Compendium of Students' Satellites

Duchifat-2 Nano-Satellite, built by Israeli School Students

Photo by Roei Greenberg

WFEO-CIC

INDIAN TECHNOLOGY CONGRESS

www.techcongress.net

ACRONYMS AND ABBREVIATIONS

Al	Aluminium
AA	Aluminium alloy
ADCS	Attitude Determination & Control System
AOCS	Attitude and orbit control subsystem
ASD	Acceleration spectral density
ATOX	Atomic oxygen
CAD	Computer-aided design
COM	Communication subsystem
CoG	Center of gravity
CoM	Center of mass
EO	Earth observation
EPS	Electric power subsystem
E-sail	Electric solar wind sail
EMC	Electromagnetic compatibility
ESD	Electrostatic discharge
EM	Engineering model
ESA	European Space Agency
FEA	Finite element analysis
FPGA	Field-programmable gate array
FH	Flight hardware
GCS	Ground Control Station
GEO	Geosynchronous orbit
CG	Gold gas
HW	Hardware
HS	High-level sine
HSCOM	High-speed communication
IFA	Inverted-F antenna
ISS	International Space Station
LV	Launch vehicle
LEO	Low Earth orbit
MoS	Margin of safety
MEO	Medium Earth orbit
OBCS	On-board computer subsystem
PSD	Power spectral density
PCB	Printed circuit board
PDF	Probability density function
PNMSat	PicoSat, NanoSat and Micro Sat
PR	Public relations
RF	Radio frequency
RW	Reaction wheel
SDOF	Single-degree-of freedom
SPL	Sound pressure level
SS	Stainless steel
ST	Star tracker
STR	Structure subsystem
Ti	Titanium
UHF	Ultra-high frequency
VHF	Very high frequency

World's Largest Database of Nanosatellites, over 2200 NanoSat and CubeSats

CubeSat constellations, companies, technologies, missions and more

"I believe the big future of Nanosatellites is still to come!"

-Erik Kulu, Nanosatellite & CubeSat Database: https://www.nanosats.eu

Facts as of 2018 August 11

- NanoSats Launched: 958
- CubeSats Launched: 875
- PocketQubes Launched: 4
- NanoSats Destroyed on Launch: 86
- Most NanoSats on a Rocket: 103
- Countries with NanoSats: 58
- Companies in NanoSats/CubeSats Business/Database: 288

Forecast: Over 3000 NanoSats to Launch in 6 Years

Classification/Category of Satellites (Based on Mass)

a) Minisatellite (100–500 kg)
b) Microsatellite (10–100 kg)
c) Nanosatellites (1 -10 kg)
d) Picosatellites (100 gm-1 kg)

} CubeSats
1U: 10x10x10 cm3
1U: 1.33 kg

e) Femtosatellites (10-100 gm)
f) PocketQube (0.25U)
g) KickSat (3.5x3.5 cm2 Single PCB with Components

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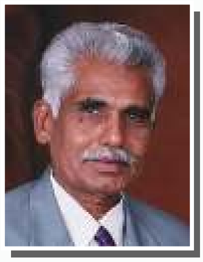
PREFACE



Space Technology is progressing rapidly ever since the dawn of space age marked by the launch of Sputnik by USSR on 4th October 1957. A host of scientific satellites, remote sensing satellites and communication satellites have been built, launched and operated for natural and global needs. Specialized satellites are making the world a global village with uninterrupted connectivity and monitoring of happenings around the globe. The educational institutions have played key role in advancing the state-of-the-art by conceiving innovative ways of building satellite systems giving birth to student built satellite programs in many countries. The satellites ranging from less than 1 kilogram to 10 kilogram class have been built, launched and operated successfully since 1999 with the CubeSat Program of California Polytechnic College with the support of NASA AMES centre. Now the field has grown manifold. As on August 11, 2018, there are 958 NanoSats, 875 CubeSats. 4 Pocket Satellites have been launched in 58 countries across the world. 3000 programs are expected in coming 6 years; Out of this 2200 are NanoSats and CubeSats.

With the successful experimental IRIDIUM low altitude communication satellites follow on missions are being executed. Satellite constellations contemplated on by SAMSUNG (4600 Satellites less than 200 Kg) Boeing (2960 Satellites < 100 Kg), OneWeb (720 Satellites less than 150 Kg) and SpaceX (4000 Satellites less than 200 Kg). It is also noted that 80% of these projects are in private sector and only 20% Satellite programmes are in public funding by national space agencies of various countries.

India has made headway by launching 9 Indian built student satellites on board PSLV free of cost and many such small satellites on payment basis for others. Recently 104 small satellites were successfully orbited by PSLV as piggyback payloads along with main satellites payload. Interestingly specialized small satellite launch vehicles are also under development to ensure economic and quick response access to space.

In order to cater to increasing demand for trained manpower and entrepreneurship promotion in this exciting field the ITC 2018 is organizing session on this challenging and exciting interdisciplinary field primarily targeting the educational institutions and aspiring students. Experts from India and abroad will be participating and delivering lectures and conduct interactive sessions for interested delegates. Financing options, management aspect will also be addressed. In this effort World Federation of Engineering Organizations-Committee on Information and Communication (WFEO-CIC) is joining with ITC-2018.

It is envisaged that with the beginning made here, we will be able to identify potential institutions and teams in various parts of our country to undertake 75 such small satellites and get them launched by 2022 synchronizing with the 75 years of India attaining Independence.

We will demonstrate to the world that we can achieve this goal contributing to practice blended education, research and innovation among the budding engineers in our technical institution. ITC 2018 will take follow up actions in this regard.

Prof. R. M. VASAGAM

Padma Shri Recipient
Chairman - National Advisory Committee
Indian Technology Congress-2018
Eminent Scientist, Formerly with ISRO
(Project Director for APPLE, India's First Experimental
Geostationary Communication Satellite Project during 1977–83)
Former Vice Chancellor, Anna University

MESSAGE

Advances in engineering and technology have powered societal development, and society has benefitted from the exploration and exploitation of space for myriad applications including weather forecasting, response to natural or man-made disasters, communication and navigation; and security. Development of space technologies has successfully contributed to man's conquest over distance and terrain to ensure equitable and sustainable social development.

Commercial off-the-shelf (COTS) devices and the revolution in microelectronics production techniques for the consumer mass market have established realizable benchmarks for high reliability of devices in space, contributing to the development and production of many smaller satellites resulting in the 'democratization of space' and the tectonic shift of 'space power' among the global comity of nations.

Proponents of the concept of small satellites have evangelized that the benefits of miniaturization would promote development of smaller sensors that can comprehensively address most Earth Sciences needs; and these sensors could be accommodated in smaller spacecraft that could be launched with the new generation of smaller launch vehicles. The positive spiral emanating of this symbiotic development would result in lower costs, shorter mission development time and accelerated absorption of contemporary technologies by society.

Analysts believe that the future holds potential for the small satellite industry. The nano and micro-satellite market is estimated to grow from $702.4 million in 2014 to $1,887.1 million in 2019.

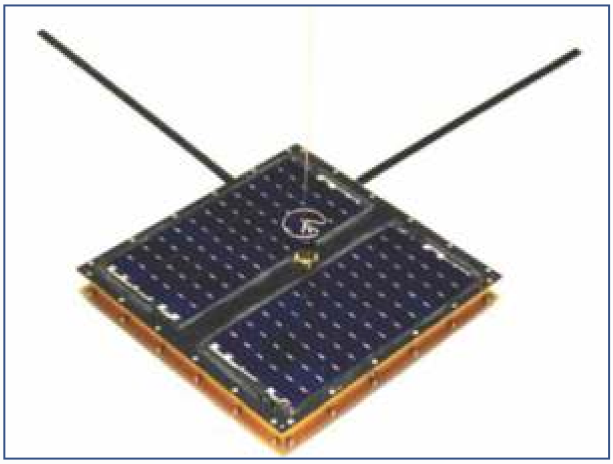
It is in this context that the **World Federation of Engineering Organizations Standing Committee on Information and Communication (WFEO-CIC)** has collaborated with the **Indian Technology Congress Association (ITCA)** to develop a **publication** titled **"Compendium of Students' Satellites"** that chronicles the various student-satellite programs being undertaken globally and will help structure a program relevant for Indian needs. Such a program would build synergy between academia, industry and international agencies to highlight the benefits of small satellites for societal advancement and inspire the engineering youth in India and help enhance their learning and readiness to join the industry.

I wish the very best to ITCA for launching a pilot programme on student-built satellites.

Er. S.S. Rathore
Vice President
WFEO Chair of the Committee on
Information and Communication

TUBSAT-N1

Mission Name	TUBSAT-N1
Organisation	Technische Universität Berlin
Organisation type	University
Nation	Germany
Type (U or mass)	3 kg
Satellite launch year	1998-07-07
Rocket	Shtil
Orbit	404 x 770 km, 78.9 deg
Mission type	Space Technology & Data Relay
Mission type description/ Configuration/Power	Tubsat-N Bus, Solar cells, batteries
Mission objectives	• Demonstration of low-cost access to space without performance reduction. • Bidirectional data transfer between autonomous stations and the satellite. • Tracking of medium-sized and large mammals.
Experiment description	The main payload are two communication transceivers for store and forward communication with a baud-rate of 1200 and 2400 baud.
Lifetime or status in orbit	Re-entry 2000-10-20. Was operational until 1999-XX-XX. About 1 year operation
Partners	DLR
Website	https://www.raumfahrttechnik.tu-berlin.de/tubsat/tubsat-nn1/
Additional comments	-
Additional sources	http://www.vectronic-aerospace.com/files/Redondo99.PDF



TUBSAT-N and Tubsat-N1 are two Nanosatellites, which were launched on the 7th of July 1998 as a satellite cluster from a submarine with a Russian Shtil-1 rocket in the Barents Sea. All systems are working well and the satellites are in a excellent overall condition. The satellites were separated in orbit via telecommand. Both satellites were developed at the Technical University of Berlin and the complete project was financed by DLR.

TUBSAT-N1 has a mass of less than 3 kg and main dimensions of 320 × 320 × 34 mm³. The main payload are two communication transceivers for store and forward communication with a baud-rate of 1200 and 2400 baud. The transceivers work in the 70 cm frequency band and use also FFSK modulation. The attitude control of TUBSAT-N1 consists of passive magnetic coils. The electrical power for TUBSAT-N1 is provided by 9 NiCd-battery cells of 2.8 Ah (SANYO). The battery cells are connected serially and provide an unregulated bus voltage from 9 to 13 V. The batteries are charged by 4 strings of solar cells with the dimensions 2 × 4 cm². Each string consists of 34 cells.

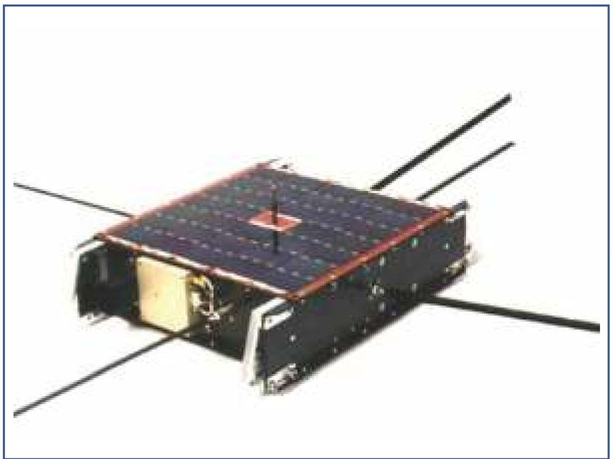
References:

Nanosatellite database by Erik | www.nanosats.eu,

http://space.skyrocket.de/doc_sdat/tubsat-n1.htm

TUBSAT-N

Mission Name	TUBSAT-N
Organisation	Technische Universität Berlin
Organisation type	University
Nation	Germany
Type (U or mass)	8.5 kg
Satellite launch year	1998-07-07
Rocket	Shtil
Orbit	404 x 770 km, 78.9 deg
Mission type	Space Technology & Data Relay
Mission type description/ Configuration/Power	Tubsat-N Bus, Solar cells, batteries
Mission objectives	• Demonstration of low-cost access to space without performance reduction. • Bidirectional data transfer between autonomous environmental stations and the satellite. • Tracking of medium-sized and large mammals.
Experiment description	The main payload are two communication transceivers for store and forward communication with a baud-rate of 1200 and 2400 baud. Reaction wheel performance. Store and forward communication
Lifetime or status in orbit	Re-entry 2000-10-20. Was operational until 1999-XX-XX. About than 2 years of operation.
Partners	DLR
Website	https://www.raumfahrttechnik.tu-berlin.de/tubsat/tubsat-nn1/
Additional comments	-
Additional sources	http://www.vectronic-aerospace.com/files/Redondo99.PDF



Like TUBSAT-N it is used for tracking medium-sized and large mammals, stolen cars and to collect data from autonomous buoys for earth environmental observation. These buoys are located in the northern Atlantic Ocean and near the Canary Islands. In spring 2000 the ground station observed the re-entry of TUBSAT-N1.

References:

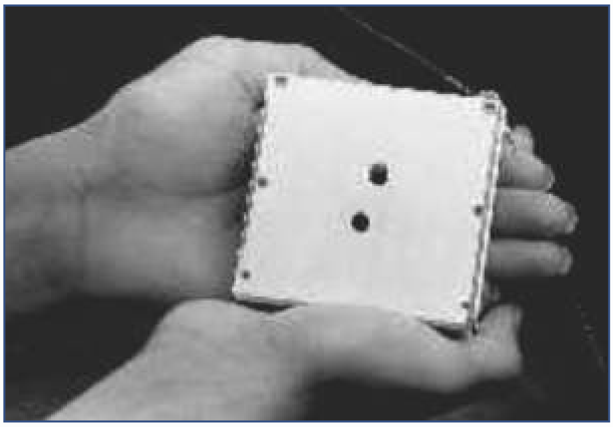
a) Nanosatellite database by Erik | www.nanosats.eu,

b) http://space.skyrocket.de/doc_sdat/tubsat-n1.htm

ARTEMIS JAK (MASat)

Mission Name	ARTEMIS JAK (MASat)
Organisation	Santa Clara University
Organisation type	University
Nation	USA
Type (U or mass)	0.2 kg
Satellite launch year	2000-Jan-27
Rocket	Minotaur I
Orbit	750 km SSO,97.5 deg
Mission type	Experimental
Mission type description/ Configuration/Power	Solar cells, batteries.
Mission objectives	Simple beacon transmitter to test the ground reception ability of spaceborne picosat broadcasts.
Experiment description	Started to investigate and design various mechanism to survive extreme environments, that includes the vacuum of space of space and the depths of the ocean.
Lifetime or status in orbit	Launched into Orbit on Feb 8 2000 and was operational until Feb 10 2000.
Partners	OPAL
Website	http://space.skyrocket.de/doc_sdat/artemis_picosat.htm , https://directory.eoportal.org/web/eoportal/satellite-missions/o/opal
Additional comments	-
Additional sources	http://screem.engr.scu.edu/artemis/

Artemis is the second undergraduate satellite project at Santa Clara University. It is part of the Santa Clara Remote Extreme Environment Mechanism (SCREEM) laboratory, which was started to investigate and design various mechanisms to survive extreme environments. These environments include the vacuum of space and the depths of the ocean.



As one of the three picosatellite providers for Stanford's Orbiting Picosat Automatic Launcher (OPAL) project, the Artemis group is using a low cost, quick prototype process to continually explore the limitations of picosatellites.

References :

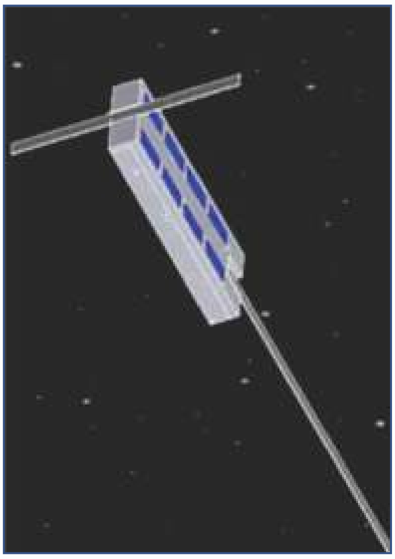
http://screem.engr.scu.edu/artemis/

http://space.skyrocket.de/doc_sdat/artemis_picosat.htm

https://directory.eoportal.org/web/eoportal/satellite-missions/o/opal

Artemis Louise (Lightning) also known as Thelma and Louise

Mission Name	Artemis Louise (Lightning) also known as Thelma and Louise
Organisation	Santa Clara University
Organisation type	University
Nation	USA
Type (U or mass)	0.89 kg
Satellite launch year	2000 – Jan – 27
Rocket	Minotaur 1
Orbit	750 km SSO , 97.5 deg
Mission type	Space Activity , Experimental
Mission type description/ Configuration/Power	Solar cells, batteries, Earth Observation
Mission objectives	The objective is to research the effects of lightning on the outer ionosphere. Lightning discharges and the effects on the Earth's near space environment can be recorded with the VLF receiver.
Experiment description	Receive frequency range is 0.1-12 kHz, with 5 kHz typcal of a lightning strike. Measurements are taken by both picosatellites. Comparison of the data permits the extraction of the occurrence and amplitudes of horizontal and vertical lightning.
Lifetime or status in orbit Partners	Feb 8 2000 to Feb 12 2000 OPAL
Website	http://screem.engr.scu.edu/artemis/
Additional comments	-
Additional sources	http://www.vectronic-aerospace.com/files/Redondo99.PDF



The Thelma and Louise satellites carried a VLF wave experiment. The VLF receiver board is the main payload aboard Artemis. The objective is to research the effects of lightning on the outer ionosphere. Measurements are taken by using the VLF radio signals traveling between the ground and the S/C. Lightning discharges and the effects on the Earth's near space environment can be recorded with the VLF receiver. The VLF receive frequency range is 0.1-12 kHz, with 5 kHz considered typical of a lightning strike. The two picosatellites have different VLF thresholds, namely 100 mV and 10 mV respectively. Measurements are taken simultaneously by both picosatellites. Comparison of the data permits the extraction of the occurrence and amplitudes of horizontal and vertical lightning.

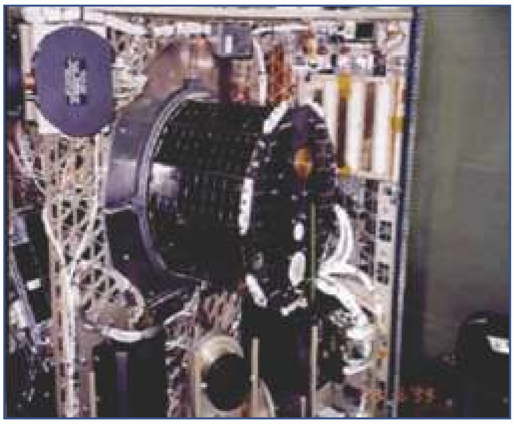
References:

http://screem.engr.scu.edu/artemis/

ASUSat 1 (Arizona State University Satellite)

Mission Name	ASUSat 1 (Arizona State University Satellite)
Organisation	Arizona State University
Organisation type	University
Nation	USA
Type (U or mass)	6 kg
Satellite launch year	2000 -Jan-26
Rocket	Minotaur 1
Orbit	750 km SSO , 97.5 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	Solar cells, batteries, On-Board Data Systems
Mission objectives	Its primary mission was Earth imaging, with several secondary missions including orbit determination, amateur-radio communications, passive stabilization techniques, attitude detection, and composite-material research
Experiment description	The satellite was designed to be placed in low Earth orbit for low-cost Earth imagery, experimental verification of composite-material models, technology demonstration of low-cost student-designed systems, boards, and sensors, and provision of an audio transponder for amateur radio (AMSAT) operators
Lifetime or status in orbit	Predicted lifetime of the satellite on battery power alone was estimated to be fifteen hours
Partners	-
Website	https://nasa.asu.edu/content/asusat1?destination=node%2F35
Additional comments	Mission objective was to show capability in a very low-mass, low-power, low-volume, and low-cost satellite.
Additional sources	http://www.vectronic-aerospace.com/files/Redondo99.PDF

ASUSat1 is a 6-kilogram-class satellite designed, fabricated, tested, and tracked by the students at ASU to perform meaningful science in space. The satellite was designed to be placed in low Earth orbit for low-cost Earth imagery, experimental verification of composite-material models, technology demonstration of low-cost student-designed systems, boards, and sensors, and provision of an audio transponder for amateur radio (AMSAT) operators. This project was begun in October 1993 and launched on January 26, 2000 at 19:03 PST to a 750km X 800km, 100 degrees inclination orbit on the first Air Force Orbital/Suborbital Program Space Launch Vehicle. We delivered the final flight hardware to Weber State on May 13, 1999, for final integration with the other payloads on the JAWSAT structure on June 23, 1999.



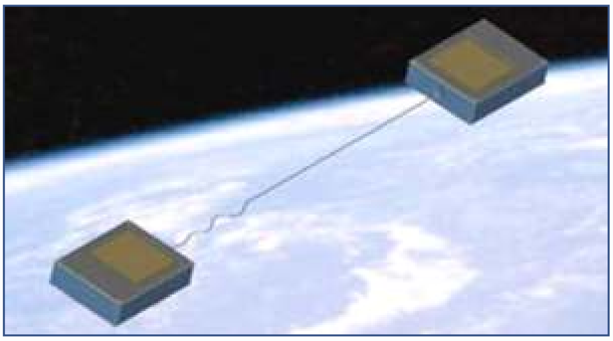
References :

https://nasa.asu.edu/content/asusat1?destination=node%2F35

http://www.vectronic-aerospace.com/files/Redondo99.PDF

MEMS 1A (Pico 21, PICOSAT-1)

Mission Name	MEMS 1A (Pico 21, PICOSAT-1)
Organisation	DARPA
Organisation type	Military
Nation	USA
Type (U or mass)	0.275 Kg
Satellite launch year	2000 -Jan-27
Rocket	Minotaur 1
Orbit	750 km SSO , 97.5 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	Solar cells, batteries, RF Payload and Systems
Mission objectives	• To demonstrate the basic functional elements of a low-power LEO "swarm" or formation PICOSAT array. • To communicate from space using node-type radios and to report the results of MEMS-switched tests.
Experiment description	Validate MEMS radio frequency switches. The two orbiting picosats are to be tethered because they will communicate via micropower radios. The tether will keep them within range of each other for crosslink purposes.
Lifetime or status in orbit	Reentry 2000-XX-XX. Was operational until 2000-02-09. Battery power decayed
Partners	Built by Aerospace Corporation, sponsored by DARPA.
Website	https://directory.eoportal.org/web/eoportal/satellite-missions/o/opal
Additional comments	Ejected from OPAL 2000-02-06.
Additional sources	-



The mission will usher in a spaceflight program to validate MEMS - tiny microelectromechanical systems being developed under sponsorship of DARPA, the Defense Advanced Research Projects Agency.

The experiment calls for two tethered picosatellites, each weighing less than one-half-pound and not much larger than a deck of cards, to be released into low Earth orbit by the OPAL satellite. OPAL is the Orbiting Picosat Automated Launcher built by Stanford University students at the school's Space Systems Development Laboratory.

The abbreviation of MEMS is Micro-electromechanical Systems).

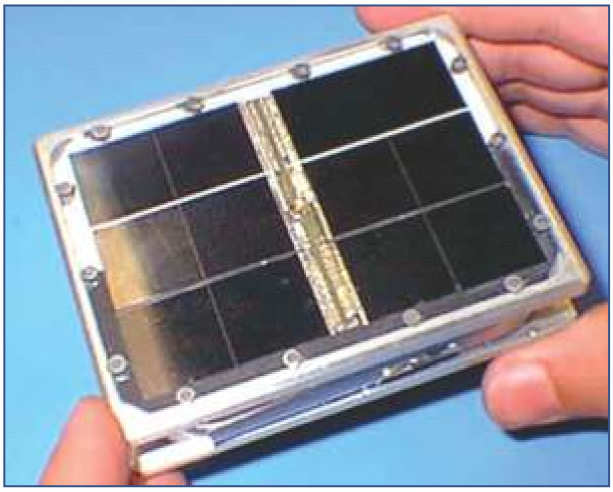
The primary goal of the DARPA/Aerospace picosasts on this mission is to validate microelectromechanical systems (MEMS) radio frequency switches designed by Rockwell Science Center, Thousand Oaks, Calif. Other MEMS devices are to be validated on subsequent picosat missions. The mission also is designed to demonstrate the principles of how constellations of nanosatellites, slightly larger than picosats, will operate in the future.

References:

http://space.skyrocket.de/doc_sdat/mems-picosat.htm

StenSa

Mission Name	StenSa
Organisation	Stensat Group
Organisation type	Company
Nation	USA
Type (U or mass)	0.2 Kg
Satellite launch year	2000 -Jan-27
Rocket	Minotaur 1
Orbit	750 km SSO , 97.5 deg
Mission type	Space Activity.
Mission type description/ Configuration/Power	Solar cells, batteries, Telecommunications.
Mission objectives	Amateur radio operators world wide and was to operate as a single channel mode "J" FM voice repeater.
Experiment description	Validate MEMS radio frequency switches. The two orbiting picosats are to be tethered because they will communicate via micropower radios. The tether will keep them within range of each other for crosslink purposes.
Lifetime or status in orbit	Reentry 2000-XX-XX. Was operational until 2000-02-09. Battery power decayed
Partners Website	Built by Aerospace Corporation, sponsored by DARPA. https://directory.eoportal.org/web/eoportal/satellite-missions/o/opal
Additional comments	Ejected from OPAL 2000-02-06.
Additional sources	-



StenSat (Stenhouse Satellite) was a small (12 cubic inch, 8.2 ounce) satellite which wass intended for use by amateur radio operators world wide and was to operate as a single channel mode "J" FM voice repeater.

The uplink frequency was 145.84 MHz and the downlink was 436.625 MHz. Stensat was to periodically transmit 1200 baud AX.25 for broadcasting telemetry. Additionally, amateur radio operators were to be able to "PING" the satellite by transmitting a six digit DTMF command to the receiver uplink.

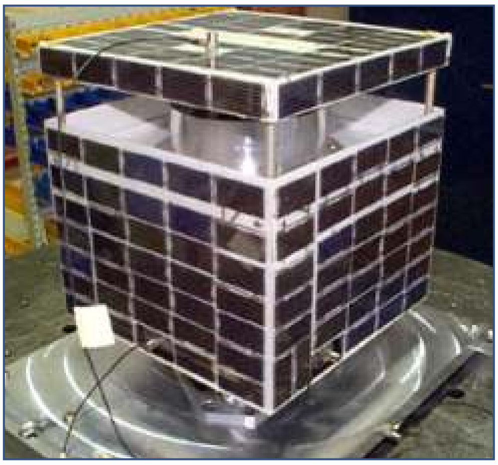
Stensat was developed as part of Stanford University's OPAL (Orbiting Picosatellite Automated Launcher) project. Stensat wass one satellite out of a cluster of six picosatellites that were ejected from the OPAL platform. Stensat was launched into orbit on 26 January 2000 and was released from the OPAL launcher on February 10th but no confirmed signals have been received from Stensat.

References :

http://space.skyrocket.de/doc_sdat/stensat.htm

Munin

Mission Name	Munin
Organisation	Swedish Institute of Space Physics
Organisation type	Institute
Nation	Sweden
Type (U or mass)	6 kg
Satellite launch year	2001-Nov-21
Rocket	Delta II
Orbit	700 x 1850 km, 96.5 deg
Mission type	Space Science.
Mission type description/ Configuration/Power	Solar and interplanetary physics.
Mission objectives	The scientific objective with Munin is to collect data on the auroral activity on both the northern and southern hemispheres, such that a global picture of the current state of activity can be made available on-line. The data acquired by Munin will then serve as an input to the prediction of space weather.
Experiment description	Collect data on the auroral activity on both the northern and southern hemispheres. Combined electron and ion spectrometer, an instrument first to be flown on the Swedish Astrid-2 mission. In addition it will measure high energy particles with a solid state detector, and image the aurora with a miniature CCD camera.
Lifetime or status in orbit	Was operational until 2001-02-21, Likely to boot PROM failure after manual CPU reset.
Partners	Luleå University of Technology, Umeå University
Website	http://munin.irf.se/frames/index.html
Additional comments	-
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/m/munin



The nanosatellite is of size 21 cm x 21 cm x 22 cm, it uses a passive magnetic stabilization system, a permanent magnet holds the satellite aligned along the geomagnetic field lines (like a compass needle). Since the S/C does not require high precision pointing, the attitude problem of restoring torque is solved by the use of a permanent magnet. Average pointing accuracies of $\pm 5^{o}$ are achieved. There are no actuators and traditional orientation sensors for attitude control. There are also no moving parts, such as deployable booms, etc.

The S/C attitude is determined by the Kiruna ground station from the following inputs: a) current measurements of the six solar arrays which cover each side of the S/C body, b) the data of two single-axis on-board magnetometers which measure the H vector, and c) images of the Earth's limb and of stars by a CCD camera. The passive magnetic attitude stabilization system of Munin, developed by IRF in cooperation with the Keldish Institute of Applied Mathematics, Moscow, employs a magnetic hysteresis damper.

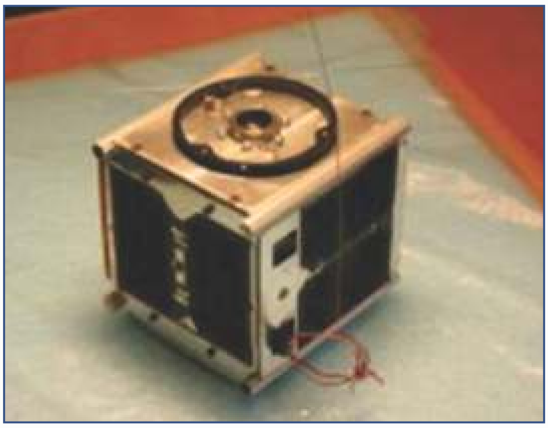
References:

a) https://directory.eoportal.org/web/eoportal/satellite-missions/m/munin

b) http://munin.irf.se/frames/index.html

AAUSAT 1

Mission Name	AAUSAT 1
Organisation	Aalborg University
Organisation type	University
Nation	Denmark
Type (U or mass)	1 U
Satellite launch year	2003-Mar-30
Rocket	Rokot-KM
Orbit	820 km, 98.73 deg
Mission type	Space Technology.
Mission type description/ Configuration/Power	System Design and verification
Mission objectives	* Sudents have achieved some useful knowledge of space technology. * That communication is established with the satellite and housekeeping information is retrieved. * Test ACS performance. * Take pictures of certain locations on earth.
Experiment description	Imaging Earth with CMOS camera. Attitude control with coils.
Lifetime or status in orbit	Was operational until 2003-09-22. Battery problems.
Partners	-
Website	http://www.space.aau.dk/cubesat/
Additional comments	Never established a solid communication link but some data was received. Might have been a problem with the on-board transmitter.
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/cubesat-launch-1



The AAU-cubesat project started in September 2001 and has had the goal to let students build and launch a nano-satellite with the purpose to provide for "hands-on" education and gain experience with nano-satellite technology. The satellite was launched on the 30th of June 2003 from Plesetsk in Russia on top of the Rockot Launcher.

Following launch the satellite was alive for two and a half months before the battery had lost too much capacity to continue operations. During this time only a limited amount of data was successfully downlinked from the satellite due to an undisclosed problem on the satellite transmitter resulting in very weak signals being transmitted.

However, as a first step into pico-satellite technology and student built satellites the projects is considered a success and will be followed up by a new student satellite, currently under definition, which will have the benefit of all the experience gained with the AAU-cubesat.

References :

a) http://www.space.aau.dk/cubesat/

b) https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/cubesat-launch-1

CanX - 1

Mission Name	CanX - 1
Organisation	Space Flight Laboratory (SFL)
Organisation type	Institute
Nation	Canada
Type (U or mass)	1 U
Satellite launch year	2003-Mar-30
Rocket	Rokot-KM
Orbit	820 km, 98.73 deg
Mission type	Space Technology.
Mission type description/ Configuration/Power	System Design and verification
Mission objectives	Its mission is to evaluate several novel technologies in space, including a low-cost CMOS horizon sensor and star-tracker, active three-axis magnetic stabilization, GPS-based position determination, and an ARM7 central computer.
Experiment description	• Testing of CMOS imagers for observation of the earth,the moon and the tracking of stars. • Powerful OBC (Onboard Computer) based on an Atmel's ARM-7 Microprocessor • A GPS receiver • An active magnetic control system including B-Dot detumbling and 3-axis stabilization.
Lifetime or status in orbit	No signal
Partners	-
Website	http://www.space.aau.dk/cubesat/
Additional comments	Never established a solid communication link but some data was received. Might have been a
	problem with the on-board transmitter.
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/cubesat-launch-1

The CanX-1 spacecraft conforms to the CubeSat standards with outer dimensions of 10 cm side length. The S/C must have four launch rails along four edges of the cube, allowing for easy ejection from the P-POD launch tube. To maintain spacing and prevent sticking with other CubeSats, standoff contacts or feet must exist at the ends of these rails. The center of mass of CanX-1 must be within 2 cm of the geometric center. The maximum mass of CanX-1 is 1 kg, and it is desired that the structure be no more than approximately 30% of the total satellite mass.

The interior structure of CanX-1 consists of four circuit boards, parallel to the x-y plane, for instrument/subsystem mounting. The power subsystem consists of a battery pack, solar arrays, a peak power tracker, a shunt regulator, and a power distribution module. Lithium-ion batteries are used with the cells connected in parallel, resulting in a 3.6 Ah nominal capacity at 3.7 V. Six surface-mounted solar arrays with triple-junction GaAs cells provide an average power of 1.63 W per array at 4.4-5 V output. Power is permanently supplied to the OBC and RF transmitter/receiver (radio), while power to the rest of the subsystems and payloads are switchable and are controlled by the OBC. - The ACS (Attitude Control Subsystem) employs magnetic control consisting of three orthogonal torquer coils (actuators), and a three-axis magnetometer (sensor to measure the magnetic field).

References:

a) http://www.space.aau.dk/cubesat/

b) https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/cubesat-launch-1

UNOSAT 1

Mission Name	UNOSAT 1 (Undergraduate Orbital Student Satellite)
Organisation	Universidade Norte do Paraná
Organisation type	University
Nation	Brazil
Type (U or mass)	8.83 kg
Satellite launch year	2003-Aug-23
Rocket	VLS-1
Orbit	Launch Failure
Mission type	System Technology
Mission type description/ Configuration/Power	Consists of an FM Transmitter, 2 rechargeable batteries and a non-rechargeable set, 4 solar panels, antenna and an on-board computer.
Mission objectives	Transmit in regular intervals a message of voice and one packet of telemetry.
Experiment description	• Testing of FM Transmitter in outer space.
Lifetime or status in orbit	No signal
Partners	SATEC - Technological Satellite
Website	http://www.inovacaotecnologica.com.br/noticias/noticia.php?artigo=010130030430
Additional comments	Rocket and satellite were destroyed when Brazilian Space Agency VLS-1 launch vechicle exploded on launch pad.
Additional sources	https://en.wikipedia.org/wiki/VLS-1_V03

SATEC was designed to test the technology equipment embedded in the VLS, providing more information for future applications. Estimated to have a shelf life of six months, it has a mass of 65 kg, measures 66 cm in width and depth and 61 cm in height.

The satellite's orbit will be circular with a 15-degree slope and altitude of 750 km, close to the SCDs 1 and 2 orbit, and will carry four technological systems to be tested: a battery, a PCU (power conditioner), a receiver GPS (global positioning system) to determine its location, and the high frequency transmitter (bandS). The structure, the battery, the PCU and the S Band transmitter were developed internally at INPE; the solar panels and the GPS were developed in partnership with national companies of the area. TNS-0 (TEKh-42, Technologicesky Nanosputnik)

References :

https://en.wikipedia.org/wiki/VLS-1_V03

http://www.inovacaotecnologica.com.br/noticias/noticia.php?artigo=010130030430

TNS-0 (TEKh-42, Technologicesky Nanosputnik)

Mission Name	TNS-0 (TEKh-42, Technologicesky Nanosputnik)
Organisation	Moscow Russian Scientific Research Institute
Organisation type	Institute
Nation	Russia
Type (U or mass)	4.5 kg
Satellite launch year	2005-02-28
Rocket	Sojuz-U
Orbit	ISS
Mission type	Space Technology
Mission type description/ Configuration/Power	RF Payload and Systems
Mission objectives	Working out the principles of small satellites control using global telecommunication systems, as well as receiving by COSPAS/SARSAT system beacon of the flight qualification.
Experiment description	Serviceability verification of the global satellite system (GLOBALSTAR) subscribers' equipment for transmission of the command and program information to the satellite and for transmission of the telemetry information from the satellite.
Lifetime or status in orbit	Re-entry 2005-08-30. Was operational until 2005-07-15. Batteries were empty and burnt in atmosphere couple of months later.
Partners	FSUE (Federal State Unitary Enterprise-meaning a `government industry')
Website	https://directory.eoportal.org/web/eoportal/satellite-missions/t/tns
Additional comments	Deployed from ISS on 2005-03-15 during a spacewalk
Additional sources	http://space.skyrocket.de/doc_sdat/tns-0.htm

The TNS-0(Technologicesky Nanosputnik), also called TEKh-42, is a small Russian experimental satellite, which was deployed from the ISS on 28 March 2005 during a spacewalk. It was delivered to the space station by Progress-M 52.

TNS 0 will serve as the prototype for future super-small craft. Specialists from the Moscow Russian Scientific Research Institute developed the TNS-0 for Space Instrument Engineering (RNII-KP). The TNS-0 weighs 4.5 kilograms. It is designed to check up the data transmission line operated by the GlobalStar satellite communications system. The satellite consists of a lithium battery, two modems, an antenna and an on-board timer. It proved too costly to launch the TNS-0 via a carrier rocket, since a separate jettisoning system would have been required. RNII KP specialists agreed that it would be launched from aboard the space station.

TNS 0 is about a foot long, weighs 5 kg and contains a transmitter. The crew activated it before leaving the airlock and stowed it on the outside of the docking compartment. The object of the experiment is to develop small satellite control techniques, monitor satellite operations and develop new attitude system sensors.

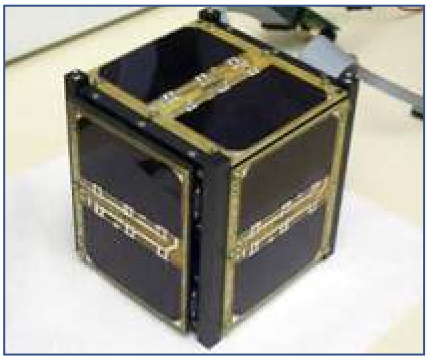
References:

https://directory.eoportal.org/web/eoportal/satellite-missions/t/tns

http://space.skyrocket.de/doc_sdat/tns-0.htm

HAUSat – 1 (Hannuri-1 Hankuk Aviation University Satellite -1)

Mission Name	HAUSat – 1 (Hannuri-1 Hankuk Aviation University Satellite -1)
Organisation	Korea Aerospace University (Hankuk Aviation University)
Organisation type	University
Nation	South Korea
Type (U or mass)	1U
Satellite launch year	2005-02-28
Rocket	Dnepr
Orbit	Launch Failure
Mission type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Development, launch, and operation of CubeSat. Space qualification of space components. Develop core satellite system technology. Establish satellite system development infrastructure. Cultivate professionals in field of satellite systems. Accomplish national-first purely student managed program.
Experiment description	Space-borne GPS Receiver. Verification of home-made Sun Sensor. Verification of Solar Panel Deployment Mechanism.
Lifetime or status in orbit	Launch failure
Partners	FSUE (Federal State Unitary Enterprise-meaning a `government industry')
Website	http://digitalcommons.usu.edu/cgi/viewcontent.cgi?filename=0&article=1892&context=smallsat&type=additional
Additional comments	Deployed from ISS on 2005-03-15 during a spacewalk
Additional sources	http://space.skyrocket.de/doc_sdat/hausat-1.htm



HAUSAT-1 (Hankuk Aviation University SATellite-1) was the first picosatellite in South Korea developed by graduate students. The primary mission objective of HAUSAT-1 development was to offer graduate and undergraduate student great opportunities and help them understand the whole development processes of satellite design, analysis, manufacturing, assembly, inefration, test, launch, and operation, and consequently make them specialists in the field of satellite development.

The satellite was built to the 1U CubeSat for factor specification. Actual mission objective in accordance with on-board payload are as followings; collecting the satellite position data with spaceborne GPS receiver, experiment on deployment mechanism of solar cell panel, space verification of homemade sun sensor, and getting data related to satellite Status of Health (SOH) from various sensors.

The HAUSAT-1 is designed with controller based on standby and warm redundancy. The payloads incorporated are a spaceborne GPS receiver, solar panel deployment mechanism, and a homemade sun sensor. A mass storage memory has 60 Mbits storage volume, which is a flash type having nonvolatile characteristic. Average power generated is about 1.5 Watt. Communication band width is amateur HAM band and UHF/VHF antenna with dipole/monopole configuration which is made of flexible steel can be folded easily.

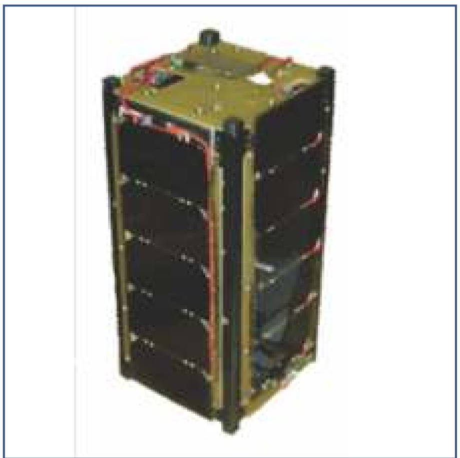
References :

http://space.skyrocket.de/doc_sdat/hausat-1.htm

http://digitalcommons.usu.edu/cgi/viewcontent.cgi?filename=0&article=1892&context=smallsat&type=additional

ION (Illinois Observing Nanosatellite)

Mission Name	ION
Organisation	University of Illinois
Organisation type	University
Nation	USA
Type (U or mass)	2U
Satellite launch year	2006-07-26
Rocket	Dnepr
Orbit	Launch Failure
Mission type	Space Science
Mission type description/ Configuration/Power	Upper Atmosphere
Mission objectives	Measuring Oxygen airglow emissions from the Earth's mesosphere. Tests a new MicroVacuum Arc Thruster (µVAT) with high dynamic range. tests a new SID processor board. Small CMOS camera for Earth imaging.
Experiment description	Measuring molecular Oxygen airglow emissions from the Earth's mesosphere using a 760nm photometer. Oxygen chemistry at this 90km altitude emits a dim glow of light. Learn how energy transfers across large spatial regions contributing to knowledge of upper atmospheric dynamics. This airglow emission is absorbed by the Earth's lower atmosphere preventing study with Earth-based sensors.
Lifetime or status in orbit	Launch failure
Partners	FSUE (Federal State Unitary Enterprise-meaning a `government industry')
Website	http://cubesat.ece.illinois.edu/
Additional comments	Deployed from ISS on 2005-03-15 during a spacewalk
Additional sources	-



The Illinois Observing Nanosatellite (ION) is the first project of the Illinois Tiny Satellite Initiative (ITSI), which is organized through an interdisciplinary senior design course. The course objectives include training students to identify, formulate, and solve engineering problems as part of a large multi-team project. As the University of Illinois' first student-developed satellite, ION has been completed and awaits launch in the near future.

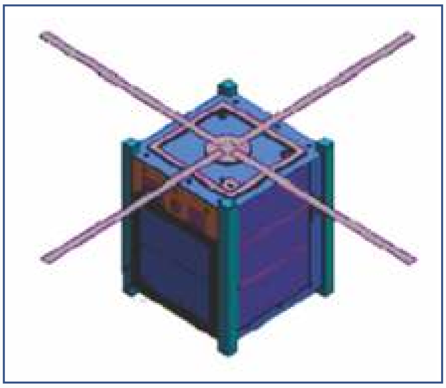
In addition to the primary educational mission that CubeSat programs perform, the University of Illinois has strived to also demonstrate the utility of these tiny satellites by following through on real missions including a science mission. The ION team hopes that the resulting product will help expand the perceptions of what these tiny satellites can do someday leading to future space sensor webs.

References:

http://cubesat.ece.illinois.edu/

KUTESat

Mission Name	KUTESat
Organisation	University of Kansas
Organisation type	University
Nation	USA
Type (U or mass)	1U
Satellite launch year	2006-07-26
Rocket	Dnepr
Orbit	Launch Failure
Mission type	Space Technology
Mission type description/ Configuration/Power	Flight Dynamics/Position, Navigation and Timing
Mission objectives	Develop and operate a simple pico-satellite in low earth orbit (LEO).
Experiment description	Measure the radiation in LEO and take photographs with an onboard camera.
Lifetime or status in orbit	Launch failure
Partners	-
Website	http://mstl.atl.calpoly.edu/~bklofas/Presentations/DevelopersWorkshop2004/2c_kansas.pdf
Additional comments	Pathfinder
Additional sources	http://space.skyrocket.de/doc_sdat/kutesat-pathfinder.htm



The KUTESat Pathfinder(Kansas Universities' Technology Evaluation Satellite) is a joint venture among several universities located in the state of Kansas that aims to promote interest in space activities while establishing the capability to design, build, test, and operate satellites at the University of Kansas.

The KUTESat satellites are 10 cm cube pico satellites. The program consists of three mission phases, each with its own purpose, development, and testing program. The objective of the first phase of the of the KUTESat program is to design, develop, and operate a simple CubeSat called Pathfinder, which will be flown in a low earth orbit (LEO). The primary mission of this satellite is to measure the radiation in LEO and take photographs with an onboard camera. The second phase of the program is to build an engineering demonstration of the satellite with an onboard attitude control system using miniature thrusters. This prototype will then be tested in the neutral gravity environment by flying it as an experiment on the NASA JSC KC135 or similar aircraft. The final phase of the KUTESat mission involves developing and testing three different prototype satellites. The Inspection Sensor Satellite (ISS) will do the imaging inspection of a target with its complete translational and rotational capabilities. The Space Environment Satellite (SES) will measure the space environment away from the mother ship. The Target Relay Satellite (TRS) will then act as a target for the ISS and as a relay satellite for both the ISS and the SES to communicate with the ground. The overall project name for this third phase of the program is Mission of ISS, SES, TRS, or also known as MIST.

Since its conception a year ago, the KUTESat Pathfinder project has undergone three major phases of design reviews; the System Concept Review, the Preliminary Design Review and the Critical Design Review. With the design and the components finalized, procurement of the various components of the satellite has begun and construction and testing will follow shortly. The team is establishing a clean room in the University of Kansas hangar at the Lawrence Airport and obtaining the necessary materials. This facility will house both the construction and testing of the satellite.

References :

http://space.skyrocket.de/doc_sdat/kutesat-pathfinder.htm
http://mstl.atl.calpoly.edu/~bklofas/Presentations/DevelopersWorkshop2004/2c_kansas.pdf

Mea Huaka'i (Voyager)

Mission Name	Mea Huaka'i (Voyager)
Organisation	University of Hawaii
Organisation type	University
Nation	USA
Type (U or mass)	1U
Satellite launch year	2006-07-26
Rocket	Dnepr
Orbit	Launch Failure
Mission type	Space Technology
Mission type description/ Configuration/Power	RF Payload and Systems
Mission objectives	Set of temperature sensors to verify UH-designed thermal modeling software, but the actual mission was just learning to build a bus.
Experiment description	Active antenna - test a 5.8-GHz active antenna (grid oscillator) for high bandwidth communication. Grid oscillators do not require deployment, are tolerant to single-point failures, and facilitate long-link communications at microwave frequencies.
Lifetime or status in orbit	Launch failure
Partners	-
Website	http://cubesat.eng.hawaii.edu/about.html
Additional comments	-
Additional sources	http://space.skyrocket.de/doc_sdat/mea-huakai.htm

The University of Hawai'i 1U CubeSat called Mea Huaka'i was a nanosatellite to incorporate the following experiments as its payload:

Active antenna - CubeSat communications currently operate at VHF/UHF frequencies. However, to support increased data rates, higher frequency communications are desired. Thus, an active antenna will be flown to determine its feasibility for use in space. The active antenna that will fly is a compact, lightweight, state-of-the-art component known as a grid oscillator. This will be the first grid oscillator in space. Compared to conventional CubeSat antennas, grid oscillators do not require deployment, are tolerant to single-point failures, and facilitate long-link communications at microwave frequencies – important advantages in satellite design, and necessary design features for future CubeSat missions.

Thermal sensors - This is the job of the Analog/Digital Sensors (ADS) team. These sensors will be used to monitor the environment of the CubeSat, as well as to provide data for verification of the MSA's Thermal group analysis.

Attitude stabilization - In order to get the maximum power out of the satellite's solar cells, the rate of spin of the satellite must be kept at a relatively slow rate (accomplished with the use of hysteresis rods). In addition, in order to make sure that the active antenna faces towards the Earth (for maximum gain), magnets will be used to align the satellite with the Earth's magnetic field. The Science (SCI) team is in charge of the passive stabilization system.

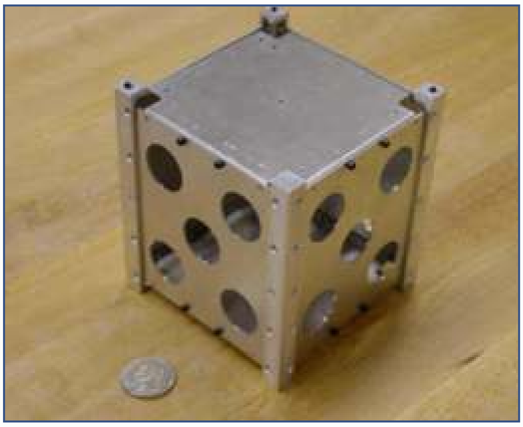
References:

http://space.skyrocket.de/doc_sdat/mea-huakai.htm

http://cubesat.eng.hawaii.edu/about.html

MEROPE (Montana Earth Orbiting Pico Explorer)

Mission Name	MEROPE (Montana Earth Orbiting Pico Explorer)
Organisation	Montana State Universir
Organisation type	University
Nation	USA
Type (U or mass)	1U
Satellite launch year	2006-07-26
Rocket	Dnepr
Orbit	Launch Failure
Mission type	Space Technology
Mission type description/ Configuration/Power	Space Environment and effects
Mission objectives	Measure the radiation of the Van Allen radiation belts, first discovered by Explorer-1 under the direction of Professor James Van Allen's group of the State University of Iowa (now The University of Iowa).
Experiment description	-
Lifetime or status in orbit	Launch failure
Partners	-
Website	http://www.montana.edu/news/3898/crash-of-russian-rocket-destroys-montana-s-first-satellite
Additional comments	-
Additional sources	https://digitalcommons.usu.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1970
	&context=smallsat



The Montana Earth-Orbiting Pico Explorer (MEROPE) is the Montana Space Grant Consortium's (MSGC) CubeSat program, being built by the Space Science and Engineering Laboratory (SSEL) at Montana State University in Bozeman. MEROPE will also be the first satellite ever built in Montana. The project is entirely student run, with faculty members acting as advisers. First and foremost, MEROPE is an educational project. Students are involved with every part of the satellite, including but not limited to: designing the satellite, constructing the onboard experiment and all subsystems, fabricating a ground station to control and communicate with the satellite, testing the engineering and flight models, and contributing to public outreach and web site development. MEROPE is being constructed on a low-cost budget of less than $50,000, including launch, by using mostly off the-shelf hardware.

In the first section of this paper, the scientific objectives of MEROPE are described in detail, including the selected Geiger tube, payload circuit, and expected data. A brief introduction to the Van Allen Radiation Belts is provided. The second section explains the systems engineering and project management. Each required subsystem needed to accomplish the mission is also described. Finally, potential future uses, strengths, and advantages of CubeSat-class satellites in space science experiments are discussed.

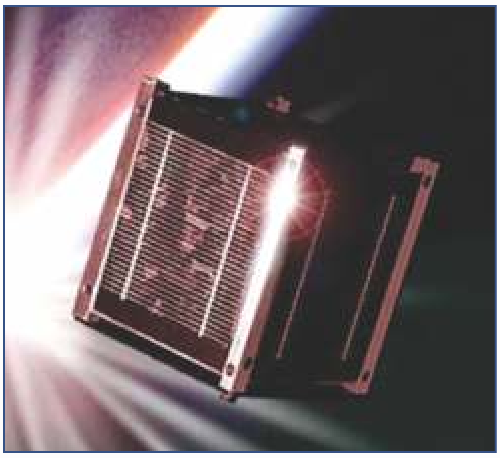
References :

https://digitalcommons.usu.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1970&context=smallsat

http://www.montana.edu/news/3898/crash-of-russian-rocket-destroys-montana-s-first-satellite

nCube – 1

Mission Name	nCube – 1
Organisation	Norwegian University of Technology and Science (NTNU), Narvik University College (HiN)
	and the Agricultural University of Norway (NLH).
Organisation type	University
Nation	Norway
Type (U or mass)	1U
Satellite launch year	2006-07-26
Rocket	Dnepr
Orbit	Launch Failure
Mission type	Space Technology
Mission type description/ Configuration/Power	RF Payload and Systems
Mission objectives	Hands-on experience with a real satellite mission. Multidisciplinary collaboration. Space project experience.
Experiment description	AIS receiver to demonstrate the capability of tracking ships from space.
Lifetime or status in orbit	Launch failure
Partners	-
Website	http://space.skyrocket.de/doc_sdat/ncube-1.htm
Additional comments	The payload is an AIS receiver (Automated Identification System), to demonstrate the capability of using this earth-based ship-tracking system from space. To further test the use of the AIS receiver, a reindeer will be fitted with a collar capable of sending AIS signals to the satellite, thus enabling tracking of the movement of the reindeer.
Additional sources	-



The Norwegian Student Satellite Project Ncube(Norwegian Cubesat) aims to design, build, integrate, test and launch a small satellite in order to provide students in Norwegian educational institutions with:

- hands-on experience with a real satellite mission
- multidisciplinary collaboration
- space project experience

To stimulate:

- Interest in science
- Increased competence in space technology among students and educational institutions
- Co-operation between educational institutions and industry
- Co-operation and exchange of knowledge between institutions in the north and in the south

By ensuring:

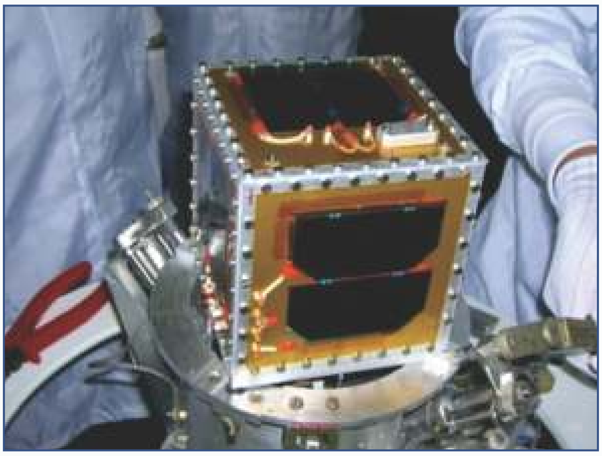
- Support and guidance from in-house expertise
- Support from expertise in related Norwegian industry and research establishments
- Testing by rocket launch or balloon mission, and in facilities available throughout Norway.

References:

http://space.skyrocket.de/doc_sdat/ncube-1.htm

PicPoT (Small Satellite of Politecnico di Torino)

Mission Name	PicPoT (Small Satellite of Politecnico di Torino)
Organisation	Polytechnic University of Turin
Organisation type	University
Nation	Italy
Type (U or mass)	2.5kg
Satellite launch year	2006-07-26
Rocket	Dnepr
Orbit	Launch Failure
Mission type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Educational
Experiment description	Camera.
Lifetime or status in orbit	Launch failure
Partners	-
Website	http://space.skyrocket.de/doc_sdat/ncube-1.htm
Additional comments	Cube with side length of 13 cm.
Additional sources	-



PicPot (Piccolo Cubo del Politecnico del Torino) is a small technology satellite built by the Polytechnic University of Torino. It has a cube-structure of 15 cm side length.

The objects of the PicPot project are:

- Students gaining experience of construction, production and control of automatic spacecraft;
- photographing the northern hemisphere of the Earth;
- technological tests under space conditions of silicic solar photoelectric elements intended for the use on Earth;
- testing the efficiency of litievo-polymeric batteries under the space conditions;
- testing a brushless direct-current motor;
- checking communication channels.

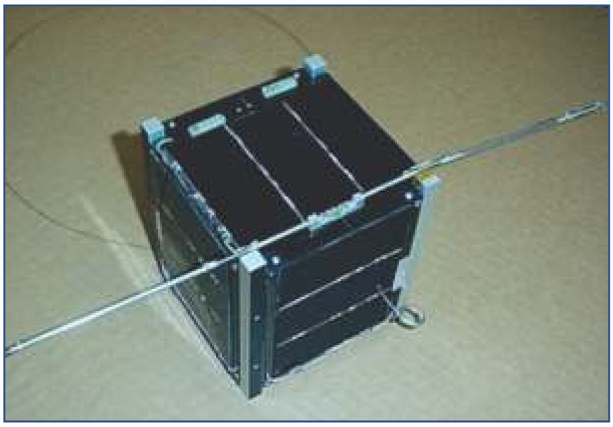
The launch was not successful, as the Dnepr failed 86 secs after launch.

References:

http://space.skyrocket.de/doc_sdat/picpot.htm

RinCon 1

Mission Name	RinCon 1
Organisation	University of Arizona
Organisation type	University
Nation	US
Type (U or mass)	1U
Satellite launch year	2006-07-26
Rocket	Dnepr
Orbit	Launch Failure
Mission type	Space Technology
Mission type description/ Configuration/Power	RF Payload and Systems
Mission objectives	Low-power beacon system, which provides a redundant means of relaying sensor data in analog form if the primary (digital) transmitter fails.
Experiment description	Sophisticated, low-power beacon board that was produced by Rincon and provides a redundant means of relaying sensor data in analog form. The beacon operates autonomous of all other satellite systems except for the power and the sensor electronics.
Lifetime or status in orbit	Launch failure
Partners	Rincon Research Corporation
Website	http://space.skyrocket.de/doc_sdat/ncube-1.htm
Additional comments	-
Additional sources	-



Rincon 1 was a CubeSatnanosatellite built by the University of Arizona Student Satellite Program.

The payload for this satellite is a sophisticated, low-power beacon board that was produced by Rincon Research Corporation and provides a redundant means of relaying sensor data in analog form. This data can be compared with the digital forms, sent by the primary transmitter. The beacon operates autonomous of all other satellite systems except for the power and the sensor electronics. Besides the main controller, it has the capability of deploying each of the antennas.

The launch was not successful, as the Dnepr failed 86 sec after launch.

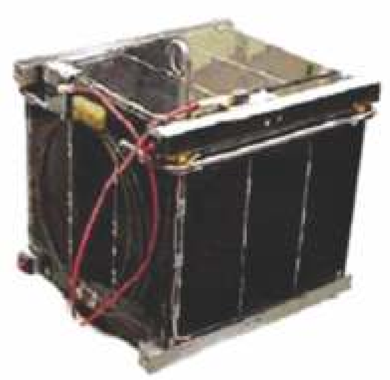
References :

http://space.skyrocket.de/doc_sdat/rincon-1.htm

https://en.wikipedia.org/wiki/Rincon_1

SACRED (AlcatelSat)

Mission Name	AlcatelSat
Organisation	University of Arizona
Organisation type	University
Nation	US
Type (U or mass)	1U
Satellite launch year	2006-07-26
Rocket	Dnepr
Orbit	Launch Failure
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Measure the total amount of high-energy radiation over a two-year span and will test the radiation properties of four commercial integrated circuits
Experiment description	The payload for this satellite was produced by Montpelier University and Alcatel and provides a valuable scientific/commercial application. The electronics board for this payload will measure the total amount of high-energy radiation over a two-year span and will test four commercial integrated circuit components for their radiation hardness, functionality and annealing properties.
Lifetime or status in orbit	Launch failure
Partners	Montpelier University and Alcatel Space Systems of France.
Website	http://space.skyrocket.de/doc_sdat/sacred.htm
Additional comments	-
Additional sources	https://en.wikipedia.org/wiki/SACRED



SACRED (formerly known as AlcatelSat) represents a cooperative effort between The University of Arizona Student Satellite Program, Montpelier University and Alcatel Space Systems of France.

The payload for this satellite was produced by Montpelier University and Alcatel and provides a valuable scientific/commercial application. The electronics board for this payload will measure the total amount of high-energy radiation over a two-year span and will test four commercial integrated circuit components for their radiation hardness, functionality and annealing properties.

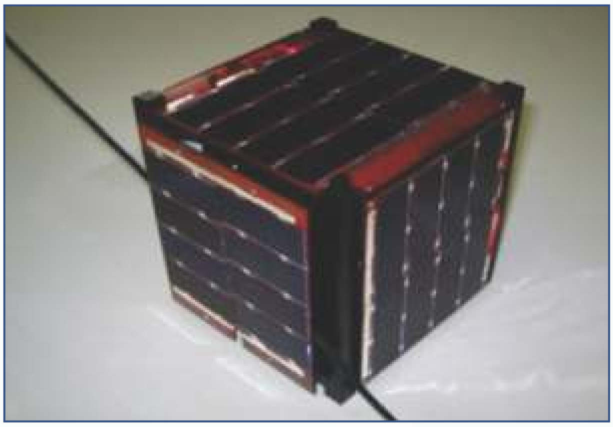
References:

http://space.skyrocket.de/doc_sdat/sacred.htm

https://en.wikipedia.org/wiki/SACRED

SEEDS

Mission Name	SEEDS
Organisation	Nihon University
Organisation type	University
Nation	Japan
Type (U or mass)	1U
Satellite launch year	2006-07-26
Rocket	Dnepr
Orbit	Launch Failure
Mission type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Communication with the amateur ground stations, the sensing of the satellite housekeeping data, and the analysis of its orbit and attitude. Each mission has many sub-missions.
Experiment description	Contains a gyro sensor for accurate determination of attitude motion.
Lifetime or status in orbit	Launch failure
Partners	Montpelier University and Alcatel Space Systems of France.
Website	http://space.skyrocket.de/doc_sdat/sacred.htm
Additional comments	-
Additional sources	https://en.wikipedia.org/wiki/SACRED



The main mission of SEEDS (Space Engineering Educational Satellite) is the communication with the amateur ground stations, the sensing of the satellite housekeeping data, and the analysis of its orbit and attitude. Each mission has many sub-missions.

The total mass of the satellite is only 1 kg. The dimension is 10 cm cube. SEEDS has a CW transmitter, a FM transmitter, a FM receiver, a monopole deployable antenna, and several sensors. SEEDS can communicate with the ground stations by using 430 MHz band (the amateur radio frequency).

References :

http://space.skyrocket.de/doc_sdat/seeds.htm

http://cubesat.aero.cst.nihon-u.ac.jp/english/main_e.html

HIT-Sat (Hokkaido Institute of Technology Satellite)

Mission Name	HIT-Sat (Hokkaido Institute of Technology Satellite)
Organisation	Hokkaido Institute of Technology
Organisation type	University
Nation	Japan
Type (U or mass)	2.7 kg
Satellite launch year	2006-09-22
Rocket	M-V-7 (M-5)
Orbit	250 x 600 km, 98 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Demonstrate the performance of the HIT-Sat bus system on orbit. HIT-Sat is an engineering test CubeSat, which is being used as a scale model for a future "Hokkaido microsatellite" .
Experiment description	-
Lifetime or status in orbit	Reentry 2008-06-18. Was operational until 2007-02-03, afterwards beacon intermittently.
Partners	-
Website	https://directory.eoportal.org/web/eoportal/satellite-missions/h/hit-sat
Additional comments	Cube with side length of 12 cm.
Additional sources	-

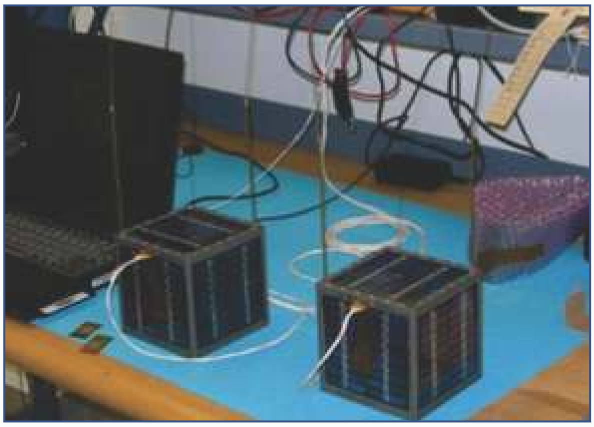
HIT-Sat is a CubeSat development of the HIT-SAT Development Team (including students and researchers at Hokkaido Institute of Technology and Hokkaido University, and some volunteer engineers), Hokkaido, Japan. The overall objective is to demonstrate the performance of the HIT-Sat bus system on orbit. HIT-Sat is an engineering test CubeSat, which is being used as a scale model for a future "Hokkaido microsatellite" intended for Earth observation (to be launched in 2009).

References:

https://directory.eoportal.org/web/eoportal/satellite-missions/h/hit-sat

RAFT 1

Mission Name	RAFT 1
Organisation	US Naval Academy Satellite Lab
Organisation type	University
Nation	US
Type (U or mass)	4 kg
Satellite launch year	2006-10-12
Rocket	Shuttle
Orbit	ISS
Mission type	Space Technology
Mission type description/ Configuration/Power	RF Payload and Systems
Mission objectives	The mission of MARScom is to explore and demonstrate a very low cost yet viable communications capability for education and training of both Midshipmen and the large numbers of Navy Marine Corps communications cadre personnel.
Experiment description	Part of RAFT mission. The satellites will be the first of their size with the ability to be tracked by the Navy Space Surveillance (NSSS) radar fence. The satellites will also function as amateur radio transponders.
Lifetime or status in orbit	Reentry 2007-05-06. No signal.
Partners	-
Website	http://space.skyrocket.de/doc_sdat/raft1_marscom.htm
Additional comments	Deployed from Shuttle on 2006-12-21
Additional sources	-



The US Naval Academy Satellite Labs RAFT Mission is to provide a cubesat in the cubesat cluster which has an on-board transponder capable of identifying itself via the NSSS satellite Radar Tracking system to help locate the Cubesats. Without this transponder, the Cubesats are too small to be detected by normal non-queued tracking systems, and so there is no easy way to find these individual cubesats once they have begun to spread from the original launch tracking elements. Secondly, RAFT will have a separate 217 MHz NSSS radar transmitter and receiver, which can help with calibration tests of the separate NSSS transmit and receive antenna beams.

The requirement for two cubesats to mark the initial front and back of the spreading constellation, also gives two opportunities for experimental communications payloads. One is called RAFT1 and the other is called MARScom.

References :

http://www.dk3wn.info/sat/afu/sat_marscom.shtml

http://space.skyrocket.de/doc_sdat/raft1_marscom.htm

MEPSI 2A

Mission Name	MEPSI 2A
Organisation	DARPA
Organisation type	Military
Nation	US
Type (U or mass)	1U
Satellite launch year	2006-12-09
Rocket	Shuttle
Orbit	ISS
Mission type	Space Technology
Mission type description/ Configuration/Power	System Design and Verification
Mission objectives	Pair is tethered. Cold gas propulsion system, with 0.1N thrust with 5 thrusters. This propulsion system includes MEMS pressure transducers
Experiment description	-
Lifetime or status in orbit	Reentry 2007-03-08. Was operational, but short lived.
Partners	Aerospace Corporation was the contractor in collaboration with NASA Jet Propulsion Laboratory.
Website	http://space.skyrocket.de/doc_sdat/raft1_marscom.htm
Additional comments	Deployed from Shuttle on 2006-12-21
Additional sources	-

The MEPSIseries (Micro Electro-Mechanical Systems-based PicoSat Inspector) consts of pairs of tethered picosatellites, similar to the CubeSat design, to develop and demonstrate the capability of deploying an onboard miniature autonomous inspector, tasked to conduct visual inspection of the host satellite.

After two precursor missions were flown in February 2000 (Pico 21 and 23) and September 2001 (Pico 20 and 22), the larger MEPSI series was developed.

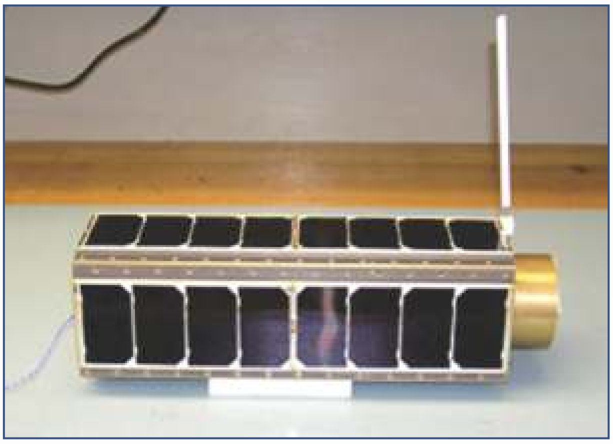
The first pair of MEPSI satellites was launched by a custom deployer aboard the STS-113 Endeavour mission on the 2 December 2002. The spacecraft were manufactured for DARPA by The Aerospace Corporation in collaboration with the NASA Jet Propulsion Laboratory. The two spacecraft are cubic in shape, weight 1 kg each, and are connected via a 15.2 m tether in order to facilitate detection and tracking via ground-based radar. The spacecraft carried a cold gas propulsion system, with 0.1 N thrust with 5 thrusters. This propulsion system includes MEMS pressure transducers and was supplied by Vacco Industries under a US $152k contract.

References :

http://space.skyrocket.de/doc_sdat/mepsi.htm

GeneSat - 1

Mission Name	GeneSat - 1
Organisation	NASA/Santa Clara University
Organisation type	Agency
Nation	US
Type (U or mass)	3U
Satellite launch year	2006-12-16
Rocket	Minotaur I
Orbit	410 km, 40 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	In-space multidisciplinary research and technology development
Mission objectives	Perform experiment on E. Coli bacteria in space, first cubesat to carry a biological experiment.
Experiment description	-
Lifetime or status in orbit	Reentry 2010-08-04. Was operational.
Partners	-
Website	https://www.scu.edu/engineering/labs--research/labs/roboticssystemslab/references/draft%20ieee%20aero%20sys%20mag%20article.pdf http://space.skyrocket.de/doc_sdat/genesat-1.htm
Additional comments	Deployed from Shuttle on 2006-12-21
Additional sources	https://www.slideshare.net/mpariente/nanosatellite-industry-overview-updated-022014 https://www.scu.edu/engineering/labs--research/labs/robotics-systems-lab/dashboard/index.htm



The GeneSat-1 CubeSat technology demonstration nanosatellite mission is a cooperative effort between NASA and various universities partnered at the Space Technology Center (STC) located at NASA/ARC (NASA/Ames Research Center) and managed by San Jose State University (SJSU), including SCU (Santa Clara University), Cal Poly, and SSDL (Space Systems Development Laboratory) and NCSBT (National Center for Space Biological Technologies) of Stanford University. The overall objective is to study the effects of the microgravity environment on biological cultures (bacteria, genetic and biological probes to detect "gene expression") - hence, the label of "GeneSat" mission due to the biological payload.

Specific mission requirements are:

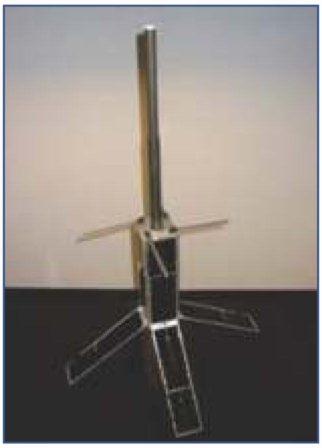
- To develop and test a flight-ready autonomous technology demonstration platform and to design advanced sensors to exploit cellular or microscopic organisms in a small form factor (miniaturized systems).
- The spacecraft must be capable of accommodating multiple instrument technologies including fluorescent imaging of single proteins using GFP (Green Fluorescent Protein) techniques.
- Support of specific investigations and assessments of technologies used in ground applications. The initial GeneSat-1 mission will focus on quantitatively detecting levels of GFP expressed in living cultures.
- The goal of GeneSat-1 is to exploit and investigate the capabilities of Smallsats to accelerate the migration of key technologies to broader applications such as autonomous spacecraft operations, man-tended space vehicles, and novel ground-based research applications.

References:

http://space.skyrocket.de/doc_sdat/genesat-1.htm

QuakeSat

Mission Name	QuakeSat
Organisation	Stanford University
Organisation type	University
Nation	US
Type (U or mass)	3 U
Satellite launch year	2003-Mar-30
Rocket	Rokot-KM
Orbit	820 km, 98.73 deg
Mission type	Space Technology.
Mission type description/ Configuration/Power	Science instruments and sensor systems
Mission objectives	* To detect, record, and downlink earthquake ELF emission data. * Demonstrate that the CubeSat Nano-Sat design is a cost-effective platform for conducting significant space science research experiments. * Demonstrate the feasibility of utilizing commercially-off-the-shelf (COTS) parts to construct a reliable, short mission micro-satellite.
Experiment description	To detect Earthquake ELF emission data.
Lifetime or status in orbit	Was operational until 2004-12-XX.
Partners	-
Website	http://www.quakefinder.com/research/quakesat-ssite/
Additional comments	-.
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/cubesat-launch-1, http://www.quakefinder.com/research/pdf/L3-3%20Bleier.pdf, https://www.quakefinder.com/pdf/Lessons_Learned_Final.pdf



QuakeSat is a research nanosatellite, a collaboration of SSDL (Space Systems Development Laboratory) at Stanford University, Stanford, CA, and of the QuakeFinder Team of Palo Alto, CA. The overall objective is earthquake signature detection. QuakeSat's primary scientific mission is to detect, record, and downlink ELF (Extremely Low Frequency) magnetic signal data, which may lead to groundbreaking techniques to predict earthquake activity. According to theory, fracturing bedrock along the fault lines creates the ELF magnetic waves. These signatures radiate from the earthquake hypocenter region (several tens of km2), through the Earth (5-80 km), through the atmosphere to the ionosphere (100-200 km), and are propagated up the Earth's magnetic field lines to satellite altitude.The nanosatellite design is based on the CubeSat concept where each CubeSat is of 10 cm side length. QuakeSat is in fact a triple CubeSat to provide a large enough size to include a 30 cm long magnetometer that extends on a telescoping boom. QuakeSat is a prime example of CubeSat technology, which utilizes COTS (Commercially-Off-The-Shelf) components for scientific experiments and payloads. QuakeSat measures slightly more than 10 cm x 10 cm x 30 cm (stacking of three CubeSat payloads) with a total mass of about 4.5 kg. The outer structure of QuakeSat (consisting of 6061 aluminum) fits inside the P-POD launch tube.

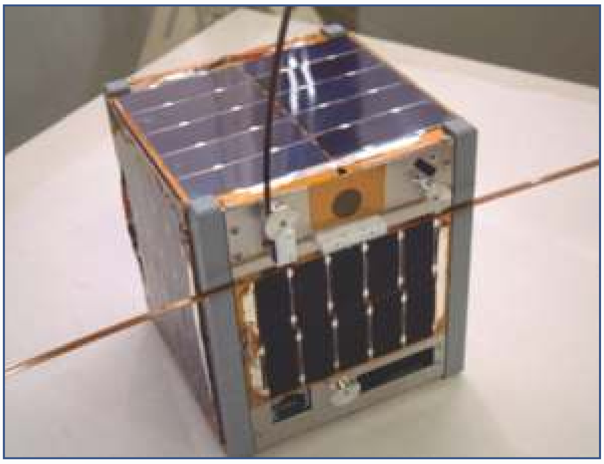
Reference:

a) https://directory.eoportal.org/web/eoportal/satellite-missions/q/quakesat

b) https://creator.zohopublic.com/plspace/nanosat-database-demo/view-perma/Nanosat_database/fRzPBsskPtSbvV6e75qU4DfKj3nTBkqQ5FUEbUTzmU3fXVN5BppyB YAXGRWa4kPdwCsgeMgdOSsTQgWkmzx7XVNgH0T5Bbz9VX2j

XI-IV

Mission Name	XI-IV
Organisation	University of Tokyo
Organisation type	University
Nation	Japan
Type (U or mass)	1U
Satellite launch year	2003-Mar-30
Rocket	Rokot-KM
Orbit	820 km, 98.73 deg
Mission type	Space Technology.
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	The objective is to demonstrate and to validate a picosatellite bus system and the space use of commercial-of-the-shelf (COTS) parts.
Experiment description	CMOS camera.
Lifetime or status in orbit	Operational
Partners	-
Website	http://www.space.t.u-tokyo.ac.jp/cubesat/index-e.html
Additional comments	-.
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/cubesat-launch-1



The first multiple launch CubeSat mission, involving some 6 Cubesats as secondary payloads, and a primary commercial payload, took place June 30, 2003. The deployment strategy of Rockot KS employed MOM (Multiple Orbit Mission), based on the multiple re-ignition capability of its Breeze upper stage. Initially, the MIMOSA payload was being deployed into an elliptical orbit of 820 km x 320 km. After another impulse maneuver of the main engine, Breeze then deployed MOST, followed by the CubeSats into a sun-synchronous orbit of 820 km near-circular altitude at pre-determined intervals. The Monitor-E mock-up will remain on the upper stage and will de-orbit together with Breeze into the atmosphere. The CubeSat launch was coordinated by UTIAS/SFL (University of Toronto, Institute for Aerospacestudies/ Space Flight Laboratory) for CanX-1, AAUSat and DTUSat. A single P-POD of CalPoly was used for XI and CUTE-I as well as for CanX-1, AAUSat and DTUSat. This integrated system was dubbed NLS-1 (Nanosatellite Launch System-1). The second launch system, NLS-2, consisted of QuakeSat and its own dedicated P-POD. CubeSat orbits: Circular sun-synchronous orbit, mean altitude = 820 km, inclination = 98.73º, local equator crossing time at 6:00 and 18:00.

References:

a) https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/cubesat-launch-1

b) https://creator.zohopublic.com/plspace/nanosat-database-demo/view-perma/Nanosat_database/fRzPBsskPtSbvV6e75qU4DfKj3nTBkqQ5FUEbUTzmU3fXVN5BppyB YA XGRWa4kPdwCsgeMgdOSsTQgWkmzx7XVNgH0T5Bbz9VX2j

nCube-2

Mission Name	nCube-2
Organisation	Norwegian University of Technology and Science (NTNU), Narvik University College (HiN) and the Agricultural University of Norway (NLH)
Organisation type	University
Nation	Noway
Type (U or mass)	1U
Satellite launch year	2005-10-27
Rocket	Kosmos-3M
Orbit	686 km, 98 deg
Mission type	Space Technology.
Mission type description/ Configuration/Power	RF Payload and Systems
Mission objectives	Hands-on experience with a real satellite mission. Multidisciplinary collaboration. Space project experience.
Experiment description	AIS receiver to demonstrate the capability of tracking ships from space.
Lifetime or status in orbit	Deployment failure from SSETI Express.
Partners	-
Website	-
Additional comments	-.
Additional sources	http://space.skyrocket.de/doc_sdat/ncube-1.htm

The Norwegian Student Satellite Project Ncube (Norwegian Cubesat) aims to design, build, integrate, test and launch a small satellite in order to provide students in Norwegian educational institutions with hands-on experience with a real satellite mission, multidisciplinary collaboration, space project experience. The payload is an AIS receiver (Automated Identification System), to demonstrate the capability of using this earth-based ship-tracking system from space. To further test the use of the AIS receiver, a reindeer will be fitted with a collar capable of sending AIS signals to the satellite, thus enabling tracking of the movement of the reindeer.Ncube 2 was launched on 27.10.2005 on a Kosmos-3M launch vehicle onboard of the SSETI-Express satellite, but was most likely not deployed.

References:

a) http://space.skyrocket.de/doc_sdat/ncube-1.htm

b) https://creator.zohopublic.com/plspace/nanosat-database-demo/view-perma/Nanosat_database/fRzPBsskPtSbvV6e75qU4DfKj3nTBkqQ5FUEbUTzmU3fXVN5BppyBYAXGRWa4kPdwCsgeMgdOSsTQgWkmzx7XVNgH0T5Bbz9VX2j

UWE-1

Mission Name	UWE-1
Organisation	University of Würzburg
Organisation type	University
Nation	Germany
Type (U or mass)	1U
Satellite launch year	2005-10-27
Rocket	Kosmos-3M
Orbit	686 km, 98 deg
Mission type	Space Technology.
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Experiments on "Internet Protocols in space", as well as to miniaturization technology demonstrations. This second objective included characterization of triple junction GaAs solar cells from European sources, which were tested first time in space.
Experiment description	Analye the applicability of TCP / IP transmission techniques for telemetry and remote controlled data taking into account typical problems of space, such as delays and disorders. Implementation of a ground station and their insertion into an international network of CubeSat users over the Internet. Eventual testing of micro-system components for position determination (Gyro, determination of declination / inclination)
Lifetime or status in orbit	Was operational until 2006-06-XX.
Partners	-
Website	http://www7.informatik.uni-wuerzburg.de/forschung/space_exploration/projects/uwe_1/
Additional comments	Deployed from SSETI Express
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/u/uwe-1

UWE-1 is a CubeSat built by students of the University of Würzburg and was launched as part of the SSETI Express mission from Plesetsk in Russia. Down/Uplink frequency is 437.505 MHz, modulation is 1200 Baud AFSK. The satellite's radio call sign is DPØUWE. UWE is a picosatellite technology project within the CubeSat family standard, developed and built by students of the University of Würzburg and Fachhochschule Weingarten, Germany. The intent is always to enrich the student training program, to stimulate interest in a problem-solving multi-disciplinary technical environment, to be imaginative and resourceful, and to take some risks – with ample and essential help from mentors and partners (industry, institutional, or otherwise). The overall project objective is to test adaptations of Internet protocols [such as: TCP (Transmission Control Protocol), UDP (User Datagram Protocol), STCP (Stream Control Transmission Protocol), HTTP (HyperText Transfer Protocol)] to the space environment, characterized by significant signal propagation delays due to the large distances and much higher noise levels compared to terrestrial links.

References:

a) https://directory.eoportal.org/web/eoportal/satellite-missions/u/uwe-1

b) https://en.wikipedia.org/wiki/UWE-1

AeroCube-1

Mission Name	AeroCube-1
Organisation	The Aerospace Corporation
Organisation type	Non-profit
Nation	US
Type (U or mass)	1U
Satellite launch year	2006-07-26
Rocket	Dnepr
Orbit	Launch failure
Mission type	Space Technology.
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Mission is to test a communication system and the system bus plus a suite of CMOS cameras done by Harvey Mudd College. An omnidirectional patch antenna is used.
Experiment description	-
Lifetime or status in orbit	Launch Failure
Partners	-
Website	-
Additional comments	-
Additional sources	http://www.aerospace.org/2013/08/14/sometimes-smaller-is-better/

AeroCube 1 was battery-powered and designed to last for a brief two weeks on orbit. Unfortunately, it was destroyed in a 2006 launch failure and never flew.

Reference:

a) http://www.aerospace.org/news/highlights/sometimes-smaller-is-better/

b) http://space.skyrocket.de/doc_sdat/aerocube-1.htm

Cp1

Mission Name	Cp1
Organisation	California Polytechnic University
Organisation type	University
Nation	US
Type (U or mass)	1U
Satellite launch year	2006-07-26
Rocket	Dnepr
Orbit	Launch failure
Mission type	Space Technology.
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Testing of a sun sensor donated by Optical Energy technoloies, as well as the use of a sungle magnetic torquer embedded within a side panel.
Experiment description	-
Lifetime or status in orbit	Launch Failure
Partners	-
Website	http://polysat.calpoly.edu/launched-missions/cp1/
Additional comments	-
Additional sources	-

The Cal Poly Picosatellite Project (PolySat) was founded in 1999 and involves a multidisciplinary team of undergraduate and graduate engineering students working to design, construct, test, launch, and operate a CubeSat. CP1, the first satellite developed at Cal Poly, is designed with the objective of providing a reliable bus system to allow for flight qualification of a wide variety of small sensors and attitude control devices. For the first launch, CP1 carries a sun sensor developed by Optical Energy Technologies and an experimental magnetorquer developed at Cal Poly by undergraduate students. The test build of CP1 has undergone vibration and thermal-vacuum qualification testing at NASA worst-case qualification levels.

Reference:

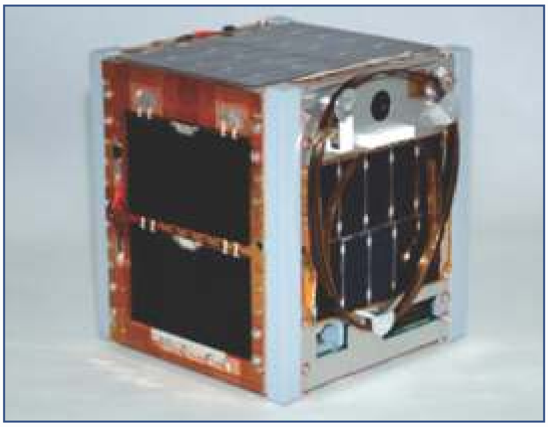
a) http://www.polysat.org/launched/

b) http://space.skyrocket.de/doc_sdat/cp-1.htm

XI-V

Mission Name	XI-V
Organisation	University of Tokyo
Organisation type	University
Nation	Japan
Type (U or mass)	1U
Satellite launch year	2005-10-27
Rocket	Kosmos-3M
Orbit	686 km, 98 deg
Mission type	Space Technology.
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Its mission is to evaluate several novel technologies in space, including a low-cost CMOS horizon sensor and star-tracker, active three-axis magnetic stabilization, GPS-based position determination, and an ARM7 central computer.
Experiment description	CMOS camera. Backup to XI-IV. Verification of newly developed solar cells
Lifetime or status in orbit	Operational
Partners	-
Website	http://www.space.t.u-tokyo.ac.jp/cubesat/index-e.html
Additional comments	Deployed from SSETI Express.
Additional sources	-

The XI-V CubeSat of ISSL (Intelligent Space Systems Laboratory) at the University of Tokyo (UT) is a follow-on mission to XI-IV launched June 30, 2003 and still operational as of 2006. Originally, XI-V was developed as a backup and a hardware simulator of XI-IV. Now, XI-V is being used as an upgraded CubeSat with the same basic design as XI-IV. The solar cells produce an average power of 1.1W. A Li-ion battery is used with a capacity of 6.2 Ah. Attitude control is provided by a passive permanent magnet (1300 mT) and hysteresis dampers.



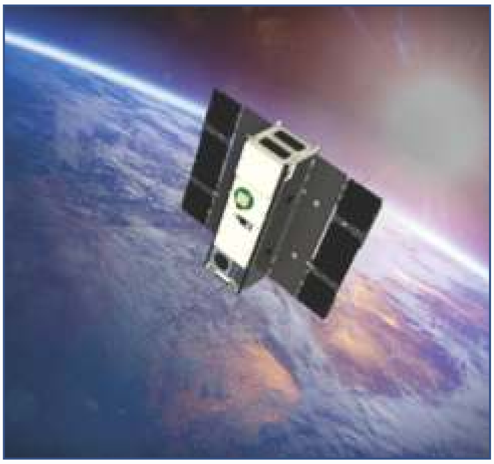
Reference:

a) https://earth.esa.int/web/eoportal/satellite-missions/c-missions/cubesat-launch-2

b) https://creator.zohopublic.com/plspace/nanosat-database-demo/view -perma/Nanosat_database/fRzPBsskPtSbvV6e75qU4DfKj3nTBkqQ5FUEbUTzmU3fXVN5BppyB YAXGRWa4kPdwCsgeMgdOSsTQgWkmzx7XVNgH0T5Bbz9VX2j

ICECube 1

Mission Name	ICECube 1 (Ionospheric sCintillation Experimental CubeSat)
Organisation	Cornell University
Organisation type	University
Nation	US
Type (U or mass)	1U
Satellite launch year	2006-07-26
Rocket	Dnepr
Orbit	Launch failure
Mission type	Space Technology.
Mission type description/ Configuration/Power	Flight Dynamics / Position, Navigation, and Timing
Mission objectives	First, to qualify the concept of small satellites as useful instruments for science and engineering, to lower the cost of space utilization and exploration; Second, to educate students in all major aspects of the design, construction, and launch of space satellite systems.
Experiment description Lifetime or status in orbit	Perform GPS scintillation science by measuring fluctuations in the signals that the GPS satellites emit when the signals pass through the ionosphere. Launch failure
Partners	-
Website	http://www.mae.cornell.edu/research/groups/campbell/satellite.cfm
Additional comments	Identical to ICECube 2.
Additional sources	-



IceCube is a NASA/GSFC (Goddard Space Flight Center) nanosatellite mission with the objective to validate a new 874 GHz submillimeter wave radiometer for cloud ice observations. The measurements of ice clouds and their processes are important for climate models and for cloud precipitation processes. - In July 2014, NASA's SMD (Science Mission Directorate) selected a team at GSFC, led by PI Dong L. Wu, to build its first Earth science-related CubeSat mission. The IceCube project is being managed and co-funded by ESTO (Earth Science Technology Office) of NASA. IceCube was scheduled for launch and subsequently release from the ISS (International Space Station) in mid-2016 for a nominal operation of 28+ days. In addition to its technology demonstration, IceCube will acquire the first 874 GHz cloud map from cloud-induced scattering radiance, thereby accelerating scientific exploration through efficient and frequent access to space using CubeSats. The receiver technology used here was initially developed by VDI (Virginia Diodes Inc.), under NASA's SBIR Phase II program. Communication with the CubeSat will be through NASA's WFF (Wallops Flight Facility) UHF station. Mission Operations and data processing and validation will be conducted at GSFC.

Reference:

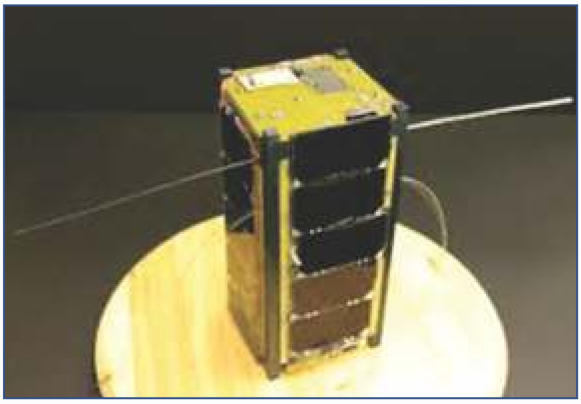
a) https://directory.eoportal.org/web/eoportal/satellite-missions/i/icecube

b) https://creator.zohopublic.com/plspace/nanosat-database-demo/view-perma/Nanosat_database/fRzPBsskPtSbvV6e75qU4DfKj3nTBkqQ5FUEbUTzmU3fXVN5BppyBYAXGRWa4kPdwCsgeMgdOSsTQgWkmzx7XVNgH0T5Bbz9VX2j

ION

Mission Name	ION
Organisation	University of Illinois
Organisation type	University
Nation	US
Type (U or mass)	2U
Satellite launch year	2006-07-26
Rocket	Dnepr
Orbit	Launch failure
Mission type	Space Science
Mission type description/ Configuration/Power	Upper atmosphere
Mission objectives	Measuring Oxygen airglow emissions from the Earth's mesosphere. Tests a new MicroVacuum Arc Thruster (µVAT) with high dynamic range. tests a new SID processor board. Small CMOS camera for Earth imaging.
Experiment description	Measuring molecular Oxygen airglow emissions from the Earth's mesosphere using a 760nm photometer. Oxygen chemistry at this 90km altitude emits a dim glow of light. Learn how energy transfers across large spatial regions contributing to knowledge of upper atmospheric dynamics. This airglow emission is absorbed by the Earth's lower atmosphere preventing study with Earth-based sensors.
Lifetime or status in orbit	Launch failure
Partners	-
Website	http://cubesat.ece.illinois.edu/
Additional comments	-
Additional sources	-

The Illinois Observing Nanosatellite (ION) is the first project of the Illinois Tiny Satellite Initiative (ITSI), which is organized through an interdisciplinary senior design course. The course objectives include training students to identify, formulate, and solve engineering problems as part of a large multi-team project. As the University of Illinois' first student-developed satellite, ION has been completed and awaits launch in the near future. The satellite was lost in the failure of the Dnepr launch on 26 July 2006. Completed in April 2005 as a part of the Illinois Tiny Satellite Initiative, the satellite took almost four years to be designed, built and tested by an interdisciplinary team of student engineers. The payloads included a photometer, a micro-thruster and a camera.



Reference:

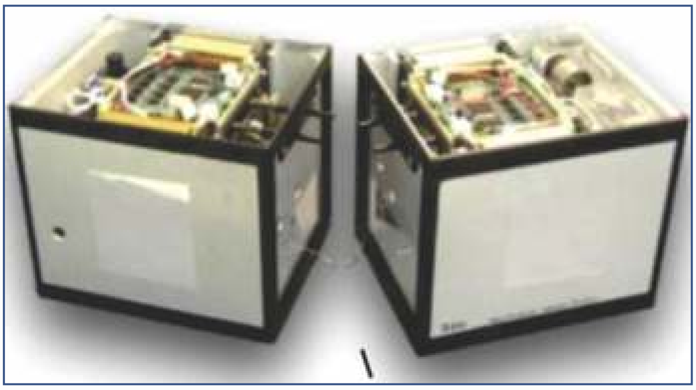
a) https://en.wikipedia.org/wiki/ION_(satellite)

b) http://cubesat.ece.illinois.edu/

c) http://mstl.atl.calpoly.edu/~workshop/archive/2006/Spring/10-Dabrowski-ION%20CubeSat.pdf

MEPSI 2B

Mission Name	MEPSI 2B
Organisation	DARPA
Organisation type	Military
Nation	US
Type (U or mass)	1U
Satellite launch year	2006-12-09
Rocket	Shuttle
Orbit	ISS
Mission type	System Design & Verification
Mission type description/ Configuration/Power	Upper atmosphere
Mission objectives	Pair is tethered. Cold gas propulsion system, with 0.1N thrust with 5 thrusters. This propulsion system includes MEMS pressure transducers
Experiment description	-
Lifetime or status in orbit	Reentry 2007-03-08. Was operational, but short lived.
Partners	Aerospace Corporation was the contractor in collaboration with NASA Jet Propulsion Laboratory.
Website	-
Additional comments	Deployed from Shuttle on 2006-12-21
Additional sources	http://www.skyrocket.de/space/doc_sdat/mepsi.htm



The MEPSI series (Micro Electro-Mechanical Systems-based PicoSat Inspector) consts of pairs of tethered picosatellites, similar to the CubeSat design, to develop and demonstrate the capability of deploying an onboard miniature autonomous inspector, tasked to conduct visual inspection of the host satellite.

Launch data:

Designation	29660 / 06055B
Launch date - time	10 Dec 2006 - 01:47:35 UT
Launch site	KSC, LC-39B
Launch vehicle	Space Shuttle (#117)

Mission

Earth orbit on Dec 21.24:

Perigee / Apogee	311 x 332 km
Eccentricity	0.002
Inclination	51.64 deg
Period	90.95 min

Spacecraft data:

Prime manufacturer	
Mass at launch	3.5 kg (together)
Dry Mass	kg
Basic shape	Cube
Dimension (m)	0.10 x 0.10 x 0.125

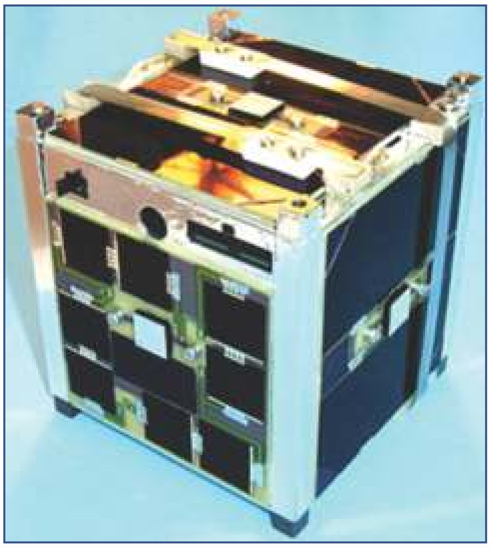
Reference:

a) http://weebau.com/satellite/M/mepsi2.htm

b) https://creator.zohopublic.com/plspace/nanosat-database-demo/view-perma/Nanosat_database/fRzPBsskPtSbvV6e75qU4DfKj3nTBkqQ5FUEbUTzmU3fXVN5BppyB YA XGRWa4kPdwCsgeMgdOSsTQgWkmzx7XVNgH0T5Bbz9VX2j

BEESAT - 1

Mission Name	BEESAT - 1
Organisation	Berlin Technical Universtity
Organisation type	University
Nation	Germany
Type (U or mass)	1U
Satellite launch year	2009-09-23
Rocket	PSLV
Orbit	730 km, 98.3 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Verification of miniaturized reaction wheels in the space environment. Test of a novel satellite bus system. Power scope improvement of pico- and nanosatellites
Experiment description	-
Lifetime or status in orbit	Operational
Partners	AstroFein Technik
Website	
Additional comments	-
Additional sources	https://en.wikipedia.org/wiki/BeeSat-1



BeeSat-1 or Berlin Experimental and Educational Satellite 1, is a German satellite operated by the Technical University of Berlin. The spacecraft is a single unit CubeSat, which was designed to test systems intended for use on future spacecraft, including a new design of reaction wheel. It has also been used for amateur radio, and is equipped with a small camera.

BeeSat-1 was launched by a Polar Satellite Launch Vehicle, serial number C14, flying in the Core Alone, or PSLV-CA, configuration. The launch took place from the First Launch Pad at the Satish Dhawan Space Centre, at 06:21 UTC on 23 September 2009. BeeSat-1 was a secondary payload aboard the rocket, which deployed the Oceansat-2 satellite. Five other secondary payloads were flown aboard the rocket; SwissCube-1, UWE-2, ITU-pSat1, Rubin 9.1and Rubin 9.2.

BeeSat-1 is operating in a sun synchronous orbit with an apogee of 723 kilometres (449 mi), a perigee of 714 kilometres (444 mi) and 98.4 degrees of inclination to the equator. It has an orbital period of 99.16 minutes. BeeSat-1 was designed to operate for at least twelve months, and as of January 2011 it is still operational.

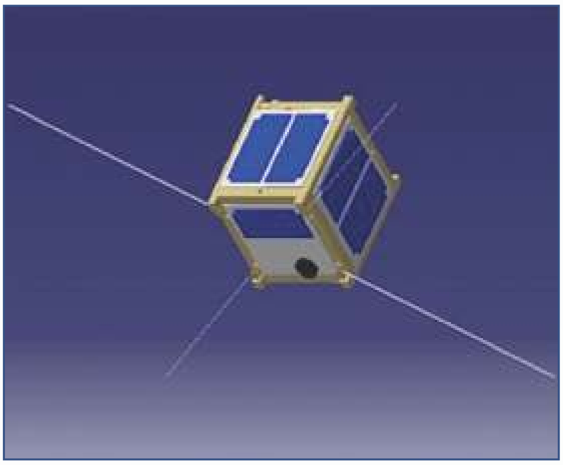
References :

a) https://en.wikipedia.org/wiki/BeeSat-1

b) https://www.raumfahrttechnik.tu-berlin.de/menue/forschung/aktuelle_projekte/beesat-1/

ITUpSAT - 1

Mission Name	ITUpSAT - 1
Organisation	Istanbul Technical University
Organisation type	University
Nation	Turkey
Type (U or mass)	1U
Satellite launch year	2009-09-23
Rocket	PSLV
Orbit	730 km, 98.3 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	The overall objectives are to provide a hands-on project environment for the students at ITU
	under faculty guidance.
Experiment description	The mission goals are to capture imagery of the CMOS payload and to study the behaviour of the passive stabilization system of the CubeSat.
Lifetime or status in orbit	Operational
Partners	-
Website	https://www.raumfahrttechnik.tu-berlin.de/menue/forschung/aktuelle_projekte/beesat-1/
Additional comments	-
Additional sources	https://en.wikipedia.org/wiki/BeeSat-1



The spacecraft structure was purchased from Pumpkin Inc. of San Francisco, CA, consisting of aluminum 6061&5052 material (CubeSat Kit by Pumpkin Inc.). The are 3 identical side faces and one face with access ports. The spacecraft stabilization concept is discussed under Payload 1. 5)

EPS (Electrical Power Subsystem): The EPS consists of face-mounted solar panels, a regulator board and associated batteries (Li-polymer). The system is able to charge itself (maximum power point tracking) and provide a regulated 3.3 V and 5 V bus service. The EPS was provided by Clyde Space.

RF communications: The primary on-board communication system is the MHX-425 transceiver from Microhard Systems. This frequency hopping spread spectrum radio which works in the UHF band has adjustable hopping patterns, a high sensitivity (-115 dBm), and output power of up to 1 W (437.325 MHz, GFSK modulation), the date rate is 19.2 kbit/s. The transceiver interfaces directly to the on-board computer, it has a mass of about 80 gram.

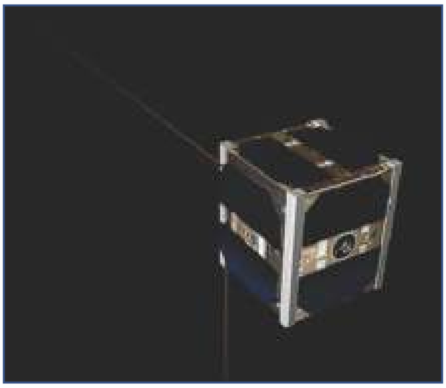
In addition, ITUpSat-1 features a beacon for easy identification and continuous reporting of critical telemetry. Unlike the other transceiver, it will always be on during the orbit and will be transmitting identification and simple telemetry in CW (e.g. Morse code) every two minutes. This means anyone with the knowledge of the orbital parameters (in particular the amateur radio community) can easily pick up our signal. The beacon has a 100 mW RF output capacity.

Reference:

https://en.wikipedia.org/wiki/BeeSat-1

SwissCube

Mission Name	SwissCube
Organisation	Swiss Federal Institute of Technology (EPFL)
Organisation type	University
Nation	Switzerland
Type (U or mass)	1U
Satellite launch year	2009-09-23
Rocket	PSLV
Orbit	730 km, 98.3 deg
Mission type	Space Science
Mission type description/ Configuration/Power	Upper Atmosphere
Mission objectives	The main objective is educational and to show the students how to build a complex engineering system from A to Z like a satellite. Carries a small telescope which will allow to obtain images of the nightglow, a luminescence phenomenon occurring at 100 km of height above the Earth surface.
Experiment description	Since the nightglow takes place in a very limited region in the high layer of the atmosphere and at well-know locations, it might be possible from the measurements to retrieve the direction towards the centre of the Earth and therefore enabling the design of a new generation of Earth sensor.
Lifetime or status in orbit	Operational
Partners	EPFL, HES-SO , Univ of Neuchatel , FHNW , Bern University
Website	https://www.raumfahrttechnik.tu-berlin.de/menue/forschung/aktuelle_projekte/beesat-1/
Additional comments	Most recent subsystem data can be checked on Mission Data tab of swisscube-live.ch.
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/s/swisscube



The outer mechanical interfaces and design of SwissCube are defined by the CubeSat design specifications. The internal layout of the SwissCube is limited by two principal restrictions: the payload and the arrangement of printed circuit boards (PCBs). The ideal configuration is one optimizing both constraints at the same time.

The satellite's primary structure is manufactured from a single block of aluminum . This "monoblock" approach offers the best relationship between mass and rigidity but has the disadvantage of significantly increasing the complexity of the satellite's assembly procedures. Secondary structures are directly attached to the external or internal sides of the monoblock.

The electronic boards inside the satellite are arranged into two PCB stacks placed on each side of the optical payload. These stacks contain the ADCS (Attitude Control and Determination Subsystem), the COM and BEACON (Communication subsystem), the CDMS (Command and Data Management Subsystem) and the EPS (Electrical Power Subsystem). Electrical and data interfaces are routed through a connection and a power distribution board (motherboard) placed perpendicular to the PCB stacks. The electronic boards are separated using aluminum spacers. Their role is to mechanically connect the different PCBs together as well as to attach the PCB's stack and battery subassembly to the primary structure.

References :

https://directory.eoportal.org/web/eoportal/satellite-missions/s/swisscube

https://www.raumfahrttechnik.tu-berlin.de/menue/forschung/aktuelle_projekte/beesat-1/

Ksat (Hayato Kagoshima Satellite, K-Sat)

Mission Name	KSat (Hayato Kagoshima Satellite, K-Sat)
Organisation	Kagoshima University
Organisation type	University
Nation	Japan
Type (U or mass)	1U
Satellite launch year	2010-05-20
Rocket	H-IIA
Orbit	288 x 309 km, 30 deg
Mission type	Space Science
Mission type description/ Configuration/Power	System Design and Verification
Mission objectives	Research That Aims to Predict the Torrential Rain and Rornadoes. On-orbit demonstration of original observation method of atmospheric water vapor using satellite.
Experiment description	Research That Aims to Predict the Torrential Rain and Rornadoes. On-orbit demonstration of original observation method of atmospheric water vapor using satellite.
Lifetime or status in orbit	Reentry 2010-07-14. Was operational but communication happened rarely due to tracking problems.
Partners	-
Website	https://www.raumfahrttechnik.tu-berlin.de/menue/forschung/aktuelle_projekte/beesat-1/
Additional comments	Most recent subsystem data can be checked on Mission Data tab of swisscube-live.ch.
Additional sources	http://space.skyrocket.de/doc_sdat/ksat.htm

KSAT (Kagoshima Satellite, also named Hayato) is a small 1U CubeSat mission developed by the Kagoshima University, which has following objectives:

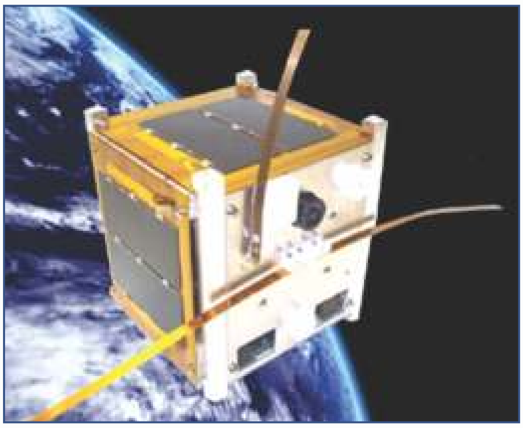
Observation experiments of atmospheric vapor distribution for predicting localized heavy rain

Shooting moving images of the Earth through microwave high-speed communications

Basic communication experiment for super-small positioning satellites

Negai (NegaiStar)

Mission Name	Negai (NegaiStar)
Organisation	Soka University
Organisation type	University
Nation	Japan
Type (U or mass)	1U
Satellite launch year	2010-05-20
Rocket	H-IIA
Orbit	288 x 309 km, 30 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	In-Space propulsion technologies
Mission objectives	Commercial FPGA for advanced information processing system. Camera for outreach purposes.
Experiment description	-
Lifetime or status in orbit	Reentry 2010-06-26. Was operational.
Partners	-
Website	https://www.raumfahrttechnik.tu-berlin.de/menue/forschung/aktuelle_projekte/beesat-1/
Additional comments	Most recent subsystem data can be checked on Mission Data tab of swisscube-live.ch.
Additional sources	http://space.skyrocket.de/doc_sdat/ksat.htm



Negai☆ (Negai-Star or Negai-Boshi, formerly known as Excelsior) is a CubeSat mission built by Soka University. It is a space verification of an advanced information processing system using commercial FPGA.

The satellite was one of a number of secondary payloads on the H-2A-202 rocket, which launched the Planet C Venus orbiter.

Negai was deployed from a JAXA Picosatellite Deployer attached to the second stage of the H-IIA 202 rocket used in the launch of the Akatsuki spacecraft towards Venus. Negai shared its dispenser with the K-Satsatellite, whilst a second dispenser contained Waseda-SAT2. The three CubeSats separated into low Earth orbit during a coast phase of the launch, between the first and second burns of the second stage. The rocket then continued to Heliocentric orbit, where it deployed Akatsuki, along with the IKAROS and UNITEC-1 spacecraft.[7]

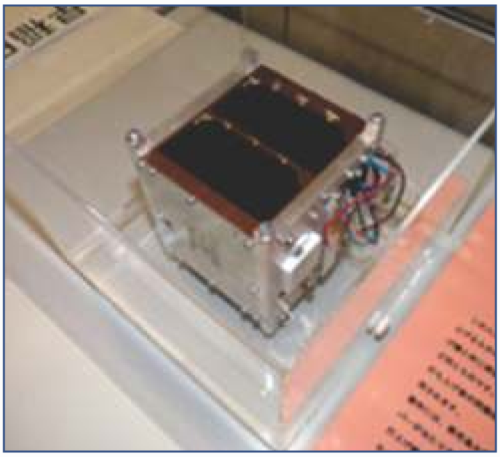
References :

http://space.skyrocket.de/doc_sdat/negaistar.htm

https://en.wikipedia.org/wiki/Negai_(satellite)

Waseda – Sat2

Mission Name	Waseda – Sat2
Organisation	Waseda University
Organisation type	University
Nation	Japan
Type (U or mass)	1U
Satellite launch year	2010-05-20
Rocket	H-IIA
Orbit	288 x 309 km, 30 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	System Design & Verifaction
Mission objectives	Earth observation and technology demonstration. It will test the use of extendible paddles to provide attitude control.
Experiment description	-
Lifetime or status in orbit	Reentry 2010-07-12. No signal.
Partners	-
Website	https://www.raumfahrttechnik.tu-berlin.de/menue/forschung/aktuelle_projekte/beesat-1/
Additional comments	Most recent subsystem data can be checked on Mission Data tab of swisscube-live.ch.
Additional sources	http://space.skyrocket.de/doc_sdat/ksat.htm



Waseda-SAT2 is a Japanese satellitewhich launched in May 2010. It is a student-built spacecraft, which will be operated by Waseda University, and is intended to be used for Earth observation and technology demonstration. It will test the use of extendible paddles to provide attitude control. The satellite is a single unit CubeSat.

The launch was conducted by Mitsubishi Heavy Industries under contract to the Japan Aerospace Exploration Agency. In preparation for a planned launch on 17 May, the H-IIA rocket was rolled out to Pad 1 of the Yoshinobu Launch Complex at the Tanegashima Space Centre on 16 May 2010. It departed the assembly building at 21:01 UTC and arriving at the launch pad 24 minutes later at 21:25 UTC. The terminal countdown began at 11:30 UTC on 17 May and by 15:28, the loading of cryogenic propellant into the rocket's first and second stages had been completed. The launch attempt was scrubbed a few minutes before lift off due to bad weather, but took place successfully at 21:58:22 UTC on 20 May 2010.

References :

https://en.wikipedia.org/wiki/Waseda-SAT2

AISSat-1

Mission Name	AISSat-1
Organisation	Norwegian Space Centre
Organisation type	Agency
Nation	Norway
Type (U or mass)	7Kg
Satellite launch year	2010-07-12
Rocket	PSLV
Orbit	630 km, SSO
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Its primary mission is to demonstrate the feasibility and performance of space-based Automatic Identification System (AIS) detection from low-Earth orbit as a means of tracking maritime assets, and the integration of space-based AIS data into a national maritime tracking information system.
Experiment description	Operational
Lifetime or status in orbit	Norwegian Space Centre, Norwegian Defence Research Establishment (FFI), Kongsberg Seatex AS, Kongsberg Satellite Services AS
Partners	-
Website	https://en.wikipedia.org/wiki/AISSat-1
Additional comments	20 cm cube.
Additional sources	http://space.skyrocket.de/doc_sdat/ksat.htm

AISSat-1 is a satelliteused to receive Automatic Identification System (AIS) signals. Launched on 12 June 2010 from Satish Dhawan Space Centeras a secondary payload, AISSat-1 is in a sun-synchronouslow-Earth orbit. Initially a development project, the satellite has since passed into ordinary operations. Via downlinks at Svalbard Satellite Station and at Vardø Vessel Traffic Service Centre it tracks vessels in the Norwegian Sea and Barents Sea for the Norwegian Coastal Administration, the Norwegian Coast Guard, the Norwegian Directorate of Fisheriesand other public agencies.

The satellite was developed as a cooperation between the Norwegian Defence Research Establishment (NDRE), the Norwegian Space Centre and the Coastal Administration. The payload was developed by Kongsberg Seatex while the University of Toronto Institute for Aerospace Studies built the bus and completed manufacture. The satellite measures 20 centimeters (7.9 in) cube and weighs 6 kilograms (13 lb). Ownership and operation passed to Statsat in 2013. The satellite has since 2014 been supplemented with AISSat-2 and from 2015 by AISSat-3.

References :

https://en.wikipedia.org/wiki/AISSat-1

http://www.utias-sfl.net/?page_id=214

TISAT-1

Mission Name	TISAT-1
Organisation	University of Applied Sciences of Southern Switzerland (SUPSI)
Organisation type	University
Nation	Switzerland
Type (U or mass)	1U
Satellite launch year	2010-07-12
Rocket	PSLV
Orbit	630 km, SSO
Mission type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Monitoring of the durability of exposed thin bonding wires, PCB tracks and lines (Atomic Oxygen effects). Verification of the system fault tolerance scheme. Acquisition of spacecraft environment and operating data. All firmware, in house developped baseband modulation schemes.
Experiment description	-
Lifetime or status in orbit	Was operational until 2015-03-15
Partners	-
Website	http://www.spacelab.dti.supsi.ch/tiSat1.html
Additional comments	20 cm cube.
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/t/tisat-1#UsgFD12bfHerb

TISat-1 is a student-developed low-cost CubeSat mission of SUPSI (Scuola Universitaria Professionale della Svizzera Italiana — University of Applied Sciences of Southern Switzerland), Lugano-Manno, Switzerland. The satellite was named after the home state (Kanton Ticino - abbreviated as TI) where Lugano is located.

The project started in 2005. The mission goals are to carry out material degradation tests on conductors of different materials and to validate the multitechnology, fault-tolerant design scheme of the spacecraft bus. COTS (Commercial-off-the-Shelf) componets are used for the whole design except for the photovoltaic cells.

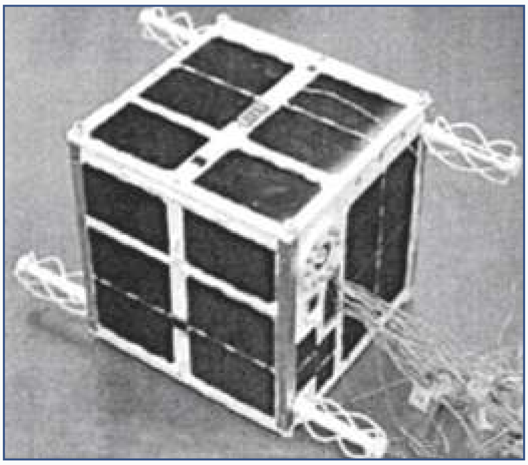
References:

https://directory.eoportal.org/web/eoportal/satellite-missions/t/tisat-1#UsgFD12bfHerb

http://www.spacelab.dti.supsi.ch/tiSat1.html

ZDPS 1A 01

Mission Name	ZDPS 1A 01 (Zheda Pixing)
Organisation	Zhejiang University
Organisation type	University
Nation	China
Type (U or mass)	3.5kg
Satellite launch year	2010-09-22
Rocket	Long March
Orbit	645 km, SSO
Mission type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Platform verification. The functionality, performance and space environmental adaption of the satellites and their subsystems were to be validated in space via on-orbit testing and operation. Experimentation of miniaturized parts.
Experiment description	Micro panoramic camera. Momentum wheel is employed to offer gyro stiffness stability in the pitch
Lifetime or status in orbit	Was operational until 2015-03-15
Partners	-
Website	https://www.sciencedirect.com/science/article/pii/S1000936111604391
Additional comments	15 cm cube.
Additional sources	http://space.skyrocket.de/doc_sdat/ksat.htm



The Zhejiang University's ZDPS 1series of picosatellites were the first Chinese picosatellites.

The ZDPS-1 and 1A satellites were built as 15 cm × 15 cm × 15 cm cubes with a weight of 2.5 kg for ZDPS-1 and a weight of 3.5 kg for ZDPS-1A-01 and ZDPS-1A-02 each.

Their purpose is to demonstrate pico-satellite technologies:

- an Universal S-Band (USB) TTC system
- an active tri-axial stabilizing attitude control
- a CMOS camera for panoramic Earth imaging

ZDPS-1 was launched as a piggy-back payload in 2007, but was apparently not successful.

ZDPS-1A-01 and ZDPS-1A-02 were both jointly launched in 2010 as piggy-back payloads and were the first pico-satellites that have been launched successfully in China. After two years successful in-orbit operation, main components of ZDPS-1A still work well.

Reference :

http://space.skyrocket.de/doc_sdat/zdps-1.htm

O/OREOS

Mission Name	O/OREOS
Organisation	NASA Ames Research Center
Organisation type	Agency
Nation	US
Type (U or mass)	3U
Satellite launch year	2010-11-20
Rocket	Minotaur IV
Orbit	650 km, 72 deg
Mission type	Space Science
Mission type description/ Configuration/Power	Organism/Organic Exposure to Orbital Stresses. An Astrobiology Technology Demonstration.
Mission objectives	-
Experiment description	Operational
Lifetime or status in orbit	Was operational until 2015-03-15
Partners	-
Website	https://www.nasa.gov/pdf/467036main_OOREOS_FactSheet_FINAL_2010-10-29.pdf
Additional comments	-
Additional sources	http://space.skyrocket.de/doc_sdat/ksat.htm

The O/OREOS nanosatellite uses a 3U CubeSat configuration with (34 cm in length) a maximum mass of 5.5 kg. The satellite attitude is controlled by permanent magnets and hysteresis rods that dampen the rotational energy. The satellite rotates about its long axis (z-axis) at a rate ranging from 1 to 2 rpm. The satellite also experiences a nutation, or "coning", rotation about its center of mass at a rate of 4-5 rpm with a cone half-angle of less than 13o. This spacecraft motion results in a microgravity environment that varies, but remains below 500 µg.

O/OREOS has a modified payload structural section, providing for dual modular payload experimental systems. The modified bus software and a new payload experiment control software are also being developed.

DOM (De-Orbit Mechanism): A simple deployable drag device is developed to assist the satellite with achieving natural orbit decay in less than 25 years. The device simply increases the surface area of the satellite (60% increase) by extending mylar panels. This results in a surface to mass ratio sufficient to achieve the required deorbit. No propellants are required.

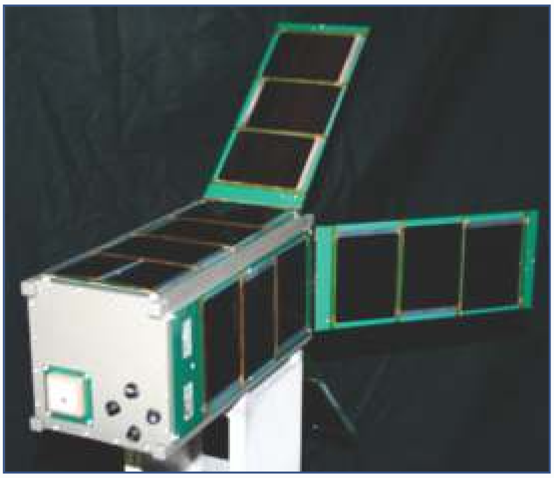
References :

https://directory.eoportal.org/web/eoportal/satellite-missions/o/ooreos

https://www.nasa.gov/pdf/467036main_OOREOS_FactSheet_FINAL_2010-10-29.pdf

Asgardia-1

Mission Name	Asgardia-1
Organisation	Space Kingdom of Asgardia
Organisation type	Agency
Nation	US
Type (U or mass)	2U
Satellite launch year	2017-11-12
Rocket	Antares 230
Orbit	450.7 km, 51.64 degrees
Mission type	Technology demonstrator
Mission type description/ Configuration/Power	Asgardia-1 is a satellite that stores long term data in an environment with radiation exposure during its orbital lifetime.
Mission objectives	The primary goals of this investigation include long-term data storage in a radiation exposure environment in low-Earth orbit (LEO). The experiments should be completed within 2 years after launch. Data from the experiments are recovered via duplex link to the GlobalStar constellation – a group of satellites orbiting around the Earth. Asgardia-1 operates in its circular orbit, without propellants, until natural orbit decay results in reentry.
Experiment description	Solid-state storage testing while in LEO
Lifetime or status in orbit	Planned: 5 years , Active
Partners	Near Space Launch and NASA
Website	https://asgardia.space/en/
Additional comments	-
Additional sources	https://en.wikipedia.org/wiki/Asgardia_(nation)



Humanity's first "space nation", Asgardia, is a step closer to getting off the ground after its first satellite was launched last week. While the ultimate goal is for millions of people to live on a constellation of satellites orbiting the Earth, don't bother packing your bags just yet: Asgardia-1 is just a CubeSat carrying 500 GB of pictures and text.

The Asgardia-1 satellite expects to launch as a payload aboard the Orbital-ATK OA-8 rocket, a NASA CRS (Commercial Resupply Mission) inside a NanoRacks CubeSat Deployer (NRCSD), from Wallops Island, VA. About 90 days after this launch, the OA-8 unberths from the International Space Station (ISS), boosts to a higher orbit, and deploys the satellite. The satellite is inserted into a near-circular orbit at 500 km at an inclination of 51.6 degrees from the equator. Transmission begins 30 minutes after deployment and remains active through the life of the mission. Atmospheric friction slows the satellite and reduce the altitude of the orbit until de-orbiting occurs, approximately 4.6 years after launch.

References:

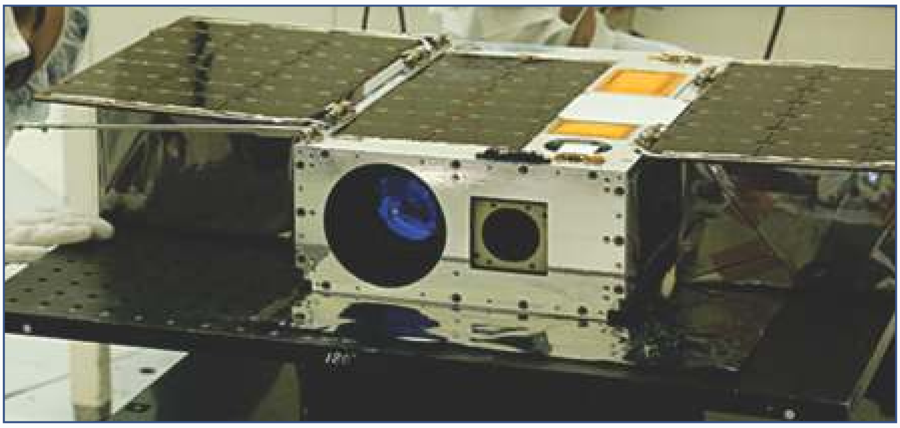
https://data3.nsldata.com/asgardia/ Asgardia-1 Tracker, NearSpace Launch Inc.

https://asgardia.space/en/news/Asgardia-1-Enters-Space-Establishing-the-Space-Nation-Sovereign-Territory

https://newatlas.com/space-kingdom-asgardia-first-satellite/52256/

ASTERIA

Mission Name	ASTERIA
Organisation	NASA
Organisation type	Agency
Nation	US
Type (U or mass)	6U
Satellite launch year	2017-08-14
Rocket	Falcon-9
Orbit	402.7 km, 51.6 degrees
Mission type	Technology demonstrator, space telescope
Mission type description/ Configuration/Power	A miniaturized space telescope meant as a technology demonstrator to advance the capabilities for astrophysical measurements.
Mission objectives	The goal is to maintain the target star image to within a fraction of a detector pixel over long durations. Image motion over the detector pixels can cause variations in the measured brightness, since both the between-pixel (interpixel) and within-pixel (intrapixel) response varies across the detector. The second objective of ASTERIA is to demonstrate milliKelvin-level temperature stability of the imaging detector. The gain of each pixel is temperature sensitive, so tight thermal control reduces instrumental photometric variation that might otherwise be mistaken as an astrophysical signal.
Experiment description	-
Lifetime or status in orbit	Nominal: 90 days Extension: up to 1 year (proposed)
Partners	MIT, NanoRacks, NASA Jet Propulsion Laboratory, California Institute of Technology, Webster
Website	https://www.jpl.nasa.gov/cubesat/missions/asteria.php
Additional comments	-
Additional sources	https://en.wikipedia.org/wiki/ASTERIA_(spacecraft)



ASTERIA (Arcsecond Space Telescope Enabling Research in Astrophysics) is a technology demonstration of astrophysical measurements using a Cubesat, with a primary goal of training early-career engineers. ASTERIA has been developed under JPL's Phaeton Program to provide recent college graduates, under the guidance of experienced mentors, with real, rapid, hands-on exposure to the multiple disciplines and phases of a flight project. ASTERIA's technical goal is to achieve arcsecond-level line-of-sight pointing error and highly stable focal plane temperature control. These technologies are important for precision photometry, i.e., the measurement of stellar brightness over time. Precision photometry, in turn, provides a way to study stellar activity, transiting exoplanets, and other astrophysical phenomena.

ASTERIA is a 6U CubeSat (roughly 10 x 20 x 30 cm, 12 kg) that will operate in low-Earth orbit. The payload consists of a lens and baffle assembly, a CMOS imager, and a two-axis piezoelectric positioning stage on which the focal plane is mounted. A set of commercial reaction wheels provides coarse attitude control. Fine pointing control is achieved by tracking a set of guide stars on the CMOS sensor and moving the piezoelectric stage to compensate for residual pointing errors. Precision thermal control is achieved by isolating the payload from the spacecraft bus, passively cooling the detector, and using trim heaters to perform small temperature corrections over the course of an observation.

In June 2017, the flight spacecraft was delivered for integration into the Nanoracks Cubesat Deployer. ASTERIA was launched to the International Space Station (ISS) with the SpaceX Falcon-9 Crew Resupply Services – 12 (CRS-12) mission on August 14, 2017. The spacecraft was deployed from the ISS on November 20, 2017 to begin the 90-day ASTERIA technology demonstration mission.

The ASTERIA project is a collaboration with MIT and is funded at JPL through the Phaeton Program for training early career employees. JPL is responsible for overall project management, systems engineering, spacecraft implementation, integration and test, and mission operations. The main spacecraft subsystem suppliers are Blue Canyon Technologies (Attitude Control Subsystem), Vulcan Wireless (Telecommunications Subsystem), MMA Design LLC (Solar Arrays), GomSpace (Power subsystem and Batteries), Spaceflight Industries (Flight computer), Ecliptic Enterprises (Focal Plane), Physik Instrumente (piezo stage), and Thermotive (thermal hardware). Morehead State University will provide spacecraft tracking, telemetry, and control services to the Mission Operations team at JPL. MIT will perform target selection and analysis of stellar photometry data from ASTERIA.

References:

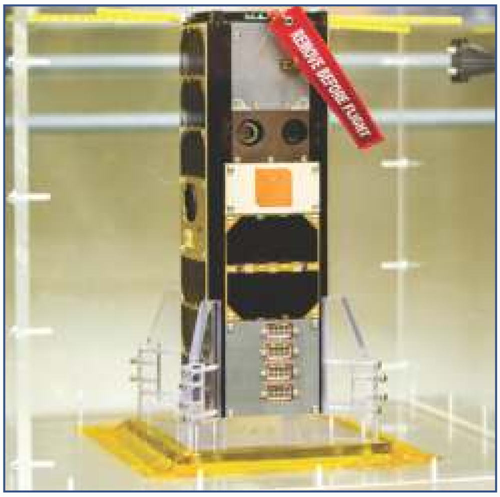
a) https://www.nasa.gov/mission_pages/station/research/experiments/2513.html

b) https://www.jpl.nasa.gov/cubesat/missions/asteria.php

c) https://en.wikipedia.org/wiki/ASTERIA_(spacecraft)

Aalto-1

Mission Name	Aalto-1
Organisation	Aalto University
Organisation type	University
Nation	Finland
Type (U or mass)	3U
Satellite launch year	2017-06-23
Rocket	PSLV
Orbit	510 km, 97.5 deg, SSO
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	To design, build and operate first Finnish Earth Observation (EO) nanosatellite. Technology demonstration of a very small imaging spectrometer for spaceborne EO. Technology demonstration of a very small radiation detector for future satellites. Development and demonstration of a deorbiting device for nanosatellites based on e-sail concept and measurement of its performance. Promotion of engineering education in Finland with the aid of a satellite project.
Experiment description	Imaging Fabry-Perot spectrometer. Radiation monitor. Electrostatic Plasma Brake.
Lifetime or status in orbit	Operational
Partners	FMI, VTT
Website	https://wiki.aalto.fi/display/SuomiSAT/Summary
Additional comments	-
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/a/aalto-1, http://www.geosci-instrum-method-data-syst.net/2/121/2013/gi-2-121-2013.pdf



Aalto-1 is a student satellite project carried out by Aalto University's Department of Diabetes and Technology. The satellite was built and planned mainly by student leaders within the framework of the volume studies and project work. The student satellite is a collaborative project involving Finnish space expertise from other universities and industry as well.

Aalto-1 is a Finnish research nanosatellite, created by students of Aalto University. Based on the CubeSat architecture, it was originally scheduled to be launched in 2013, it was launched on 23 June 2017. It is Finland's first student satellite project and indigenously-produced satellite.

The Aalto-1 project began in 2010 with a feasibility study, which was conducted as part of a university course on space technology. The study was followed by the publication of a preliminary design in 2011. A critical design review of the satellite was conducted in 2012. In all, over 80 students of Aalto University's School of Electrical Engineering were involved in the project.

The solar-powered CubeSat-based satellite will weigh approximately 3 kilograms (6.6 lb), and will carry a miniature Fabry-Pérot spectrometer, designed by VTT Technical Research Centre. The satellite incorporates an electric sail (dubbed a "brake tether"), which is designed to deorbit it at the end of its 2-year operational lifespan, with the intent of avoiding the creation of space junk.

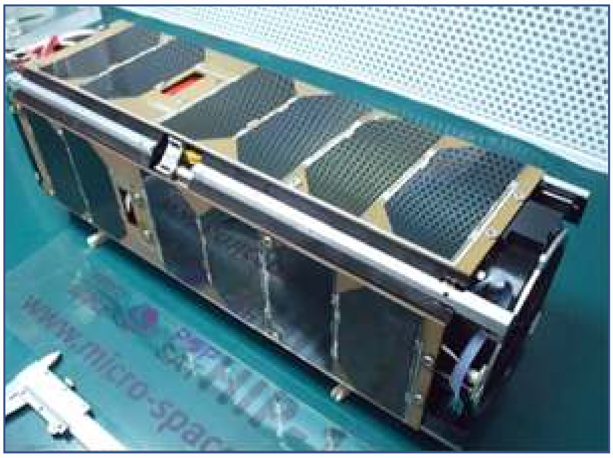
Aalto-1 was launched on 23 June 2017 by PSLV-C38 rocket from India.

References:

https://wiki.aalto.fi/display/SuomiSAT/Aalto-1+nanosatellite+project
https://en.wikipedia.org/wiki/Aalto-1

POPSAT-HIP 1

Mission Name	POPSAT-HIP 1
Organisation	Microspace Rapid Pte Ltd.
Organisation type	Company
Nation	Singapore
Type (U or mass)	3U
Satellite launch year	2014-06-19
Rocket	Dnepr
Orbit	610 x 700 km, 98 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Demonstrate the functionality of a high resolution optical payload and attitude control propulsion system on a Cubesat Class Nano-satellite.
Experiment description	GSD 5 m from LEO and 5 km swath.
Lifetime or status in orbit	Was operational for 1 year
Partners	-
Website	http://pop-sat.com/
Additional comments	-
Additional sources	http://www.dk3wn.info/sat/afu/sat_popsat.shtml,
	http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=3190&context=smallsat



POPSAT-HIP1 is a 3U amateur radio CubeSat developed in Singapore. It aims to demonstrate the functionality of a high resolution optical payload and attitude control propulsion system.

PoPSat has been designed to fly on a sun-synchronous, dawn-dusk orbit at 460 km. This orbit enables the required optimal instrument resolution for precipitation events occurring within the troposphere, between 8 and 12 km altitude. Additionally, with an 18? instrument half-cone angle capability, both phased-array radars can provide a 300 km swath width at this altitude. This results in an optimal atmospheric layer coverage of 91% for latitudes above 50? N after 72 hr. A required total system power of 1021 W of the satellite will be sustained using 7.2 m2 of solar arrays, housed on the sunward side of the spacecraft. The mission has an expected total cost of an M-class mission for a nominal lifetime of 5 years.

The PoPSat mission has been developed by 15 students of Team Blue supported by a group of experts at the Alpbach Summer School 2016, a ten-days design challenge organised by FFG and ESA and devoted to 'Satellite Observations of the Global Water Cycle'. PoPSat was selected by the jury to be further developed at the Post-Alpbach design challenge at the ESA Redu Centre for an additional four days, with 15 students out of all 4 teams from the Alpbach Summer School

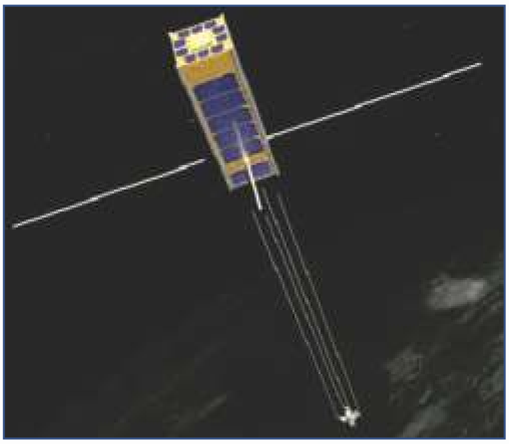
References:

https://meetingorganizer.copernicus.org/EGU2017/EGU2017-1099-12.pdf

https://directory.eoportal.org/web/eoportal/satellite-missions/p/popsat-hip1

Firefly

Mission Name	Firefly
Organisation	NASA Goddard Space Flight Center
Organisation type	Agency
Nation	US
Type (U or mass)	3U
Satellite launch year	2013-11-20
Rocket	Minotaur-1
Orbit	500 km, 40.5 deg
Mission type	Space Science
Mission type description/ Configuration/Power	-
Mission objectives	Investigate Terrestrial Gamma-ray Flashes (TGFs). How are TGFs produced? Current evidence suggests production deep in the atmosphere, near the tops of thunderclouds. Another possibility, which may occur at the same time, is high-altitude production in the 30-80 km altitude range.
Experiment description	What types of lightning produce TGFs, and how do they differ from non-TGF lightning? How common are the TFGs? How large an area do they cover? What effect do they have on the upper atmosphere and near-Earth space? To what extent do they represent a source of energetic electrons for the inner radiation belt?
Lifetime or status in orbit	Reentry 2017-11-01. Was operational.
Partners	National Science Foundation, Siena College, Universities Space Research Association,
	Hawk Institute for Space Sciences, University of Maryland Eastern Shore.
Website	http://firefly.gsfc.nasa.gov/
Additional comments	-
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/f/firefly



Firefly is a low-cost NASA/GSFC led nanosatellite mission, a collaborative effort sponsored by NSF (National Science Foundation). The overall objective is to study the relationship between lightning and TGFs (Terrestrial Gamma-ray Flashes) which are sudden (transient) energetic bursts in the upper atmosphere. The phenomenon of TGFs was first observed on NASA's CGRO (Compton Gamma Ray Observatory) mission in 1994 (CGRO launch on April 5, 1991 aboard the Space Shuttle Atlantis). A subsequent study from Stanford University in 1996 linked a TGF to an individual lightning strike occurring within a few ms of the TGF.

The Firefly mission, funded and managed by NSF, will be developed as a collaborative effort by NASA/GSFC, USRA (Universities Space Research Association) of Columbia, MD; Siena College of Loudonville, NY; University of Maryland Eastern Shore, Princess Anne, MD; and the Hawk Institute for Space Sciences, in Pocomoke City, MD. NASA/GSFC, USRA and Siena College will provide the instrument payload, while the Hawk Institute will build the nanosatellite. NASA's Wallops Flight Facility on Wallops Island, VA, will provide technical oversight for the integration of Firefly to the launch vehicle.

TGFs are likely produced by beams of very energetic electrons, which are accelerated in the intense electric fields generated by large thunderstorm systems. These electron beams are more powerful than any produced in near-Earth space, and understanding their acceleration mechanisms will shed light on a physical process that may occur on other planets, or in astrophysical environments, as well as in the sun's corona.

The objective of Firefly is to explore which types of lightning produce these electron beams and associated TGFs. In addition, Firefly will study the occurrence rate of TGFs that are weaker than any previously studied. The goal is to examine the link between lightning and TGFs.

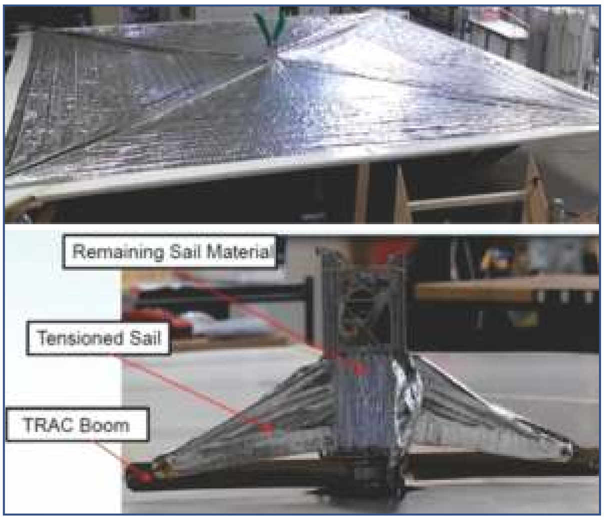
References:

https://www.nasa.gov/content/goddard/nasa-led-firefly-mission-to-study-lightning/

http://www.fireflyspace.com/about/why-firefly

LightSail-A

Mission Name	LightSail-A
Organisation	The Planetary Society
Organisation type	Non-profit
Nation	US
Type (U or mass)	3U
Satellite launch year	2015-05-20
Rocket	Atlas V
Orbit	370 x 700 km, 55 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Demonstrate the deployment of a 32 m2 solar sail from a 3-unit CubeSat platform. Following deployment from the launch vehicle, LightSail-A will power on engineering subsystems, and a system checkout will be performed.
Experiment description	It is anticipated that solar sail deployment will occur approximately two weeks after launch. Following sail deployment, engineering telemetry and imaging of the sail deployment event will be downlinked.
Lifetime or status in orbit	Reentry 2015-06-15. Was operational until 2015-06-11. Various problems, but deployed solar sail.
Partners	Aerospace Corp, Stellar Exploration Systems, California Polytechnic University, Georgia Institute of Technology
Website	http://www.planetary.org/explore/projects/lightsail-solar-sailing/
Additional comments	-
Additional sources	http://www.nesdis.noaa.gov/CRSRA/files/LightSail-A_Public_Summary.pdf, http://amsat-uk.org/2015/05/26/lightsail-1-stops-transmitting/, http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=3196&context=smallsat



LightSail-A is a 3-Unit CubeSat developed and operated by The Planetary Society to demonstrate sunlight, or rather solar pressure, as a means of spacecraft propulsion for potential future use in large sails for deep space propulsion. The LightSail-A mission will only function as a demonstration of the mechanical systems used in the deployment of the sail and validate the satellite bus for a longer test mission in a higher orbit in 2016 to actually demonstrate spacecraft acceleration through solar pressure.

The Planetary Society and its partners attempted to send a first solar sail mission, Cosmos 1, into orbit in June 2005, but the submarine-launched Volna rocket failed to deliver the spacecraft to orbit.

In 2009, The Planetary Society took over control of NASA's NanoSail-D project that had encountered a launch failure the year before when its Falcon 1 launcher ran into problems during stage separation. A replacement, NanoSail-

D2, was launched in 2010, but experienced trouble during its deployment from the FASTSAT spacecraft that was delayed by over a month. Deployment of the sail was confirmed via ground-based observations and the satellite re-entered in September of 2011.

The LightSail project was announced by the Planetary Society in November 2009 and is technically much more ambitious than NanoSail, aiming for two test flights – the first to a low, short-lived orbit to demonstrate the mechanics of the sail deployment and the subsystems of the satellite; and the second to a higher orbit where drag is no longer a factor and solar-pressure propulsion can actually be demonstrated and quantified. Unlike NanoSail, the LightSail spacecraft has a precise attitude control system which will allow it to maintain a commanded orientation relative to the sun to generate a targeted thrust force for measurements. Furthermore, LightSail has a lower mass-to-area ratio to increase the effect of solar propulsion.

The LightSail-A spacecraft uses the 3U CubeSat form factor measuring 34 by 10 by 10 centimeters in size with a total mass of around five Kilograms. Two of the CubeSat Units are occupied by the stowed sail and its deployment system while the remaining Unit hosts the various satellite support systems. The satellite was built by Stellar Exploration Inc. and the platform is a design provided by CalPoly.

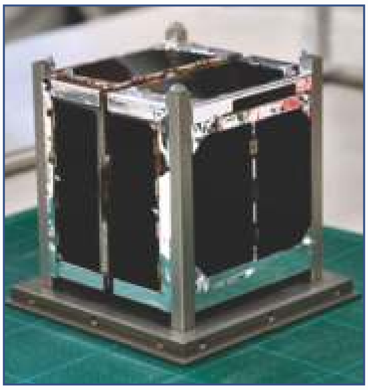
References:

http://spaceflight101.com/spacecraft/lightsail-a/

https://en.wikipedia.org/wiki/LightSail_2

ARTSAT 1: INVADER

Mission Name	ARTSAT 1: Invader (INteractiVe satellite for Art and Design Experimental Research)
Organisation	Tama Art University
Organisation type	University
Nation	Japan
Type (U or mass)	1U
Satellite launch year	2014-02-27
Rocket	H-2A
Orbit	408 km, 65 deg
Mission type	Space Activity
Mission type description/ Configuration/Power	Emergent and future domains
Mission objectives	Art use of satellite data (telemetry). Platform for implementation of satellite data utilization. Production of interactive works and media satellite. Expansion of outreach through work of art.
Experiment description	-
Lifetime or status in orbit	Reentry 2014-09-02. Was operational.
Partners	-
Website	http://artsat.jp/en
Additional comments	-
Additional sources	https://www.facebook.com/artsat



The Interactive Satellite for Art and Design Experimental Research or INVADER, also known as Cubesat Oscar 77 (CO-77) and Artsat-1 is an artificial satellite for artistic experiments in space. The satellite was built by the University of Tokyo in collaboration with Tama Art University. It has a size of 100x100x100mm (without antennas) and built around a standard 1U cubesat bus. The primary satellite payload is an FM voice transmitter. Also, it includes low-resolution CMOS camera and thermochromic panels for artistic purposes.

The satellite is to contribute to the amateur radio community from the view point of the art field using this satellite. The satellite features following equipment:

- Some sensors to provide data for art work. For example to use the downlinked data to control lighting equipment, which changes color according to the satellite temperature data and distributing it to people, to promote interest in satellite and amateur radio.
- A low resolution camera (150 × 150 pixels) for acquiring the Earth image for utilizing in art work.
- A Digi-Talker, which transmits voice data using FM and to transmit sensor data using the Digi-Talker.

Three UHF downlinks are proposed including one CW beacon, one 1k2 AFSK data transmission and one FM Voice transmitter.

It was launched into orbit by a H-IIA launch vehicle on 27 February 2014 as a sub-payload of GPM Core satellite. It reentered Earth's atmosphere on 2 September 2014.

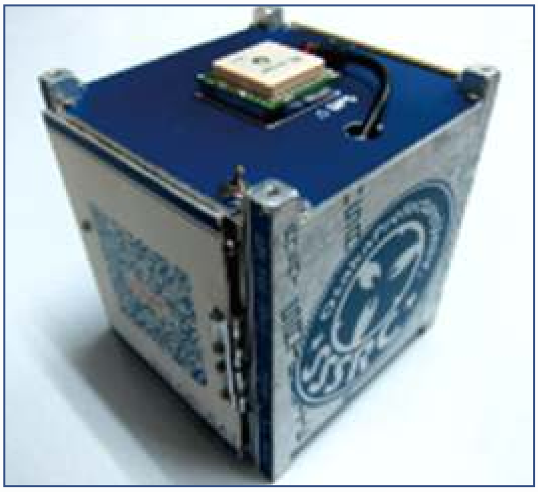
References:

https://en.wikipedia.org/wiki/INVADER

https://space.skyrocket.de/doc_sdat/invader.htm

OPUSAT

Mission Name	OPUSAT
Organisation	Osaka Prefecture University
Organisation type	University
Nation	Japan
Type (U or mass)	1U
Satellite launch year	2014-02-27
Rocket	H-2A
Orbit	408 km, 65 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Demonstration of anti-space environment performance of lithium ion capacitor. Realization of high-efficiency power storage technology using MPPT control. Sun-oriented control using magnetic Toluca, Solar Array
Experiment description	-
Lifetime or status in orbit	Reentry 2014-07-24. Was operational.
Partners	-
Website	http://www.sssrc.aero.osakafu-u.ac.jp/projects/OPUSAT/home.html
Additional comments	-
Additional sources	-



The Osaka Prefecture University Satellite, or OPUSAT was a technology demonstration cubesat built and operated by Japan's Osaka Prefecture University. It had a size of 100x100x100mm (without antennas and solar paddles) and build around a standard 1U cubesat bus. The primary satellite purpose is the space testing of the power system based on a Lithium-ion capacitor. The tests were largely successful and it finished operation by reentry to Earth atmosphere on 24 July 2014. The OPUSAT is a development successor to "Maido Ichigo" satellite by East Osaka Craftmen Astro-Technology SOHLA in Osaka.

OPUSAT nickname "CosMoz" was selected as one of the compact sub-satellites of the global precipitation observation plan (GPM) main satellite by the Japan Aerospace Exploration Agency (JAXA) , and on February 28, 2014, the T- It was launched from the Tanegashima Space Center in the IIA rocket. After that, OPUSAT re-entered into the atmosphere on July 24, 2014, and finished operation at Osaka Prefecture University ground station.

OPUSAT challenged two missions in roughly divided. The first is space demonstration of a new electric storage device combining two power supply devices, a lithium-ion battery and a lithium-ion capacitor (lower left). If this mission succeeds, we can realize a compact, lightweight, long-life power system compared to the past.

The second is space demonstration of a satellite system that acquires a large electric power. In outer space OPUSAT develops a paddle (see the right figure below) to which the solar cell is attached at a certain timing. By directing the satellite in the direction of the sun (solar control), we gain a lot of energy from the sun.

OPUSAT demonstrates a mechanism to acquire large electric power by paddle deployment and solar pointing control and store the electric power in a new electric storage device in space, thereby contributing to the development of satellite development and the space development as a whole in universities and colleges It can make a big contribution.

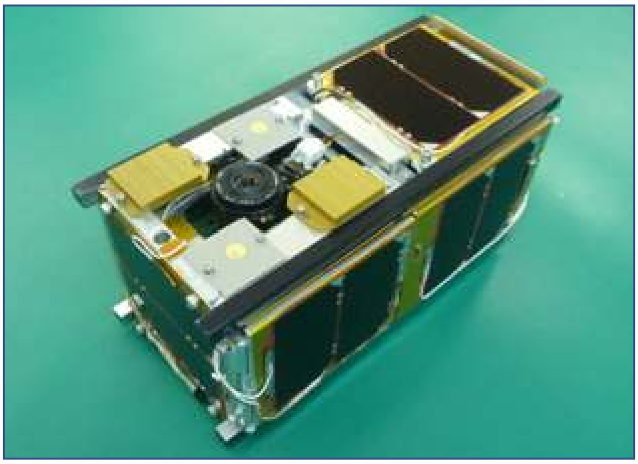
References:

https://en.wikipedia.org/wiki/OPUSAT

https://directory.eoportal.org/web/eoportal/satellite-missions/o/opusat

RAIKO

Mission Name	RAIKO
Organisation	Tohoku University
Organisation type	University
Nation	Japan
Type (U or mass)	2U
Satellite launch year	2012-07-21
Rocket	H-IIB
Orbit	400 km, 51.6 deg, ISS
Mission type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Demonstration of new electronics or mechanism usable for 50-kg microsatellites, which are CMOS color sensor, CCD color sensor, CCD star sensor, and film deployment mechanism.
Experiment description	-
Lifetime or status in orbit	Reentry 2013-08-06. Was semi-operational until 2013-07-15. Command link could not be established.
Partners	Wakayama University
Website	http://www.astro.mech.tohoku.ac.jp/RAIKO/
Additional comments	Deployed from ISS on 2012-10-04.
Additional sources	http://www.astro.mech.tohoku.ac.jp/RAIKO/Paper_ISTS_2013-f-13_RAIKO.pdf,
	https://directory.eoportal.org/web/eoportal/satellite-missions/r/raiko



Raiko is a Japanese satellite which was built and operated by Tohoku and Wakayama Universities. A two-unit CubeSat, Raiko was deployed from the International Space Station on October 4, 2012, having been launched in July.

Raiko was launched aboard the Kounotori 3 spacecraft, atop an H-IIB carrier rocket flying from Pad 2 of the Yoshinobu Launch Complex at the Tanegashima Space Centre. The launch occurred at 02:06 UTC on 21 July 2012. Four other CubeSats were launched with Raiko; We-Wish, Niwaka, TechEdSat and F-1. The five CubeSats was delivered to the International Space Station for deployment. CubeSats were deployed from Japanese Experiment Module Kibo via the J-SSOD system on October 4, 2012.

Named after a Japanese god of thunder, Raiko is a 2-kilogram (4.4 lb) spacecraft, which will be used for technology demonstration. It carries a camera with a fish-eye lens for Earth imaging, a prototype star tracker, a deployable membrane to slow the satellite, lowering its orbit, a photographic system to measure the satellite's movement relative to the International Space Station, and a Ku-band antenna for communications and Doppler ranging experiments.

References:

https://en.wikipedia.org/wiki/Raiko

http://www.tohoku.ac.jp/english/2012/06/news20120625-03.html

e-st@r-II

Mission Name	e-st@r-II
Organisation	Polytechnic University of Turin
Organisation type	University
Nation	Italy
Type (U or mass)	1U
Satellite launch year	2016-04-25
Rocket	Sojuz
Orbit	442 x 686 km, 98.2 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Demonstrate the capability of autonomous determination, control and manoeuver, through the development and test in orbit of an A-ADCS entirely designed and manufactured by students. Test in orbit COTS technology and self-made hardware.
Experiment description	-
Lifetime or status in orbit	Was operational until 2016-09-XX? (Last DK3WN report 2016-09-04)
Partners	-
Website	http://areeweb.polito.it/cubesat-team/missions/e-star-ii/
Additional comments	ESA Fly Your Satellite
Additional sourcesp	http://www.esa.int/Education/University_teams_selected_for_phase_2_of_Fly_Your_Satellite%21

e-st@r-II (Educational Satellite @ Polytechnic University of Turin 2) is a miniaturized satellite designed and built by Polytechnic University of Turin, as part of the "Fly Your Satellite" program of the European Space Agency.

It is a CubeSat satellite, placed in orbit by Arianespace with Soyuz Booster, VS14 flight, on April 25, 2016 at 21:02 GMT (23:02 CEST) from Europe's spaceport in Kourou, French Guiana . The main payload of the launch was Sentinel-1B from program Copernicus and Microscope designed by the CNES, the French space agency.

In addition to e-st@ r-II there was other two CubeSats 1U (AAUSAT 4, .htm OUFTI 1) they were packed aboard the Soyuz. These small satellites, each measuring just 10 × 10 × 11 cm in height, have been developed by teams of university students through ESA programs.

E-st@ r-II is the successor of e-st@r, the first Italian CubeSat and the first Cubesat of the Polytechnic University of Turin. More than 30 students have been working on this project, with the unique opportunity of practical experience of space applications.

E-st@r-II is a 1U CubeSat developed for demonstrating the autonomous active attitude control capabilities based on magnetic actuation: in fact, the payload is an Active Attitude Determination and Control System. The commissioning phase foresees that the payload is deactivated leaving the satellite in its free tumbling motion, without any attitude stabilization. The A-ADCS starts its work when commanded from GCS, controlling the angular velocities and the attitude of the satellite.

ICECube 1

The primary scientific objectives of e-st@r-II mission are:

- To demonstrate the capability of autonomous determination, control and manoeuver, through the development and test in orbit of an A-ADCS entirely designed and manufactured by students
- To test in orbit COTS technology and self-made hardware

E-st@r-II is a follow-on of e-st@r-I, the first Italian CubeSat and the first satellite of Politecnico di Torino to be inserted on orbit. More than 30 students worked on this project, using a unique opportunity of hands-on experience on space applications. It will demonstrate the ability of determining (with gyros and magnetometers) and actively controlling its attitude. The bus functionalities, as a basis for other CubeSats, will be demonstrated: it is a step towards future missions and applications.

Once deployed into orbit, e-st@r-II will begin transmitting signals to Earth approximately 30 minutes after activation. Signals can be picked up by anyone with common amateur radio equipment. To celebrate the launch of this second CubeSat, e-st@r-II, the world amateur radio community are invited in a contest to listen out for satellite.

Currently the team that developed the satellite, the CubeSatTeam of Politecnico di Torino, is actively working on development of the Next model: 3-STAR, a 3U CubeSat.

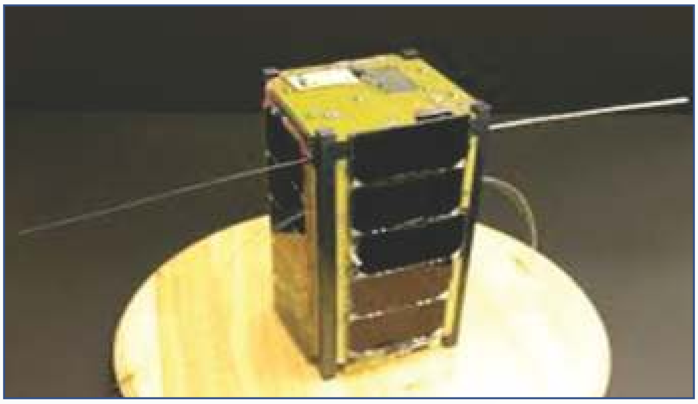
References:

https://en.wikipedia.org/wiki/E-st@r-II

http://www.cubesatteam-polito.com/missions/e-star-ii/

T-LogoQube

Mission Name	T-LogoQube (BeakerSat 1, MagPocketQube, Eagle-1)
Organisation	Sonoma State University
Organisation type	University
Nation	US
Type (U or mass)	PocketQube 2.5p
Satellite launch year	2013-11-21
Rocket	Dnepr
Orbit	670 km, 97.79 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	T-LogoQube is measuring the Earth's magnetic field in order to determine the satellite's pointing direction
Mission objectives	-
Experiment description	Was operational until?
Lifetime or status in orbit	Was operational until 2015-03-15
Partners	Morehead State University
Website	http://universe.sonoma.edu/T-LogoQube/
Additional comments	Had CZT array payload but did not fly in the end. Deployed from UniSat-5.
Additional sources	http://space.skyrocket.de/doc_sdat/ksat.htm



References :

http://lbym.sonoma.edu/T-LogoQube/?q=public

https://www.google.co.in/imgres?imgurl=http%3A%2F%2Flbym.sonoma.edu%2FT-LogoQube

http://mstl.atl.calpoly.edu/~workshop/archive/2006/Spring/10-Dabrowski-ION%20CubeSat.pdf

NEE 02 Krysaor

Mission Name	NEE 02 Krysaor
Organisation	Ecuadorian Space Agency
Organisation type	Agency
Nation	Ecuador
Type (U or mass)	1U
Satellite launch year	2013-11-21
Rocket	Dnepr
Orbit	670 km, 98.2 deg, SSO
Mission type	Space Techonology
Mission type description/ Configuration/Power	Space Design & Verification
Mission objectives	Serving education and also acting as orbital sentinels watching for possible threats from small NEOs in last phase of atmospheric entry and helping to catalog orbital debris.
Experiment description	Also it has the latest advances in active deployment of its solar arrays, high speed digital transmission and a higher resolution video camera.
Lifetime or status in orbit	No recent public news found
Partners	-
Website	http://www.exa.ec/nee-02-eng.htm
Additional comments	-
Additional sources	-

The NEE-02 KRYSAOR is a PEGASUS class sateliite, which means that is a twin of the original NEE-01 PEGASUS, it was built after it and completed on June 2012, its primary function is to be a backup of the NEE-01 in case of any eventuality in the NEE-01 launch operation.

The NEE-02 will be launched in to a 98.7 degree inclination, helio synchronous orbit, 720km perigee and 890km apogee on November 21, 2013

Its mission is the same as PEGASUS, serving education and also acting as orbital sentinels watching for possible threats from small NEOs in last phase of atmospheric entry and helping to catalog orbital debris. Also it has the latest advances in active deployment of its solar arrays, high speed digital transmission and a higher resolution video camera.

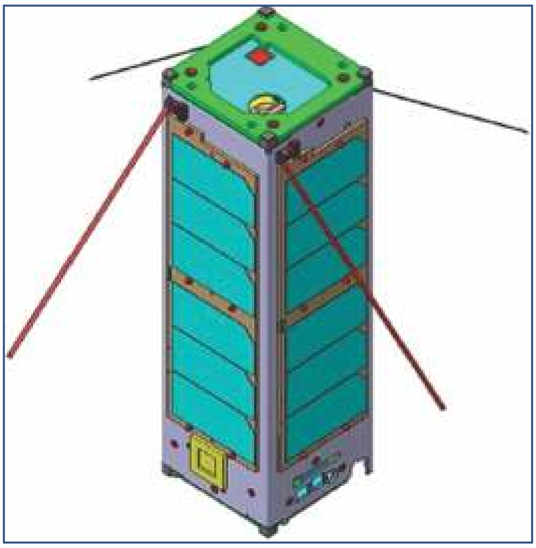
References :

https://en.wikipedia.org/wiki/NEE-02_Krysaor

OPTOS

Mission Name	OPTOS (Optical Nanosatellite)
Organisation	National Institute of Aerospace Technology
Organisation type	Agency
Nation	Spain
Type (U or mass)	3U
Satellite launch year	2013-11-21
Rocket	Dnepr
Orbit	670 km, 98.2 deg, SSO
Mission type	Space Science
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Demonstrate new technologies.
Experiment description	Distributed OBDH (On-Board Data Handling) subsystem based on FPGAs (Floating Point Gate Arrays), and CPLDs (Complex Programmable Logic Devices), an optical wireless communication system (OBCom) with a reduced CAN (Controller Area Network) protocol is implemented, internal structure is based on composite materials.
Lifetime or status in orbit	No recent public news found
Partners	-
Website	https://directory.eoportal.org/web/eoportal/satellite-missions/o/optos
Additional comments	-
Additional sources	-

OPTOS is a low-cost triple-cube nanosatellite project of INTA (Instituto Nacional de Tecnica Aerospacial), the Spanish Space Agency, Madrid. The overall objective is to demonstrate new technologies in spacecraft development such as: a distributed OBDH (On-Board Data Handling) subsystem based on FPGAs (Floating Point Gate Arrays), and CPLDs (Complex Programmable Logic Devices), an optical wireless communication system (OBCom) with a reduced CAN (Controller Area Network) protocol is implemented, the internal structure is based on composite materials.

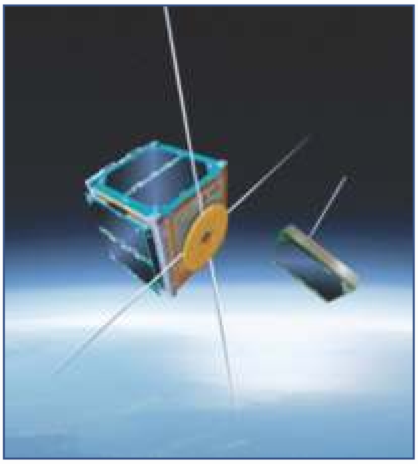


References :

https://en.wikipedia.org/wiki/NEE-02_Krysaor

PUCP - Pocket

Mission Name	PUCP - Pocket
Organisation	Pontifical Catholic University of Peru
Organisation type	University
Nation	Peru
Type (U or mass)	0.127 kg
Satellite launch year	2013-11-21
Rocket	Dnepr
Orbit	670 km, 98.2 deg, SSO
Mission type	-
Mission type description/ Configuration/Power	Transmit Temperature measurements
Mission objectives	Demonstrate new technologies.
Experiment description	Distributed OBDH (On-Board Data Handling) subsystem based on FPGAs (Floating Point Gate Arrays), and CPLDs (Complex Programmable Logic Devices), an optical wireless communication system (OBCom) with a reduced CAN (Controller Area Network) protocol is implemented, internal structure is based on composite materials.
Lifetime or status in orbit	No recent public news found
Partners	-
Website	https://directory.eoportal.org/web/eoportal/satellite-missions/o/optos
Additional comments	Deployed from PUCPSat-1 on 2013-12-06
Additional sources	http://www.southgatearc.org/news/december2013/pucp_sat1_deploys_pocket_pucp_femtosatellite.htm#.W2M1StIzbMV



The Peruvian CubeSat PUCP-SAT-1 (145.840 MHz AX.25 FM) was carried by the microsatellite UNISAT-5 which was launched on a Dnepr on November 21, 2013.

When in orbit UNISAT-5 deployed PUCP-SAT-1 and Neilsao Vilchez reports PUCP-SAT-1 has in turn deployed an even smaller satellite POCKET-PUCP.

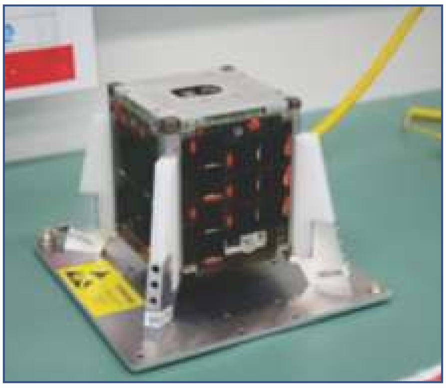
The femtosatellite POCKET-PUCP measures just 8.35 by 4.95 by 1.55 cm and has a 10 mW 12 wpm CW (On-Off-Keying OOK) beacon on 437.200 MHz. The team at the Pontificia Universidad Católica del Perú would welcome any reception reports.

References :

http://inras.pucp.edu.pe/en/proyectos/pucp-sat-1/especificaciones-del-satelite/

ZACUVE – 1

Mission Name	ZACUVE – 1 (TshepisoSat)
Organisation	Cape Peninsula University of Technology
Organisation type	University
Nation	South Africa
Type (U or mass)	1U
Satellite launch year	2013-11-21
Rocket	Dnepr
Orbit	670 km, 98.2 deg, SSO
Mission type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Training of post-graduate students in Satellite Systems Engineering. Earth observation using a visible band matrix imager payload and an S-Band payload data transmitter (2.4 to 2.45 GHz). UHF Store & Forward system (70 cm amateur band). Experimental 115200 bps L-Band to S-band data transponder. HF beacon payload for characterization of Hermanus Magnetic Observatory's Dual Auroral Radar Network antenna at SANAE base in Antarctica (14 MHz).
Experiment description	Space-weather experiment to take measurements in the ionosphere. High frequency (HF) beacon transmitter that will be used to help characterize the Earth's ionosphere and to calibrate SANSA's (South African National Space Agency) auroral radar installation at the SANAE base in Antarctica
Lifetime or status in orbit	2018-06-26
Partners	Stellenbosch University, F'SATI (French South African Institute of Technology)
Website	http://www.cput.ac.za/blogs/fsati/zacube-1/
Additional comments	-
Additional sources	-



The satellite makes use of the CubeSat form factor and contains a mix of in-house developed and commercial-of-the-self components. Components where sourced from Clyde Space and Innovative Solutions In Space. ZACUBE-1 is South Africa's first launched CubeSat and third Satellite (ZA-003).

The UHF/VHF transceiver used on ZACUBE-1 was developed and built in-house at F'SATI/CPUT and is still functioning nominally after more than two years on orbit. This transceiver served as the base design for the CMC UHF/VHF transceiver which is now commercially available.

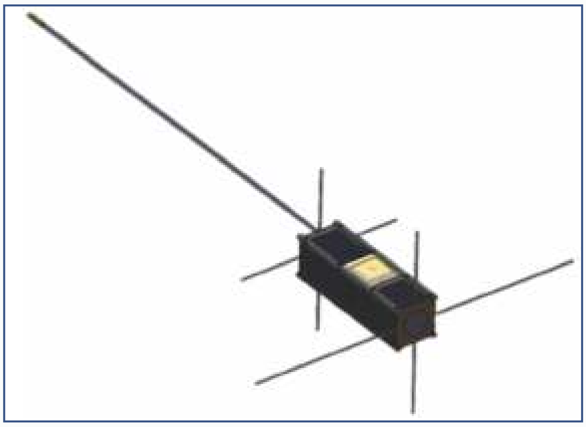
References :

https://en.wikipedia.org/wiki/ZACube-1

OSIRIS – 3U

Mission Name	OSIRIS – 3U
Organisation	The Pennsylvania
Organisation type	University
Nation	US
Type (U or mass)	3U
Satellite launch year	2017-08-14
Rocket	Falcon 9
Orbit	400 km, 51.6 deg, ISS
Mission type	Space Science
Mission type description/ Configuration/Power	Upper atmosphere
Mission objectives	Ground-based heaters will modify the atmosphere in order to create artificial space weather events that will be studied by OSIRIS-3U. The mission provides research into radiowave-plasma interactions and plasma transport. 1. Provide in situ and remote sensing measurements of the stimulated (heated) ionosphere produced by ground-based heaters 2. Characterize the spatial extent of the heated region “bite out” 3. Correlate in situ and remote sensing heated ionosphere measurements with ground-based measurements including incoherent scatter radars and ionosondes 4. Develop the aerospace workforce by training students in space systems engineering through hands-on projects.
Experiment description	1. Investigate anomalous electron number density enhancements in the night-time ionosphere 2. Correlate in situ and remote sensing measurements at Arecibo’s conjugate point with heating events The use of the ionospheric heater at Arecibo, and if available the heaters at HAARP and EISCAT will allow the OSIRIS-3U mission to mimic natural ionospheric irregularities at defined locations and times, as well as perform research on active experiments. Combination of instruments to map ionospheric irregularities over Arecibo using a Langmuir Probe and two remote sensing instruments: the Coherent Electromagnetic Radio Tomography (CERTO) beacon and the Compact Total Electron Content Sensor (CTECS)
Lifetime or status in orbit	2018-06-26
Partners	The Aerospace Corp, Naval Research Laboratory
Website	http://php.scripts.psu.edu/dept/sspl/index.php?/categories/8-OSIRIS-CubeSat
Additional comments	Deployed from ISS on 2017-11-21.
Additional sources	https://www.gwu.edu/~spi/assets/docs/USRA%20March%2028%20Presentations/Bilen.pdf, http://space.skyrocket.de/doc_sdat/osiris-3u.htm, http://www.amsatuk.me.uk/iaru/finished_detail.php?serialnum=506

OSIRIS-3U(Orbital Satellite for Investigating the Response of the Ionosphere to Stimulation and Space Weather) is a 3U Cubesat developed by students at the Penn State University to study space weather's impact on communications networks.



OSIRIS-3U will investigate where plasma goes when high-power radio waves cause large ionospheric drops in electron density, in the ionosphere's F-region, which begins approximately 190 km above sea level. The primary scientific goal of OSIRIS is to characterize these events by flying through the heated region of our ionosphere. Results of the mission, beyond understanding radio-wave interaction with the ionosphere, can be used for research into space weather forecasting and for developing countermeasures to prevent damage to our infrastructure.

References :

https://space.skyrocket.de/doc_sdat/osiris-3u.htm

DELLINGR

Mission Name	DELLINGR (RBLE, Radiation Belt Loss Experiment)
Organisation	NASA Goddard Space Flight Center
Organisation type	Agency
Nation	US
Type (U or mass)	6U
Satellite launch year	2017-08-14
Rocket	Falcon 9
Orbit	400 km, 51.6 deg, ISS
Mission type	Space Technology
Mission type description/ Configuration/Power	Upper atmosphere
Mission objectives	The scientific payload includes a magnetometer deployed on a boom and a set of two internal magnetometers. In addition to collecting data about the magnetic field, the boom mounted magnetometer will validate the use of the two internal magnetometers for future missions. An Ion Neutral Mass Spectrometer will collect data about the ionosphere-thermosphere-mesosphere system.
Experiment description	-
Lifetime or status in orbit	Operational
Partners	-
Website	-
Additional comments	Deployed from ISS on 2017-11-21.
Additional sources	https://www.gwu.edu/~spi/assets/docs/USRA%20March%2028%20Presentations/Bilen.pdf, http://space.skyrocket.de/doc_sdat/osiris-3u.htm, http://www.amsatuk.me.uk/iaru/finished_detail.php?serialnum=506

This mission of firsts will serve as a pathfinder for new radiation-tolerant technologies that could help scientists realize a long-sought dream: deploying a constellation of small satellites beyond low-Earth orbit to gather simultaneous, multi-point measurements of Earth's ever-changing magnetosphere, which protects the planet from the constant assault of charged particles streaming off the Sun.

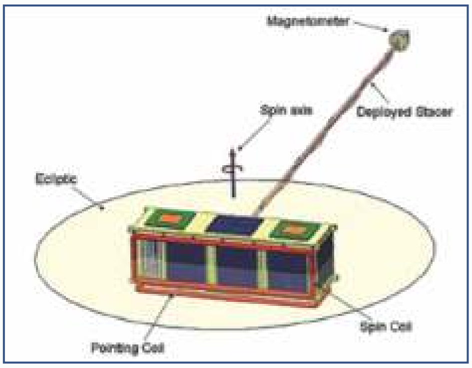
Furthermore, it will be the first CubeSat to operate in geostationary transfer orbit, or GTO — from which it derives its name — and the first to use the latest, more robust version of the NASA-developed Dellingr spacecraft bus — the Dellingr-X.

References :

https://www.nasa.gov/feature/goddard/2018/nasa-s-new-dellingr-spacecraft-baselined-for-pathfinding-cubesat-mission-to-van-allen-belts

CINEMA (CubeSat for Ions, Neutrals, Electrons & Magnetic Fields)

Mission Name	CINEMA (CubeSat for Ions, Neutrals, Electrons & Magnetic Fields)
Organisation	University of California
Organisation type	University
Nation	US
Type (U or mass)	3U
Satellite launch year	2012-09-13
Rocket	Atlas V
Orbit	480 x 770km, 66 deg
Mission type	Space Science
Mission type description/ Configuration/Power	Upper atmosphere
Mission objectives	Stereo imaging of magnetospheric energetic neutral atom, multi-point measurements of suprathermal electrons and ions associated with auroral acceleration as well as electron microbursts, and complementary measurements of magnetic fields for particle data.
Experiment description	Each satellite is equipped with a SupraThermal Electron, Ion, Neutral (STEIN) instrument covering the energy range ~2-200 keV, and a 3-axis magnetometer of magnetoresistive sensors.
Lifetime or status in orbit	Operational
Partners	Kyung Hee University, Imperial College London, NASA Ames Research Center
Website	https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/cinema
Additional comments	-
Additional sources	-



CINEMA is an international nanosatellite science mission of cooperative university institutions with the objective to provide critical space weather measurements, including unique high sensitivity mapping of ENAs (Energetic Neutral Atoms), and high cadence movies of ring current ENAs in stereo from low Earth orbit. By the selection of its sensor complement, the mission will pave the way for “magnetospheric constellations” with many satellites making multipoint observations. The project emphasizes student involvement with guidance by experienced engineers and scientists. The implementation of the project is realized using a combination of flight heritage and innovation that balances risk and safety.

References :

https://earth.esa.int/web/eoportal/satellite-missions/content/-/article/cinema

CP5

Mission Name	CP5
Organisation	California Polytechnic University
Organisation type	University
Nation	US
Type (U or mass)	1U
Satellite launch year	2012-09-13
Rocket	Atlas V
Orbit	480 x 770km, 66 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	De-orbiting experiment using a thin-film deployable mechanism. The main goal is to identify whether the mechanism can feasibly become a practical solution for mitigating space debris on future small satellites.
Experiment description	-
Lifetime or status in orbit	Was Operational for short time. Deployed solar sail.
Partners	-
Website	https://space.skyrocket.de/doc_sdat/cp-5.htm
Additional comments	-
Additional sources	-

The Cal Poly Picosatellite Project (PolySat) was founded in 1999 and involves a multidisciplinary team of undergraduate and graduate engineering students working to design, construct, test, launch, and operate a CubeSat.

The CP5 Project development began in 2007, and has been through several revisions and worked on by various teams. The final team completed development in December 2011 to prepare for integration on the ELaNa-6 mission. The program was extended well-beyond its desired completion date, as with most projects. However, the team envisions a successful sail deployment and de-orbit of the spacecraft after deployment from NROL-36.

Additional Resource :

http://www.dk3wn.info/sat/afu/sat_cp5.shtml

Dragon Sat 1

Mission Name	Dragon Sat 1
Organisation	Drexel University
Organisation Type	University
Nation	US
Type (U or mass)	1U
Satellite Launch Year	20-11-2013
Rocket	Minotaur-1
Orbit	500 km, 40.5 deg
Mission Type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Educate undergraduate students and to provide hands-on experience in space system development. Take pictures of aurora (northern and southern lights) to observe the radiation dissipation intensity during the solar events, and to perform technology demonstration of boom deployment mechanism in space.
Experiment description	The payload of the DragonSat-1 will consist of a package of various sensors, including one µCam camera, one HMC2003 magnetometer, one MMA7260QT accelerometer, and seven LM335 temperature sensors.
Lifetime or status in orbit	Reentry 2016-08-31. No signal.
Partners	U.S. Naval Academy
Website	http://satellite.mem.drexel.edu/projects/dragonsat-1/
Additional comments	-
Additional sources	-

DRAGONSat (Dual RF Astrodynamic GPS Orbital Navigator Satellite) is a pair of nanosatellites that will be demonstrating autonomous rendezvous and docking (ARD) in low Earth orbit (LEO) for NASA. It will be gathering flight data with a global positioning system (GPS) receiver strictly designed for space applications to gather flight data in the space environment. ARD is the capability of two independent spacecraft to rendezvous in orbit and dock without crew intervention. One DRAGONSat was built by the University of Texas and the other one was built by Texas A and M University, the Space Shuttle Payload Launcher(SSPL), These satellite projects will rendezvous and dock with each other in space without the benefit of human intervention.

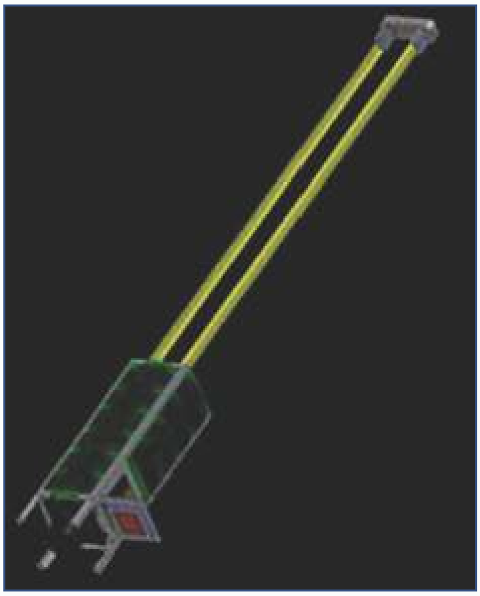
References:

Nanosatellite Database by Erik | www.nanosats.eu

Ho'oponopono 2

Mission Name	Ho'oponopono 2 (H2)
Organisation	University of Hawaii at Manoa
Organisation Type	University
Nation	US
Type (U or mass)	3U
Satellite Launch Year	20-11-2013
Rocket	Minotaur-1
Orbit	500 km, 40.5 deg
Mission Type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Continue a long-existing radar calibration service, provided currently with a microsatellite (RADCAL) and with a payload suite on a meteorological mission (DMSP-15).
Experiment description	Demonstrate the collection of accurate (< 5 m) ephemeris data. Provide radar calibration information at an average rate of five radar ranges every day for 1 year.
Lifetime or status in orbit	No signal
Partners	United States Air Force
Website	-
Additional comments	-
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/h/ho-oponopono

Ho'oponopono 2 is a 3U CubeSat mission developed by students of the University of Hawaii, Honolulu (Ma-noa), to perform radar calibration.The development of the nanosatellite was the basis for the University of Hawaii's participation in the AFOSR (Air Force Office of Scientific Research) UNP (University Nanosat-6 Program), kickoff in Jan. 2009, a rigorous two-year satellite design and fabrication competition.. The objective of the mission is to continue a long-existing radar calibration service for the 80 plus C-band radar tracking stations distributed around the world, provided currently with the microsatellite RADCAL and with a payload suite onboard the meteorological satellite DMSP-5D3 F-15 — with a sensor complement on a nanosatellite mission.



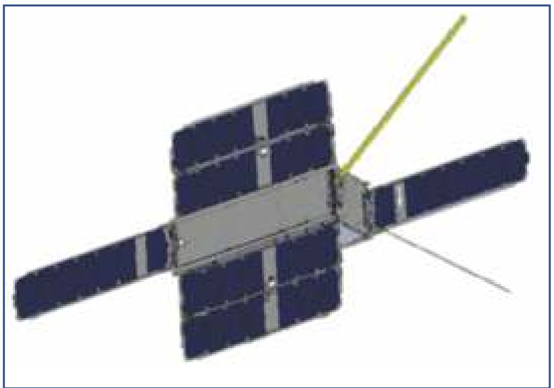
References:

Nanosatellite Database by Erik | www.nanosats.eu

https://space.skyrocket.de

Horus

Mission Name	Horus (STARE B, Space-Based Telescopes for Actionable Refinement of Ephemeris)
Organisation	Lawrence Livermore National Laboratory
Organisation Type	Institute
Nation	US
Type (U or mass)	3U
Satellite Launch Year	20-11-2013
Rocket	Minotaur-1
Orbit	500 km, 40.5 deg
Mission Type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Observe objects that are predicted to pass close to a valuable space asset based on conjunction analysis using the AFSPC (Air Force Space Command) catalog. Refinement of orbital parameters of space objects to reduce uncertainty in position estimation and improve accuracy of conjunction analysis.
Experiment description	Full set of reaction wheels for attitude control and a more sensitive imager
Lifetime or status in orbit	Reentry 2018-04-26. Was semi-operational?
Partners	Boeing
Website	-
Additional comments	-
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/s/stare



The High-ORbit Ultraviolet-visible Satellite (HORUS) is a 2.4-meter Probe-class space telescope concept designed to conduct a comprehensive and systematic study of the astrophysical processes and environments relevant for the births and life cycles of stars and their planetary systems, to investigate and understand the range of environments, feedback mechanisms, and other factors that most affect the outcome of the star and planet formation process. HORUS provides 100x greater imaging efficiency and combines the resolution of STIS with the throughput of COS. The HORUS mission will contribute vital information on how solar systems form and whether habitable planets should be common or rare. It also will investigate the structure, evolution, and destiny of galaxies and the universe. This program relies on focused capabilities unique to space that no other planned NASA mission will provide: near-ultraviolet (UV)/visible (200-1100 nm) wide-field (14' square), diffraction-limited imaging; and high-sensitivity, high-resolution FUV (100-320nm) spectroscopy. From its baseline orbit at L2 HORUS enjoys a stable environment for thermal and pointing control, and long-duration target visibility. The core HORUS design provides wide field of view imagery and high efficiency point source far-ultraviolet (FUV) spectroscopy using a novel combination of spectral selection and field sharing. The HORUS Optical Telescope Assembly (OTA) design uses a three-mirror anastigmatic configuration to provide excellent imagery over a large FOV. The UV/optical Imaging Cameras use two 21k x 21k Focal Plane Arrays (FPAs) consisting of multiple tiled Si CCD elements. The FUV spectrometer uses cross strip anode based microchannel plates (MCPs) improved from HST-COS technology. Fine guidance sensing is accomplished via Si arrays mounted at the Cassegrain focus.

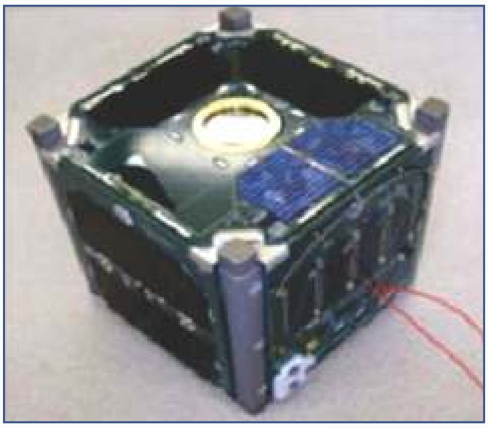
References:

Nanosatellite Database by Erik | www.nanosats.eu

https://www.sofia.usra.edu

NPS-SCAT

Mission Name	NPS-SCAT (Naval Postgraduate School Solar Cell Array Tester)
Organisation	Naval Postgraduate School
Organisation Type	University
Nation	US
Type (U or mass)	1U
Satellite Launch Year	20-11-2013
Rocket	Minotaur-1
Orbit	500 km, 40.5 deg
Mission Type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Solar Cell Measurement System (SMS), as its payload.
Experiment description	This experiment measures the characteristics of a solar cell to gain an understanding of how the experimental solar cells degrade over time due to interactions with the space environment.
Lifetime or status in orbit	Reentry 2015-10-28. Was operational until 2014-11-21? First beacon heard
Partners	
Website	-
Additional comments	-
Additional sources	http://www.dk3wn.info/p/?s=nps&x=0&y=0



The NPS-SCAT (Naval Postgraduate School Solar Cell Array Tester) is a 1U CubeSat in development by the Space Systems Academic Group at NPS.The objective of the NPS-SCAT CubeSat program is to provide a responsive platform to test solar cells in orbit while focusing on the education of NPS students. In addition, the knowledge gained from this CubeSat will be used to further develop the CubeSat program at NPS. The CubeSat development program educates NPS Space Systems military officer and civilian students in the full life cycle of space flight systems with the goal of providing a trained, educated, and experienced cadres of space professionals.The NPS-SCAT CubeSat takes a single experiment from the NPSAT1 satellite, the Solar Cell Measurement System (SMS), as its payload. This experiment measures the characteristics of a solar cell to gain an understanding of how the experimental solar cells degrade over time due to interactions with the space environment. The supporting subsystems are fulfulled primarily by commercial-off-the-shelf (COTS) components, including the command and data handling subsystem, electrical power subsystem, and the primary communications subsystem.

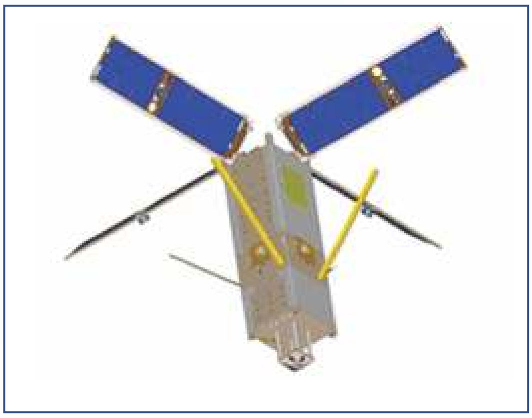
References:

Nanosatellite Database by Erik | www.nanosats.eu

https://space.skyrocket.de

ORS Tech 1

Mission Name	ORS Tech 1
Organisation	John Hopkins University
Organisation Type	University
Nation	US
Type (U or mass)	3U
Satellite Launch Year	20-11-2013
Rocket	Minotaur-1
Orbit	500 km, 40.5 deg
Mission Type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Created a flexible and modular, Multi-Mission Nanosatellite (MMN) spacecraft architecture for low-cost execution of critical missions.
Experiment description	-
Lifetime or status in orbit	Reentry 2015-03-23. Was operational.
Partners Website	- -
Additional comments	-
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/o/ors-tech-1-2



The ORS Tech 1 and 2 (Operationally Responsive Space - Technology) satellites, formerly known as MBD 1 and 2(Multimission Bus Demonstration), were created by the Johns Hopkins University Applied Physics Laboratory (JHU/APL) as a flexible and modular multi-mission nano-satellite spacecraft architecture for low-cost execution of critical missions.Under the pathfinder Multi-Mission Bus Demonstration (MBD) program, two triple (3U) CubeSat hardware prototypes have been developed. The ORS Tech 1 ans 2 mission are to validate a robust end-to-end system architecture, CONOPS, and key enabling nano-satellite technologies for future missions.The two satellites were launched on a Minotaur-1 booster on the ORS 3 mission. The technology demonstration segment of the mission ended in June 2014, when APL handed command and control of the spacecraft and ground system to its Department of Defense customer. ORS Tech 1 became unresponsive before the operational phase, but ORS Tech 2 performed well over the 10-month operational period until the spacecraft reentered Earth's atmosphere. ORS-Tech-1 reentered on 21 March 2015 and ORS-Tech-2 on 3 April 2015.

References:

Nanosatellite Database by Erik | www.nanosats.eu

https://space.skyrocket.de

ORS Tech 2

Mission Name	ORS Tech 2
Organisation	John Hopkins University
Organisation Type	University
Nation	US
Type (U or mass)	3U
Satellite Launch Year	20-11-2013
Rocket	Minotaur-1
Orbit	500 km, 40.5 deg
Mission Type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Created a flexible and modular, Multi-Mission Nanosatellite (MMN) spacecraft architecture for low-cost execution of critical missions.
Experiment description	-
Lifetime or status in orbit	Reentry 2015-04-03. Was operational.
Partners	-
Website	-
Additional comments	-
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/o/ors-tech-1-3

The ORS Tech 1 and 2 (Operationally Responsive Space - Technology) satellites, formerly known as MBD 1 and 2(Multimission Bus Demonstration), were created by the Johns Hopkins University Applied Physics Laboratory (JHU/APL) as a flexible and modular multi-mission nano-satellite spacecraft architecture for low-cost execution of critical missions.Under the pathfinder Multi-Mission Bus Demonstration (MBD) program, two triple (3U) CubeSat hardware prototypes have been developed. The ORS Tech 1 ans 2 mission are to validate a robust end-to-end system architecture, CONOPS, and key enabling nano-satellite technologies for future missions.The two satellites were launched on a Minotaur-1 booster on the ORS 3 mission. The technology demonstration segment of the mission ended in June 2014, when APL handed command and control of the spacecraft and ground system to its Department of Defense customer. ORS Tech 1 became unresponsive before the operational phase, but ORS Tech 2 performed well over the 10-month operational period until the spacecraft reentered Earth's atmosphere. ORS-Tech-1 reentered on 21 March 2015 and ORS-Tech-2 on 3 April 2015.

References:

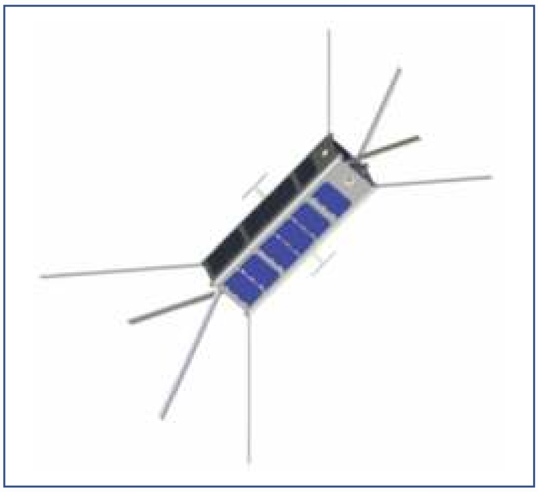
Nanosatellite Database by Erik | www.nanosats.eu

https://space.skyrocket.de

ORSES (ORS 1)

Mission Name	ORSES (ORS 1)
Organisation	Space & Missile Defense Command
Organisation Type	Military
Nation	US
Type (U or mass)	3U
Satellite Launch Year	20-11-2013
Rocket	Minotaur-1
Orbit	500 km, 40.5 deg
Mission Type	Space Technology
Mission type description/ Configuration/Power	
Mission objectives	Provide communications and data capabilities for underserved tactical users.
Experiment description	Based on the SMDC-ONE satellite that flew in December 2010 and on the OUTSat mission with an upgraded communication radio and encryption.
Lifetime or status in orbit	Reentry 2016-01-03. Was operational until 2013-11-25.
Partners	DoD Operationally Responsive Space Office
Website	-
Additional comments	-
Additional sources	http://spaceflightnow.com/minotaur/ors3/payloads.html

US Army's ORSES (Operationally Responsive Space Enabler Satellite) satellite is an experimental 3U CubeSat designed by the ORS Office and SMDC to provide communications and data capabilities for underserved tactical usersThe satellite is based on the SMDC-ONE communications cubesats, but with an upgraded radio communication system and encryption.The ORS Office independently developed the Vulcan Wireless Software Defined Radio (SDR) and the Raytheon Gryphon Type-I NSA certified encryption for first flight demonstration on the ORS-3 Mission. The SDR and Type-I encryption will provide significant performance and security upgrades to any future CubeSat mission.The satellite deployed successfully and contact was established. Unfortunately, general system failures limited demonstration success. It reentered on 3 January 2016.



References:

Nanosatellite Database by Erik | www.nanosats.eu

https://space.skyrocket.de

PhoneSat 2.4a

Mission Name	PhoneSat 2.4a
Organisation	NASA Ames Research Center
Organisation Type	Agency
Nation	US
Type (U or mass)	1U
Satellite Launch Year	20-11-2013
Rocket	Minotaur-1
Orbit	500 km, 40.5 deg
Mission Type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Test the smartphone's capability as communication technology for nanosatellites and as hardware to manage pointing, taking images and software execution.
Experiment description	Several improvements over the previous mission, including a two-way radio to enable command of the satellite from the ground, solar arrays to enable it to be operational for up to a year, and a system for attitude control.
Lifetime or status in orbit	Reentry 2017-01-31. Was operational.
Partners	-
Website	http://www.nasa.gov/directorates/spacetech/small_spacecraft/phonesat.html
Additional comments	-
Additional sources	http://www.nasa.gov/content/nasa-launches-next-generation-phonesat-ames-developed-launch-adapter/#.VFtSwPnCZ8E, http://www.thespacereview.com/article/2491/1

PhoneSat 2.4, a second-generation smartphone cubesat sponsored by NASA's Space Technology Mission Directorate. This mission will test the smartphone's viability as a communications technology for nanosatellites while verifying that its hardware can manage pointing, taking images, and executing software appropriately. It has been upgraded from the previous PhoneSat mission to include a two-way radio, which enables command of the satellite from the ground. In addition, solar arrays enable operation for up to a year. A system for attitude control also has been included.

References:

Nanosatellite Database by Erik | www.nanosats.eu

https://www.mwrf.com

$50Sat

Mission Name	$50Sat (50-Dollarsat, Eagle 2, Morehead-OSCAR-76)
Organisation	Morehead State University
Organisation Type	University
Nation	US
Type (U or mass)	PocketQube 1.5p
Satellite Launch Year	21-11-2013
Rocket	Dnepr
Orbit	670 km, 98.2 deg, SSO
Mission Type	Space Technology
Mission type description/ Configuration/Power	System Design & Verification
Mission objectives	Demonstrate that very low cost satellites are viable in low Earth orbit. The low build cost of $50SAT (less than $250 in parts) means that Engineering models are readily affordable by schools and colleges.
Experiment description	The PocketQube chassis has no precision mechanical parts and can be built from locally obtained sheet metal.
Lifetime or status in orbit	Reentry 2018-05-19. Was operational until 2015-07-19. http://amsat-uk.org/2015/08/30/50sat-falls-silent/
Partners	-
Website	http://www.50dollarsat.info/
Additional comments	Deployed from UniSat-5.
Additional sources	http://www.arrl.org/news/satellite-made-on-the-cheap-closing-in-on-2-years-in-orbit-and-still-ticking

$50SAT, also called Eagle 2, is femto-satellite to test miniaturized components in a satellite built to the 1.5U PocketQub form factor (7.5 cm × 5 cm × 5 cm). It is a collaborative project between collaborative education project between Professor Bob Twiggs, Morehead State University and three radio amateurs, Howie DeFelice (AB2S), Michael Kirkhart (KD8QBA), and Stuart Robinson (GW7HPW). $50SAT is a PocketQub micro satellite made from commercial electronic components and designed to fit in a 50 mm cube. The concept for the satellite is to see if a micro radio transceiver, the HOPE RFM22, is sufficient for transmitting and receiving data from a satellite in orbit. The satellite transmited a callsign in 15WPM Morse, send some environmental data as 60WPM Morse as well as transmitting a data packets containing information about the satellites operation. The satellite listened for incoming data packets in order to provide a transmit on or off command functionality

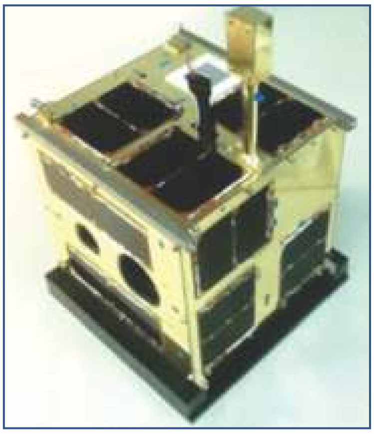
References:

Nanosatellite Database by Erik | www.nanosats.eu

https://space.skyrocket.de

BRITE-PL-1 Lem

Mission Name	BRITE-PL-1 Lem (CanX 3C)
Organisation	The Space Research Centre of the Polish Academy of Sciences
Organisation Type	Institute
Nation	Poland
Type (U or mass)	6 kg
Satellite Launch Year	21-11-2013
Rocket	Dnepr
Orbit	670 km, 98.2 deg, SSO
Mission Type	Space Science
Mission type description/ Configuration/Power	Observational astronomy
Mission objectives	Investigation of the brightness oscillations of massive luminous stars by differential photometry.
Experiment description	The scientific instrument is an optical camera with a high-resolution CCD to take images from distant stars with magnitude of 3.5.
Lifetime or status in orbit	Operational (http://www.tugsat.tugraz.at/)
Partners	The Nicolaus Copernicus Astronomical Centre of the Polish Academy of Sciences,
	University of Toronto Space Flight Laboratory
Website	http://www.brite-pl.pl/pliki/main_en.html
Additional comments	-
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/b/brite-poland



BRITE-PL (BRIght-star Target Explorer - Poland), is a mission planned to make photometric observations of some of the brightest stars in the sky in order to examine these stars for variability. The observations will have a precision at least 10 times better than achievable using ground-based observations, and it is packaged inside a CanX-class nanosatellite.The Polish Consortium supporting the BRITE-PL Project was established in October 2009 by:The Space Research Centre of the Polish Academy of Sciences and The Nicolaus Copernicus Astronomical Centre of the Polish Academy of Sciences and was chartered with the research, design and construction of scientific instruments in the international research project BRITE-PL

References:

Nanosatellite Database by Erik | www.nanosats.eu

https://space.skyrocket.de

CINEMA 2

Mission Name	CINEMA 2 (TRIO 2, KHUSAT 1)
Organisation	Kyung Hee University
Organisation Type	University
Nation	South Korea
Type (U or mass)	3U
Satellite Launch Year	21-11-2013
Rocket	Dnepr
Orbit	670 km, 98.2 deg, SSO
Mission Type	Space Science
Mission type description/ Configuration/Power	
Mission objectives	Stereo imaging of magnetospheric energetic neutral atom, multi-point measurements of suprathermal electrons and ions associated with auroral acceleration as well as electron microbursts, and complementary measurements of magnetic fields for particle data.
Experiment description	MAGIC (MAGnetometer from Imperial College). STEIN (SupraThermal Electrons Ions & Neutrals) particle detector.
Lifetime or status in orbit	Was semi-operational until 2014-11-28?
Partners	UC Berkeley, Imperial College London
Website	http://khusat.khu.ac.kr/
Additional comments	-
Additional sources	-

CINEMA (Cubesat for Ion, Neutral, Electron, Magnetic fields) is an international nanosatellite science mission of cooperative university institutions with the objective to provide critical space weather measurements, including unique high sensitivity mapping of ENAs (Energetic Neutral Atoms), and high cadence movies of ring current ENAs in stereo from low Earth orbit.By the selection of its sensor complement, the mission will pave the way for "magnetospheric constellations" with many satellites making multipoint observations. The project emphasizes student involvement with guidance by experienced engineers and scientists. The implementation of the project is realized using a combination of flight heritage and innovation that balances risk and safety. The CINEMA nanosatellite consists of bus avionics providing power, communications, and C&DHS (Command and Data Handling System), plus two instruments: the MAGIC (MAGnetometer from Imperial College), and the STEIN (SupraThermal Electrons Ions & Neutrals) particle detector. The system is based on existing bus and instrument designs. Both CINEMA-2 and -3 satellites were successfully deployed in orbit, but no signals were received from them.

References:

Nanosatellite Database by Erik | www.nanosats.eu

https://space.skyrocket.de

CINEMA 3

Mission Name	CINEMA 3 (TRIO 3, KHUSAT 2)
Organisation	Kyung Hee University
Organisation Type	University
Nation	South Korea
Type (U or mass)	3U
Satellite Launch Year	21-11-2013
Rocket	Dnepr
Orbit	670 km, 98.2 deg, SSO
Mission Type	Space Science
Mission type description/ Configuration/Power	
Mission objectives	Stereo imaging of magnetospheric energetic neutral atom, multi-point measurements of suprathermal electrons and ions associated with auroral acceleration as well as electron microbursts, and complementary measurements of magnetic fields for particle data.
Experiment description	MAGIC (MAGnetometer from Imperial College). STEIN (SupraThermal Electrons Ions & Neutrals) particle detector.
Lifetime or status in orbit	No signal
Partners	UC Berkeley, Kyung Hee University and Imperial College London
Website	http://khusat.khu.ac.kr/
Additional comments	-
Additional sources	-

CINEMA (Cubesat for Ion, Neutral, Electron, Magnetic fields) is an international nanosatellite science mission of cooperative university institutions with the objective to provide critical space weather measurements, including unique high sensitivity mapping of ENAs (Energetic Neutral Atoms), and high cadence movies of ring current ENAs in stereo from low Earth orbit.By the selection of its sensor complement, the mission will pave the way for "magnetospheric constellations" with many satellites making multipoint observations. The project emphasizes student involvement with guidance by experienced engineers and scientists. The implementation of the project is realized using a combination of flight heritage and innovation that balances risk and safety. The CINEMA nanosatellite consists of bus avionics providing power, communications, and C&DHS (Command and Data Handling System), plus two instruments: the MAGIC (MAGnetometer from Imperial College), and the STEIN (SupraThermal Electrons Ions & Neutrals) particle detector. The system is based on existing bus and instrument designs. Both CINEMA-2 and -3 satellites were successfully deployed in orbit, but no signals were received from them.

References:

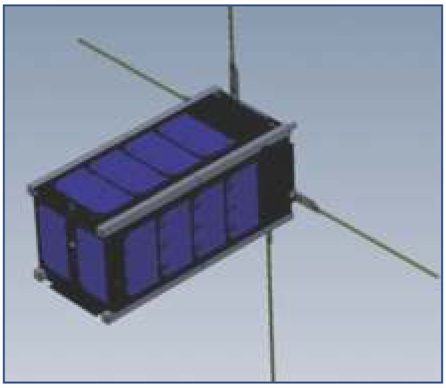
Nanosatellite Database by Erik | www.nanosats.eu

https://space.skyrocket.de

CubeBug-2

Mission Name	CubeBug-2 (Manolito)
Organisation	Satellogic
Organisation Type	Company
Nation	Argentina
Type (U or mass)	2U
Satellite Launch Year	21-11-2013
Rocket	Dnepr
Orbit	670 km, 98.2 deg, SSO
Mission Type	Space Technology
Mission type description/ Configuration/Power	
Mission objectives	Open Nano-Satellite platform, first technology demonstration satellite. As payload on this first mission, some custom designed components will be tested: an ARM based on-board computer, a nano-reaction wheel with its driver circuit and a low resolution camera to image stars, all based on COTS components.
Experiment description	It will carry an amateur radio AX.25 packet radio digipeater. As payload on this second mission, some custom designed components will be tested: an antenna, solar panels, and an on-board computer, a camera, a GPS transceiver and a software defined radio based on COTS components.
Lifetime or status in orbit	Operational (Last report 2018-05-31)
Partners	Argentinian Ministry of Science,, INVAP S.E., Radio Club Bariloche.
Website	http://2.cubebug.org/
Additional comments	-
Additional sources	http://www.pe0sat.vgnet.nl/satellite/cube-nano-picosats/cubebug-2/

The CubeBug-1 2U CubeSat, also known as El Capitán Beto, is the first technology demonstration mission for a new cubesat platform design (mechanics, hardware and software) intended to be released as Open Source and Open Hardware for its use in Amateur projects, University projects and research labs. This project is sponsored by the Argentinian Ministry of Science, Technology and Productive Innovation, INVAP S.E., Satellogic S.A., and Radio Club Bariloche.As payload on this first mission, some custom designed components for the BugSat earth observation satellites were tested: an ARM based on-board computer, a nano-reaction wheel with its driver circuit and a low resolution camera, all based on COTS components. After the technology demonstration part of the mission is over, the satellite will enter a mode that will include services to the Amateur radio community, including a Digipeater and science data downloads from the payload.



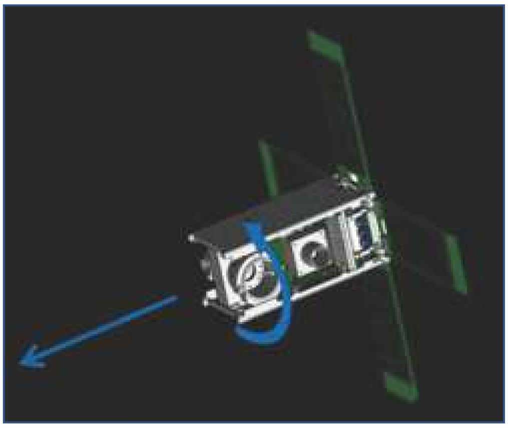
References:

Nanosatellite Database by Erik | www.nanosats.eu

https://space.skyrocket.de

CXBN (Cosmic X-Ray Background Nanosatellite)

Mission Name	CXBN (Cosmic X-Ray Background Nanosatellite)
Organisation	Morehead State University/Kentucky Space
Organisation type	University
Nation	US
Type (U or mass)	2U
Satellite launch year	Launched on 2012-03-21
	Was operational until 2013 - 01 – 23. Too weak signal since the beginning for science mission.
Rocket	Atlas V
Orbit	480 x 770 km, 66 deg
Mission type	Space Technology
Mission type description/	Increase the precision of measurements of the Cosmic X-Ray Background (CXRB) in the 30-
Configuration/Power	50 keV range. Constrain models that explain the relative contribution of cosmic X-Ray sources
	to the CXRB.
Mission objectives	Produce data that will lend insight into the underlyng physics of the Diffuse X-Ray Background.
	Provide flight heritage for CXT-based X-Ray gamma-ray detectors and CubeSat technologies.
Experiment description	-
Lifetime or status in orbit	Operational
Partners	Lawrence Livermore National Laboratory, Noqsi Aerospace
Website	-
Additional comments	-
Additional sources	https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/cxbn



This mission of firsts will serve as a pathfinder for new radiation-tolerant technologies that could help scientists realize a long-sought dream: deploying a constellation of small satellites beyond low-Earth orbit to gather simultaneous, multi-point measurements of Earth's ever-changing magnetosphere, which protects the planet from the constant assault of charged particles streaming off the Sun.

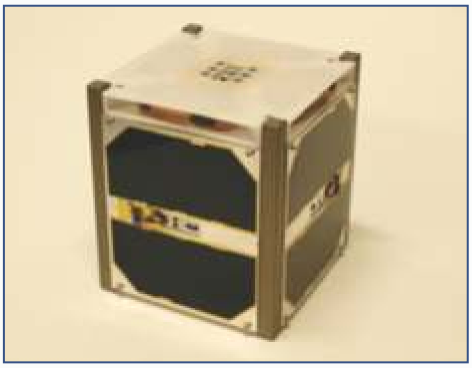
Furthermore, it will be the first CubeSat to operate in geostationary transfer orbit, or GTO — from which it derives its name — and the first to use the latest, more robust version of the NASA-developed Dellingr spacecraft bus — the Dellingr-X.

References :

https://www.nasa.gov/feature/goddard/2018/nasa-s-new-dellingr-spacecraft-baselined-for-pathfinding-cubesat-mission-to-van-allen-belts

AAUSAT 3

Mission Name	AAUSAT 3
Organisation	Aalborg University
Organisation type	University
Nation	Denamrk
Type (U or mass)	1U
Satellite launch year	2013 – 02 -25
Rocket	PLSV
Orbit	780 km, 98.5 deg, SSO
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	The AAUSAT3 mission is to test two AIS receivers developed by students. Proof of concept of our very strict modular design with no central OBC/CDH managing the satellite.
Experiment description	-
Lifetime or status in orbit	Operational
Partners	-
Website	https://directory.eoportal.org/web/eoportal/satellite-missions/a/aausat3
Additional comments	-
Additional sources	-



AAUSat3 is the third student-developed 1U CubeSat in the Department of Electronic Systems of Aalborg University (AAU), Aalborg, Denmark. The satellite is the successor to AAUSat-2 which was launched in April 2008 and is still operational to some extent in 2011.

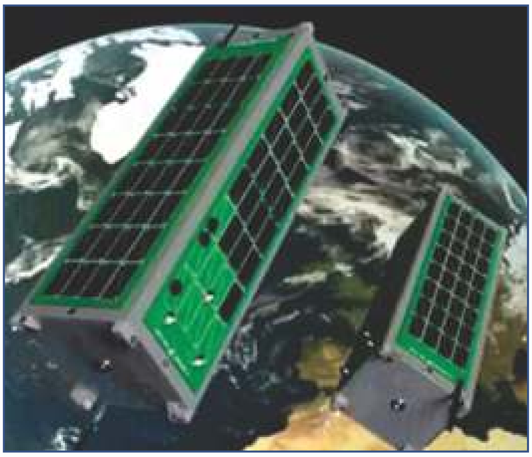
The AAUSat3 educational project was initiated in the fall of 2007 - introducing students to all aspects of satellite design and development. The objective of the AAUSat3 mission is to fly two different types of AIS (Automated Identifications System) receivers. One of the AIS receivers onboard AAUSat3 is an SDR (Software Defined Radio) based AIS receiver. The other one is a conventional hardware AIS receiver. The goal is to investigate the quality of ship monitoring from space.

References :

https://www.nasa.gov/feature/goddard/2018/nasa-s-new-dellingr-spacecraft-baselined-for-pathfinding-cubesat-mission-to-van-allen-belts.

STRaND 3

Mission Name	STRaND 3
Organisation	Surrey Satellite Technology
Organisation type	Company
Nation	UK
Type (U or mass)	3U
Satellite launch year	2013 – 02 -25
Rocket	PLSV
Orbit	780 km, 98.5 deg, SSO
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Technology path finding for future commercial operations. Modern Commercial Off The Shelf (COTS) Android smartphone as a payload.
Experiment description	BPS (Butane Propulsion Subsystem), PPT (Pulsed plasma Thruster).
Lifetime or status in orbit	Operational
Partners	University of Surrey Space Centre
Website	https://directory.eoportal.org/web/eoportal/satellite-missions/a/aausat3
Additional comments	First Smartphone in space.
Additional sources	https://www.sstl.co.uk/space-portfolio



Space innovators at the University of Surrey and SSTL are developing STRaND 3(Surrey Training Research and Nanosatellite Demonstrator 3), a twin-satellite mission to test a novel in-orbit docking system based on the XBOX Kinect technology.

Similar in design to STRAND 2, the identical twin satellites will each measure 30 cm (3-unit Cubesat) in length, and will utilise components from the XBOX Kinect games controller to scan the local area and provide the satellites with spatial awareness on all three axes - thus allowing them to dock. It works on ANDROIND based hardware.

References :

http://epubs.surrey.ac.uk/26828/2/STRaND-1%20IAC%20Paper.pdf

$50Sat (Eagle-2)

Mission Name	$50Sat (Eagle-2)
Organisation	Amateur Group
Organisation type	Amateur Mission
Nation	US
Type (U or mass)	1.5p
Satellite launch year	2013-11-21, 07:11
Rocket	Dnepr
Orbit	670 km, 97.79 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	T-LogoQube is measuring the Earth's magnetic field in order to determine the satellite's pointing direction
Mission objectives	-
Experiment description	Was operational until?
Lifetime or status in orbit	Was operational until 2015-03-15
Partners	Morehead State University
Website	http://universe.sonoma.edu/T-LogoQube/
Additional comments	Had CZT array payload but did not fly in the end. Deployed from UniSat-5.
Additional sources	http://space.skyrocket.de/doc_sdat/ksat.htm



QubeScout S1

Mission Name	QubeScout S1
Nation:	USA
Type / Application:	Technology
Operator:	University of Maryland, Baltimore County (UMBC)
Contractors:	University of Maryland, Baltimore County (UMBC)
Equipment:	Satellite
Satellite	QubeScout S1
COSPAR	2013-066AD
Date	21.11.2013
LS	Do LC-370/13
Launch Vehicle	Dnepr
Configuration:	2.5U PocketQube
Propulsion:	None
Power:	Solar cells, batteries
Lifetime:	
Mass:	0.4 kg
Orbit:	590 km × 639 km, 97.80°
Remarks	with DubaiSat 2, STSAT 3, WNISAT 1, SkySat 1, BRITE-PL, AprizeSat 7, AprizeSat 8, UniSat
	5, Delfi-n3Xt, Dove 3, Dove 4, Triton 1, CINEMA 2, CINEMA 3, OPTOS, CubeBug 2,
	GOMX 1, NEE 02 Krysaor, FUNcube 1, HiNCube, ZACUBE 1, ICube 1, HumSat-D, PUCP-
	SAT 1, First-MOVE, UWE 3, VELOX P2, Pocket-PUCP, BeakerSat 1, Wren, $50SAT, BPA 3

QubeScout S1 is a FemtoSat built to the 2.5U PocketQub form factor (12.5 cm × 5 cm × 5 cm) designed and built by the University of Maryland, Baltimore County (UMBC).

It will Flight test fine sunsensor developed in UMBC LACO lab and determine the dynamic attitude of the QubeScout platform and will monitor the change in rotation of QubeScout as a function of changing moment of inertia during solar panel/ de-orbiter.

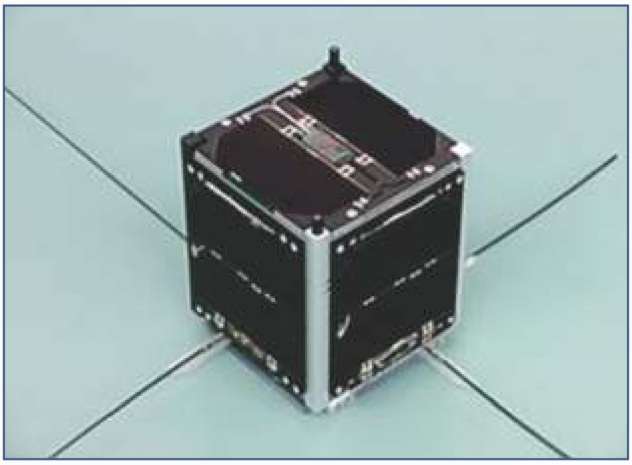
The satellite will be deployed from the Italian UniSat 5 satellite from a MR-FOD (Morehead Roma Femtosat Orbital Deployer) deployer after launch on a Dnepr booster.

References :

https://space.skyrocket.de/doc_sdat/qubescout-s1.htm

FUNcube-1 (AO-73)

Mission Name	FUNcube-1 (AO-73)
Mission type	Amateur Radio
Operator	AMSAT-UK
COSPAR ID	2013-066AE
SATCAT no.	39444
Website	funcube.org.uk
Mission duration	4 years, 10 months and 6 days elapsed
Spacecraft properties	
Bus	1U CubeSat[1]
Manufacturer	ISIS-BV, AMSAT-NL, AMSAT-UK
Launch mass	0.98 kilograms (2.2 lb)
Power	2.2 watts
Start of mission	
Launch date	21 November 2013
Rocket	Dnepr
Launch site	Yasny Launch Base
Contractor	ISL
Orbital parameters	
Reference system	Geocentric
Regime	Low Earth
Perigee	592.6 kilometers (368 Mi)
Apogee	678.6 kilometers (421 Mi)
Inclination	97.7 Degrees
Period	97.3 Minutes



FUNcube-1 is a complete educational single unit CubeSat satellite with the goal of enthusing and educating young people about radio, space, physics and electronics. It is part of a program which aims to launch more of these educational CubeSats. It is the first satellite with outreach as its primary mission.

Project

The FUNcube project was started in the UK by AMSAT-UK. The satellite has been developed by a team of volunteers from AMSAT-UK and AMSAT-NL, and was assembled at ISIS in Delft. It has been designated with OSCAR number 73 by AMSAT and is now also known as AO-73.

Mission

As part of its mission, FUNcube-1 carries a materials science experiment, from which the school students can receive telemetry data and which they can compare to the results they obtained from similar reference experiments in the classroom. This experiment resembles the Leslie's Cube experiment. One of the first schools to use FUNcube-1 in the classroom was Abbeys Primary School in Bletchley which also featured in the BBC breakfast news two days after launch.

Satellite

Instruments

FUNcube-1 is equipped with a UHF to VHF linear transponder with approx 300 mW PEP output and which can be used by Radio Amateurs worldwide for SSB and CW communications during the weekends.

Specifications

Frequencies:

Telemetry down link 145.935 MHz 1200bd BPSK with FEC

Transponder Uplink 435.150 - 435.130 MHz LSB (Inverting)

Downlink 145.950 - 145.970 MHz USB

Maximum uplink power of 5 watts to a 7 dBi gain antenna, more power is not needed to use the transponder. Transponder is SSB/CW Inverting.

Launch

FUNcube-1 was launched at 07:10:11 UTC on 21 November 2013, as part of the ISILaunch03 campaign, aboard a Dnepr rocket, from Yasny Launch Base, Russia. The launch was contracted by ISL, and operated by ISC Kosmotras.

Distribution

The FUNcube distributed ground station network (DGSN) is used in which radio amateurs receive packets and send these via the internet to the central data collection server, called the data warehouse Data decoding is possible with the free dashboard software provided by the FUNcube team.

To enable easy reception, one of the FUNcube team members, Howard Long G6LVB, has created a USB connected receiver called the FUNcube Dongle

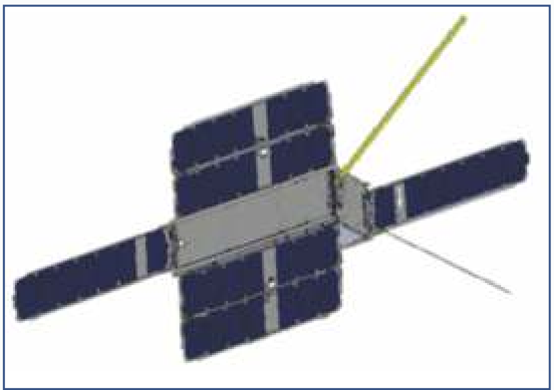
References:

https://amsat-uk.org/tag/ozqube-1/

FUNcube Website

Ukube 1 (FUNcube 2)

Mission Name	UKube 1 (FUNcube 2)
Nation:	UK
Type / Application:	Technology
Operator:	UK Space Agency
Contractors:	ClydeSpace
Equipment:	
Configuration:	CubeSat (3U)
Propulsion:	None
Power:	Solar cells, batteries
Lifetime:	
Mass:	3 kg
Orbit:	
Satellite	UKube 1 (FUNcube 2)
COSPAR	2014-037F
Date	08.07.2014
LS	Ba LC-31/6
Launch Vehicle	Soyuz-2-1b Fregat-M
Remarks	with Meteor-M 2, Relek, TechDemoSat 1, SkySat 2, DX 1, AISSat 2, M3MSat-Dummy



UKube 1 is a 3U CubeSat nanosat to test new technologies in space.

The UK Space Agency's pilot programme to design and launch a CubeSat - a miniature cube-shaped satellite that will allow the UK to test cutting-edge new technologies in space - is now well underway. In December 2010 the payload competition for the pilot mission, UKube-1, stimulated more than 20 high quality proposals from UK industry and academia, and from these the Space Agency selected 7 excellent proposals for further development. In March 2011 four payloads were finally selected to fly on UKube-1. These will be integrated onto the spacecraft, which measures just 10 cm × 10 cm × 34 cm, by Clyde Space. In addition UKube-1 will fly FunCube-2, an educational payload provided by AMSAT-UK, with the goal of enthusing and education young people about space, electronics, physics and radio. The FUNcube-2 payload is similar to the dedicated FUNcube 1 satellite.

The winning payloads from the UK Space Agency's payload competition include the first GPS device aimed at measuring plasmaspheric space weather; a camera that will take images of the Earth and test the effect of radiation on space hardware, using a new generation of imaging sensor; an experiment to demonstrate the feasibility of using cosmic radiation to improve the security of communications satellites and to flight test lower cost electronic systems; and a payload made up of 5 experiments that UK students and the public can interact with.

UKube-1 is the pathfinder mission for a national cubesat programme of one mission a year.

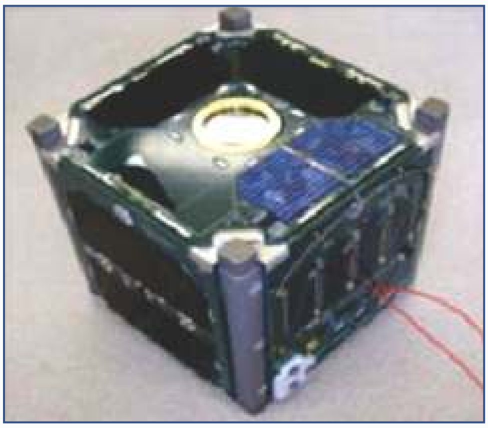
It is envisaged that the national CubeSat programme will not only increase the UK's ability to market new space technologies; it will also provide hands-on, real-time training and research opportunities for the next generation of space engineers and scientists, at relatively low-cost and within a short timescale.

UKube-1 is collaboration between the UK Space Agency, industry and academia. The funding partners for UKube-1 are the UK Space Agency, the Technology Strategy Board and STFC. The spacecraft is being developed through a Knowledge Transfer Partnership with innovative Scottish company Clyde Space and the University of Strathclyde, supported with internal funding from Clyde Space. The UK's largest space company, EADS Astrium Ltd, is providing engineering and programme management support to the Agency for the pilot programme. UK industry and academia are providing the payloads and the ground support operations.

References:
https://space.skyrocket.de/doc_sdat/ukube-1.htm

QB50P1 (EO 79, European-OSCAR 79, FUNcube 3)

Mission Name	QB50P1 (EO 79, European-OSCAR 79, FUNcube 3)
Nation:	Belgium
Type / Application:	Technology, thermospheric research
Operator:	von Karman Institute
Contractors:	ISIS
Equipment:	INMS, Thermocouple experiment, AMSAT-NL 435/145 MHz linear transponder
Configuration:	CubeSat (2U)
Propulsion:	None
Power:	Solar cells, batteries
Lifetime:	
Mass:	2 kg
Orbit:	604 km × 621 km, 97.98°
Satellite	QB50P1 (EO 79, European-OSCAR 79, FUNcube 3)
COSPAR	2014-033R
Date	19.06.2014
LS	Do LC-370/13
Launch Vehicle	Dnepr
Remarks	with Deimos 2, KazEOSat 2, Saudisat 4, TabletSat-Aurora, BugSat 1, AprizeSat 9, AprizeSat 10, UniSat 6, BRITE-CA 1, BRITE-CA 2, Hodoyoshi 3, Hodoyoshi 4, Perseus-M 1, Perseus-M 2, Flock-1c 1, ..., 11, POPSAT-HIP 1, QB50P2, PACE, TigriSat, ANTELSAT, Lemur 1, NanoSatC-Br 1, Duchifat 1, PolyITAN 1, DTUSat 2, AeroCube 6A, AeroCube 6B



QB50P1 is one of two precursor satellites for the QB50 project, which demonstrates the possibility of launching a network of 50 CubeSats built by Universities Teams all over the world as a primary payload on a low-cost launch vehicle to perform first-class science in the largely unexplored lower thermosphere.

QB50P1 is a 2U-CubeSat built on a structure delivered by ISIS to test the Set 1 (INMS) payload.

The following payloads were integrated into the ISIS satellite platforms:

- INMS Payload from MSSL, UK
- QB50 ADCS system from SSC, UK
- Thermocouple experiment from VKI, Belgium
- AMSAT-NL 435/145 MHz linear transponder (FUNcube-3) from AMSAT-NL, The Netherlands

After reaching orbit, the satellite received the additional radio amateur name EO 79 (European OSCAR 79).

References:

QB50: The QB50 Precursor Flight
AMSAT-UK: Two QB50 satellites with ham radio payloads delivered, 4 May 2014
https://space.skyrocket.de/doc_sdat/qb50p1.htm

Further QB50 missions:

Set 1 (INMS)
QB50 P1 (QB50P1)
QB50 AU01 (SUSat)
QB50 AU02 (UNSW-EC0)
QB50 AZ01 (ZA-AeroSat)
QB50 CN01 (BUSAT 1)
QB50 CN02 (LilacSat 1)
QB50 CN04 (Aoxiang 1)
QB50 CN06 (NUDTSat)
QB50 ES01 (QBITO)
QB50 GB03 (UCLSat)
QB50 KR01 (LINK)
QB50 TW01 (Phoenix)
QB50 US01 (QBUS 1, Challenger)
Qb50 US03 (QBUS 3, Discovery)

Set 2 (FIPEX)
QB50 P2 (QB50P2)
QB50 AZ02 (nSIGHT 1)
QB50 BR01 (14-BISat)
QB50 CN03 (NJUST 1)
QB50 CZ02 (VZLUsat 1)
QB50 DE02 (SOMP 2)
QB50 FR01 (X-CubeSat)
QB50 FR03 (IP2SAT)
QB50 FR05 (SpaceCube)
QB50 IN01 (ANUSAT 2)
QB50 KR02 (SNUSAT 1)
QB50 KR03 (SNUSAT 1b)
QB50 LT01 (LituanicaSAT 2)
QB50 PT01 (GAMASAT 1)
QB50 RU01 (SamSat-QB50)
QB50 SE01 (qbee50-LTU-OC)
QB50 UA01 (PolyITAN-2-SAU)
QB50 US02 (QBUS 2, Atlantis)
Qb50 US04 (QBUS 4, Columbia)

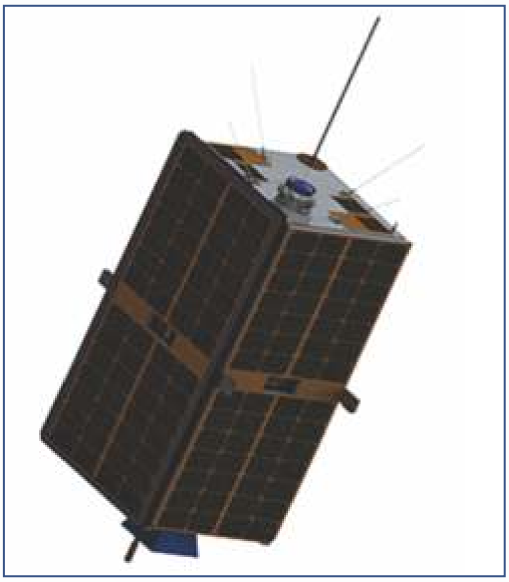
Set 3 (mNLP)
QB50 AT03 (Pegasus)
QB50 AU03 (i-INSPIRE 2)
QB50 CA03 (Ex-Alta 1)
QB50 FI01 (Aalto 2)
QB50 GR01 (DUTHSat)
QB50 GR02 (UPSat)
QB50 IL01 (Hoopoe, Duchifat 2)
QB50 IT02 (URSA MAIOR)
QB50 RO01 (RoBiSAT 1)
QB50 RO02 (RoBiSAT 2)
QB50 TR01 (BeEagleSat)
QB50 TR02 (HAVELSAT)

IOD
QB50 BE05 (QARMAN)
QB50 DE04 (DragSail-CubeSat)
QB50 GB06 (InflateSail)

Further FUNcube missions:
FUNcube 1
FUNcube 2 (UKube 1)
FUNcube 3 (QB50P1)
FUNcube 4 (ESEO)
FUNcube 5 (Nayif 1)

ESEO (FUNcube 4)

Mission Name	ESEO (FUNcube 4)
Nation:	Europe
Type / Application:	Technology
Operator:	ESA
Contractors:	ALMASpace, SITAEL (bus)
Equipment:	
Configuration:	SITAEL S-50 bus
Propulsion:	
Power:	Solar cells, batteries
Lifetime:	6 months
Mass:	44 kg
Orbit:	
Satellite	ESEO (FUNcube 4)
COSPAR	
Date	2018
LS	Va SLC-4E
Launch Vehicle	Falcon-9 v1.2
Remarks	with SkySat 14, 15, Eu:CROPIS, STPSat 5, FalconSat 6, NEXTSat 1, KazSTSAT, eXCITe, SeeMe, ICEYE X2, BlackSky Global 2, Hawk 1, 2, 3, Capella 1, AISTECHSAT 2, CSIM-FD, Hiber 2, ITASAT 1, Landmapper-BC 4 v2, ROSE 1, ORS 7A, 7B, Al-Farabi 2, Astrocast 0.1, Audacy 0, BRIO, Centauri 2, Eaglet 1, Flock-3s 1, 2, 3, ICE-Cap, K2SAT, MinXSS 2, Orbital Reflector, RAAF M1, SeaHawk 1, SNUSAT 2, THEA, VESTA, ZACUBE 2, PW-Sat 2, SNUGLITE, VisionCube, RANGE A, B, Elysium-Star 2, Fox 1C, Hamilton 1, Irvine 02, JY1-Sat, KNACKSAT, MOVE 2, SpaceBEE 9, 10, 11, Suomi-100, WeissSat 1, BeeSat 5, 6, 7, 8, BlackHawk, Exseed, KazSciSat, ORS 1, SIRION Pathfinder 2, (US Gov), (US Gov), (US Gov), (US Gov), (US Gov)



The ESEO (European Student Earth Orbiter) is a micro-satellite mission to Low Earth Orbit developed, integrated, and tested by European university students as part of the ESA Education Office projects.

ESEO is the third mission within ESA's Education Satellite Programme and builds upon the experience gained with SSETI Express (launched in 2005) and the YES2 tether and re-entry capsule experiment. The satellite's mission is taking pictures of the Earth from orbit, measuring radiation levels and testing technologies for future education satellite missions. The educational component is aimed at providing students with valuable and challenging hands-on space project experience in order to contribute to prepare a well qualified space engineering workforce for the future.

ALMASpace, Italy, is the industrial System Prime Contractor and is managing the ESEO project. In coordination with the ESA Education Office they provide system-level and specialist technical support to the student teams during the development and execution of the project. The spacecraft subsystems, payload and ground support systems are provided by student teams as part of their academic studies.

The mission objectives are:

- To take pictures of the Earth and/or other celestial bodies for educational outreach purposes.
- To provide measurements of radiation levels in Low Earth Orbit.
- To gain experience with technologies for possible future ESA education missions
- To involve the amateur radio community in the downlink of telemetry and payload data from the satellite to enable them to contribute to the mission and to provide a UHF/S-Band linear transponder for amateur radio use until the end of the mission

Instruments on board of ESEO are:

- a microcamera developed by DTU Space, Denmark.
- Dedicated sensors (a Langmuir probe and a TriTel three axis dosimeter to measure the absorbed radiation dose, the dose equivalent and the LET spectra of the cosmic radiation), developed by University of Budapest, Hungary.
- ESEO serves as a test bed for a student built S-band communication system by the Wroclaw University of Technology, a GPS receiver for orbit determination developed by the University of Bologna, an AODCS software experiment coordinated by Delft University and a de-orbiting payload built by Cranfield University.
- AMSAT-UK provides an amateur radio payload called FUNcube 4 consisting of a 1260/145 MHz FM transponder and a 145 MHz BPSK telemetry beacon.

ESEO has a mass of 40 kg and measures 33 × 33 × 63 cm. It is powered by body mkounted solar cells.

After entering Low Earth orbit, the ESEO satellite's mission has a planned minimal life time of six months, with the possibility of an extended mission afterwards. It will use a Sun Synchronous, meaning that it will always cross the equator at about the same local time every orbit, and its maximum altitude will be no higher than 600 km. After concluding its mission, ESEO will deploy a drag sail being supplied by Cranfield University, UK, similar to the one tested in TechDemoSat 1. This will inrease the drag to ensure that ESEO re-enters and burns up in Earth atmosphere faster.

ESEO is a candidate to launch on one of the VERTA test flights of the Vega launch vehicle. The satellite is to be launched into Low Earth Orbit (LEO) in 2015–16.

References :

https://space.skyrocket.de/doc_sdat/eseo.htm

ESA: ESEO mission

Nayif 1 (FUNcube 5, EO 88, OSCAR 88)

Mission Name	Nayif 1 (FUNcube 5, EO 88, OSCAR 88)
Nation:	United Arab Emirates
Type / Application:	Technology, education
Operator:	EIAST, American University of Sharjah (AUS)
Contractors:	EIAST, American University of Sharjah (AUS)
Equipment:	
Configuration:	CubeSat (1U)
Propulsion:	None
Power:	Solar cells, batteries
Lifetime:	
Mass:	1 kg
Orbit:	496 km × 507 km, 97.51°
Satellite	Nayif 1 (FUNcube 5, EO 88, OSCAR 88)
COSPAR	2017-008BX
Date	15.02.2017
LS	Sr FLP
Launch Vehicle	PSLV-XL
Remarks	with Cartosat 2D, INS 1A, INS 1B, Flock-3p 1, ..., 88, Lemur-2 22, ..., 29, BGUSat, DIDO 2, PEASSS, Al-Farabi 1

Nayif 1 is the UAE's first 1U CubeSat mission, developed by the Dubai based Emirates Institution for Advanced Science and Technology (EIAST), in partnership with American University of Sharjah (AUS).

The development program aims at investing and developing capabilities of Emirati engineering students in space technologies. A group of Emiratis consisting of seven students from various engineering disciplines at AUS, including computer engineering, electrical engineering and mechanical engineering, have been assigned to the project. Students will go through an intense systems design and testing training and will partake in the program as their Senior Engineering Design project and participate in the design, assembly, integration and testing of the CubeSat. Nayif-1 will carry out a communication mission with development taking place in AUS, EIAST's facilities and Delft in the Netherlands.

Nayif 1 carries the FUNcube 5 amateur communications payload.

Nayif-1 was originally scheduled to be launched piggy-back on board a Falcon-9 v1.2 rocket by the end of 2015. Due to delays, it was moved to a PSLV-XL launch. A ground station will be built at AUS and operated by Emirati engineering students, responsible for mission planning and operations.

After reaching orbit, Nayif 1 received the designation Emirates OSCAR 88 (EO 88).

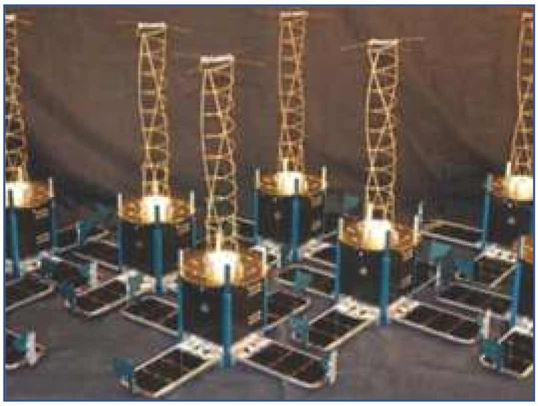
References:

SatellitePro: 'EIAST launches UAEs first CubeSat Mission, Nayif-1, 4 November 2014

https://space.skyrocket.de/doc_sdat/nayif-1.htm

Prometheus 1-1 to 1-6

Mission Name	Prometheus 1-1 to 1-6
Organisation	Los Alamos National Laboratory
Organisation Type	Military
Nation	US
Type (U or mass)	1.5U
Satellite Launch Year	20-11-2013
Rocket	Minotaur-1
Orbit	500 km, 40.5 deg
Mission Type	Space Technology
Mission type description/ Configuration/Power	
Mission objectives	Dual objective of evaluating new low-cost development and operations methodologies while also assessing the operational utility that can be provided with CubeSat technology.
Experiment description	-
Lifetime or status in orbit	Reentry 2015-12-12. Was operational.
Partners	US Department of Defense
Website	-
Additional comments	-
Additional sources	http://www.carahsoft.com/dco/documents/MITMagazineVol18Is5_MarkMills-DCOIndustryInterview.pdf, http://www.thespacereview.com/article/2491/2



Prometheus is series of 1.5U CubeSats for technology development and demonstration. It was developed by the Los Alamos National Laboratory (LANL) with the dual objective of evaluating new low-cost development and operations methodologies while also assessing the operational utility that can be provided with CubeSat technology. It was DoD funded.The Prometheus system consists of CubeSats along with supporting ground and field segment equipment, all designed as an integrated system. LANL is serving as the primary builder and system integrator and will perform on-orbit system checkout, test, and evaluation. The satellites were based on the earlier Perseus satellites. The Prometheus satellites cost less than $100,000 each, are expected to have a service life of three to five years and are demonstrating the capability to transfer audio, video, and data files from man-portable, low-profile, remotely located field units to deployable ground stations terminals using over-the-horizon satellite communications. Each satellite features four deployable solar arrays and a deployable helix antenna.The eight satellites were launched on a Minotaur-1 booster on the ORS 3 mission. Reportedly, all were performing normally.Ten more improved Prometheus Block 2 satellites were launched in 2016 to 2018 as a piggy-back payloads on several missions.

References:

Nanosatellite Database by Erik | www.nanosats.eu

https://space.skyrocket.de

UniSat 7

Mission Name	UniSat 7
Nation:	Italy
Type / Application:	Technology
Operator:	GAUSS Srl
Contractors:	GAUSS Srl
Equipment:	
Configuration:	Octagonal prism
Propulsion:	None
Power:	Solar cells, batteries
Lifetime:	2 years
Mass:	32 kg
Orbit:	SSO
Satellite	UniSat 7
COSPAR	
Date	2019
L S	Ba / Vo
Launch Vehicle	Soyuz-2-1a Fregat-M or Soyuz-2-1b Fregat-M
Remarks	with Arduiqube, FEES, Unicorn 1, ?

UniSat 7 is a technology satellite built at GAUSS Srl. It is intended to test customer equipment under space conditions and to deploy Cubesats and PocketQubes in orbit.

The UniSat-7 features a new octagonal prism satellite platform built from reinforced aluminum and carbon honeycomb panels. It is 3-axis stbilited. Power is provided by body-mounted solar panels.

A wide angle camera is on board to acquire imagery of the deployment sequence and a nadir facing camera to image the earth.

The satellite features four 3U CubeSat deployers and four deployers for PocketQubes (among them Arduiqube).

Launch was planned for the second half of 2016 on a Dnepr rocket as part of a multi-satellite mission. As the availability of Dnepr had become doubtful, the satellite was delayed to 2019 or 2020 to be launched on a Soyuz-2-1a Fregat-M or Soyuz-2-1b Fregat-Mrocket.

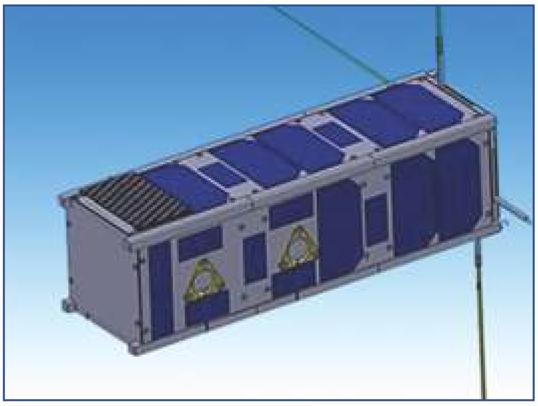
References:

https://www.gaussteam.com/satellites/gauss-latest-satellites/unisat-7/

Arduiqube	1P	DIYSATELLITE	Technology Demonstrator	Q4 2019	Soyuz	GAUSS	Team Interview	www.diysatellite.com/arduiqube.html
SMOG-1	1p	Budapest University of Technology and Economics, Hungary	Measurement of the radio spectrum in the UHF TV band	Q4 2019	Soyuz	GAUSS	In development	
ArduOrbiter-1	1p	Reid Technologies	TBC	TBC	TBC	N/A		https://www.reidtech.global/
Discovery 1a	1p	Beyond Earth	Camera / Photo Sat	TBC	TBC	Alba Orbital Cluster 2	In development	Company Website
Unicorn-1	2p	Alba Orbital	LEO > GEO Relay Demonstrator	Q4 2019	Soyuz	GAUSS	In development	Satellite Webpage
UoMBSat1	1p	University of Malta + University of Birmingham	Technology Demonstrator + Ionospheric Sounder	TBC	TBC	TBC	In development	ASTREA Website @ UoM SERENE Website @ UoB
Delfi-PQ	3p	Delft University of Technology	Technology Demonstrator	H2 2018	Vector-R	Alba OrbitalCluster 1	In development	Delfi Space
Unicorn-2a	3p	Alba Orbital	Technology Demonstrator	H2 2018	Vector-R	Alba OrbitalCluster 1	In development	Alba Orbital
ATL-1	2p	Advanced Technology of Laser	Test a new thermal isolation material in space	TBC	TBC	Alba Orbital Cluster 2	In development	ATL 1 Website
EASAT-2	2p	Amsat EA	Amateur Mission	TBC	TBC	TBC	In development	https://www.amsat-ea.org/easat-2/
Exploration I	1p	British Columbia Institute of Technology - Satellite Launch Program	test structural feasibility at 30,000 feet for new design	June 2018	University of British Columbia's Second Rocket (under production)	TBC	In development	
SATLLA	2p	Ariel University	Testing a laser communication link	TBC	TBC	TBC	In development	
APRS PocketQube	1p	National Chiao-Tung University	APRS PocketQube for Moving Objects Tracking	TBC	TBC	TBC	In development	
TRSI Sat	1p	Union Aerospace	Picking up ADS-B packets from aircraft	TBC	TBC	Alba Orbital Cluster 2	In Development	http://www.pocketqub.de/
Nepal-PQ1	1p	ORION Space	Education	TBC	TBC	TBC	In Development	http://www.myrepublica.com/news/21899/
SMOG-P	1p	BME	Spectrum Monitoring	TBC	TBC	Alba Orbital Cluster 2	In Development	
TBA	1p	Croatian Makers	STEM	TBC	TBC	Alba Orbital Cluster 2	In Development	http://croatianmakers.hr/hr/project/prvi-hrvatski-satelit/
UBO	1p	Satellite Applications Catapult	Outreach	TBC	TBC	TBC	In Development	http://buildubo.co.uk/build/
Myansat-1	1p	Independent	Outreach	TBC	TBC	TBC	In Development	http://myansat.com/

PEASSS

Mission Name	PEASSS (PiezoElectric Assisted Smart Satellite Structure)
Organisation	ISIS (Innovative Solutions in Space)
Organisation type	Company
Nation	Netherlands
Type (U or mass)	3U
Satellite launch year	2017-02-15
Rocket	PLSV
Orbit	500 km, 97.5 deg, SSO
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	EU FP7 project to develop, manufacture, test and qualify “smart structures” which combine composite panels, piezoelectric materials, and next generation sensors, for autonomously improved pointing accuracy and power generation in space.
Experiment description	Smart structures will enable fine angle control, thermal and vibration compensation, improving all types of future Earth observations, such as environmental and planetary mapping, border and regional imaging. Develop and test the following smart structures: piezo actuated “smart panels” for pointing of optical instruments/sensors; piezo actuated “smart panels” for power harvesting; fiber bragg gratings for composite structure strain and temperature measurement; next generation of power conditioners for future applications in space missions.
Lifetime or status in orbit	Operational
Partners	TNO, NSL Satellites, Active Space Technologies, Israel Institute of Technology, SONACA
Website	http://www.peasss.eu/
Additional comments	First Piezoelectric based satellite in space.
Additional sources	https://www.isispace.nl/news/isis-11-years-anniversary/



PEASSS is under development as part of a FP7 European Commission project involving Active Space Technologies GmbH (Germany), TNO and ISIS (Netherlands), SONACA (Belgium), Technion and NSL (Israel).

The main objective of the project is to develop, manufacture, test and qualify "smart structures" which combine composite panels, piezoelectric materials, and next generation sensors, for autonomously improved pointing accuracy and power generation in space. The system components include new nano satellite electronics, a piezo power generation system, a piezo actuated smart structure and a fiber-optic sensor and interrogator system.

The satellite was launched on a bulk Cubesat launch on an Indian PSLV-XL in February 2017.

References:

https://space.skyrocket.de/doc_sdat/peasss.htm

Space Cube

Mission Name	Space Cube
Organisation	Mines Paristech
Organisation type	University
Nation	France
Type (U or mass)	2U
Satellite launch year	2017-04-18
Rocket	Atlas V
Orbit	400 km, 51.6 deg, ISS
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	The purpose of this CubeSat includes: upper atmosphere science; radio communication experiments; technology demonstrator; education, training and outreach. It will also provide an Amateur FM transponder.
Experiment description	Qb50
Lifetime or status in orbit	Operational
Partners	Qb50
Website	
Additional comments	Deployed from ISS on 2017-05-18. QB50. Frequency application submitted.
Additional sources	http://www.amsatuk.me.uk/iaru/formal_detail.php?serialnum=332, https://janus.cnes.fr/fr/JANUS/Fr/spacecub.htm

SpaceCube is a 2U-CubeSat for technolgy development and upper atmosphere science. It is developed and built at Mines ParisTech.

The purpose of this CubeSat include upper atmosphere science for the QB50 project, radio communication experiments, technology demonstrator, education, training and outreach. It also provides an Amateur FM transponder.

It is a part of the QB50 constellation to gather science data in the upper layers of the troposphere in the altitude range from 350 km down to 200 km. The QB50 project, which demonstrates the possibility of launching a network of 50 CubeSats built by Universities Teams all over the world to perform first-class science in the largely unexplored lower thermosphere.

It carries the FIPEX (Flux-F -Probe Experiment) of TU Dresden as the primary payload for the QB50 project, which is able to distinguish and measure the time-resolved behaviour of atomic and molecular oxygen as a key parameter of the lower thermosphere.

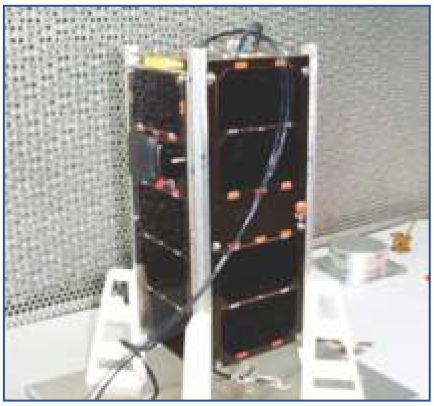
The satellite was launched with the bulk of the QB50 constellation to the ISS in 2017, from where the satellite was deployed on 18 May 2017. The in-orbit lifetime of SpaceCube is about 3 months, from deployment to de-orbit.

References:

https://space.skyrocket.de/doc_sdat/spacecube.htm

SuSat

Mission Name	SuSat
Organisation	University of Adelaide
Organisation type	University
Nation	Australia
Type (U or mass)	2U
Satellite launch year	2017-04-18
Rocket	Atlas V , Qb50
Orbit	400 km, 51.6 deg, ISS
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Purpose of this CubeSat include: upper atmosphere science; radio communication experiments; technology demonstrator; education, training and outreach.
Experiment description	Qb50
Lifetime or status in orbit	No Signal
Partners	Qb50
Website	http://www.amsatuk.me.uk/iaru/formal_detail.php?serialnum=325
Additional comments	QB50. Frequency coordinated.
Additional sources	-



SUSat (University of Adelaide Satellite) is a 2U-CubeSat for technolgy development and upper atmosphere science. It is developed and built at the University of Adelaide.

The purpose of this CubeSat includes upper atmosphere science, radio communication experiments, technology demonstrator, education, training and outreach.

It is a part of the QB50 constellation to gather science data in the upper layers of the troposphere in the altitude range from 350 km down to 200 km. The QB50 project, which demonstrates the possibility of launching a network of 50 CubeSats built by Universities Teams all over the world to perform first-class science in the largely unexplored lower thermosphere.

It carries a Science Unit (SU) named INMS (Ion/Neutral Mass Spectrometer) for sampling of low mass ionized and neutral particles in lower thermosphere, such as O, O2, and N2.

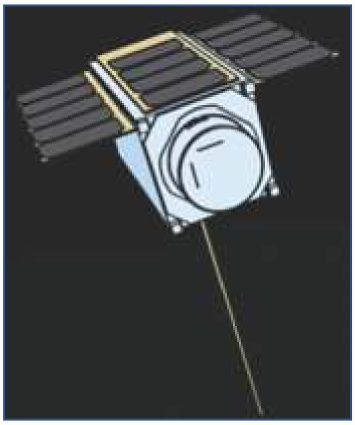
The satellite was launched with the bulk of the QB50 constellation to the ISS in 2017, from where the satellite was deployed on 25 May 2017, but does not appear to work.. The in-orbit lifetime of SUSat is about 3 months, from deployment to de-orbit.

References:

https://space.skyrocket.de/doc_sdat/susat.htm

Challenger (QBUS 1)

Mission Name	Challenger (QBUS 1)
Organisation	University of Colorado Boulder
Organisation type	University
Nation	US
Type (U or mass)	2U
Satellite launch year	2017-04-18
Rocket	Atlas V, Qb50
Orbit	400 km, 51.6 deg, ISS
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Carries the Ion/Neutral Mass Spectrometer (INMS), which measures the mass of ions and neutral atoms. QB50.
Experiment description	Qb50
Lifetime or status in orbit	Operational (Last report on 2018-07-25)
Partners	Qb50
Website	https://www.qb50.eu/index.php/community
Additional comments	Deployed from ISS on 2017-05-25/26.
Additional sources	-



QBUS 1 or Challenger is an US 2U-CubeSat designed by the University of Colorado Boulder participating in the QB50 project.

The QB50 project, which demonstrates the possibility of launching a network of 50 CubeSats built by Universities Teams all over the world to perform first-class science in the largely unexplored lower thermosphere.

QBUS is a consortium comprised of Stanford University, Johns Hopkins Applied Physics Laboratory, the University of Colorado at Boulder, the University of Michigan and the Universidad del Turabo Puerto Rico, who participate on th QB50 project. The QBUS team employed four double CubeSats (one from each university with system engineering and project management oversight provided by JHUAPL and USU-SDL), with participating members providing the usual satellite functions (attitude determination and control, uplink and downlink telecommunications, power subsystem including a battery and body-mounted solar cells, on-board data handling and storage by a CPU) as defined by the QB50 Call for Proposals, and the QB50 project providing the standardized sensors for lower thermosphere and re-entry research.

As a payload for QB50, the satellite carries the Ion/Neutral Mass Spectrometer (INMS), which measures the mass of ions and neutral atoms.

The satellite was launched with the bulk of the QB50 constellation to the ISS in 2017, from where the satellite was deployed on 25 May 2017.

References:

https://space.skyrocket.de/doc_sdat/qbus-1.htm

UCLSat

Mission Name	UCLSat
Organisation	University College London
Organisation type	University
Nation	UK
Type (U or mass)	2U
Satellite launch year	2017-06-23
Rocket	PSLV, Qb50
Orbit	500 km, 97.5 deg, SSO
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Demonstration of in-house technology development and will carry two payloads to monitor the space environment
Experiment description	The first, Ion and Neutral Mass Spectrometer (INMS) is a common instrument across a number of the QB50 satellites. The second contains a suite of sensors to analyse the energetic particle and magnetic field environment.
Lifetime or status in orbit	Operational (Last report on 2017-08-13)
Partners	Qb50
Website	https://www.qb50.eu/index.php/community
Additional comments	Deployed from ISS on 2017-05-25/26.
Additional sources	-

UCLSat (University College London Satellite) is a 2U-CubeSat for technolgy development and upper atmosphere science. It is developed and built at the MSSL, University College London.

UCLSat provides demonstration of in-house technology development and carries two payloads to monitor the space environment. The first, Ion and Neutral Mass Spectrometer (INMS) is a common instrument across a number of the QB50 satellites. The second contains a suite of sensors to analyse the energetic particle and magnetic field environment. Data from these instruments was to be transmitted to the ground.

It is a part of the QB50 constellation to gather science data in the upper layers of the troposphere in the altitude range from 350 km down to 200 km. The QB50 project, which demonstrates the possibility of launching a network of 50 CubeSats built by Universities Teams all over the world to perform first-class science in the largely unexplored lower thermosphere.

It carries a Science Unit (SU) named INMS (Ion/Neutral Mass Spectrometer) for sampling of low mass ionized and neutral particles in lower thermosphere, such as O, O2, and N2.

The satellite is one of six QB50 science satellites, which were to be launched on a Dneprrocket on the QB50-DS flight. As the availability of Dnepr has become doubtful, they were transfered to an Indian PSLV-XL launch. The satellite was deployed in orbit, but does not appear to work.

References:

https://space.skyrocket.de/doc_sdat/uclsat.htm

Venta -1

Mission Name	Venta -1
Organisation	University of Applited Sciences Bremen, OHB systems
Organisation type	University
Nation	Latvia
Type (U or mass)	7.5kg
Satellite launch year	2017-06-23
Rocket	PSLV.
Orbit	500 km, 97.5 deg, SSO
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Provide a flying testbed as a counterpart of the new satellite technology laboratory at the Ventspils University College. Advanced technology AIS (maritime Automatic Identification System) receivers in order to get AIS data from space and to study the AIS signal reception in LEO. Intersatellite link experimental systems for the two way, near real time, permanent communication via Orbcomm and Iridium LEO based satellite systems. Plug-and-Play electronics unit with new data handling systems, sensors and beacon to a geostationary satellite system. Small onboard camera with advanced optics for low resolution earth monitoring.
Experiment description	-
Lifetime or status in orbit	Operational (Last report on 2017-08-13)
Partners	Ventspils High Technology Park, Ventspils University College, University of Applied Sciences Bremen, University of Latvia and the Riga Technical University, OHB-System AG
Website	https://www.qb50.eu/index.php/community
Additional comments	Deployed from ISS on 2017-05-25/26.
Additional sources	-

Venta 1 is a nanosatellite with Automatic Identification System (AIS) receivers for supervising ship traffic in Europe. The satellite was built by the University of Applied Sciences, Bremen, Germany for Latvia under the contract with the University College Ventspils and VATP Latvia., and the signals aired by the satellite will be received at the Ventspils International Radio Astronomy Center.Venta-1 carries a LuxSpace 1st generation SATAIS receiver as the main payload. Additionally there is a small camera for low resolution earth monitoring.

The AIS data will be downloaded via a dedicated S-band frequency link. The satellite is attitude controlled via magnetic torquers around three axes and stabilized by a slow rotation around the sun generator axis pointing to the Sun.

Venta-1 was stacked for launch together with Max Valier Sat. Both payloads separated only in orbit after being deployed together by the PSLV launch vehicle.

On the surface of the satellite, a prototype femtosatellite (sprite) for Breakthrough Starshot is fixed. It is similar to the Sprites to be deployed from KickSat.

References:

https://space.skyrocket.de/doc_sdat/venta-1.htm

ROBUSTA -1B

Mission Name	ROBUSTA -1B
Organisation	University of Montpellier II
Organisation type	University
Nation	France
Type (U or mass)	1U
Satellite launch year	2017-06-23
Rocket	PSLV.
Orbit	500 km, 97.5 deg, SSO
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Measure the radiation induced degradation of electronic devices.
Experiment description	-
Lifetime or status in orbit	Operational (Last report on 2017-08-13)
Partners	CNES, Van Allen Foundation
Website	http://www.ies.univ-montp2.fr/robusta/satellite/spip.php?rubrique40&lang=en
Additional comments	Reflight of Robusta-1A.
Additional sources	https://janus.cnes.fr/en/JANUS/Fr/robusta-1b.htm

ROBUSTA (Radiation on Bipolar Test for University Satellite Application) is a Cubesat project of the University of Montpellier II. The mission of ROBUSTA is to check the deterioration in flight of electronic components based on bipolar transistors when exposed to space radiation environment. The results of this experiment will be used to validate a test method proposed in the laboratory.

Faint signals were heard after launch on the 13th of february. A few days after launch no more signals were recieved: after investigation an anomaly was detected on the system of battery recharge.

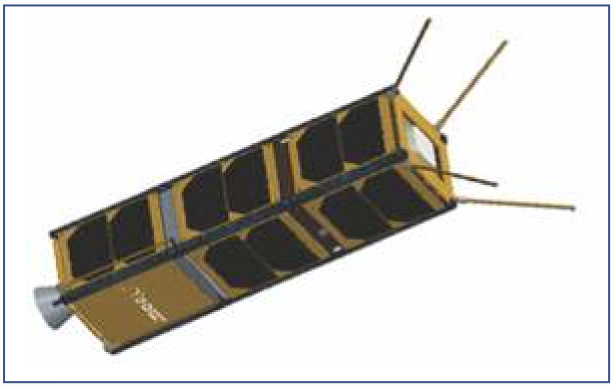
A reflight of the mission is planned as ROBUSTA 1B. ROBUSTA 1B is one of the educational CubeSats chosen for Phase 1 of ESA's 'Fly Your Satellite!' initiative.

References:

https://space.skyrocket.de/doc_sdat/robusta.htm

D-SAT (Deorbit Satellite)

Mission Name	D-SAT (Deorbit Satellite)
Organisation	D-Orbit
Organisation type	Company
Nation	Italy
Type (U or mass)	3U
Satellite launch year	2017-06-23
Rocket	PSLV.
Orbit	500 km, 97.5 deg, SSO
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Demonstrate in-orbit the capability of D-Orbit's technology. First satellite ever to be actively de-orbited in a quick, safe, reliable and controlled way.
Experiment description	Disaster Alert proof of concept payload. Will also demonstrate de-orbit capabilities.
Lifetime or status in orbit	Operational (Last report on 2017-10-17)
Partners	CNIT
Website	http://www.deorbitaldevices.com/site/our-mission/
Additional comments	-
Additional sources	http://www.amsatuk.me.uk/iaru/finished_detail.php?serialnum=399



The D-Sat(Deorbit Satellite) is a 3U CubeSatmission by Italian company D-Orbit to demonstrate active end-of-life reentry.

The satellite carries D-Orbit Decommissioning Device (D3), a device with three key characteristics. First of all, it needed to be compact and lightweight, easy to integrate it inside existing satellite platforms during design and manufacturing. Second, it had to be able to execute a quick and direct re-entry maneuver at the end of the satellite's mission. Finally, it had to be independent from the main spacecraft's systems, so it would work even in case of major malfunction of the hosting satellite. It is a smart propulsive system that can be scaled to easily fit any size spacecraft. Its compact solid rocket motor is designed to execute a single high-trust burn to quickly remove a spacecraft form orbit. Its independent control unit and communication system ensures that the system can be activated and controlled from the ground even if the spacecraft has ceased operations.

Besides the de-orbiting device, D-Sat carries three more experiments:

SatAlert, designed in collaboration with CNIT and the University of Florence, is an in-orbit validation of the Multiple Alert Message Encapsulation (MAMES) emergency protocol. D-Sat will collect MAMES emergency messages sent from a ground station, store them onboard, and re-broadcast them to national public safety entities upon receiving a trigger command. This experiment will validate a typical emergency scenario where civil defense agencies need a means to broadcast instructions in areas affected by natural disasters when the ground telecommunication infrastructures have been damaged

DeCas, developed in by Aviosonic, is an experiment to assess the dynamics of the debris footprint associated to the re-entry of a spacecraft. DeCas is a sort of small and lightweight "smart fragment" with the ability to determine its own position during re-entry phase. During the re-entry, DeCas activate itself and broadcast information about its location. In a real-world scenario, this information would be processed on the ground to determine the debris footprint, which would then be transmitted in real-time to airplanes flying over that zone and populated areas below. D-Sat will validate this approach by simulating the use of DeCas during the orbital phase, and performing an actual test during re-entry.

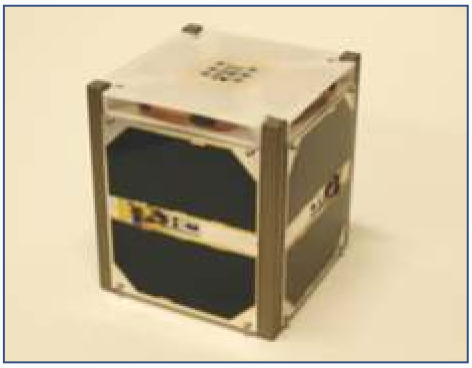
Atmosphere Analyzer is a data collection experiment aimed at collecting in-situ atmospheric data from the lower ionosphere during the re-entry maneuver. Before breaking up, D-Sat will cross the region between 80 km and 150 km. This is the least studied region of the atmosphere because it can't be reached by satellites or stratospheric balloons.

References:

https://space.skyrocket.de/doc_sdat/d-sat.htm

NUDTSat

Mission Name	NUDTSat
Organisation	National University of Defence Technolog
Organisation type	University
Nation	China
Type (U or mass)	2U
Satellite launch year	2017-06-23
Rocket	PSLV,QB50
Orbit	500 km, 97.5 deg, SSO
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	NMS (Ion/Neutral Mass Spectrometer) for sampling of low mass ionized and neutral particles in lower thermosphere, such as O, O2, and N2.
Experiment description	Qb50
Lifetime or status in orbit	Operational (Last report on 2017-05-xx)
Partners	Qb50
Website	http://www.deorbitaldevices.com/site/our-mission/
Additional comments	QB50. Frequency application submitted.
Additional sources	http://www.amsatuk.me.uk/iaru/formal_detail.php?serialnum=379



NUDTSat (National University of Defense Technology Satellite) is a 2U-CubeSat for technolgy development and upper atmosphere science. It is developed and built at the National University of Defense Technology (NUDT).

It is a part of the QB50 constellation to gather science data in the upper layers of the troposphere in the altitude range from 350 km down to 200 km. The QB50 project, which demonstrates the possibility of launching a network of 50 CubeSats built by Universities Teams all over the world to perform first-class science in the largely unexplored lower thermosphere.

It carries a Science Unit (SU) named INMS (Ion/Neutral Mass Spectrometer) for sampling of low mass ionized and neutral particles in lower thermosphere, such as O, O2, and N2.

The satellite is one of six QB50 science satellites, which were to be launched on a Dneprrocket on the QB50-DS flight. As the availability of Dnepr has become doubtful, they were transfered to an Indian PSLV-XL launch.

References :

https://space.skyrocket.de/doc_sdat/nudtsat.htm

UBAKUSAT

Mission Name	UBAKUSAT
Organisation	ITU (Istanbul Technical University)
Organisation type	University
Nation	Turkey
Type (U or mass)	3U
Satellite launch year	Deployed from ISS on 2018-05-11.
Rocket	Falcon 9, CRS-14
Orbit	400 km, 51.6 deg, ISS
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Provide voice communication between suitable locations from Low Earth Orbit for duration of about 10 minutes max.
Experiment description	Secondary payload namely TAMSAT Simplesat card will also send the telemetry data about the simplesat conditions and the relative radiation data absorbed by the card to the ground station
Lifetime or status in orbit	Operational (Last report on 2018-06-xx)
Partners	-
Website	http://space.skyrocket.de/doc_sdat/ubakusat.htm, http://www.amsatuk.me.uk/iaru/finished_detail.php?serialnum=526
Additional comments	-
Additional sources	-

UBAKUSAT is a joint Turkish and Japanese 3U-cubesat built by the Istanbul Technical University (ITÜ), Istanbul, Turkey in cooperation with JPF (Japan Space Forum), KIT (Kyushu Institute of Technology).

The satellite is a simplified version of the TurkSat-3USat. This version is less complex with respect to its previous version. New subsystems will be tested in this satellite.

UBAKUSAT was launched to the International Space Station, from where it will be later deployed.

References :

https://space.skyrocket.de/doc_sdat/ubakusat.htm

RAINCUBE

Mission Name	RAINCUBE
Organisation	NASA
Organisation type	Agency
Nation	Turkey
Type (U or mass)	6U
Satellite launch year	2018-05-21.
Rocket	Antares-230
Orbit	400 km, 51.6 deg, ISS
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Ka-band precipitation radar technologies on a low-cost, quick-turnaround platform. The
	proposed mission is to develop, launch, and operate a 35.75 GHz radar payload on a 6U
	CubeSat.
Experiment description	This mission will validate a new architecture for Ka-band radars and an ultra-compact
	deployable Ka-band antenna in a space environment.
Lifetime or status in orbit	Operational
Partners	-
Website	-
Additional comments	-
Additional sources	http://nspires.nasaprs.com/external/viewrepositorydocument/cmdocumentid=484317/solicitationId=%7B4FCC09A9-DFF6-4DF5-EC7A-3881AF72A6A3%7D/viewSolicitationDocument=1/INVEST15%20selections.pdf, https://pbs.twimg.com/media/CkXWMDZUkAEvQz6.jpg:large

RainCube is a technology validation mission by NASA's Jet Propulsion Laboratory to demonstrate the operation and performance of a miniaturized Ka-band Atmospheric Radar for CubeSats (miniKaAR-C) in the space environment on a low-cost, quick-turnaround platform.

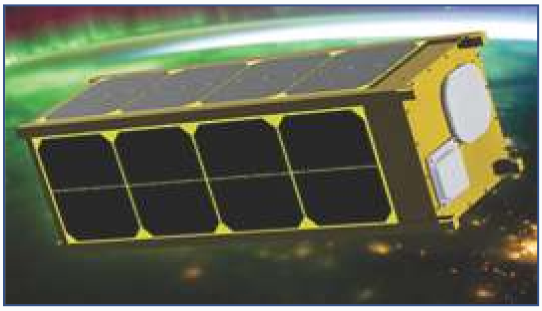
RainCube would develop, launch, and operate a 35.75 GHz radar payload on a 6U CubeSat. This mission will validate a new architecture for Ka-band radars and an ultra-compact deployable Ka-band antenna in a space environment. RainCube would also demonstrate the feasibility of a radar payload on a CubeSat platform. This new instrument will enable constellation missions and potentially transform climate science and weather forecasting.

References :

https://space.skyrocket.de/doc_sdat/raincube.htm

UNITE

Mission Name	UNITE (Undergraduate Nano Ionospheric Temperature Explorer)
Organisation	Purdue University
Organisation type	University
Nation	US
Type (U or mass)	3U
Satellite launch year	2018-11-21.
Rocket	Antares-230
Orbit	400 km, 51.6 deg, ISS
Mission type	Space Technology
Mission type description/	-
Configuration/Power	
Mission objectives	Make a series of global measurements in the lower ionosphere, take space weather measurements, assess drag, and take temperature measurements to compare against thermal models.
Experiment description	Target the least explored layer of the atmosphere, the lower ionosphere. probe plasma density, determine drag characteristics of the vehicle, and measure temperature on the skin and in the interior of the spacecraft.
Lifetime or status in orbit	Not Launched
Partners	University of Southern Indiana, Near Space Launch
Website	-
Additional comments	-
Additional sources	https://www.usi.edu/news/releases/2016/11/usi-engineering-and-physics-team-to-put-spacecraft-into-orbit/?utm_content=38411251&utm_medium=social&utm_source =twitter, https://www.nasa.gov/feature/nasa-announces-eighth-class-of-candidates-for-launch-of-cubesat-space-missions, https://www.nasa.gov/sites/default/files/atoms/files/2017_02_17_cubesat_manifest_list.pdf



The UNITE (Undergraduate Nano Ionospheric Temperature Explorer) is University of Southern Indiana's 3U CubeSat mission to make a series of global measurements n the largely unexplored lower ionosphere.

The objective is to explore the Extremely Low Earth Orbit environment and would feature

- space weather measurements using a Langmuir plasma probe,
- assessment of CubeSat drag in this lower region of the ionosphere and
- CubeSat temperature measurements to compare against a thermal model.

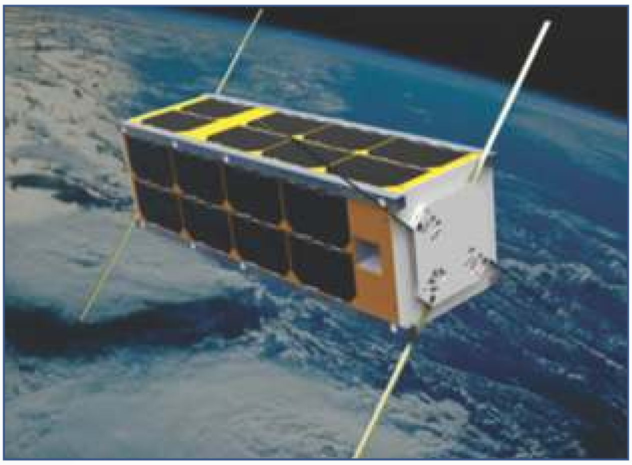
UNITE is to to probe plasma in the lower ionosphere to measure both electron and ion densities. It will measure temperatures throughout its flight and importantly in the last stages of reentry. The archived data will be used to compare against modeled drag throughout flight.It was funded through National Aeronautics Space Administration (NASA) Undergraduate Student Instrument Project (USIP) and was selected in 2017 by NASA to be launched as part of the ELaNa program.

References :

https://space.skyrocket.de/doc_sdat/unite.htm

SERPENS

Mission Name	SERPENS
Organisation	SERPENS (Sistema Espacial para Realização de Pesquisa e Experimentos com
	Nanossatélites) programme university consortium
Organisation type	University
Nation	Brazil
Type (U or mass)	3U
Satellite launch year	2015-08-19.
Rocket	H 2B
Orbit	400 km, 51.6 deg, ISS
Mission type	Space Technology
Mission type description/	-
Configuration/Power	
Mission objectives	Transponder to test VHF and S-band communications for store and forward messaging,a UHF transponder fully compatible with the HUMSAT store and forward messaging system and pulsed plasma thruster (PPT) built by Mars Space Ltd. and Clyde Space.
Experiment description	-
Lifetime or status in orbit	Reentry 2016-03-27. Was operational.
Partners	-
Website	-
Additional comments	Deployed from ISS on 2015-09-17.
Additional sources	http://www.amsatuk.me.uk/iaru/finished_detail.php?serialnum=418



SERPENS is Brazilian 3U Cubesat built by the SERPENS (Sistema Espacial para Realização de Pesquisa e Experimentos com Nanossatélites) university consortium.

The satellite features a transponder to test VHF and S-band communications for store and forward messaging, a UHF transponder fully compatible with the HUMSAT store and forward messaging system and a pulsed plasma thruster (PPT) built by Mars Space Ltd. and Clyde Space, both from U.K.

The satellite was delivered to the ISS by the HTV 5 cargo craft. It was deployed on 17 September 2015.

On 27 March 2016 SERPENS reentered the atmosphere.

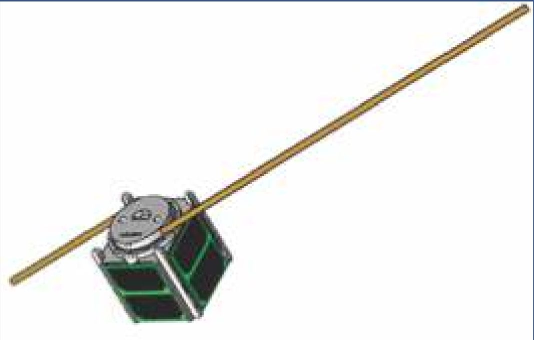
References:

https://space.skyrocket.de/doc_sdat/serpens.htm

PRINTSAT

Mission Name	PRINTSAT
Organisation	Montana State University
Organisation type	University
Nation	US
Type (U or mass)	1U
Satellite launch year	2015-11-04.
Rocket	Super Strypi
Orbit	400 km, 51.6 deg, ISS
Mission type	Space Technology
Mission type description/	-
Configuration/Power	
Mission objectives	Measure and report on the characteristics of the Windform XT2.0 printed material and plating during its mission life in order to verify the utility of additive manufacturing for spacecraft structures and mechanisms. The entire structure of the small satellite will be printed with nano-carbon-impregnated plastic using a 3D printer.
Experiment description	-
Lifetime or status in orbit	Launch Failure
Partners	-
Website	http://www.southgatearc.org/news/june2012/printsat.htm
Additional comments	Deployed from ISS on 2015-09-17.
Additional sources	http://www.amsatuk.me.uk/iaru/finished_detail.php?serialnum=418

PrintSat was a picosatellite built by Students at Montana State University (MSU) with nano-carbon-impregnated plastic using a 3D printer.



Additive manufacturing (also called 3-D printing) has evolved in the past few years to be a very inexpensive and fast way to make mechanical parts. With PrintSat, the entire structure of the small satellite was printed utilizing industrial 3D Printing using Windform XT 2.0 material.

When in orbit PrintSat was to measure and report on the characteristics of the Windform XT 2.0 printed material and plating during its mission life in order to verify the utility of additive manufacturing for spacecraft structures and mechanisms.

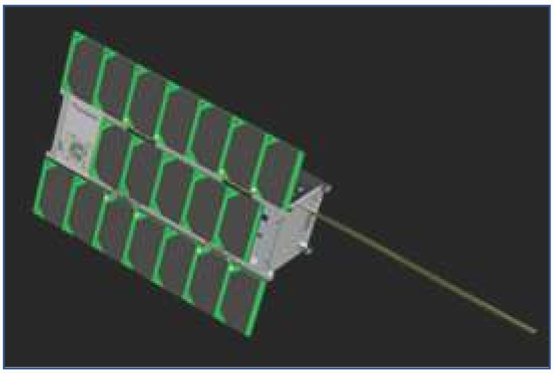
The satellite was launched on the maiden flight of the Super-Strypi rocket from Hawaii into a 415 km × 490 km polar orbit, but was lost in a launch failure.

References :

https://space.skyrocket.de/doc_sdat/printsat.htm

MinXSS

Mission Name	MinXSS (Miniature X ray Solar Spectometer CubeSat)
Organisation	University of Colorado at Boulder
Organisation type	University
Nation	US
Type (U or mass)	3U
Satellite launch year	2015-12-06.
Rocket	Atlast V
Orbit	400 km, 51.6 deg, ISS
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	The importance of the MinXSS mission is providing new spectral obser-vations of the solar SXR near the maximum of solar cycle 24, improving the understanding of how highly variable solar X-rays affect the ITM, and advancing the knowledge of flare energetics in the SXR.
Experiment description	Measure the intensity of the soft x-ray spectrum from 0.6 keV (20Å) to 25 keV (0.5Å).
Lifetime or status in orbit	Reentry 2017-05-05. Was Operational.
Partners	-
Website	http://lasp.colorado.edu/home/minxss/
Additional comments	Deployed from ISS on 2016-05-17.
Additional sources	http://www.amsatuk.me.uk/iaru/finished_detail.php?serialnum=411, http://mstl.atl.calpoly.edu/~workshop/archive/2016/Summer/Day%202/Session%205/3_JamesMason.pdf



MinXSS(Miniature X-ray Solar Spectrometer) is a nanosatellite project of the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado at Boulder to built a 3U-CubeSatto take observations of the Sun.

MinXSS is a 4-year, ~US$1 million project to design, build, integrate, test, and operate the 30 cm × 10 cm × 10 cm satellite, that was launched into low-Earth orbit in December 2015 to measure the intensity of the soft X-ray spectrum from 0.4 keV (30 Å) to 30 keV (0.4 Å) with a resolution better than 0.15 keV full-width half-max.

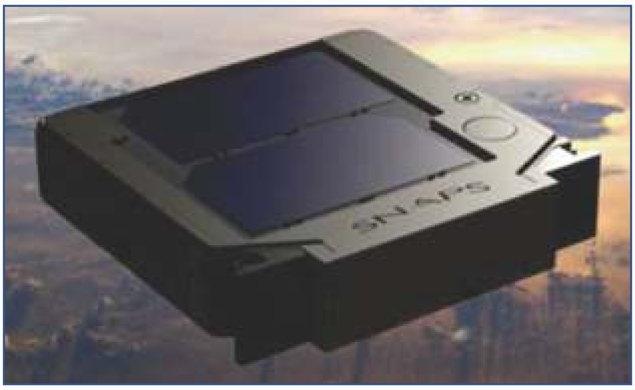
This region is of particular interest for observations of solar flares and active regions. The MinXSS project heavily involves its graduate student team members with scientists and engineers at the University of Colorado, Boulder and the Laboratory for Atmospheric and Space Physics (LASP).MinXSS replaces the original HiLITE (High Latitude Ionospheric Thermospheric Experiment) proposal, which was selected by NASA for the ELaNa program. MinXSS will be launched via ELaNa towards the ISS, from where it will be deployed.

References:

https://space.skyrocket.de/doc_sdat/minxss.htm

SNAPS

Mission Name	SNAPS (Standford nano Picture Satellite)
Organisation	Stanford University
Organisation type	University
Nation	US
Type (U or mass)	0.25U
Satellite launch year	2015-12-06.
Rocket	Atlast V
Orbit	400 km, 51.6 deg, ISS
Mission type	Space Technology
Mission type description/	-
Configuration/Power	
Mission objectives	Image other CubeSats autonomously using H264 compression. Xreate a reference design for an inspector satellite that others can build off of and a reference process where university students can launch productive CubeSats with the highest chance of success.
Experiment description	1080p camera, 32-bit ARM microcontroller with SRAM and FRAM, UHF radio and non-deploying antenna, nondeploying solar array, and ~20Wh of lithium-ion battery capacity.
Lifetime or status in orbit	Was Operational. (No public news found)
Partners	-
Website	https://sites.stanford.edu/ssdl/snaps
Additional comments	Deployed from ISS on 2016-05-17.
Additional sources	http://space.skyrocket.de/doc_sdat/snaps.htm



SNAPS(Stanford Nano Picture Satellite) is a nanosatellite built by Stanford (SSDL), which is intended to image other CubeSats autonomously using H264 compression.

This spacecraft has dimensions of 25 × 113 × 113 mm (0.25U CubeSat form factor), has a mass of less than 0.5 kg, which allows it to be placed into a Containerized Satellite Dispenser (CSD) besides a 3U-Cubesat. It sports a 1080p camera, 32-bit ARM microcontroller with SRAM and FRAM, UHF radio and non-deploying antenna, non-deploying solar array, and ~20 Wh of lithium-ion battery capacity.

It was planned for the maiden Falcon-9 v1.1(ex) launch from Vandenberg AFB in April 2013 together with several other satellites, sharing a deployer with POPACS, but was eventually not launched on this mission. Later a launch in 2014 on the maiden Super Strypi was planned, but dit not take place. It was eventually launched in late 2015 towards the ISS, likely on the Cygnus CRS-4 mission, to be deployed from there later in 2016.

References:

https://space.skyrocket.de/doc_sdat/snaps.htm

CADRE

Mission Name	CADRE (CubeSat investigating Atmospheric Density Response to Extreme Driving)
Nation:	Germany
Organisation	University of Michigan
Organisation type	University
Nation	US
Type (U or mass)	3U
Satellite launch year	2015-12-06.
Rocket	Atlast V
Orbit	400 km, 51.6 deg, ISS
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Wind Ion Neutral Composition Suite (WINCS). Flight-test low-cost dual-frequency GPS to measure atmospheric and ionospheric total electron content. Advance CubeSat capabilities to enable Armada and other NanoSat missions. Reduce the costs to perform in-situ measurements of the upper thermosphere. ADCS system pointing/knowledge accurate to 1.0°/0.1° for CubeSats. Flight testing of deployable solar panels.
Experiment description	-
Lifetime or status in orbit	Reentry 2017-01-03. No signal
Partners	-
Website	http://exploration.engin.umich.edu/blog/?page_id=961
Additional comments	Deployed from ISS on 2016-05-17.
Additional sources	-

CADRE (CubeSat investigating Atmospheric Density Response to Extreme driving) is a 3U CubeSatdeveloped by the University of Michigan's Student Space Systems Fabrication Lab (S3FL). Development began in 2007.

CADRE is a risk reducing precursor of the future Armada mission, which endeavors to characterize the dynamics of the upper thermosphere using the WINCS instrument. CADRE will operate WINCS in low earth orbit that explores the auroral oval and advance capabilities of CubeSat class spacecraft as a test for Armada.

CADRE has following mission goals:

- Deploy a University of Michigan CubeSat housing the Wind Ion Neutral Composition Suite (WINCS)
- Flight-test low-cost dual-frequency GPS to measure atmospheric and ionospheric total electron content
- Advance CubeSat capabilities to enable Armada and other NanoSat missions

It will demonstrate following technologies:

- Reduce the costs to perform in-situ measurements of the upper thermosphere
- Low-cost TEC count measurements and occultation using a dual-band GPS
- ADCS system pointing/knowledge accurate to 1.0°/0.1° for CubeSats
- Flight testing of deployable solar panels
- Create a standardized CubeSat bus for multiple missions

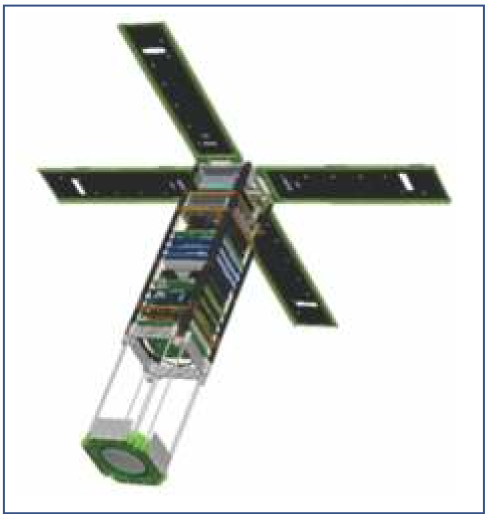
CADRE was selected in 2012 for launch with NASA's ELaNa program. It was launched with Cygnus CRS-4 to the ISS and deployed into orbit on 16 May 2016, but no signals from CADRE were received.

References:

https://space.skyrocket.de/doc_sdat/cadre.htm

VELOX – II

Mission Name	VELOX – II
Organisation	Nanyang Technological University
Organisation type	University
Nation	Singapore
Type (U or mass)	6U
Satellite launch year	2015-12-06.
Rocket	PSLV
Orbit	540 km, 15 deg
Mission type	Space Technology
Mission type description/	-
Configuration/Power	
Mission objectives	Experimental satellite-based communication hardware developed by Addvalue Innovation Pte Ltd, a subsidiary of Singapore Exchange mainboard listed Addvalue Technologies Ltd. This unique payload transmits data it collects to a Inmarsat geostationary communications satellite. If proven successful in space, the payload will allow the VELOX-II to send data back to the NTU ground station from anywhere even if the satellite is not flying above Singapore, as is presently the case.
Experiment description	-
Lifetime or status in orbit	Was Operational
Partners	Addvalue Innovation (Avi)
Website	-
Additional comments	Deployed from ISS on 2016-05-17.
Additional sources	http://space.skyrocket.de/doc_sdat/velox-2.htm, http://spacenews.com/after-months-of-secret-in-space-testing-inmarsat-avis-satellite-data-relay-service-exits-stealth-mode/



The VELOX-I mission is a Singaporean nanosatellite mission consisting of two satellites - VELOX-1 and the VELOX P3 subsatellite - to operate in sun synchronous Low Earth's Orbit (LEO). The project is part of NTU's Undergraduate Satellite Program, which provides an opportunity for engineering students to participate in a multidisciplinary hands-on space project.

The objective of the mission is to provide hands-on experience on a space project for students and to conduct several technology demonstrations. The mission objectives are:

- To launch a nanosatellite, which is designed, built, and operated by students from different schools in the College of Engineering, NTU.
- To acquire images of Earth and transmit them back to ground station using a narrow angle camera with tele-optics to provide high-resolution images of Earth from LEO.

References :

https://space.skyrocket.de/doc_sdat/velox-1.htm

Galassia

Mission Name	Galassia
Organisation	National University of Singapore
Organisation type	University
Nation	Singapore
Type (U or mass)	2U
Satellite launch year	2015-12-06.
Rocket	PSLV
Orbit	540 km, 15 deg
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	Main objective is for students to understand space technologies and to gain practical experiences while building, integrating and testing 2U CubeSat bus and payloads.
Experiment description	First payload aims to measure the Total Electron Count (TEC) in the ionosphere above Singapore. The second primary payload is the Small Photon-Entangling Quantum System (SPEQS) payload, which is developed by the Center for Quantum Technologies (CQT) in NUS. A compact and efficient system for generating and detecting photon pairs is conducted. The SPEQS experiment utilizes a process called Spontaneous Parametric Down Conversion (SPDC) to generate entangled photon pairs. The generation and detection of photon pairs are performed within the package to check the quality of the entanglement.
Lifetime or status in orbit	Operational
Partners	DSO National Laboratories
Website	-
Additional comments	-
Additional sources	http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=3089&context=smallsat, http://www.quantumlah.org/highlight/141013_space_hybrid.php, http://space.skyrocket.de/doc_sdat/galassia.htm

Galassia is a 2U Cubesatdeveloped by undergraduate students at the National University of Singapore (NUS).

Galassia is the first NUS Cubesat. There are many educational and scientific objectives in this project. The educational objectives are for students to gain hands-on experience with real hardware and software integrations, to design and verify Cubesat system mechanisms, to test some in-house developed devices, and to work and integrate the two scientific experiments into the Cubesat.

The first primary payload measures the Total Electron Count (TEC) in the Ionosphere above Singapore. TEC is a measure used to characterize the conductivity of the ionosphere, which consists of ionized layers in the upper atmosphere. The free electrons in the ionosphere affect the propagation of radio waves. TEC is measured by Galassia using the three frequencies method.

The second primary payload is the Small Photon-Entangling Quantum System (SPEQS) payload, which is developed by the Center for Quantum Technologies (CQT) in NUS. A compact and efficient system for generating and detecting photon pairs is conducted. The SPEQS experiment utilizes a process called Spontaneous Parametric Down Conversion (SPDC) to generate entangled photon pairs. The generation and detection of photon pairs are performed within the package to check the quality of the entanglement. This package achieves high entanglement fidelity and enables a quantum light source to be deployed on mobile field communication systems where resources are scarce. The SPEQS payload conducts the science experiment for a maximum duration of 30 minutes.

Galassia is scheduled to launch as a piggy-back payload in the 4th quarter of 2015 on an Indian PSLV-CA vehicle into a near equatorial orbit with an altitude of 550 km and an inclination of 15°.

References:

https://space.skyrocket.de/doc_sdat/galassia.htm

SamSat – 218/D

Mission Name	SamSat – 218/D (Kontact Nanosputnik)
Organisation	Samara State Aerospace University
Organisation type	University
Nation	Russia
Type (U or mass)	3U
Satellite launch year	2016-04-28..
Rocket	Sojuz-2.1a
Orbit	470km, 97 deg, SSO
Mission type	Space Technology
Mission type description/	-
Configuration/Power	
Mission objectives	The main objective of this satellite is a demonstration of navigation and control technologies. Researches aimed at improving of performance reliability of equipment will make space experiments more efficient.
Experiment description	-
Lifetime or status in orbit	Was Semi Operational
Partners	DSO National Laboratories
Website	-
Additional comments	-
Additional sources	http://www.ssau.ru/engnews/10917-In-2015-the-first-nanosatellite-manufactured-in-SSAU-will-go-into-space/, http://ria.ru/science/20160504/1426240292.html

SamSat-QB50 is a 2U-CubeSat being developed by the Samara State Aerospace University (SSAU) flying a science unit with the FIPEX (Flux-F -Probe Experiment) sensor for QB50 and an aerodynamic stabilisation experiment.

The main design idea of the SamSat-QB50 is using atmospheric influence for obtaining needed orientation. For achieving this goal the satellite has a deployable aerodynamic stabilizer providing aerodynamic stability and hysteresis rods for oscillation energy dissipation.

As a payload for QB50, the satellite carries the Flux-F -Probe Experiment (FIPEX) of TU Dresden, which is able to distinguish and measure the time-resolved behaviour of atomic and molecular oxygen as a key parameter of the lower thermosphere. Atomic oxygen is the dominant species in these regions and therefore its measurement is crucial in the validation of atmosphere models.

The satellite will be launched with the bulk of the QB50 constellation to the ISS in 2017, from where they will be deployed.

References:

https://space.skyrocket.de/doc_sdat/samsat-qb50.htm

Hoopoe (Duchifat 2, QB50 IL01)

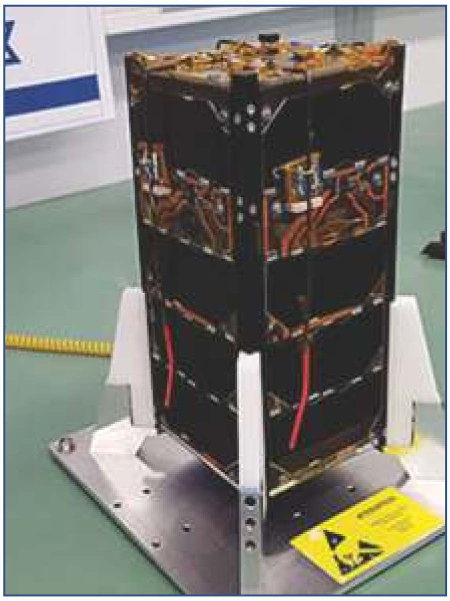
Mission Name	Hoopoe (Duchifat 2, QB50 Il01)
Nation:	Greece
Type / Application:	Technology
Operator:	Space Laboratory of the Herzliya Science Center
Contractors:	Space Laboratory of the Herzliya Science Center
Equipment:	mNLP
Configuration:	CubeSat (2U)
Propulsion:	None
Power:	Solar cells, batteries
Lifetime:	3 months
Mass:	2 kg
Orbit:	400 km × 403 km, 51.64°
COSPAR	1998-067LZ
Date	18.04.2017
LS	CC SLC-41
Launch Vehicle	Atlas-5(401)
Remarks	with Cygnus CRS-7, ALTAIR 1, SUSat, UNSW-EC0, i-INSPIRE 2, ZA-AeroSat, nSIGHT 1, Ex-Alta 1, LilacSat 1,

Hoopoe is an Israeli 2U-CubeSat constructed by the Space Laboratory of the Herzliya Science Center as part of the QB50 mission.

The purpose of this CubeSat includes upper atmosphere science, radio communication experiments, technology demonstrator, education, training and outreach.

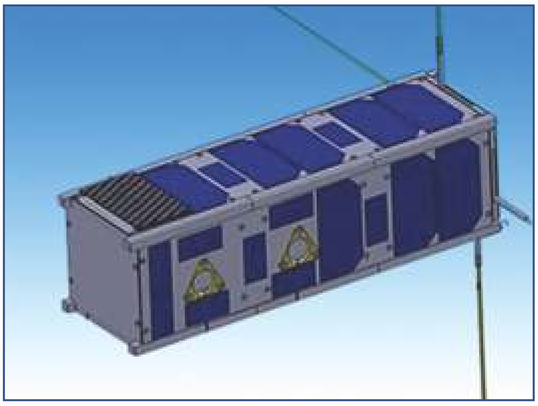
As a payload for QB50, the satellite carries a multineedle Langmuir probe (mNLP) sampling the electron density of the space around it, Thermistors and a Magnetometer.

The satellite was launched with the bulk of the QB50 constellation to the ISS in 2017, from where the satellite was deployed on 18 May 2017.



PEASSS

Mission Name	PEASSS (PiezoElectric Assisted Smart Satellite Structure)
Organisation	ISIS (Innovative Solutions in Space)
Organisation type	Company
Nation	Netherlands
Type (U or mass)	3U
Satellite launch year	2017-02-15
Rocket	PLSV
Orbit	500 km, 97.5 deg, SSO
Mission type	Space Technology
Mission type description/ Configuration/Power	-
Mission objectives	EU FP7 project to develop, manufacture, test and qualify "smart structures" which combine composite panels, piezoelectric materials, and next generation sensors, for autonomously improved pointing accuracy and power generation in space.
Experiment description	Smart structures will enable fine angle control, thermal and vibration compensation, improving all types of future Earth observations, such as environmental and planetary mapping, border and regional imaging. Develop and test the following smart structures: piezo actuated "smart panels" for pointing of optical instruments/sensors; piezo actuated "smart panels" for power harvesting; fiber bragg gratings for composite structure strain and temperature measurement; next generation of power conditioners for future applications in space missions.
Lifetime or status in orbit	Operational
Partners	TNO, NSL Satellites, Active Space Technologies, Israel Institute of Technology, SONACA
Website	http://www.peasss.eu/
Additional comments	First Piezoelectric based satellite in space.
Additional sources	https://www.isispace.nl/news/isis-11-years-anniversary/



PEASSS is under development as part of a FP7 European Commission project involving Active Space Technologies GmbH (Germany), TNO and ISIS (Netherlands), SONACA (Belgium), Technion and NSL (Israel).

The main objective of the project is to develop, manufacture, test and qualify "smart structures" which combine composite panels, piezoelectric materials, and next generation sensors, for autonomously improved pointing accuracy and power generation in space. The system components include new nano satellite electronics, a piezo power generation system, a piezo actuated smart structure and a fiber-optic sensor and interrogator system.

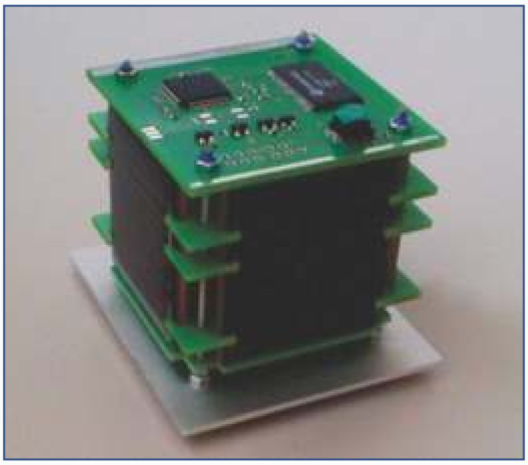
The satellite was launched on a bulk Cubesat launch on an Indian PSLV-XL in February 2017.

References:

https://space.skyrocket.de/doc_sdat/peasss.htm

WREN SSTV Sat

Mission Name	WREN SSTV Sat
Nation:	Germany
Type / Application:	Technology
Operator:	STADOKO UG
Contractors:	STADOKO UG
Satellite	Wren
Equipment:	Camera
Configuration:	1U PocketQube
Propulsion:	4 × pulsed plasma thrusters
Power:	Solar cells, batteries
Lifetime:	
Mass:	0.250 kg
Orbit:	593 km × 639 km, 97.80°
COSPAR	2013-066V
Date	21.11.2013
LS	Do LC-370/13
Launch Vehicle	Dnepr
Remarks	with DubaiSat 2, STSAT 3, WNISAT 1, SkySat 1, BRITE-PL, AprizeSat 7, AprizeSat 8, UniSat 5, Delfi-n3Xt, Dove 3, Dove 4, Triton 1, CINEMA 2, CINEMA 3, OPTOS, CubeBug 2, GOMX 1, NEE 02 Krysaor, FUNcube 1, HiNCube, ZACUBE 1, ICube 1, HumSat-D, PUCP-SAT 1, First-MOVE, UWE 3, VELOX P2, Pocket-PUCP, QubeScout S1, BPA 3



Wren is a crowd-funded femto-satellite by start-up company STADIKO to test miniaturized µPP-Thrusters, 3-axis control and a new image based navigation system in a satellite built to the 1U PocketQub form factor (5 cm × 5 cm × 5 cm).

It will be equipped with a camera system in order to remotely take pictures of the earth, the sun and deep space objects. The camera will also be connected to the board computer. In this way the implemented artificial intelligence will evaluate the pictures in order to detect the earth's nadir relative to the sun. Together with the conventional gyro- and magnetic field attitude sensors, those three components will constitute an adaptive feedback guidance system which could precisely navigate the satellite on its own into the specified orbit by using its four micro pulsed plasma thrusters (micro-PPTs). The guidance system will be the main part of our mission as this could not be investigated in a non-micro-gravitational environment.

An Additional feedback position controller will be installed in order to optimally adjust the direction of the high transfer rate antenna, through which Wren will obtain mission orders to be executed. In return, Wren will send back the collected pictures, scientific and telemetric data to mission control. Due to the flexible and highly modular design, ground control will also be able to uplink software updates to the Wren board computer.

The satellite will be deployed from the Italian UniSat 5 satellite from a MR-FOD (Morehead Roma Femtosat Orbital Deployer) deployer after launch on a Dnepr booster.

Sacha Tholl in the WREN Mission Control Center

The tiny PocketQube satellite WREN, just 5x5x5 cm and weighing 250 grams, aims to transmit amateur radio Slow Scan TV (SSTV) pictures using the Martin-1 format.

Despite its small size WREN is equipped with a camera, a gyro, a magnetic field sensor, momentum wheels and pulsed plasma microthrusters. The camera is equipped with an image processing system which can find the position of the Sun and the Earth automatically.

The communications uplink and downlink will take place on the IARU coordinated frequency of 437.405 MHz.

WREN is flying inside a larger satellite called UNISAT-5 that will be launched in late November, 2013 on a Dnepr rocket from Dombarovsky near Yasny. UNISAT-5 should deploy WREN after launch.

On September 7, 2013 Paul Kocyla and Sacha J. Tholl presented the working engineering model of the WREN PocketQube satellite to the public at the Maker Faire at Kerkrade in The Netherlands. In this video they are sending live pictures during the faire using amateur radio SSTV, just as WREN will do in orbit.

The four team members explain in the following video the mission objectives of WREN, believed to be the smallest satellite ever to carry Pulse Plasma Thrusters.

https://amsat-uk.org/2013/10/24/wren-a-ham-radio-sstv-pocketqube/

Watch Satellite Wren, sending Pictures by SSTV at the continium Maker Faire in Kerkrade NL September 7, 2013

Watch Fly a Satellite in Space…Without Leaving Your Couch

In this video Sacha J. Tholl talks to Chantal Cappelletti, CEO from GAUSS S.R.L., the WREN PocketQube launch provider, and Paride Testani, principal investigator of the UNISAT-5 Project.

Watch How is WREN, the tiniest Satellite with Thrusters (5 cm^3, 250gram) getting into Orbit?

Watch The Wren flight model being build and the mission control software updated

WREN Kickstarter

https://www.kickstarter.com/projects/1467273745/wren-fly-a-real-spacecraft-by-yourself

First picture transmitted by WREN in Martin-1 SSTV format – Ronghua Wang and Paul Kocyla

The Team

Even nowadays space is not opened to the public,
but we will change that - this year !

We are four guys in a garage, and we have dedicated ourselves to open space for everyone. For that purpose we designed the miniaturized satellite WREN. It's a so called Pocketqub-Femtosatellite. It has only 5x5x5cm³ of volume and 250g of mass, and fits perfectly into your hand, like a tennis ball. Despite of its size, it even has real thrusters.

It can be remotely positioned by you in every direction and it has a camera onboard for taking pictures from outer space. It will be released into a polar orbit before the end of this year on board of the UNISAT-5 deployer, which is launched inside a DNEPR Rocket from Yasni in Russia. In the little interview Video just below, you will experience how we will get our little Baby "pocketqub WREN" into Orbit.

http://kck.st/176VG5e

It will race around the globe every 98 minutes, passing every point of the earth during each day, seven days a week, just waiting for the command to be remotely flown by you.

System Overview

WREN is equipped with a camera, a gyro and a magnetic field sensor. Those three components will form an adaptive feedback guidance system which helps you to easily navigate the satellite by your own by using its momentum wheels and microthrusters. The camera is equipped with an image processing system which can find the position of the sun and the earth automatically. This technology will make the control of the satellite more easy. With the camera system you can of course remotely take pictures of the earth, the sun and other space objects. You can navigate the satellite directly in order to make your own picture.

The communication up- and downlink will be performed at 437,405 MHz, a frequency in the 70cm amateur radio band which has been kindly assigned to us by the International Amateur Radio Union (IARU). Wren will be flying in a sun synchronous orbit at 700km of altitude at an incredible speed of 7500 m/second, so that it will take only 98 minutes to fly one time all around the planet. Practically, a link is possible for about 10 minutes from a single ground station, up to three times a day. The mission control software is equipped with prediction algorithms in order to predict the flyby- time according to your location, so you can prepare yourself for the upcoming communication window and take control over the satellite again.

We hope that amateur radio enthusiasts will join our network and provide a link from time to time to use WRENs lifetime as long as possible.

OzQube-1: Australia's first PocketQube

OzQube-1 is an Earth Observing (EO) PocketQube satellite, designed to take images of Australia, and other Southern Hemisphere targets. It will store the images onboard, then transmit them via Amateur Radio frequencies to people on the ground. People will be able to receive these images using basic, low-cost hardware.

I've created a project profile on the STEM Network site to summarise the project to date. This blog has various posts relating to the development of OzQube-1. Other development info can be found on Twitter @ozqube1 and Facebook.

Once final designs are in place, and I have some completed hardware, I'll post some updates here.

Here's a few teaser images that I've posted on various social media outlets:

From Backyard Shed to Orbit

OzQube-1 is a tiny satellite that's being built in a backyard shed in suburban Perth, Western Australia.

It's the first of its kind to be built in Australia. It is a new type of satellite called a PocketQube - a cube measuring 5cm on each side. OzQube-1 is a demonstration that building a satellite can be done by anyone, not just nations, large companies and well funded institutions. It is a fully functioning Earth Observation satellite - meaning that it has a camera onboard. It is designed to take photos of the Southern Hemisphere - especially Australia! It will send those images via radio down to the ground and anyone can try their hand at receiving them with low cost hardware connected to a computer.

Here's a couple of online articles describing the project:

ScienceNetwork WA (produced by Scitech)

http://www.sciencewa.net.au/topics/space/item/3605-diy-satellite-launches-from-backyard-shed-to-lower-orbit

SatMagazine

http://www.satmagazine.com/story.php?number=1481898241

With your help, OzQube-1 will be able to make it to orbit!

Once upon a time, building a satellite was extremely expensive. The PocketQube form factor is changing that. But getting satellites into space is still expensive. PocketQubes can't change the cost of operating a rocket, but because they are small, the cost for each satellites is much less compared to their cubesat cousins.

In order to get OzQube-1 into space, I need help to fund the launch costs (~$30,000), along with other necessary things like insurance, government permits (potentially up to $10,000) and specialized testing of the satellite (several thousand dollars). The testing is required by the organisations that launch the rockets. They want to make sure that my satellite is not going to fall apart during the extreme forces that occur during the rocket flight.

Who Am I?

The creator of this tiny marvel is me - Stuart McAndrew. By day, I work as an IT professional. By night, I teach myself how to design and build satellites.

Space is cool! Building something yourself that can go into space is even cooler! This project shows that if you learn the right skills, you can achieve something amazing.

Why should you contribute to my project?

Australia's first amateur satellite – Oscar 5 - was launched into orbit in 1970. Since then, there haven't been any other Australian amateur satellites. In the meantime, other countries have continued to develop their capability in space, and Australia has lagged a long way behind.

I want to change that.

By funding my project, you're not just helping me to get my satellite into orbit. You're helping to show the world that Australia isn't going to be left behind any more. You're helping to build the foundations of an emerging national industry. You're helping to show kids that there's more to space than being an astronaut. You're helping to show them that STEM education can lead to exciting careers. You're helping to inspire others to follow their dreams and to aim for the sky.

This is SPACE 2.0!

Follow the project on Facebook and Twitter .

Check out the project profile on the STEM Network

https://www.gofundme.com/ozqube1

Indian Space Research Organisation (ISRO) & List of University / Academic Institute Satellites

SN	Name of Satellites	Launch Date	Launch Mass	Launch Vehicle	Project Duration	Project Cost in Rs.	Name of University/EEI
9	NIUSAT	Jun 23, 2017	15 kg	PSLV-C38 / Cartosat-2 Series Satellite	10/13 Years	37 Cr	Noorul Isalm University
8	PRATHAM	Sep 26, 2016	10 kg	PSLV-C35 / SCATSAT-1	10 Years	1.5 Cr	IIT-Bombay
7	PISAT	Sep 26, 2016	5.25 kg	PSLV-C35 / SCATSAT-1	5 Years	1.25 Cr	PES University & Others
6	SATHYABAMASAT	Jun 22, 2016	1.5 kg	PSLV-C34 / CARTOSAT-2 Series Satellite	7 Years	2 Cr	Sathyabama University
5	SWAYAM	Jun 22, 2016	1kg	PSLV-C34 / CARTOSAT-2 Series Satellite	8 Years	60 + 35 Lacs	College of Engg, Pune
4	SRMSat	Oct 12, 2011	10.9 kg	PSLV-C18/Megha-Tropiques	2/3 Years	1.5 Cr + 60 Lacs	SRM University
3	Jugnu	Oct 12, 2011	3 kg	PSLV-C18/Megha-Tropiques	2/3 Years	2.5 Cr	IIT-Kanpur
2	STUDSAT	Jul 12, 2010	> 1 kg	PSLV-C15/CARTOSAT-2B	1 Year	55 + 45 Lakhs	7EEls of KAR & AP
1	ANUSAT	Apr 20, 2009	40 kg	PSLV-C12 / RISAT-2	3/5/7 Years	5.5 Cr	Anna University

ANUSat is a cooperative microsatellite mission of Anna University of Chennai and ISRO. An ISRO initiative of microsatellite development at Indian universities was approved in January 2002 and formally announced on Feb. 18, 2002: A preliminary design review took place in Dec. 2002. Project Duration: 3 years, Extended to 7 Years.

ANUSat was planned to be launched with CartoSat-2 of ISRO (January 10, 2007).

ANUSat was launched on April 20, 2009 as a secondary payload to RISAT-2 of ISRO on the PSLV-C12 vehicle (the primary payload mass of ~ 300 kg).

ANUSat 2: Proposed budget: Rs.7 Cr & 2 Years

A brainchild of former Anna University Vice-Chancellor R M Vasagam, who was also the project director of ISRO's first ever satellite 'Apple', ANUSat is expected to encourage other universities and technical institutions to involve themselves in the complex process of satellite making. K S Seshadri, a retired space scientist from ISRO is playing the role of the moderator between ISRO and Anna University for this project.

STUDSAT:

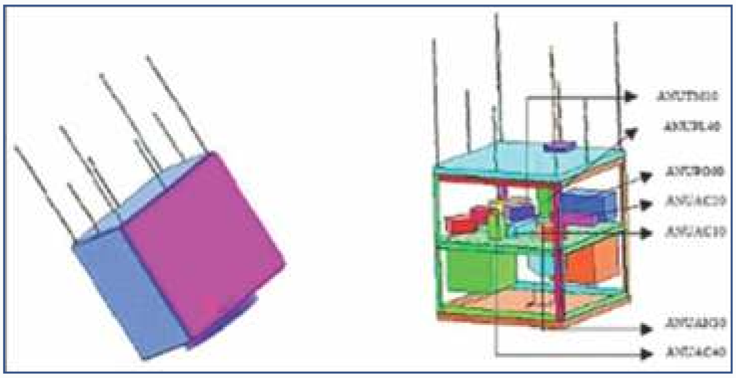
Nitte Meenakshi Institute of Technology, Bangalore.[Lead College with Few AP Colleges] Also Invested on Ground Control Station: Rs.45 Lakhs *(Approximately),* M S Ramaiah Institute of Technology, Bangalore, RV College of Engineering, Bangalore. B M S Institute of Technology, Bangalore, Chaitanya Bharathi Institute of Technology, Hyderabad, Vignan Institute of Technology & Science, Hyderabad, RNS Institute of Technology, Bangalore and Institute of Aeronautical Engineering, Hyderabad.

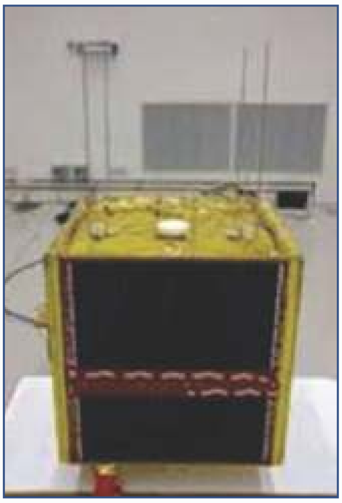
PISAT

The PISat project actually consists of a consortium of Indian colleges, with the support of ISRO (Indian Space Research Organization) and IEI (The Institution of Engineers-India) of India, to provide a hands-on environment for students in all aspects of satellite building and operations.

ANUSAT

Mission Name	ANUSAT
Application	Digital Communication using Store & Forward Techniques
Size	600 mm x 600 m x 600 mm Cuboid
Mass	40 kg
Solar Array	Body Mounted Ga As Solar Cells Generating 40 W
Battery	Li Ion (4x5) 20 Cells
Telecommand	ON/OFF and Data commands VHF PCM/FSK/AM 100 bps 149.2 MHz
Telemetry	VHF/PCM/FSK/AM 512 bps 137.4 MHz
Store and Forward	VHF 145.8 MHz Uplink, UHF 435 MHz Downlink
Attitude control	Spin stabilized with spin axis orientation using magnetic Stabilization torque
Spin Rate	8 +/- 0.5 rpm (Automatic SRC)
Spin Axis Orientation	+/- 3o (SAOC) Sun normal or Orbit normal
Sun sensor	+/- 75o with 0.5 o resolution
Magnetometer	+/- 60,000 Gamma with 500 gamma resolution
Torquers	4.5 Am2 capacity (2 Nos. Z Axis), 1 each in X Y axis
Launch	PSLV-C12





ANUSAT (Anna University Satellite) is the first University Satellite of India to be launched by Polar Satellite Launch Vehicle (PSLV). The 40 kg micro satellite developed by the Anna University carries a Store and Forward Payload. Apart from this secondary payloads are MEMS Gyro, MEMS Magnetometer and Satellite Positioning System.

ANUSAT is launched into 41o inclined orbit. Major accomplishments of student community are:

1. Design and build a spacecraft by the university
2. Spacecraft power system of 40W provided by GaAs solar cells with a backup of 10 Ah Li Ion battery
3. Telemetry system in VHF with data for house keeping and auxiliary payloads
4. Telecommand system in VHF to command the spacecraft
5. AOCS system consisting of Sensor systems, magnetometer and Twin slit sensors and actuators consisting of torquers along the three axes.
6. Control spin rate to 8 rpm +/- 0.5 rpm
7. Up link data in VHF band for store and forward payload
8. Store and Forward payload data down link transmission in UHF

References :

https://www.isac.gov.in/student-satellites/html/anusat.jsp

STUDSAT

Mission Name	STIDSAT
Payload	Imaging (Near IR) camera of resolution 90 m
Lift-off Mass:	<1 kg
Spacecraft Power	4 W
Launch Vehicle	PSLV-C15
Launch Date	12th July 2010

STUDSAT was built by NITTE Meenakshi Institute of Technology, Bangalore.

STUDSAT (STUDent SATellite) is a unique satellite technology endeavour undertaken by the Under-Graduate students of India. STUDSAT is the first Pico-Satellite launched by India, and it is even more special, as this project has been developed by Under-Graduate students from seven different Academic Institutions, under the guidance of the Indian Space Research Organization (ISRO).

The Pico Satellite, weighing less than 1 kg, volume of 1.1 litres is designed to operate in Low Earth Orbit (LEO) at an altitude of 647 km. The payload of the satellite is a CMOS camera which was developed by students and it is capable of capturing images with a ground resolution of 90 meters. The satellite will send the image and telemetry data to the ground station NASTRAC (Nitte Amateur Satellite Tracking Centre) developed at NMIT by the students which is again first of its kind in the country. The mission life of the satellite was estimated to be six months, with the total development cost of Rs. 55 Lakh.

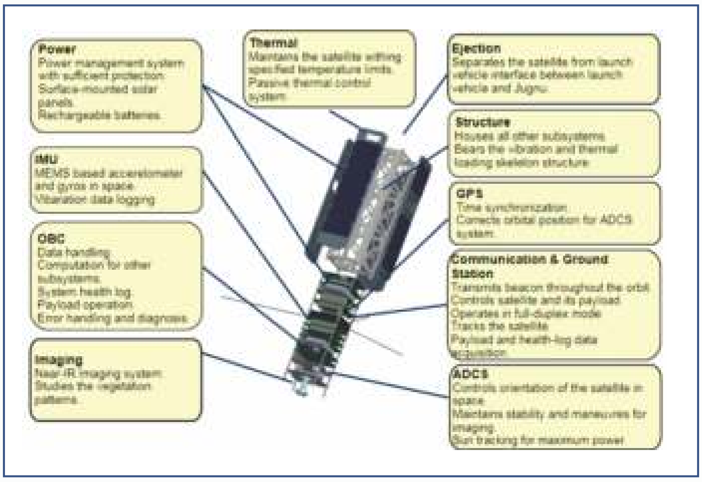
The functional objective of the satellite is to perform remote sensing, and capture images of the surface of the earth using the camera having a resolution of 90 meters which is the best resolution hitherto achieved by any Pico Satellite in the world.

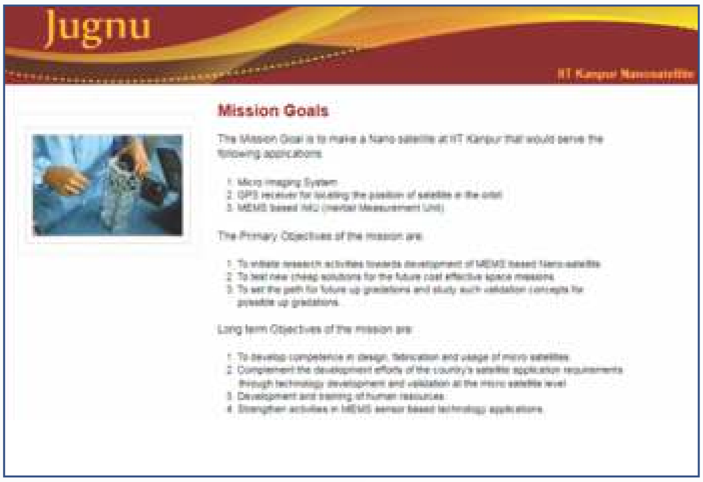
References :

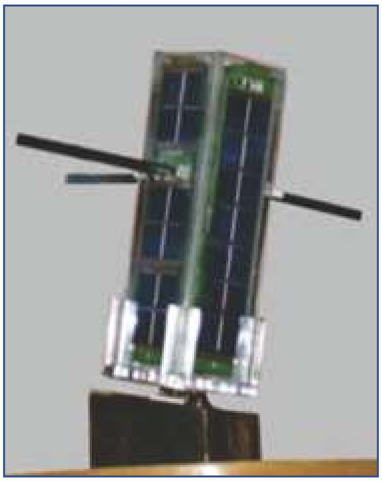
https://www.isac.gov.in/student-satellites/html/studsat.jsp

JUGNU

Mission Name	JUGNU
Payload	Near IR camera to capture near IR images of earth surface
Lift-off Mass:	4 kg
Spacecraft Power	5 W
Launch Vehicle	PSLV-C18 The nanosatellite Jugnu weighing 3 kg is designed and developed by Indian Institute of Technology, Kanpur under the guidance of ISRO.
The satellite is intended	To prove the indigenously developed camera system for imaging the Earth in the near infrared region and test image processing algorithms. Evaluate GPS receiver for its use in satellite navigation. Test indigenously developed MEMS based Inertial Measurement Unit (IMU) in space.
Launch Date	12th October 2011





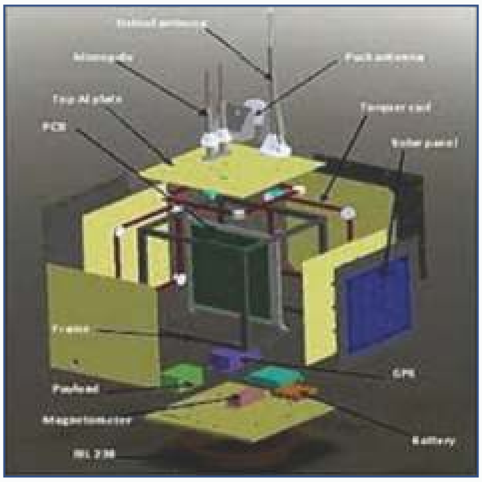


References :

https://www.isac.gov.in/student-satellites/html/jugnu.jsp

SRMSat

Mission Name	RAINCUBE
Payload	Grating spectrometer to monitor green house gases in Near Infra-red region 900nm - 1700nm
Lift-off Mass	8.5 kg
Spacecraft Power	10 W approximately
Launch Vehicle	PSLV-C18
Launch Date	12th October 2011



SRMSat is a student developed nanosatellite of SRM (Sri Ramaswamy Memorial) University, Chennai, India. Students from SRM university were working on the project SRMSat. The nanosatellite has been developed under the technical guidance of ISRO (Indian Space Research Organization).

The satellite is a cuboid made out of Al-6061 alloy. The structure consists of 2 frames and 4 beams which can bear the launch loads of approx 11 g longitudinal and approx 6 g lateral and frequency requirement of > 90 Hz in longitudinal and > 45 Hz in lateral directions. The mainframe has a launch size of 286 mm x 286 x 294 mm. The structure is made as a satellite bus such that it can be used for future missions.

References :

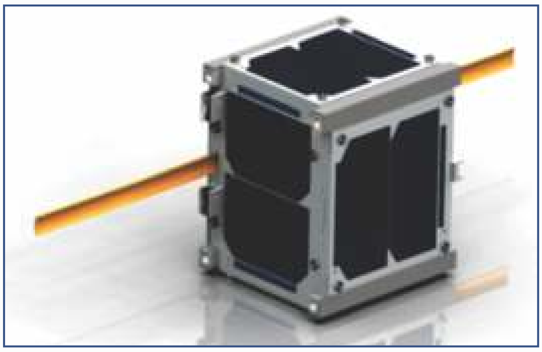
https://www.isac.gov.in/student-satellites/html/srmsat.jsp

Parameters

NORAD	37841
COSPAR designator	2011-058-D
Inclination	19.970
RA of A. Node	106.259
Eccentricity	0.0012093
Argument of Perigee	99.676
Revs per day	14.10196386
Period	1h 42m 06s (102.10 min)
Semi-major axis	7 237 km
Perigee x Apogee	850 x 867 km
BStar (drag term)	0.000000000 1/ER
Mean anomaly	260.509
Uplink (MHZ)	145.900
Downlink (MHZ)	437.500
Beacon (MHZ)	437.425
Mode	CW
Call sign	
SRMVU	

SWAYAM

Mission Name	SWAYAM
A pico satellite	Developed by College of Engineering, Pune, under the technical guidance and support from ISRO
Mission objectives	• To demonstrate passive attitude stabilization in polar low Earth orbit using a permanent magnet along the direction of Earth's magnetic field and two pairs of hysteresis rods, each pair mounted along two axes mutually perpendicular with respect to axis of the magnet. • To characterize the 434-438 MHz amateur HAM band for low Earth orbit
Payload	• Point-to-point messaging services in HAM band • Messaging capability: 18,00,000 messages (70 bytes each)
Structure	1U Cubesat,
Satellite dimensions	100 mm x 100 mm x 113.5 mm
Satellite mass	990 g
Attitude stabilization system	Stabilization detection using a 3-axis MEMS Gyroscope Pointing accuracy < = ±8o Drift rate < = 0.3o/s
Onboard computer	32-bit microcontroller,
Storage	2 GB
House-keeping Sensors	11 Voltage Sensors and 11 Current Sensors, 4 Temperature Sensors
RF Communication	Amateur band One deployable UHF dipole antenna & Beacon
Battery	13,600 mAh Li-ion cells
Solar Array	Body mounted Triple-junction solar cells
Power generation	2.5W
Thermal management	Passive thermal control system
Altitude/Orbit	Approximately 509 km, Polar
Inclination	97.41o
Launch Date	June 22, 2016
Launch Vehicle	PSLV- C34
Launch site	SHAR Centre, Sriharikota, India



References :

https://www.isac.gov.in/student-satellites/html/swayam.jsp

SATHYABAMASAT

Mission Name	SATHYABAMASAT
A nano satellite	Developed by Sathyabama University, Chennai, under the technical guidance and support from ISRO
Mission objectives	• To collect data on green house gases: • Water vapor, Carbon monoxide, Carbon dioxide, Methane and Hydrogen fluoride
Payload	Argus 1000 multispectral IR grating type spectrometer Spectral range: 900 nm - 1700 nm Swath and spatial Resolution: 1.5 km
Structure	2U Cubesat Satellite dimensions: 100 mm x 100 mm x 227 mm (accuracy: ± 0.1 mm) Satellite mass : 1.591 kg
Attitude control system	Stabilization detection using a 3-axis MEMS Gyroscope Air core magnetic torquers - 3Nos. Sun Sensors- 6 Nos. Pointing accuracy: < = ±8o Drift rate: < = 1o/s
Onboard computer	32-bit Microcontroller 2MB Static RAM, 4MB Data Storage 4MB Code Storage, 8MB Serial Flash
House-keeping Sensors	Voltage sensors - 4 Nos. Current Sensors - 5 Nos. Temperature sensor - 6 Nos.
RF Communication	Amateur band Two deployable dipole antennas with Beacon
Battery	1800 mAh Li-ion cells
Solar Array	Body mounted Triple-junction solar cells Power generation: 4.2W
Thermal management	Passive thermal control system
Altitude/Orbit	Approximately 509 km, Polar
Inclination	97.41o
Launch Date	June 22, 2016
Launch Vehicle	PSLV- C34
Launch site	SHAR Centre, Sriharikota, India

References:

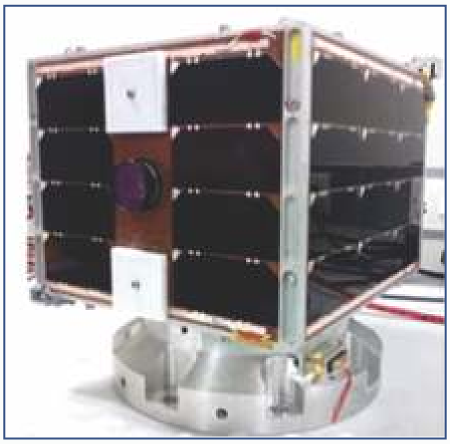
https://www.isac.gov.in/student-satellites/html/sathyabamasat.jsp

PISAT

Mission Name	PISAT
A nano satellite	Developed by PES University, Bangalore and its consortium, under the technical guidance and support from ISRO
Mission objectives	• To design and develop a nano satellite carrying an imaging payload for Earth remote sensing applications. • To track, maintain and operate PISAT.
Payload	Gomspace NanoCam C1U with following features • Sensor: 3MP 10 bit color CMOS sensor with 2048 H x 1536 V pixels • Color filter array: RGB Bayer's pattern • Resolution: ~91m/pixel • Focal Length: 35mm, Aperture : F/4 • Field of View: 9.22o (Half Cone Angle) • Swath: ~186km H x 140km V • Integration Time: 4ms (programmable from 1.0 ms to 83.3 ms) • Pixel Gain : 16 (programmable from 1.0 to 128.0) • Spectral Range: 400-1000 nm (RGB)
Structure	Construction: Aluminum (Al 6061-T6) panels with integral ribs fastened to form cubical structure Satellite dimensions: 254 mm x 226 mm x 181 mm Satellite mass : ~5.35kg (with IWL-150 separation system Fore End Ring)
Attitude determination	3-axis attitude stabilisation
and control system	Pointing accuracy: = ±5o (about all 3 axes) Drift rates: = ±0.01o/sec (about all 3 axes) Sensors: • 4p Sun Sensor: 2 heads (each with 3 cells); accuracy: 5o • Tri-axial Inertial Measurement Unit : Magnetometer, Gyroscope and Accelerometer Actuators: Magnetic Torquers (0.2 Am2 capacity, 3 Nos.) Orbit determination and propagation: SGP4 model.
On-board computer	High Performance 32 bit AVR32 (AT32UC3A0512) RISC µC with in-built ROM, RAM, Timers, Analog data channels, PWM and ACTEL Anti Fuse FPGA (A54SX72A-208) for Telemetry, Telecommand, and glue logic Real Time Clock Interface: On Board Time (OBT) updates every 128 ms count Clock speed: 12MHz Memory: 64 kB SRAM, 512 kB Flash Memory (in-built), 4MB EEPROM

	Storage & file handling system : • HK-Telemetry storage (RAM): Stores 1 frame for every 1 minute (programmable duration) • Payload data storage (2MB EEPROM) Serial Interfaces: • I2C for Payload (NanoCam C1U) EEPROM • SPI for Inertial Measurement Unit (IMU) House Keeping Sensors (Analog Interface): Temperature sensors - 9 Nos. Voltage Sensors -2 Nos. Current Sensors - 2 Nos. External Bus interface: Data bus and Address bus Driving capabilities: GPIO output 5V/ ± 0.04A using H-bridge driver for 3 Torquers - 6 Nos. Heater driver output 5V/0.2A – 5 Nos. Safety Features: Watch Dog Timer (400ms)
RF Communication	S Band Telemetry, Tracking and Telecommand System Uplink and Downlink Frequency (Full duplex): 2030MHz and 2240 MHz Antennas System: 4 Microstrip patch antennae with Omni Coverage (RHC + LHC) Antenna Gain: + 2 dBi at Nadir and -5dBi at 90o Housekeeping data every 128 ms with 100 mW Tx. power Uplink Modulation, Data rate, Rx. Sensitivity: FSK/FM, 100 bps, -90 dBm Downlink Modulation, Data rate, Tx. power: BPSK, 10 kbps (20 kbps after convolution coding), 100mW
Electrical Power System	Battery tied bus Battery: Li-ion cells, 2S-2P Configuration, 5200 mAh capacity Solar array distribution: Total 52 Triple-junction Ga-As body mounted solar cells with 4S-13P configuration distributed as follows: 3 parallel strings mounted on + Roll, -Roll and + Pitch 2 parallel strings mounted on + Yaw and -Yaw Power : Generation: 10W (Average) Power Electronics: DC-DC converters (Buck-Boost) SMD type Special PCB with a Copper Clad Thermal layer for heat sink Current Limiters Snap switch realization using solid state switches (MOSFETs)

Thermal management	Active Thermal Control System Heaters : Payload and Battery – 2 Nos.
Satellite Separation System	IWL-150 (ISRO-VSSC developed and qualified)
Altitude/ orbit	~ 670 km, Polar
Inclination	98.165o
Launch date & lift-off time	September 26, 2016, 9:17 Hrs IST
Launch vehicle	PSLV-C35
Launch site	SHAR Centre, Sriharikota, India



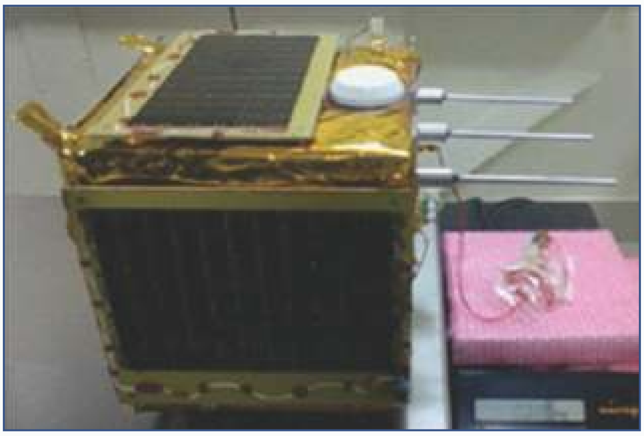
References:

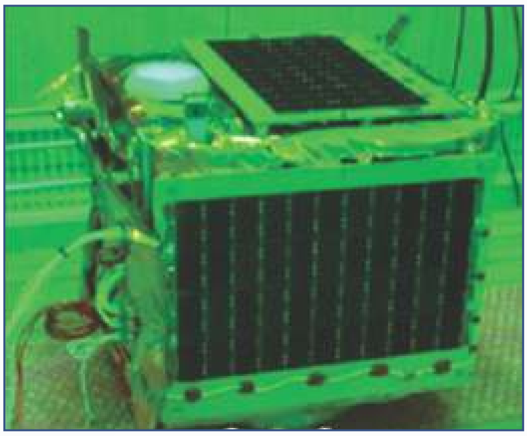
https://www.isac.gov.in/student-satellites/html/pisat.jsp

PRATHAM

Mission Name	PRATHAM
A nano Satellite	Developed by Indian Institute of Technology Bombay, Mumbai, under the technical guidance and support from ISRO
Mission objectives	To measure Total Electron Count (TEC) of ionosphere over India and Paris with a resolution 1km x 1km location grid
Payload	An instrument consisting of two monopole antennae transmitting linear polarized waves at frequencies 145.98 MHz and 437.455 MHz for measurement of TEC of ionosphere.
Structure	Satellite dimensions: 305 mm x 335 mm x 466 mm Material: AL6061-T6 for side panels Satellite mass: ~10.7 kg (with IBL-230 separation system Fore End Ring)
Attitude stabilization system	3 axis attitude stabilization Pointing Accuracy: = ±10o (about all 3 axes) Drift rate: = ±0.01o/s (max.) (about all 3 axes) Sensors: 1) Tri-axial magnetometer Range: ±2 G, Resolution: ±75 µG, Error (1s): 0.1 mG 2) 6 Sun-sensors (LEOS) mounted in orthogonal pairs on three Aluminum housings FOV: ±85o 3) 12-Channel Global Positioning System (GPS) receiver (Accord) • Cold start time: 75 s • Position and velocity accuracy (1s): 10-15 m, 0.12-0.15 m/s Actuator: Magnetic torquers (0.95 Am2, 3 Nos.)
On-board computer	ATmega-128 Microcontroller 16 MIPS throughout at 16 MHz, 128 kB on-chip Flash & 4 kB on-chip EEPROM. On-chip watchdog timer to restart microcontroller in case of lockup Storage system on EEPROM (I2C interface) Real-Time-Clock, 8 MHZ Crystal
House-keeping Sensors	3 Voltage & 2 Current sensors 4 Temperature sensors
RF Communication	Amateur frequency band Uplink and Downlink Frequency (half duplex): 437.455 MHz Antennas: Three monopole antennas • Uplink (UHF) • Downlink (UHF) • Beacon (VHF)

	Beacon: 145.98 MHz, CW, Morse code, 35 words/minute, 200 mW Tx. power Downlink (Modulation, Tx. power & data rate): FSK, 80 mW & 1200 bps Uplink (Modulation, Rx. sensitivity & data rate): FSK, -118 dBm & 1200 bps
Battery	Li-ion cells pack, 2S-3P configuration Capacity: 7800 mAh
Solar Array	Distribution: Total 4 solar panels. Single junction Ga-As body mounted solar cells with 11S-4P configuration on three sides (sun-side, leading and lagging sides) and 11S-3P configuration on zenith side. Power generation: 10 W (average)
Thermal management	Passive thermal control system
Satellite Separation System	IBL-230 (ISRO-VSSC developed and qualified)
Altitude/ orbit	~670 km, Polar
Inclination	98.165o
Launch date & lift-off time	September 26, 2016, 9:17 Hrs IST
Launch vehicle	PSLV-C35
Launch site	SHAR Centre, Sriharikota, India





References:

https://www.isac.gov.in/student-satellites/html/pratham.jsp

NIUSAT

Mission Name	NIUSAT
Nano Satellite	Developed by Noorul Islam University , Kumaracoil, Thukkalay, Kanyakumari District, Tamil Nadu, under the technical guidance and support from ISRO
Mission objectives	Imaging Earth in visible range
Payload	Indigenously developed 3 Band (RGB) multispectral camera - 30M resolution and 60 square km area
Structure	Satellite dimensions: 348 mm x 348 mm x 370 mm Material: AL6061-T6 for side panels Satellite mass: ~14.93 kg
Attitude stabilization system	3 axis attitude stabilization Reaction Wheel : Maximum momentum storage = 30 mNms Maximum torque = 1.5 mNm Pointing Accuracy: = ±0.5o (about all 3 axes) Drift rate: = ±0.02o/s (max.) (about all 3 axes) Sensors: 1) Tri-axial magnetometer Range: ±1.3 G, Resolution: ±92 µG, Error (1s): 0.1 mG 2) 8 Sun-sensors mounted in orthogonal pairs on four Aluminum housings FOV: 120o 3) Gyroscope : Digital Resolution- 0.02o / sec Operation Range +/- 450 o / sec Actuator: Magnetic torquer Maximum magnetic Dipole (B) =3.75 mA sq. meter
On-board computer	High performance dual core 32 bit E200 power architecture 2MB code Flash Memory with ECC 16 GB storage flash for payload data Support I ^ 2 C ,CAN, SPI, and UART ports Support software timers and WDT
House-keeping Sensors	12 Temperature sensors
RF Communication	HKTM data transmitter in UHF (420-450 MHZ) Tele-command receiver in VHF (144-148 MHZ)

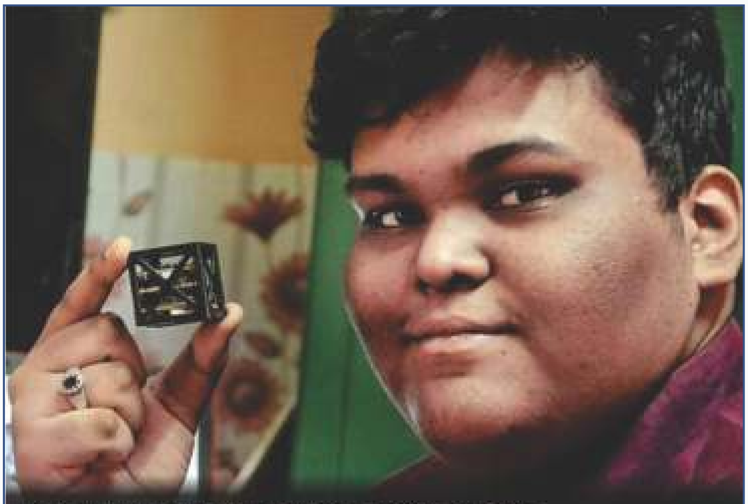
	Antennas: Monopole antenna for UHF/VHF data transmission and Reception • Uplink (VHF) • Downlink (UHF) • S band transmitter for payload data High gain patch antenna for S-Band transmitter ; 2200MHz to 2500MHz Downlink (Demodulation, & data rate): FSK and AFSK for TM,& 1200 bps Uplink (Modulation, & data rate): FSK & AFSK, & .5Kbps to 80 Kbps
Battery	Li-ion cells pack, 2 Battery 5Ah Capacity: 10Ah
Solar Array	Distribution: Total 4 Multi junction solar cells based solar array with deployable panels.40 W power generation using $ numbers of deployable and sun tracking solar panels. Power generation: 40 W (average)
Thermal management	Passive and active thermal control system
Satellite Separation System	IBL-230 (ISRO-VSSC developed and qualified)
Altitude/ orbit	560-880 km, Polar
Inclination	97-99 deg
Launch date & lift-off time	23rd June 2017, 9:30 Hrs IST
Launch vehicle	PSLV-C38
Launch site	SHAR Centre, Sriharikota, India

References:

https://www.isac.gov.in/student-satellites/html/niusat.jsp

THE HINDU
May 12, 2017 07:53 IST

Karur student's satellite model to soar high



Rifath Shaarook with the satellite model at Pallapatti, Karur. | Photo Credit: A. Muralitharan

It is the only model selected from India to be launched by SR 4 rocket

For eighteen-year-old Md. Rifath Shaarook, who is awaiting his Plus Two results, a small room in his house situated in a narrow lane of Pallapatti in Karur district, Tamilnadu is his space research station. He is not perturbed about his Plus Two results, which will be out on Friday. But his actions and thoughts centre around the "Femto" experimental satellite designed by him with a group of five other students.

The satellite that weighs just 64 grams was among 80 models selected among 86,000 designs submitted by young contestants belonging to 57 countries in the "Cubes in Space" contest organised by Idoodle Learning in association with NASA. The satellite is the only model selected from India to be launched into the sub-orbital space by SR 4 rocket.

The satellite is made of reinforced carbon fibre with 3-D printing technology. It took more than two-years for Shaarook and his team to design the less weight satellite using the 3-D printing technology at a cost of just ?1 lakh.

"I am eagerly awaiting the launch of our satellite. It will be a big day for not only me but also for the aspiring space scientists," says a beaming Shaarook, who lost his father Mohamed Farook when he was studying in Class-V at a government primary school in Pallapatti.

The satellite with sensors would carry out its mission from the moment of its launch.

It would be in sub-orbital spaceflight for 12 minutes and would then land back in the ocean.

It would capture and record temperature, atmosphere, radiation level, rotation buckling and magnetosphere, said Shaarook, who is a "lead scientist" in Chennai-based Space Kidz India, which is encouraging aspiring space students.

Vinay Bharadwaj, Tanishq Dwevdi, Yagnasai, Abdul Kashif and Gobi Nath were part of the team that designed the satellite.

Srimathy Kesan, Chief Executive Officer, Space Kidz India, Chennai, said that hard work, commitment and innovation of the team led by Rifath Shaarook had given a splendid recognition to young aspiring scientists. It would motivate other students too.

Ever since Shaarook revealed the selection of his satellite for the launch, his house in Pallapatti continues to get steady visitors. Moreover, Crescent Matriculation Higher Secondary School in Pallapatti, where he is now studying has also got congratulatory messages.

Courtesy by
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Conference on Small Satellites

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Small Launch Vehicles – A 2018 State of the Industry Survey

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ABSTRACT

The 2010's has seen a dramatic increase in potential small launch vehicle contenders, which we define as rockets capable of carrying at most 1000 kg to Low Earth Orbit. Spurred on by government programs such as SALVO, VCLS, and Horizon 2020, and the rapid proliferation of CubeSats and nanosatellites, more than 50 different commercial, semi-commercial, and government entities worldwide are now working on new entrants of this class. To date the most successful small launcher, the Northrop Grumman Pegasus has launched 43 times, but its flight rate has dropped to less than one a year. At the same time launch opportunities on ESPA rings, secondary slots on larger launchers, and CubeSat missions as cargo to the International Space Station have proliferated. Despite this seemingly bleak market environment, new entrants have merged looking for a new magic formula. This paper presents an overview of the small satellite launch systems under development today. We compare capabilities, stated performance goals, cost, and funding sources where available. This paper is a yearly update of a paper originally presented at the 2015 AIAA/USU Conference on Small Satellites.[1] The authors welcome any comments, feedback, or corrections.

INTRODUCTION

The Tradition of Small Launch Vehicles

Many of today's heavy launch vehicles (LVs) – Atlas V, Delta IV, Falcon 9, and Ariane 5 – started their lives in a smaller form. The Delta IV as Thor, growing from an Intermediate Range Ballistic Missile with space launch capabilities a bit above a metric ton to one of the heaviest launch vehicles the US is currently flying. Atlas V from an InterContinental Ballistic Missile with staging engines and a pressure stabilized tank to today's launch vehicle that nearly equals the Delta IV heavy in capability. Ariane 5 grew from the purpose-designed Ariane 1. Similarly SpaceX's Falcon 1 was quickly abandoned in favor of the larger Falcon 9 which in turn evolved into the Falcon Heavy. Of the small launchers in the 60s and 70s, only the Scout stayed small – limited by its technology and eventually being replaced by the Pegasus to fulfil NASA's need for a small space launch vehicle. Athena joined Pegasus and Taurus, and several versions of Minotaur came along to utilize excess government assets in meeting the small space launch need, but the low launch rate destined these vehicles to high-priced niche markets.

The Second Small Sat Revolution

Just like ORBCOMM and Iridium led the commercial perception of a need for small launchers in the 1980s and 90s (and directly resulted in the Pegasus development), CubeSats and new constellations such as OneWeb and Planet are leading the demand now. As small satellite capability increases, operators are no longer satisfied with the traditional rideshare and secondary payload opportunities available to them. During the past decade, there has been an increasing swell of interest in having new, lower cost, dedicated small launchers. This has led to a new wave of proposed small launch vehicles ranging in capability from a single 3U CubeSat (roughly 5 kg) to larger small launch vehicles reaching up to 1000 kg to Low Earth Orbit (LEO).

These vehicles are hoping to solve the same problem that vexed the earlier generation of small launchers and satellites – large constellations are only financially feasible if launch costs are low, but launch costs can only be kept low if there is a high rate of launch. This "chicken and egg" problem proved untenable in the 90s, and it remains to be seen whether it can be solved today.

Drivers and Motivation

For many of the new entrants the drive to develop a new vehicles is purely commercial. Driven by visions of hundreds, if not thousands, of small satellites launching annually; buoyed by venture capitals markets that become friendlier to space endeavors; and inspired by the highly visible success of SpaceX, entrepreneurs across the globe have embarked on what was once considered the incredibly risky and financially non-rewarding venture of designing and fielding a new rocket. Furthermore, beyond the commercial visions of economic glory, the lure of government contracts has likewise increased.

In recent years, The U.S. Department of Defense (DOD) and NASA have significantly increased the attention paid to small launchers. As small satellites increase in utility and capability, DoD and its associated agencies are interested not just in traditional launch services, but also in “launch on demand” services. Programs like DARPA’s Airborn Launch Assist Space Access (ALASA) and NASA’s Venture Class Launch Services (VCLS) promised to fund new entrants in their development of small launch vehicles. The latest DARPA launch challenge aims to launch payloads with just 14 day notice to a previously unspecified orbit. The successful team stands to win a $2M reward on the initial launch and $10M reward on a second launch within two weeks. To many of the small launch vehicle contenders, DARPA’s interest makes a lot of sense. “[DARPA's] seeing the same scenarios or requirements that a lot of us are seeing — the need for more responsive access," said John Garvey, president of launch services at Vector.[2]

Across the Atlantic, European governments have not been idle either. ESA’s Future Launchers Preparatory Programme (FLPP)[3] and studies funded through the European Union’s Horizon 2020[4] have both contributed needed investment in the European market. Individual countries have also taken a new interest in small satellites; for instance the United Kingdom has been actively pursuing potential launch sites for many of the new entrants.

A significant new player in the small launch vehicle arena is China. While China has been on the foreground of global launch services for many years, in the past four years they have also made significant investments in the domain of small launch vehicles. Of the 40 vehicles captured in this survey, six are from China. Three of them are currently operational, the most of any country. One of the factors that makes Chinese involvement particularly interesting is that several of the companies, such as Linkspace, are privately held. In the past all of Chinese launch efforts were carried out through state-owned companies or agencies. It is not clear at this point how much government involvement, technology, or funding has been given to these companies, but it is evident that, at least on paper, there is a formal separation between the Chinese government and the launch vehicle developers. This is all part of a big bigger effort in China; the Beijing-Based consulting firm Future Aerospace recently stated that there are over 60 private Chinese firms in existence.[5]

Although at the moment U.S. companies are prohibited from using Chinese launch services, companies in most of the rest of the world do not have such limitations. Thus U.S. launch companies will feel significant competitive pressure from their Chinese counterparts. This is part of an overall drive by Chinese leadership to significantly increase commercial space activities in the country.[6]

Underlying all the government and commercial investment is the very fast growth in small satellites over the past ten years. SpaceWorks Commercial in their 2018 Nano-Microsatellite Market Forecast projects up to 2,600 nano-microsatellites launching in the next 5 years as shown in Figure 1.[7] This growth matches the growth in private investment dollars and government interest throughout the world, but especially in the United States. There is also a perceived shortage of launch opportunities with many of the new entrants habitually quoting a “2 year backlog” on existing vehicles as a potential differentiator for their on endeavor. The potential for capturing even a small portion of this market is what drives many of the organizations developing new vehicles.

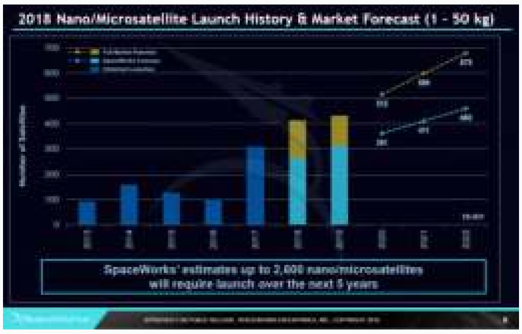

Figure 1: Growth in nano/microsatellite market (Source: SpaceWorks)

SURVEY CRITERIA

This survey’s goal is to identify active commercial (or so designated) efforts in the field of small launch vehicles. Before starting the survey we laid down some requirements for inclusion in the list. This was needed both to limit the field and to provide some clear definition of what an “active effort” entails. These requirements are neither scientifically rigorous nor complete; rather they are simply designed to serve as a filtering mechanism. The requirements, with some minor variations have remained the same in every yearly edition of the survey (the 2016 edition limited the upper mass of the payload performance to 500 kg, with only 3 vehicles dropping out of the survey).

To be included in this list a launch vehicle under development must meet the following requirements:

- Have a maximum capability to LEO of 1000 kg (definition of LEO left to the LV provider).

Table 3: Small Launch Vehicles Under Development

Organization	Vehicle Name	Country	Latest Launch Date
ABL Space Systems	RS1	USA	Q3 2020
Aphelion Orbitals	Helios	USA	2021
Bagaveev Corporation	Bagaveev	USA	2019
bspace	Volant	USA	2018
Celestia Aerospace	Sagitarius Space Arrow CM	Spain	2016
Cloud IX	Unknown	USA	
CONAE	Tronador II	Argentina	2020
CubeCab	Cab-3A	USA	2020
Departamento de Ciencia e Tecnologia Aeroespacial	VLM-1	Brazil	2019
ESA	Space Rider	Europe	2020
Firefly Aerospace	Firefly Alpha	USA	Q3 2019
Gilmour Space Technologies	Eris	Australia/Singapore	Q4 2020
Interorbital Systems	NEPTUNE N1	USA	
ISRO	PSLV Light	India	Q1 2019
LandSpace	LandSpace-1	China	H2 2018
Launcher	Rocket-1	USA	2025
LEO Launcher	Chariot	USA	Q4 2018
Linkspace Aerospace Technology Group	NewLine-1	China	2020
One Space Technology	OS-M1	China	2018
Orbex	Orbex	United Kingdom	
Orbital Access	Orbital 500R	United Kingdom	2020
PLD Space	Arion 2	Spain	3Q 2021
Rocketcrafters	Intrepid-1	USA	Q1 2019
RocketStar	Star-Lord	USA	2018
Skyrora	Skyrora XL	UK/Ukraine	
Space Ops	Rocky 1	Australia	2019
SpaceLS	Prometheus-1	United Kingdom	Q4 2017
SpinLaunch	Unknown	USA	
Stofiel Aerospace	Boreas-Hermes	USA	2019
Stratolaunch	Pegasus (Strato)	USA	
VALT Enterprises	VALT	USA	
Vector Space Systems	Vector-R	USA	H2 2018
Virgin Orbit	LauncherOne	USA	H1 2018
zero2infinity	Bloostar	Spain	2017

MARKET SURVEY

We conducted a market survey to identify a variety of performance, design, and financial parameters. Each of the following sections presents a subset of these parameters. Not all companies will be listed in all tables, as some information may not be available. For simplicity sake, subsequent tables will only refer to the ***Vehicle Name***. Where one organization has multiple vehicles under development, the smallest vehicle will be listed. All operational vehicles are also included to provide a comparison. Operational vehicles are highlighted in **Green**.

Launch Method/Location

To start the characterization of the launch system, we will start with the fundamental base – how/where the space launch system starts its journey to space. For many of the launch systems, this has not been designated at this time; in that case only the launch mode will be designated – ground, water, air (carrier aircraft), or balloon. Table 4 lists details of how the space launch system starts its journey upward, and the published launch location. It is worth noting that while ground, water, and carrier aircraft based systems already exist, balloon-based systems are a new concept not previously seen. In the "Other Potential Player" section, there are also entrants with more exotic launch methods such as electro-rails and gas guns.

Vehicle Technology

Many of the new entrant launch vehicles have a technology or concept that is their key to reducing the cost of space access. All are assuming that many launches will be in the manifest – almost nobody goes into this market assuming that they are only going to launch every few years. In this section, we will outline the vehicle details – number of stages, propellant, "breakthrough" idea, and any other pertinent facts that make the vehicle stand out from their competitors. The benefits of the technology described are as presented by the developer; the authors have not attempted to validate,

Table 4: Launch Type and Location

Vehicle Name	Launch Type	Launch Location
Arion 2	Land	South Europe
Bagaveev	Land, Sea	
Bloostar	Balloon	Int'l Water
Boreas-Hermes	Balloon	
Cab-3A	Air	KSC, Int'l Water
Chang Zheng 11	Land, Sea	China
Chariot	Air	
Cloud IX	Air	
Electron	Land	Birdling's Flat, New Zealand
Eris	Land	Queensland, Australia
Firefly Alpha	Land	VAFB, Cape Canaveral, Spaceport Camden, Wallops
Helios	Land	
Intrepid-1	Land	Kennedy Space Center
Kaituozhe-2	Land	China
Kuaizhou-1A	Land	China
LandSpace-1	Land	Wenchang, Hainan, China
LauncherOne	Air	Int'l Water
Minotaur I	Land	VAFB, KLC, WFF, CCAFS
NEPTUNE N1	Land, Sea	Moody Space Centre, Australia. Int'l Water; also US?
Orbital 500R	Air	Malta
Pegasus (Strato)	Air	Mojave, CA
Pegasus XL	Air	Int'l Water – Multiple locations demonstrated
Prometheus-1	Land	
PSLV Light	Land	
RS1	Land	Camden, GA; Kodiak, AK
Sagitarius Space Arrow CM	Air	Int'l Water, Spanish airport
Skyrora XL	Land	Scotland
Space Rider	Land	Kouru
Star-Lord	Sea	KSC, 20 km offshore
Tronador II	Land	Puerto Belgrano Naval Base
VALT	Land, Sea, Air	
Vector-R	Land, Sea	Kodiak, Cape Canaveral, Wallops
VLM-1	Land	Alcatara, Brazil
Volant	Land	Kodiak

evaluate, or in any other way judge the described technology.

Arion 2 – PLD Space's vehicle is a liquid fueled, three stage rocket. In an effort to reduced costs, PLD plans to make portions of the rocket reusable. Due to its southern Europe launch site, the rocket will be able to access retrograde orbits with inclinations up to 140°. Unique amongst most vehicles here, PLD also lists potential payload mass delivered to lunar orbit (5 kg).

Bagaveev – Bagaveev's rocket is a very small launch vehicle optimized for CubeSat-class spacecraft. It will utilize a 3D printed engine (the company claims to have been the first to successfully test-fly a 3D printed engine). The vehicle is a two stage rocket which can be launched from land or a sea-faring platform.

Bloostar – Zero2Infinty offers a unique launch vehicle design that is lofted via high altitude balloon before being air launched. Since the powered flight occurs in the upper atmosphere where atmospheric density is negligible, the Bloostar utilizes three concentric, toroidal stages rather than traditional, elongated, in-line stages. All stages utilize liquid cryogenic propellants and identical engines – varying the number of engines per the stage requirements.

Boreas-Hermes – The Hermes is launched from a balloon system dubbed Boreas being developed by Stofiel Aerospace. Key to their design is what the company claims is the first solid fuel rocket to thrust, throttle, and vector, as well as a proprietary thermal coating. The system is designed to have a wide range of payload scalability from 15 kg to 250 kg.

Cab-3A – CubeCab's small launch vehicle is optimized for launching a 3U CubeSat. The CubeCab is launched from an F-104 fighter yet. Details on the rocket design are not publically available, but the propellants will be room-temperature storable to facilitate aircraft-like operations.

Chang Zheng 11 – Also known as Long March 11, CZ11 is developed by China's Aerospace Science and Technology Corporation (CASTC). It is a four stage solid motor rocket believed to be derived from the DF-31 ICBM. There are reports that in addition to land launches, the CZ11 will also be compatible with sea launches. OPERATIONAL as of 25 September 2015.

Chariot – The Chariot from LEO Launcher intends to use only previously developed technology, but the details of the rocket have not been released. Some reports indicate that it may not just utilize previously developed technology, but a previously developed flight-proven system.

Cloud IX – This currently unnamed rocket by Cloud IX is a balloon lofted vehicle which will deploy from an altitude of 41 km. It is a relatively small two stage, solid motor rocket. Cloud IX is aiming for rapid deployment within 60 days of contract authorization anywhere in North America.

Electron – Rocket Lab's Electron rocket is a two stage vehicle powered by LOx and RP-1. To reduce the complexity of the engines while maintaining high performance, Electron has designed electric turbopumps that are powered by batteries rather than combustion products. The Electron also utilizes a composite structure and 3D printed engines to increase performance and decrease cost. OPERATIONAL as of 21 January 2018.

Eris – Rocket engine developer Gilmour Space Technologies is hoping to expand its business into full suborbital and orbital launch vehicles. The Eris is a three stage rocket utilizing hybrid propulsion. Unique to its propulsion technology is hydrogen peroxide as an oxidizer combined with a proprietary high Isp fuel that will be 3D printed.

Firefly Alpha – Firefly Aerospace utilized and expanded the design of the former Firefly Space Systems Firefly α to develop a larger launch vehicle. The Alpha abandons a number of Firefly α's more exotic technologies such as a methane-based aerospike engine for "well established" technologies such as a LOX/Kerosene conventional engines. Firefly Alpha is a two stage rocket able to launch twice a month from a wide variety of sites.

Helios – Aphelion Orbitals is developing the Trailblazer suborbital vehicle that will also serve as the second stage for the three stage orbital Helios rocket. The Helios utilizes a combination of Lox/Methane and solid stages. An aerospike engine and proprietary high density propellant combination allow the vehicle to remain tailored for its small-sized specifications. This is one of the few vehicles that have had an *increase* in potential launch mass as the concept evolve (from 14 kg to 20 kg).

Intrepid-1 – The Rocketcrafter's Intrepid-1 uses a patented and proprietary hybrid rocket technology to power its two stages. Initial plans are to launch Intrepid-1 from existing pads at the Kennedy Space Center in Florida. The company has previously looked at point-to-point delivery systems as well as larger variants of the Intrepid.

Kaituozhe-2 – Kaitouzhe-2 is another entrant from the China Aerospace Science and Technology Corporation (CASTC). While not much information is available, it is believed to be derived from the DF-31 missile. OPERATIONAL as of 3 March 2017.

Kuaizhou-1A – Sometime's also known as Fei Tian 1, the Kuaizhou-1A is believed to be a commercial variant of the Kuaizhou-2 military launch vehicle. It is developed by ExSpace, the private sector arm of the China Aerospace Science and Industry Corporation (CASIC). It is a three stage solid motor rocket designed for rapid response launches from a mobile launch platform, especially of imaging satellites. OPERATIONAL as of 9 January 2017.

LandSpace-1 – Sometimes billed as the "Chinese SpaceX" LandSpace plans to offer one-stop-shop solutions to its customers, including launch services, logistics, TT&C, and insurance. The LandSpace rocket is a four stage solid motor rocket that is small enough to fit on a mobile launch platform and be transported by cargo container.

LauncherOne – LauncherOne is Virgin Orbit's (formerly Virgin Galactic) entry into the orbital space launch domain. LauncherOne is air launched from a modified Boeing 747 as its carrier aircraft. The company is applied the experience gained in developing Spaceship Two to the initial development of LauncherOne, but has since separated operations into two different companies under the Virgin umbrella. LauncherOne is a two stage vehicle powered by LOx/RP-1 and utilizes an all composite design.

Minotaur I – The Minotaur I is a four stage solid launch vehicle. It uses the lower two stages from a Minuteman ICBM (USAF provided) and the upper two solid rocket motors, avionics, and fairing that were originally derived from Pegasus. It has the option for a larger fairing that takes advantage of the greater mass capability to orbit that the Minotaur I has over Pegasus. Originally developed by Orbital Sciences, which is now part of Northrop Grumman. It has had 11 launches with 100% reliability. OPERATIONAL as of 27 January 2000.

NEPTUNE N1 – The N1 from Interorbital systems is the smallest in their line of modular NEPTUNE launchers. All NEPTUNE launchers are assembled from multiple Common Propulsion Modules (CPMs) with an engine utilizing a mixture of white fuming nitrous acid and turpentine. The N1 utilizes one CPMs as its first stage with two smaller tandem upper stages.

Orbital 500R – Orbital Access will use an air launched scheme utilizing a converted jet liner, likely a DC-10, as the carrier aircraft. The company has not disclosed any design details for its rocket.

Pegasus Strato – Stratolaunch is developing a custom-built carrier aircraft specifically designed for air launching rockets. In its initial configuration the Stratolaunch aircraft will be able to carry up to three Pegasus XL rockets. Different from all the other entrants in our list, this is primarily an aircraft development effort rather than a launch vehicle development effort.

Pegasus XL – The Northrop Grumman Pegasus, uses three solid rocket motors and is launched from a modified Lockheed L-1011 carrier aircraft. The aircraft allows the small space launch vehicle to be launched from any site with local large aircraft landing facilities and appropriate range safety capabilities. Originally designed by Orbital Sciences (now part of Northrop Grumman), Pegasus has launched (taken off) from seven different launch sites, and used 5 different ranges over its 43 launch lifespan.

Prometheus-1 – SpaceLS seeks to keep costs down by optimizing the design and production of its Prometheus-1 rocket even if it comes at the expense of system performance. Prometheus-1 utilizes hydrogen peroxide/kerosene engines and will have a reusable first stage.

PSLV Light – PSLV Light is a derivative of the Indian Space Research Organization (ISRO) Polar Space Launch Vehicle (PSLV). Designed to cater to the smaller satellite market, PSLV Light will be able to undergo final assembly in 3 days and will have manufacturing costs that are one tenth of the larger variant.

RS1 – ABL Space Systems is utilizing propulsion systems from Ursa Major Technologies to outfit its RS1 space launch vehicle. The RS1 will utilize a "Dirt Simple" design in order to minimize costs. As a result launch operations are expected to require no fixed infrastructure and have service will have a one-week call up time. RS1 is a two stage vehicle with RP-1/LOX engines.

Sagitarius Space Arrow – Celestia Aerospace's Sagitarius Space Arrow is a flexible air launch system utilizing existing fighter jet and missile vehicles. The modified missiles are carried aloft by a MiG 29 UB fighter. The MiG 29 permits use of two different configurations: four smaller rockets, or one larger rocket. The rockets utilize solid propellants for their propulsion.

Skyrora XL – The same Ukranian team that helped develop the first engine from the Antares and Sea Launch rockets has spun off to develop a new launch vehicle known as Skyora XL. It will be a three stage rocket utilizing Hydrogen Peroxide and RP-1.

Space Rider – Funded by ESA, the Space Rider is a reusable space plane launched on top of a Vega-C. The Vega-C itself is a four stage vehicle (3 solids + 1 liquid) with performance that exceeds the 1000 kg threshold for this survey. However, the Space Rider system will have a lower payload capability. Reusability of the spaceplane is partially achieved by a parafoil landing system.

Spin Launch – Spin Launch is a unique company aiming to "revolutionize the space-launch industry". Very little is known about their solution other than it is based on a centrifuge/sling shot that achieves 4800 km/hr. While there does not seem to be enough information to include them in this survey, financial findings indicate that they have raised as much as $55M USD, warranting inclusion due to their being one of the best funded companies on our list.

Star-Lord – RocketStar is developing the two stage Star-Lord vehicle. The first stage utilizes a cluster of eight engines to create an aerospike engine. Production will utilize a significant number of 3D printed parts. This LOX/Methane system is baselined to launch form an off-shore platform. The ultimate goal of the company is to achieve a Single Stage to Orbit (SSTO) design.

Tronador II – Comision Nacional de Actividades Espaciales (CONAE)'s two stage Tronador II uses LOX/RP-1 in the first stage, and hydrazine/nitrogen tetroxide for the second stage.

VALT – The Vertical Air Launch Technology (VALT) rocket from VALT enterprises uses an air-breathing vertical multi-stage rocket to eliminate the need to carry oxidizers for part of the trajectory, greatly decreasing the size of the rocket. The performance of a 20,000 lb rocket should be accomplished with a rocket weighing only 3500 lbs.

Vector-R – Vector Space's Vector-R launch vehicle is a two stage all composite, pressure fed propylene/LOX liquid rocket, with an optional electric propulsion third stage. Cost control is achieved through a high flight rate. The rocket is designed to be mass produced to reduce costs. An optional electric propulsion third stage is available.

VLM-1 – The VLM-1 is being designed by Brazil's Department of Aerospace Science and Technology (CTA by its Portuguese initials). It will utilize the VS-50 suborbital vehicle's first stage motor. The German DLR is assisting with the qualification of the motors. It is a two stage vehicle utilizing solid propellants.

Volant – bspace plans to use Orion and Star motors developed for the Pegasus and optimize them to create a 3-stage, land-launch rocket system.

KEY PARAMETERS

There are several factors that one looks at when investigating a launch vehicle, regardless of size. These are explored, to the extent possible, with the small launch vehicles.

Performance

The primary parameters of launch performance is how much mass the vehicle can lift to space. Vehicle developers do not have a standard way of quoting

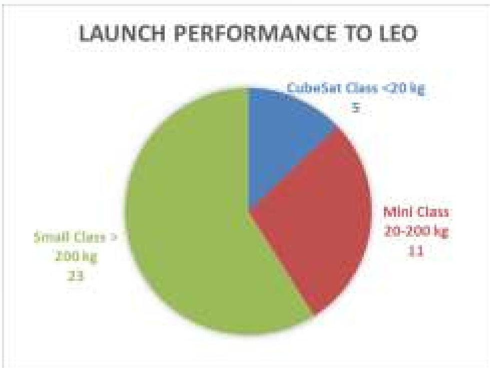

Figure 2: Performance Classes for Launch Vehicles

performance, so it is difficult to normalize across multiple vehicles. Roughly speaking vehicles can be broken down into "CubeSat" (< 20 kg), "Mini sat" (2-200 kg), and "Small Sat" (200-1000kg) classes. The distribution of entrants in these three categories is shown in Figure 2.

Table 5 lists the published payload capability for each vehicle. When a developer has specified it, a definition for a reference "LEO" orbit is provided. Unless labeled as Sun Synchronous Orbit (SSO), it is assumed that the reference LEO orbit is between 0° and 28.5° inclination. For vehicle's that are part of a multi vehicle family, performance for the smallest vehicle is given. For vehicles that have enhanced/optional upper stages the highest vehicle performance is given when available. No accounting has been made for the mass of supporting hardware (for example, separation systems). Different systems treat this differently, for instance: for Minotaur USAF missions, the separation system mass is considered payload weight; for Pegasus NASA missions, it is Launch Vehicle weight. For small missions, this is not insignificant. Because the performance numbers are not normalized a one-to-one comparison is not necessarily possible, even though we have presented the vehicles sorted by their nominal performance value.

Table 5: System Performance

Vehicle Name	Performance	Orbit
Cab-3A	5 kg	400 km
NEPTUNE N1	6 kg	310 km SS)
Bagaveev	10 kg	SSO
Rocky 1	10 kg	600 km SSO
Sagittarius Space Arrow CM	16 kg	LEO
Helios	20 kg	400 km
Cloud IX	22 kg	515 km
VALT	25 kg	500 km SSO
Vector-R	30 kg	450 km SSO
Bloostar	75 kg	600 km SSO
OS-M1	143 kg	300 km SSO
Arion 2	150 kg	400 km
Electron	150 kg	500 km SSO
VLM-1	150 kg	LEO
LandSpace-1	200 kg	500 km SSO
NewLine-1	200 kg	500 km SSO
Volant	215 kg	LEO
Orbex	220 kg	200 km
Boreas-Hermes	250 kg	LEO
Kaituozhe-2	250 kg	SSO
Kuaizhou-1A	250 kg	500 km SSO
Prometheus-1	250 kg	LEO
Tronador II	250 kg	600 km SSO
LauncherOne	300 kg	500 km SSO
Rocket-1	300 kg	200 km
Star-Lord	300 kg	185 km
Skyora XL	320 kg	600 km SSO
Chang Zheng 11	350 kg	SSO
Intrepid-1	376 kg	500 km SSO
Eris	380 kg	350 km
Pegasus (Strato)	455 kg	LEO
Pegasus XL	468 kg	200 km
Orbital 500R	500 kg	600 km SSO
PSLV Light	500 kg	LEO
Minotaur I	584 kg	200 km
Firefly Alpha	600 kg	500 km SSO
RS1	650 kg	500 km SSO
Chariot	681 kg	LEO
Space Rider	800 kg	400 km

Mission Cost

Perceived advantage in cost is the real key to this sudden expansion in small launch vehicles. The current launch vehicles on the market are seen to be far too expensive to support the business plans of the upcoming small satellite market expansion. Cost containment is also the key to continued market success of the vehicle as past vehicles have seen their cost increase significantly from original estimates once they became operational. Table 6 outlines the planned launch service price, with a comparative cost basis utilizing Table 5's mass performance extrapolated in an attempt to normalize the metric. Launch costs are in millions of US Dollars; costs per kg are in thousands of US Dollars per kg.

Table 6: Launch Costs

Vehicle Name	Projected Launch Cost (US$M)	Estimated Cost per kg (US$k)
Firefly Alpha	$10.0 M	$10.0 k
Sagitarius Space Arrow CM	$0.2 M	$14.7 k
OS-M1	$3.2 M	$15.5 k
RS1	$17.0 M	$18.9 k
Kuaizhou-1A	$5.0 M	$20.0 k
Star-Lord	$6.0 M	$20.0 k
Boreas-Hermes	$5.0 M	$20.0 k
LauncherOne	$10.0 M	$20.0 k
Vector-R	$1.5 M	$22.7 k
Eris	$8.7 M	$23.0 k
NewLine-1	$4.7 M	$23.4 k
Intrepid-1	$9.0 M	$23.9 k
Bagaveev	$0.3 M	$25.0 k
Helios	$0.6 M	$27.5 k
Electron	$4.9 M	$32.7 k
Rocket-1	$10.0 M	$33.3 k
NEPTUNE N1	$0.3 M	$39.7 k
Space Rider	$32.0 M	$40.0 k
Bloostar	$4.0 M	$40.0 k
Arion 2	$7.1 M	$47.1 k
Cab-3A	$0.3 M	$50.0 k
VLM-1	$10.0 M	$66.7 k
VALT	$1.7 M	$68.0 k

Figure 3 shows the same data graphically. The cost per kg metric should only be used as a rough comparison metric. Absent more specific data, a number of assumptions had to be made in order to normalize the data. For instance, mass to a nominal low LEO orbit (e.g. 200 km) was treated the same as mass to a high sun-synchronous LEO orbit. When multiple orbits or a range of launch costs were given, we picked the numbers that resulted in the lowest cost per kilogram. No obvious trend is discernable in the cost per kg, but it is interesting to note that all vehicles with performance under 500kg have a cost under $10M. Nonetheless, none of the vehicles come close to the much lower per kilogram cost of larger rockets such as the Falcon 9 ($2.7k/kg for the reusable variant).

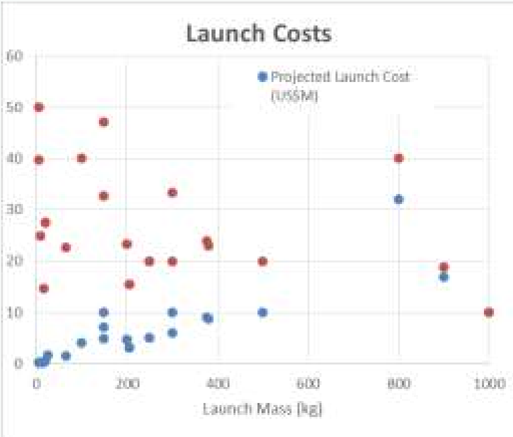

Figure 3: Launch Costs

Launch Frequency

A key aspect of many of these newer systems is the goal of achieving very high launch rates. These high launch rates are seen as critical to helping drive costs down. Several of the teams designing new vehicles have publically stated what their ultimate launch rate goal is. Note that for most systems, it is expected that it will take several years before this optimal launch rate is achieved. Table 7 captures the publically announced target launch rates.

Table 7: Projected Launch Frequency

Vehicle Name	Launch Frequency
Arion 2	10/year
Bagaveev	50/yr
Electron	1/week
Firefly Alpha	2/month
Kuaizhou-1A	10/year
LauncherOne	24/yr
Star-Lord	1/month
VALT	1000s/year
Vector-R	100/yr
Volant	Multiple/quarter

Funding Source

Traditionally, governments have been the main source of funding for launch vehicle development; however, much like in the wave of development in the 1990s, many of vehicles under development today are utilizing private funding. Some are entirely founder-funded, while others are funded through venture capital, prizes, and other mechanisms. This section details a key parameter to system achieving initial launch success. Any space launch vehicle can be made to successfully achieve launch if funding is adequate to overcome all obstacles that will be encountered in development. Table 8 lists all the identified external sources of funding for each vehicle. Self-funding for all the vehicles is assumed and therefore not called out in the table. The amount of external funding varies from a few thousand dollars to millions of dollars in investment; e.g. NASA may have provided the company a small SBIR contract valued at $50k. Because of strategic reasons many companies keep this information under tight control, and thus it is not publically available.

Table 8: Financial Investment Sources

Organization	Funding Source
Aphelion Orbitals	Angel investors
Bagaveev Corporation	Tim Draper, Adam Draper, DCVC, New Gen Silicon Valley Partners, Wei Guo, Data Coolective, Sand Hill Angels
Celestia Aerospace	One signed up customer
CubeCab	Biz Plan Competition, Self funded
ESA	ESA
ExPace	8 investment institutions
Gilmour Space Technologies	Blackbird Ventures, 500 Startups
Interorbital Systems	Self, Presales
LandSpace	Angel Investors; Series B (all from non-government)
One Space Technology	Legend Holdings, HIT Robot Group at Harbin Institute of Technology, Chun Xiao Capital, Land Stone Capital
Orbex	High-Tech Gründerfonds, private investors, the UK Space Agency and the European Commission Horizon 2020 programme
PLD Space	Spanish government, EC, Caixa Capital Risc, Gobierno de Aragon, GMV, ESA, Gonzalo de la Pena, EC
Rocket Lab	NZ Gov, Kholsa, VBP, K1W1, LM, Promus Ventures, Bessemer, Data Collective
Rocketcrafters	State of Florida, DARPA
SpinLaunch	Adrian Aoun, Asher Delug
Stratolaunch	Paul Allen
VALT Enterprises	Office of Naval Research, Mainte Space Grant
Vector Space Systems	Seed Angels, NASA, DARPA, Space Angels, Sequoia Capital
Virgin Orbit	Virgin Group; Aabar Investments; Saudi Arabia
zero2infinity	Pre sales, Investors, Caixa Capital

OTHER POTENTIAL PLAYERS

A number of other proposed launch vehicles were identified in the course of our research. They failed to meet one or more of the criteria for inclusion in the survey. For completeness and future reference, they are listed in Table 9. Many of these vehicles are "paper studies" funded by governments. For other vehicles, not enough public information is known to warrant inclusion in the main list. Others can be classified as unconfirmed "rumors". We have found out about many of these vehicles by word of mouth from readers of our previous papers.

Table 9: Watch List

Organization	Vehicle Name	Country
Aerojet Rocketdyne	Hera II	USA
Aevum	Ravn	USA
Airbus	Unknown	France
ArianeGroup	Q@ts	Europe
Astra Space	Astra	USA
Avio SpA	VegaC Lite	Italy
B2Space	Colibri	UK
Blue Origin	New Shepard+	USA
bluShift Aerospace	Unknown	USA
Cloud Aerospace	CloudOne Plus	USA
Deimos	Unknown	Portugal
FORE Dynamics	NFR-1	USA
Generation Orbit	GOLauncher 2	USA
Heliaq Advanced Engineering	Austral Launch Vehicle	Australia
HyImpulse	Unknown	Germany
Independence-X Aerospace	DNLV	Malaysia
InterStellar Technologies	Zero	Japan
iSpace	Hyperbola-1	China
JAXA	SS-520-4	Japan
JP Aerospace	Airship to Orbit (ATO)	USA
KB Yuzhnoye	Unknown	Ukraine
Leaf Space	Primo	Italy
LEO Aerospace	Rockoon	USA
MT Aerospace	Unknown	Germany
New Ascent	Unknown	USA
New Rocket Technologies	Light Satellite Launch Vehicle	Russia
Odyne Space	Unknown	USA
Onera	Altair	France
Pangea Aerospace	Meso	Spain
Pipeline2Space	Unknown	USA
Roketsan	Space Launch System	Turkey
Rose Galactic	Anthium Orbital Cannon	USA
SMILE	SMILE	Europe
Thor Launch Systems	Thor	USA
TiSpace	Unknown	Taiwan
U. Hawaii, Aerojet Rocketdyne, Sandia	Super Strypi	USA
UP Aerospace	Spyder	USA
Vanguard Advanced Systems	Athena	UK
Vogue Aerospace	Vogue RLV	USA/Italy

Several of the vehicles on the watch list warrant some additional notes:

- Airbus and Avio Spa do not have a known small vehicle effort, but there have been varying reports that Europe will develop a vehicle smaller than Vega (sometimes termed Vega Light)
- Blue Origin has not publically disclosed any intent to create a small sat launcher, however there has been speculation that they are modifying the New Shepard suborbital vehicle for this purpose.
- Generation Orbit and UP Aerospace appear to have abandoned any near-term goal of completing a space launch vehicle in favor of focusing on their suborbital vehicle.
- The funding for a new Super Strypi launch is currently in question and subject to political discussions in the U.S. Congress
- JAXA had indicated that the SS-520-4 launch was a one-time effort to convert a sounding rocket into an orbital launch vehicle. After its second test flight was successful reports in the media indicated that there may be an attempt to commercialize the vehicle.

CHANGES FROM PAST SURVEYS

This is the fourth edition of this market survey to be published, the fist having been presented at the 29th SmallSat Conference[1] in 2015. Subsequent editions were presented at the 64th International Aerospace Congress in 2016[8], and at the 98th Transportation Research Board Annual Meeting in early 2018[9] (2017 edition of survey). As such it is instructive to see what has over the years.

In 2015 we identified 22 organizations and their corresponding launch vehicle efforts that qualified for inclusion in our survey. This stands in dramatic contrast to the 40 efforts identified this year. However, the number of additional teams is even more impressive when one considers that a number of the 2015 entrants dropped out altogether in the intervening years. Two of the teams identified to "watch" in 2015 have been "promoted" to the main list, with additional "watch" teams in 2016 and 2017 also being considered active now.

Of the 19 teams we identified in 2015 only one, the Super Strypi, conducted a flight in the following 12 months, even though five teams had stated that they would conduct a flight before the second half of 2016. Unfortunately the Super Strypi launch resulted in loss of vehicle and mission. Since then Electron has also conducted a successful flight. The three Chinese vehicles currently operational, Chang Zheng 11, Kaituozhe-2, and Kuaizhou-1A were not in our original 2015 list.

Some vehicles and organizations previously on the list were downgraded to "watch" status over the years. This included Super Strypi due to its uncertain funding status, UP Aerospace and Generation Orbit which appear to be focusing on their suborbital vehicles, and Leaf Space and Heliaq which appear to be active but show very little information on their orbital launch vehicle.

Finally 21 vehicles that appeared on the active or watch list in previous editions of the survey have been removed altogether from this year's version. These include 10 programs we consider "defunct" since they have been officially canceled or the companies that have ceased operations, and 11 programs for which no new information has been available for over two years and thus have an “unknown” status.

Some programs like the ALASA program and the closely related SALVO pathfinder were canceled by their DARPA customer leading to an end of the program.

Over the past four years several companies have disbanded, undergone bankruptcy proceedings, or stopped all development on a space launch vehicle thereby eliminating them from our list. XCOR Aerospace decided to stop all work on the Lynx spaceplane and focus solely on engine development. MicroLaunchers ceased operations after its founder passed away in 2015.

Swiss Space Systems and Firefly Space Systems underwent bankruptcy proceedings. Swiss Space did not re-emerge, while Firefly Space reemerged as Firefly Aerospace with significant investment from Noosphere Ventures. Garvey Spacecraft Corporation was bought out and merged into Vector Space Systems. In the case of both Firefly and Vector, the new vehicle under development utilizes technology from the previous company, but is significantly different. As such the original vehicle is considered to be “defunct” and a new vehicle has been added to the list.

Orbital ATK was bought and merged into Northrop Grumman Corporation. Because both the Pegasus XL and Minotaur I vehicles were already operational, and no vehicle changes resulted from the acquisition, the original entries in the list have been kept, with just a change in organization name.

Table 10: Defunct or Status Unknown Efforts

Organization	Vehicle Name	Status
Boeing	ALASA	Defunct
Bristol Spaceplanes	Spacecab	Defunct
Firefly Space Systems	Firefly α	Defunct
Garvey Spacecraft Corporation	Nanosat Launch Vehicle	Defunct
Lockheed Martin	Athena Ic	Defunct
MicroLaunchers LLC	ML-1	Defunct
Open Space Orbital	Neutrino I	Defunct
Swedish Space Corporation	Rainbow Smallsat Express	Defunct
Swiss Space Systems	SOAR	Defunct
Ventions	SALVO	Defunct
XCOR Aerospace	Lynx Mark III	Defunct
ARCA Space Corporation	Haas 2CA	Unknown
EXO Corp	EXO	Unknown
Horizon Space Technologies	Black Arrow 2	Unknown
Lin Industrial	Taimyr-1A	Unknown
MISHAAL Aerospace	M-OV	Unknown
Nammo	North Star Launch Vehicle	Unknown
Newton Launch Systems	Unknown	Unknown
Scorpius Space Launch Company	Demi-Sprite	Unknown
Tranquility Aerospace	Devon Two	Unknown
Unreasonable Rocket	Unreasonable Rocket	Unknown
Whittinghill Aerospace	Minimum Cost Launch Vehicle	Unknown

Of note in the status unknown category is Arca Space Corporation. Its CEO was arrested and then released without indictment, and subsequently told that he was subject to deportation. As such, the status of the company is currently unknown.

Table 10 lists the efforts that were previously considered active or on our watch list that are now considered defunct or have an unknown status.

CONCLUSIONS

The past four years have been an extremely dynamic period for the launch vehicle industry. Larger players have announced or introduced new rockets such as the Blue Origin New Glenn, the SpaceX BFR, the ULA Vulcan, and the Northrop Grumman OmegA. But the real action has been in the extremely fast introduction of potential new vehicles in the sub-1000 kg to LEO class.

It is clear that the market will not be able to support most of this new entrants, but it is equally clear that both the founders and the capital markets think that there will be room for multiple players. We have seen some of the new entrants commence operations, and a number of other players are likely to have their first flight in the next few months.

To best illustrate this growth, Figure 3 summarizes the changes over the past four editions of this survey. The bar chart shows the total number of vehicles tracked in our survey and divides them into four categories:

- **Operational** – The vehicle has conducted a successful first flight and more flights are planned.
- **Active** – The vehicle meets the criteria set out in this paper for inclusion
- **Watch** – The vehicle has the potential to meet the criteria for inclusion, but it is currently just a “paper study” or not enough information is publically known.
- **Unknown** – The vehicle was either active or on the watch list in a previous survey but no updates have been seen in two or three years.
- **Defunct** – The vehicle development has been cancelled or the company developing it has disbanded.
- **Total** – The total number of efforts we are tracking, which has increased from a mere 31 in 2015 to over 101 in 2018.

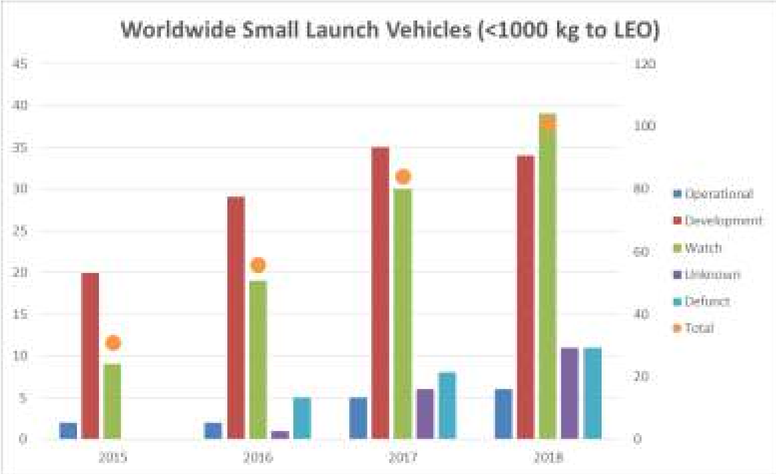

Figure 4: Growth of the Small Launcher Market 2015-2018

ACKNOWLEDGEMENTS

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REFERENCES

The majority of the included research was collected from public references, including the web sites of the vehicles discussed and corporations discussed. Additional references are provided below.

1. Frick, Warren, and Carlos Niederstrasser. "Small Launch Vehicles – A 2015 State of the Industry Survey". *Proceedings of the 29th Annual AIAA/USU Conference on Small Satellites.* Logan, UT.
2. Masunga, Samantha. "The Defense Department wants small rockets that can launch satellites at a moment's notice." *LA Times*. 24 May 2018: Web.
3. "ESA Explores Microlaunchers for Small Satellites". *ESA*. 8 February 2018: http://www.esa.int/Our_Activities/Space_Transportation/ESA_explores_microlaunchers_for_small_satellites
4. Oving, Berti, et al. "Small Innovative Launcher for Europe: achievement of the H2020 project SMILE". *Proceedings of the 7th European Conference for Aeronautics and Space Sciences*. 2017
5. Staff Writers. "Sunrise for China's Commercial Space Industry." *Space Daily*. 14 May 2018: Web: www.spacedaily.com
6. Jones, Andrew. "Chinese commercial launch sector nears takeoff with suborbital rocket test." *Space News*. 15 May 2018: Web.
7. *2018 Nano/Microsatellite Market Forecast, 8th Edition.* SpaceWorks Commercial. 2018.
8. Frick, Warren, and Carlos Niederstrasser. "Small Launch Vehicles – A 2016 State of the Industry Survey". *Proceedings of the 64th International Astronautical Congress*. Guadalajara, Mexico. 2016.
9. Frick, Warren, and Carlos Niederstrasser. "Small Launch Vehicles – A 2017 State of the Industry Survey". *Proceedings of the 98th Transportation Research Board Annual Meeting.* Washington, DC. 2018.

SATELLITE DESIGN – Course Description

(A Course in Pico/Nano/Micro-Satellites - PNMSats)

Objectives: As part of the short course, the participants will engage in learning the methods & processes for designing and experience hands on training in assembling, testing of PNMSat systems/subsystems.

- Understand systems engineering approach to the design & development of PNMSats.
- Review principles of Orbital Mechanics relevant to the design of PNMSats.
- Understand the functions of various subsystems of a PNMSat and engage in their preliminary design.
- Design, simulate & analyze PNMSat subsystems using one or more of the following tools:
  - MATLAB and/or Octave
  - CAD Tools
  - Satellite/System Tool Kit and/or GMAT
- Understand the development, integration and testing of PNMSats.

As part of the hands on training, the course will be taught using a classroom satellite kit from EyasSat, which has all the subsystems of a satellite. The students will also learn to use satellite tracking, telemetry communication (analog & digital) and conceptual understanding of telecommand operation.

(a) (b) (c)

Figure 1 - (a) EyasSat Classroom Satellite Kit, (b) Ham Radio Communication, (c) Packet Radio Communication

Recommended References:

1. Space Mission Analysis and Design, Third Edition (Space Technology Library), James R. Wertz and Wiley J. Larson (editors)
2. Satellite Basics For Everyone: An Illustrated Guide to Satellites for Non-Technical and Technical People Paperback – June 5, 2012 by C. Robert Welti (Author) ISBN-13: 978-1475925937

Lecture Hour: Monday, Tuesday, Thursday – 9 AM to 10:00 AM and 11 AM to 12 Noon

Moderated Group Activity: Wednesday – 10 AM to 1 PM (or as desired and Lab hours: Friday – 10 AM to 1 PM;

Assessment Breakdown:

1. Weekly Reports/Presentation	30%
2. Final Design (Document):	40%
3. Final Design (Presentation):	20%
4. Attendance:	10%

Course Content - The course & design activity will be conducted for 4 weeks as per the following schedule:

Week 1: Review & Introduction to PNMSats and their Subsystems

- Review of Orbital Mechanics (relevant to PNMSats)
- Brainstorming a Novel Payload for a PNMSat Mission
- Overview & Example of PNMSat Subsystems Design
  - Electrical power system
  - Command and data handling system
  - Telemetry, tracking and command
  - Attitude determination & control system
  - Structural & Thermal System
  - Propulsion system
  - Ground operations
- PNMSat System Design Process
- Apply System Design Process (Friday laboratory exercise)

Week 2 & 3: Preliminary/Detail Design of PNMSat Subsystems

- Electrical power system (Excel, Microsoft Visio, PCB Design Tool)
  - Power Budget
  - Electrical circuit diagram
  - PCB (or Visio schematic) Design of the EPS
  - Electrical Power System Components
- Command and data handling system (Microsoft Visio, PCB Design Tool)
  - PCB (or Visio schematic) Design of the Onboard computer
  - Visio Flowcharts
- Telemetry, tracking and command (Microsoft Excel)
  - Schematic of Onboard Radio
  - Antenna design
  - Antenna stowing and deployment design
- Attitude determination & control system (MATLAB/Octave, Simulink, STK)
  - Schematic of ADCS
  - MATLAB implementation of ADCS
- Structural & Thermal System (CAD Tools)
  - CAD Design of the PNMSat Assembly
- Propulsion system (MATLAB/Octave Simulink)
- Ground operations (Microsoft Excel)
  - Link Budget
- Compile System Design as Design Documents (Friday laboratory exercise)

Week 4: Design Level Integration, Simulation, Analysis & Presentation

- Electrical power system
  - Simulate eclipse and Sun time for power cycling
  - Analyze power generation & distribution for various subsystems
- Attitude determination & control system
  - Analyze attitude determination and control for mission (MATLAB)
- Structural & Thermal Design
  - CAD model structural analysis if feasible
- Document each design as a subsystem design
- Showcase the design activity as either a poster or a presentation

Courtesy:

Course Designed by Prof. Sharan Asundi, Ph.D, Department of Aerospace Science Engineering, Tuskegee University, Tuskegee, AL 36088, USA

A more detailed day-to-day activity of the course is presented in Table 1.

	Weekday & Hours	Activity Title	Activity Description
Week 1	Day 1 – Monday (~2 Lecture Hours)	Course overview, expectations, limitations, overview of Orbital Mechanics, etc.	The first of interaction will focus on course overview, scope, expectations, and most importantly learning outcomes. Kepler's Laws, Newton's Laws, conservation of linear momentum, angular momentum, total mechanical energy, orbital elements
	Day 2 – Tuesday (~2 Lecture Hours)	Overview of satellite subsystems	Overview of electrical power system (EPS), on-board computing (CDH), communications (TT&C), attitude determination & control (ADCS), structural and thermal (S&T), ground communication, payload systems
	Day 3 – Wednesday	Moderated Group Activity (Review of articles relevant to PNMSats & CubeSats)	
	Day 4 - Thursday (~2 Lecture Hours)	Overview of systems engineering	PNMSat systems engineering approach, requirements flow down, mission mapping, N2 chart, components, interfaces, tasks, mission profile, circuit schematics, power budgets, telemetry budgets, link budget, operating modes.
	Day 5 – Friday (~4 Lecture + Lab Hours)	First week lab interaction	STK simulations of orbit scenarios, application of orbital mechanics, application of systems engineering for an example mission.
Week 2	Day 1 – Monday (~2 Lecture Hours)	Payload brainstorming	Second week will focus on the conceptual design of a satellite bus (PNMSat mission) to support a novel payload, either proposed by the instructor or brainstormed with participants.
	Day 2 – Tuesday (~2 Lecture Hours)	Mission specific implementation of the PNMSat systems engineering	Identify mission statement/goal, mission objectives, mission requirements (allocated & derived), identification of basic building blocks, N2 chart, Mission profile, etc.
	Day 3 - Wednesday	Moderated Group Activity (Conceptualize a mission and prepare for presentation) – The class will be divided into groups and each group will put together ideas for a potential mission and discuss it in class on Thursday.	
	Day 4 - Thursday (~2 Lecture Hours)	Mission Presentations	The various groups will discuss their mission ideas in class. Based on consensus and instructor's discretion, a mission payload will be selected.
	Day 5 – Friday (~4 Lecture + Lab Hours)	Second week lab interaction	A classroom satellite kit will be used to demonstrate the various subsystems and their operation in space.
Week 3	Day 1 – Monday (~2 Lecture Hours)	Detail design of satellite subsystems	Third week will focus on the design of subsystem level architecture, component-level selection, interface/protocol design, simulation & analysis. The focus of Week 2 - Day 1 will be to provide an overview of the detail/mid-level design.
	Day 2 – Tuesday (~2 Lecture Hours)	Mission specific detail design of satellite subsystems – Part 1	Detail design of EPS (power generation, distribution, storage, monitoring PCB panels, etc.), CDH (overall software architecture, operating modes), TT&C (telemetry budget, antenna structure, stowing and deployment, link budget), ADCS (actuator design/selection, attitude sensor design/selection, control laws/algorithms, on-board models) S&T (payload)
	Day 3 - Wednesday	Moderated Group Activity (Subsystem design) – The class will be divided into subsystem teams and each team will do a trade study and advance towards designing their subsystem.	
	Day 4 - Thursday (~2 Lecture Hours)	Mission specific detail design of satellite subsystems - Part 2	specific CAD design, chassis design to accommodate payload requirements, thermal provision), ground station (data uplink/downlink capability, link budget)
	Day 5 – Friday (~4 Lecture + Lab Hours)	Third week lab interaction	Detail design of PNMSat physical system layout (CAD tools), EPS (MS Excel, Visio, PCB tools), CDH (MS Visio, PCB tool), ADCS (MATLAB/Octave), TT&C (MS Excel)
Week 4	Day 1 – Monday (~2 Lecture Hours)	Detail design of satellite subsystems	The final week of the course will focus on subsystem-level integration, simulation, analysis, creating test scenarios, design documents,
	Day 2 – Tuesday (~2 Lecture Hours)	Design simulation, analysis & documentation - Part 1	As part of EPS design simulation/analysis, the participants will learn to assess system performance during Sun & eclipse time for various angular rates, etc.; ADCS design simulation/analysis will include system stabilization, control, sensor emulation, etc.; TT&C design simulation/analysis will include antenna performance at various angular rates; preparation of design documents (EPS, CDH, TT&C, S&T, ADCS); design level integration
	Day 3 - Wednesday	Moderated Group Activity (Subsystem design) – The subsystem teams will again meet and work towards consolidating their final design, simulation/analysis and presentation.	
	Day 4 - Thursday (~2 Lecture Hours)	Design simulation, analysis & documentation - Part 2	(N2 chart, circuit schematics, interface schematics); poster/presentation of subsystem-level design & integration.
	Day 5 – Friday (~4 Lecture + Lab Hours)	Third week lab interaction	Consolidation of design, simulation & analysis; design documentation, test design/report, 3D printing of CAD model (based on availability); presentation/poster.

Suggested Courses on Satellites

Satellite Design Credits: 3

Introduction to the design of small satellites, including aspects of orbital mechanics, power and propulsion, sensors, communication and the space environment. Group design projects will simulate some component of a practical satellite. All engineering disciplines are encouraged to take this course.

Prerequisite(s): Fundamentals of Space Mechanics Credits: 3

Introduction to the dynamics of aerospace vehicles capable of attaining orbit and/or space travel. Topics include: descriptions of vehicle motion, Kepler's laws, orbital elements, ballistic trajectories and orbital flight dynamics.

Prerequisite(s): Dynamics Credits: 3

Kinematics and kinetics of particles, systems of particles and rigid bodies; work and energy method; power; impulse and momentum.

Prerequisite(s): Statics Credits: 3

Resolution and composition of forces and moments; centroid and second moment of areas; free body diagrams; equilibrium of particles and rigid bodies; simple trusses.

Advanced Space Mechanics Credits: 3

This course investigates powered and un-powered orbital trajectories, methods used in advanced trajectory analysis and mission design, spacecraft stability and control and other space related topics.

Online Courses

Advanced Orbital Mechanics Credits: 4

This course covers circular-restricted three-body problem; surfaces of zero velocity, libration points, and halo orbits; perturbed two-body motion; Gauss and Lagrange planetary equations, Hamilton's principle, canonical equations and Delaunay variables; application to artificial Earth satellites; and orbit determination.

Orbital Mechanics Credits: 3-4

Analysis of orbits in an inverse-square gravitational field; elementary rocket dynamics, impulsive orbit transfer and rendezvous, and Lambert's Theorem with applications; patched-conic trajectories, planetary gravity-assist maneuvers, and linearized orbit theory with application to simplified analytical models; perturbations are covered in this course.

Principles of Automatic Control

This course introduces the design of feedback control systems as applied to a variety of air and spacecraft systems. Topics include the properties and advantages of feedback systems, time-domain and frequency-domain performance measures, stability and degree of stability, the Root locus method, Nyquist criterion, frequency-domain design, and state space methods.

Integrated CubeSAT Engineering Workshop by Teaching Science and Technology, Inc (TSTI)

Course Description:

This four-day tailorable course examines the application of Systems Engineering tools and techniques that will provide participants with the necessary skills, industry standards, information, and tools necessary to plan and implement a credible CubeSat Development Program. Emphasis is on practice over theory using a fully-functional (hardware and software) desktop (non-flight) CubeSat as the system of interest. Using the 3U EyasSAT3TM (ES3) desktop satellite, the course follows the progression of a hypothetical CubeSat mission – NanoMet – designed to deliver large-scale meteorological imagery from LEO. NanoMet serves as an end-to-end systems engineering and project management training platform to examine issues that develop during each phase of a project lifecycle. The course is organized along the lines of a real space mission, starting with Pre-Phase A concept development and then progressing from Phase A to D, introducing systems engineering artifacts that would be developed at each major milestone and providing hands-on examples using the NanoMet mission. NanoMet, based on the ES3 platform, is designed to conform to the 3U CubeSat standard in terms of form and fit and includes all standard spacecraft bus functions (power, data handling, communication, and 3-axis attitude determination and control). All hardware was designed to be for use around the world and is “ITAR-free,” (it is not space qualified or even qualifiable). NanoMet serves as an end-to-end instructional tool throughout the workshop. Participants are provided with key lectures and resources and through a variety of in-class exercises will learn by doing.

Course Objectives:

At the end of this course, you'll walk away with….

- Define mission needs, goals, objectives and ConOps for a CubeSat mission to satisfy a Pre-Phase A requirements
- Develop and organize detailed mission and system requirements as required by a Phase A System Requirements Review (SRR)
- Describe the tools and techniques needed to develop the complete preliminary design for a CubeSat and conduct a Phase B preliminary design review (PDR)
- Evaluate the typical products produced for a critical design review (CDR) at the end of Phase D including system specifications and test plans
- Implement a typical assembly, integration and test plan for a representative CubeSat system to apply the flow down from requirements to verification activities
- Conduct simulated operations using a representative CubeSat system to develop and apply operational planning and procedures implementation
- Apply Model-based Systems Engineering (MBSE) to each phase of a project lifecycle
- Overall, Enter any phase of the space mission life cycle and apply principles and practices to achieve practical results

Who Should Attend:

Systems engineers, project managers, integrated product team members involved with any aspect of system engineering and analysis, especially design and development, test and evaluation of CubeSats.

Course Materials

Each participant will receive:

- A complete electronic set of course presentation material
- E-book copy of Applied Space Systems Engineering
- NanoMet MBSE Model

Testimonials

"This class was beneficial for all areas of design. All Systems Engineers should take this." –Boeing Engineer

"The course exceeded my expectations. I did not think that the course could cover so many fundamentals of space missions!" – ESA Engineer

" Theory tied to practical applications well. Great presenters with thorough knowledge of the material." – NASA Engineer

Course Agenda

Day 1

- Intro to Space Systems Engineering
- Overview of the NanoMet and the EyasSAT3 System of Interest
- Conceptual Space Mission Design
- Pre-Phase A/Phase A Planning
- Essential Design Review Products
- Project Scope Definition*
- Introduction to Model-based Systems Engineering Tools and Techniques

Day 2

- Requirements Engineering
- Functional Analysis
- Model-based NanoMet MCR/SRR/SDR*
- Orbit Design
- NanoMet orbit analysis using Systems Tool Kit (STK)*
- Spacecraft Subsystems and Sizing

Day 3

- Phase B Planning
- Essential PDR Products
- Spacecraft Design*
- Model-based NanoMet PDR*
- Preparing for Space System Verification
- Verification in Space Environment
- Phase C/D Planning
- Essential CDR Products
- Model-based NanoMet CDR*
- NanoMet Test Plan Review*

Day 4

- NanoMet payload and subsystem verification events*
- NanoMet Integration events*
- NanoMet Integrated verification and validation events*
- NanoMet simulated operational events*
- Course Review and Wrap-up *Guided Hands-on Exercises

Ref: https://www.tsti.net/onsite-training-courses/integrated-cubesat-engineering-workshop/

TSTI Introduces New Model-Based Systems Engineering Courses

Date Published: February 13th, 2018

TSTI is proud to announce that we were competitively selected by NASA's Academy of Program/Project and Engineering Leadership (APPEL) to develop and present modular applied model-based systems engineering courses. In support of that effort, we have completely re-engineered our existing Applied MBSE course so that it can now be offered in a unique one, two or three day modular format. With this unique configuration, MBSE-01 is the first day of the MBSE-02 and MBSE-03 courses, and MBSE-02 is the first and second day of MBSE-03. Participants an elect to stay for one day, two days or all three depending on how deeply you'd like to dive into the application of model-based systems. The courses are “tool agnostic,” and designed for those who are totally new to MBSE. The courses range from a broad overview to specifics in design, development and application of MBSE in programs and projects. We can can further customize the course to meet the specific needs of your organization.

For more details, view the course descriptions here:

Foundations of Model-Based Systems Engineering - MBSE-01

Applied Model-Based Systems Engineering - MBSE-02

Model-Based Systems Engineering Design and Analysis - MBSE-03

Visit our course overview for a better look into all our model-based engineering courses.