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# LOW COST MICROSATELLITES FOR EXPANDED MISSION CAPABILITIES

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FASTSAT is a microsatellite developed to provide rapid access to space for a variety of scientific, research, and technology payloads. The spacecraft is designed to carry multiple instruments and launch as an ESPA class secondary "rideshare" payload, greatly reducing overall mission costs. Because small satellites are vital to the future of space, Dynetics and its partners have commercially developed FASTSAT as an affordable spacecraft in the microsatellite market. FASTSAT will expand opportunities for space flight to the Department of Defense (DoD), NASA, universities, the intelligence community and the aerospace industry. The first spacecraft, FASTSAT-HSV01, was developed in collaboration among Dynetics, NASA's Marshall Space Flight Center (MSFC), and the Von Braun Center for Science & Innovation (VCSI) in Huntsville, Alabama, for the Department of Defense Space Test Program (DoD STP). FASTSAT HSV-01 will carry six experiment payloads to low Earth orbit on the STP-S26 mission. The FASTSAT team has created additional spacecraft models and configuration options for future missions that offer increased capabilities to support a broad range of missions from technology demonstrations to gap-filling operational systems.

## I. INTRODUCTION

Microsatellites such as FASTSAT (see Figure 1.0) and Cube/NanoSats fit are rapidly becoming a core element of Department of Defense (DoD), NASA and other civil/commercial programs. These assets offer the ability to provide responsive, persistent and affordable data for the user – from the battlefield commander to the research scientist. One goal is to provide on-demand space support, augmentation, and reconstitution. The small size of these satellites allows them to be produced affordably and launched on multiple systems – reducing the time from call-up to operation.

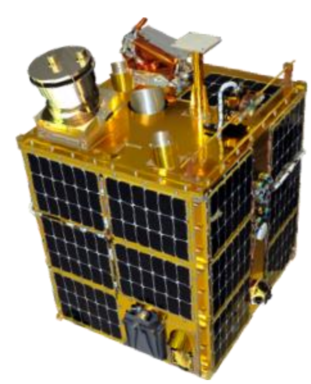


**Figure 1.0: FASTSAT-HSV01 Microsatellite**

Because small satellites are vital to the future of space, Dynetics and its partners have commercially developed FASTSAT.

The first FASTSAT spacecraft (FASTSAT-HSV01) was managed by NASA's Marshall Space Flight Center (MSFC) and developed in collaboration with Dynetics and the Von Braun Center for Science & Innovation (VCSI) in Huntsville, Alabama.

The FASTSAT bus enables a broad range or missions for a fraction of the cost and schedule of other options. Future missions include:

- Space Tests and Experiments
- Technology Demonstrations
- Rapid Response Gap Filler
- Augmenting Large Systems
- CubeSat Constellation Deployment
- Earth and Atmospheric Observation
- Space Weather
- Intelligence, Surveillance, and Reconnaissance

The FASTSAT project leverages the deep base of space systems development expertise in Huntsville, an innovative business model through VCSI, and Dynetics' advanced engineering, rapid product development, and manufacturing capabilities. The team executes rapid development processes while applying the rigors for engineering excellence, safety, mission assurance, and manufacturing quality. FASTSAT has been designed from the ground up to meet short schedules with modular components and configurable layouts to enable a broad range of payloads at a lower cost and shorter timeline than scaling down more complex spacecraft.

This approach gives the FASTSAT team (Dynetics, MSFC, & VCSI) the ability to rapidly take the spacecraft from design to launch readiness in 12 to 18 months, dependent on options, enhancing affordability and responsiveness.

## II. MARKET PROJECTIONS

Market elasticity appears to be high for microsatellites. According to the Federal Aviation Administration's (FAA) recent report, "Launch rates may increase beyond forecasted levels if a new microsatellite launch capability emerges…. The emergence of a micro-satellite launch vehicle, with competitive launch costs, may cause microsatellite payloads to shift from the multi-manifest approach to individual launch on these new vehicles. This would result in a larger number of launches."[1]

As can be seen in Figure 2.0, the FAA predicts 262 Low Earth Orbit (LEO) satellites will be required over the next decade. If history is a guide, approximately 25% of these will be in the microsatellite class (<200 kg).[1]

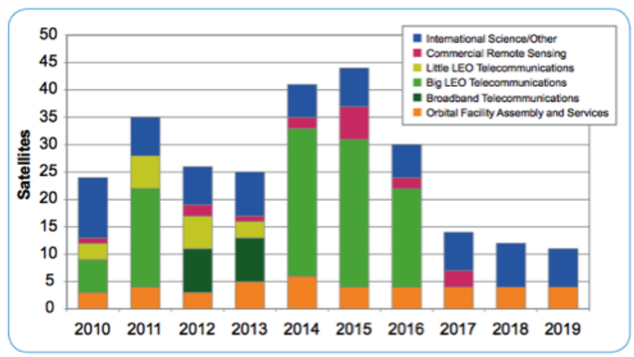



**Figure 2.0 FAA LEO Satellite Projections**

There are similar signs and trends in the U.S. government market:

– NASA Small Satellite Missions:
  - Franklin/Edison Small Satellite Demonstration Program
  - Venture Class Earth Science Missions

– Continued DoD Push for Small Satellites: "Deputy Secretary of Defense William Lynn…indicated that the responsive space concept will be a major part of the document…..can help us counter threats to our space capabilities. By building systems on small satellites, using modular components, ORS [Operationally Responsive Space] gives us the ability to rapidly augment our space systems."[2]

## III. FASTSAT HSV-01

Aboard STP-S26, FASTSAT-HSV01 will be flying a total of six instruments approved by the U.S. Department of Defense (DoD) Space Experiments Review Board. STP-S26 is executed by the DoD Space Test Program (STP) at the Space Development and Test Wing (SDTW), Kirtland Air Force Base, N.M., which is a unit of the Air Force Space and Missile Systems Center.

FASTSAT HSV-01 was developed using commercial funding from Dynetics and a unique public-private partnership with the NASA Marshall Space Flight Center, through the VCSI. FASTSAT rapidly moved through development – going from ATP to environmental test in 10 months and then to ready-for-flight in another 5 months. The bus underwent a rigorous development and test process and was certified to both USAF and NASA standards, receiving a NASA Certificate of Flight Readiness.

FASTSAT-HSV01 carries a record six SERB experiments on one bus: three technology demonstrations, and three NASA atmospheric research experiments. The technology demonstrations are Threat Detection System (TDS), NanoSail Demonstration (NanoSail-D), and a Miniature Star Tracker (MST). TDS is space-qualifying advanced technology. NanoSail-D is a free flying solar sail that will deploy from a P/POD built into the satellite after FASTSAT has separated from the launch vehicle (See Figure 3.0). The NASA atmospheric research experiments are Thermospheric Temperature Imager (TTI), Plasma Impedance Spectrum Analyzer (PISA), and Miniature Imager for Neutral Ionospheric atoms and Magnetospheric Electrons (MINI-ME). TTI's objective is to increase the orbit propagation accuracy of LEO assets during solar and geomagnetic storms by remotely measuring thermospheric temperature and atmospheric atomic oxygen. PISA measures resonance frequencies which depend on electron density, temperature, and magnetic field strength. Finally, MINI-ME remotely senses magnetospheric plasma to improve space weather forecasting.

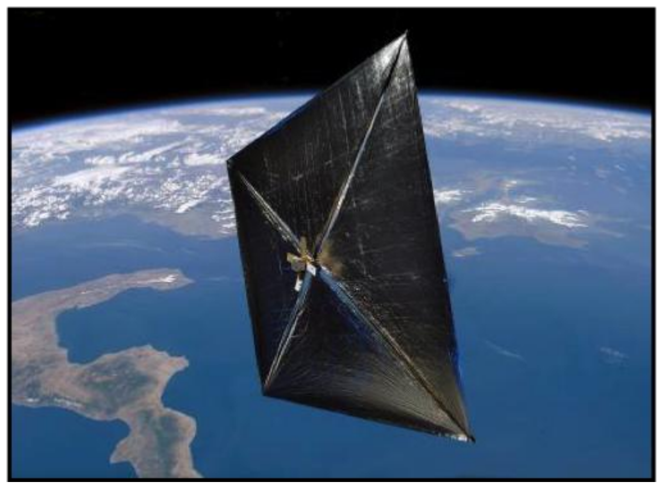


**Figure 3.0 NanoSail-D After Deployment from FASTSAT**

## IV. FUTURE MISSION CAPABILITY

The FASTSAT team has created additional spacecraft models and configuration options for future missions that offer increased capabilities to support a broad range of missions from technology demonstrations to gap-filling operational systems. As shown in Table 1.0, these include the A-110, 210, 210-M and B210 bus families. The A-110 bus provides basic payload services and is fully ESPA compliant. The A-210 model adds more precise attitude control and the B-210 model further adds a 150W+ power upgrade. While intended to be a standardized bus, Dynetics has explored other growth options including large deployables.

One capability unique to the FASTSAT microsatellite is the ability to deploy CubeSats from orbit, on-demand as depicted in Figure 5.0. A 1st generation capability will be demonstrated on the STP-S26 mission with the deployment of NanoSail-D. As the acceptability of microsatellites evolves, the need to deploy constellations of microsatellites flying in formation is receiving greater recognition. Such missions include ISR, Space Weather and Earth Observation. To execute these missions, Dynetics and VCSI have secured funding and are planning to design a multi-cubesat deployer that can be integrated into the FASTSAT bus in collaboration with MSFC and Ames Research Center. Such a concept is illustrated in Figure 5.0 with the A210-M bus, which can deploy up to 4, 3U CubeSats. This initiative capitalizes on existing deployer technology and reengineers it to provide users with a new capability to strategically emplace CubeSats or store them on orbit for future on-demand deployment. Such a capability offers several "firsts," including:

- On-orbit charging, health & status of CubeSats
- Ability to protect CubeSats from the space radiation environment
- Launch on-demand of 6-8 CubeSats
- Constellation deployment and communication
- Test a potential conop: the element of surprise to an enemy tracking our actions
- Optional video of deployment
- Late integration – secondary payload

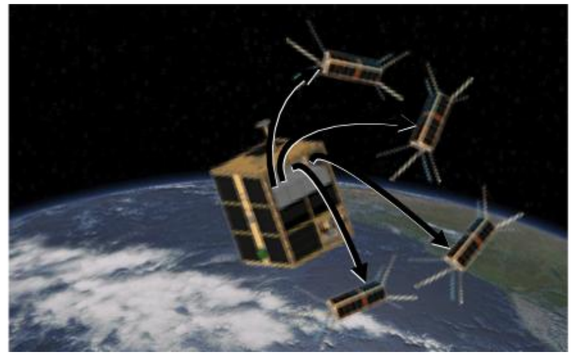


**Figure 5.0 Multi-Cubesat Deployment**

The rapid delivery of CubeSat constellations from the FASTSAT microsatellite provides a responsive, persistent and affordable data to the user.

## V. CONCLUSION

Microsatellites such as FASTSAT and Cube/NanoSats fit are rapidly becoming a core element of Department of Defense (DoD), NASA and other civil/commercial programs. These assets offer the ability to provide responsive, persistent and affordable data for the user – from the battlefield commander to the research scientist. The goal is to provide on-demand space support, augmentation, and reconstitution. The small size of these satellites allows them to be produced affordably and launched on multiple systems – reducing the time from call-up to operation.

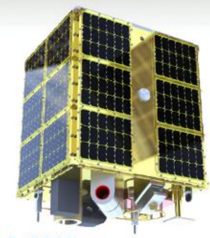
The FASTSAT bus enables a broad range or missions for a fraction of the cost and schedule of other options.

## FASTSAT-HSV Microsatellite Standard Models

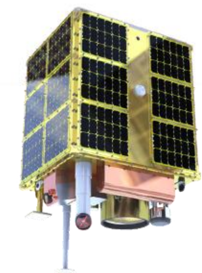
### Spacecraft Capabilities

| | |
|---|---|
| Total Mass | 110 - 180 kg |
| Size | 24” x 28” x 38” |
| Low Earth Orbit | 400 – 850 km |
| Orbit Inclination | 65° - 99° (110 models)<br>30° - 99° (210 models) |
| Stabilization | 1-Axis (110 models)<br>3-Axis (210 models) |
| Attitude Control* | 1-3° (110 models)<br>< 0.5 (210 models) |
| Attitude Knowledge* | 0.03° |
| Communications | Spaceflight Tracking and Data Network (STDN)<br>or Space Ground Link Subsystem (SGLS)<br>COMSEC Interface |
| Downlink | S-band, 5 Mbps |
| Uplink | S-band, 19.2 kbps |
| Mission Life | 1 – 4 years |
| Number Payloads | Up to 6<br>Up to 4x3U (A210-M model) |
| Payload Mass* | 65 - 70 kg |
| Payload Power (Peak)* | 60 - 70 W<br>> 150 W (B210 model) |
| Payload Volume* | 125,000 cc |
| Payload Interface | RS-422, Digital I/O |
| Payload Data Storage | 7.8 GByte |
| Launch Options | Minotaur I & IV, Delta IV, Atlas V, Pegasus,<br>Falcon 1e & 9, etc. (ESPA compatible) |

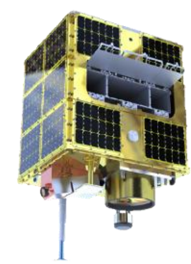
Additional model configurations and capabilities as needed
*Preliminary specifications (dependent on mission parameters)



**Model A110**
ESPA Class
Single Axis Stabilized
Optional P-POD



**Model A210**
110 Common Design
Improved Attitude Control
Three Axis Stabilized



**Model A210-M**
210 Architecture
Multiple Cubesat Launcher
Up to 4 x 3U

**Model B210**
210 Architecture
Increased Payload Power

**Table 1.0 FASTSAT Standardized Bus Options**

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[1] Commercial Space Transportation Forecasts, 2010, Federal Aviation Administration
[2] Small Satellites, July 2010, National Defense Industries Association Magazine