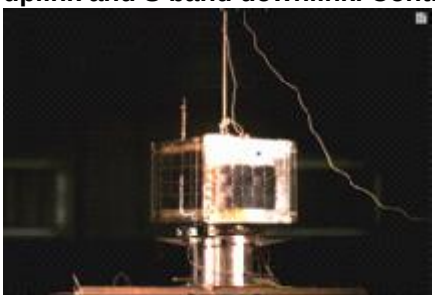
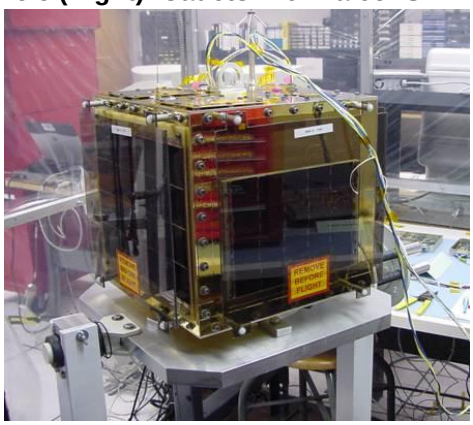


Figure 2 (Left): USAFA and SpaceX used the qualification model for separation tests. USAFA used the qualification model to train their space operations cadets, while another system was developed so the ground station could communicate with the satellite. Figure 3 (Right):

Cadets, faculty and SpaceX attach the satellite to the separation system.

Figure 4 (Left): Cadets and faculty in front of the Falcon I launch vehicle on Omelek Island (Nov 05)
Figure 5 (Right): Cadets with FalconSAT-2 prior to encapsulation in SpaceX hangar at Omelek



Figures 6 and 7: FalconSAT-2 before and after the launch. Unfortunately, the satellite cannot be used again since the solar arrays, MESA, antennas, and batteries were destroyed. However, USAFA cadets were "impressed that their mechanical structure survived terminal velocity," and want FalconSAT-2 added to its Falconry Club as an honorary member. For years, cadets have trained falcons (the only performing mascot at NCAA division I football games). FalconSAT-2 showed its excellent homing skills in the launch failure by avoiding the sea and returning to its shipping container so it "could come home to roost." We hope to display FalconSAT-2, with appropriate honors, at the Academy Visitor's Center or the Department of Astronautics' Space Museum soon.