



## LOOKING FOR SMALLSAT TECHNOLOGY? ASK GODDARD!

NASA's Goddard Space Flight Center brings years of expertise in small satellite technology development and mission planning to the SmallSat community. Through NASA's Technology Transfer Program, members of the public can license patented technologies for their own use, saving valuable time and resources. Instead of starting from scratch, companies can incorporate Goddard technologies into their mission design, freeing up resources for other parts of the mission. Below, please find a list of featured technologies. To learn more about these licensing opportunities, or if you have questions about specific technology needs, please contact Goddard's [Strategic Partnerships Office](#) at [techtransfer@gsfc.nasa.gov](mailto:techtransfer@gsfc.nasa.gov).

### OPTICAL COMMUNICATION

#### OPTIMETRIC MEASUREMENTS OVER COHERENT FREE SPACE

#### OPTICAL COMMUNICATION

Through utilizing coherent optical communication to combine optometric measurements over an optical carrier, one can accurately measure Doppler and absolute ranging. This process works through a looping and synchronizing iteration, measuring frame, bit, and phase change values using a phase detector and clock data recovery apparatus. The technique improves free space optical communications.

*Patent Number: 10,148,352*

#### STEERING MIRROR ASSISTED LASER FINE POINTING

The system more finely points lasers so as to improve the precision of space optical communications and ranging. Through linking a laser beam mirror steering mechanism and associated closed loop control, any residual error in pointing to a desired target is reduced dramatically.

*Patent Number: 10,228,465*

#### ON-DEMAND, DYNAMIC RECONFIGURABLE BROADCAST TECHNOLOGY FOR SPACE LASER COMMUNICATION

The mirror system can address likely obstacles in space optical communications. Through using miniature adjustable mirrors and programmed phase delays to diffract a single communication beam, numerous diffracted beams can be sent to other satellites in various directions for communication and tracking.

*Patent Pending*

### SPACECUBE

#### SPACECUBE V2.0 PROCESSOR CARD, ENGINEERING MODEL

SpaceCube is a cross-cutting, in-flight reconfigurable Field Programmable Gate Array (FPGA) based on-board hybrid science data processing system. The goal of the SpaceCube program is to provide 10 to 100 times improvements in on-board computing power while lowering relative power consumption and cost.

*Patent Number: 9,705,320*

#### SPACECUBE DEMONSTRATION PLATFORM

This fault-tolerant framework allows for recovery from radiation upsets. It is reconfigurable from the ground while in orbit. It can be used to produce fault tolerance technologies and serves as a generic data processing solution for space-based applications.

*Patent Number: 8,484,509*

#### SPACECUBE V2.0 FLIGHT PROCESSOR CARD

This flight processor card leverages six years of heritage SpaceCube designs while advancing the technology one more step. The processor architecture is designed to be better suited to handle radiation upsets than its predecessors, and it is built for a longer life cycle.

*Patent Number: 9,549,467*

#### SPACECUBE V2.0 MICRO

This technology is a subset of the SpaceCube v2.0 Engineering Model, Mini, and Engineering Test Unit designs. It is a Single Board Computer (SBC) intended for systems requiring low power and a very powerful data processor.

*Patent Number: 9,851,763*

#### SPACECUBE 2.0 FLIGHT CARD MECHANICAL SYSTEM

SpaceCube 2.0 is a family of high-performance reconfigurable systems designed for spaceflight applications requiring on-board processing. The SpaceCube 2.0 Flight Card Mechanical System is inherently adaptable and configurable for various configurations.

*Patent Number: 10,681,837*

#### SPACECUBE V2.0 PROCESSOR WITH DDR2 MEMORY UPGRADE

The improved version of the card assembly extends the life and design of the processor and provides even greater memory throughput to support the next generation of instruments.

*Patent Number: 10,667,398*

#### SPACECUBE V3.0 FLIGHT PROCESSOR CARD

SpaceCube v3.0 features the radiation-tolerant multi-core T2080 processor and the radiation-tolerant Kintex UltraScale FPGA. The SpaceCube v3.0 Flight Processor Card meets the industry standards in lightweight systems specifications.

*Patent Pending*

#### SPACECUBE V3.0 RADHARD MONITOR

The SpaceCube v3.0 RadHard Monitor is an FPGA IP that is responsible for providing monitoring to the SpaceCube v3.0 processor card for single-event upsets and other faults.

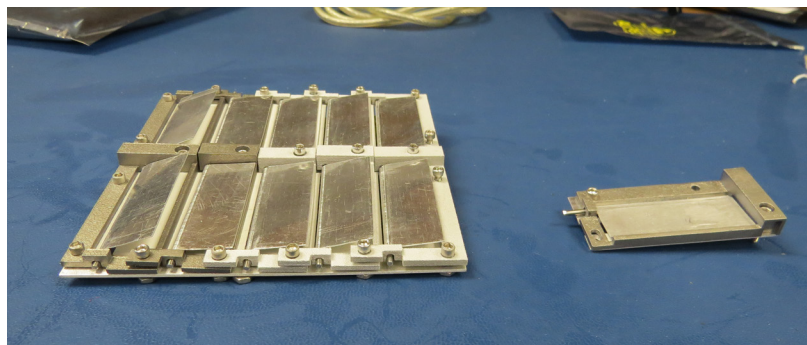
*Patent Pending*

#### SPACECUBE V3.0 MINI EVALUATION BOARD

The Evaluation Board is designed as a breakout and test platform for the SpaceCube v3.0 Mini. It breaks out several debug and communication interfaces, as well as a large amount of General Purpose I/O to common standard PCB connectors.

*Patent Pending*

*Photo Credit: NASA/Amy Klarup*



#### **SPACECUBE V3.0 FMC+ MEZZANINE TEST CARD**

The Mezzanine Card is an FMC+ daughter card that enables testing and development of SpaceCube v3.0 and SpaceCube v3.0 Mini processor cards.

*Patent Pending*

#### **SPACECUBE V3.0 MINI ASTM BOARD**

The SpaceCube v3.0 Mini ASTM Board provides a way to connect the SpaceCube v3.0 Mini Processor Card to the Automated Safe-to-Mate Machine for electrical testing.

*Patent Pending*

#### **SPACECUBE V3.0 AUTOMATED TEST SUITE**

This technology provides automated testing of the functionality of the SpaceCube v3.0 hardware. Individual functional tests are collected into a test suite that are run automatically.

*Patent Pending*

#### **SPACECUBE V3.0 FMC+ ASTM CARD**

The FMC+ ASTM Card provides a way to perform tests on the SpaceCube v3.0 Processor Card.

*Patent Pending*

#### **OTHER HARDWARE**

##### **WALLOPS FLIGHT FACILITY 6U ADVANCED CUBESAT EJECTOR (ACE)**

The ejector system interfaces to the launch vehicle and functions to protect the primary payload from the nanosatellite, constrain the nanosatellite during launch, and perform a guided ejection afterwards.

*Patent Number: 9,434,486*

##### **MINIATURE RELEASE MECHANISM OR DIMINUTIVE ASSEMBLY FOR NANOSATELLITE DEPLOYABLES (DANY)**

NASA's DANY technology uses spring-loaded metal pins, a reliable burn-through mechanism, efficient bracketing, and a circuit board to reliably stow and release deployables on command. Using DANY, stowed deployables are securely fastened using the spring-loaded locking pins.

*Patent Number: 9,546,008*

##### **RADIATION HARDENED 10BASE-T ETHERNET PHYSICAL INTERFACE**

This Ethernet solution combines a custom circuit and a front-end field programmable gate array (FPGA) design to implement an Ethernet Physical Interface (PHY) in compliance with IEEE 802.3. The custom circuit uses available radiation-hardened parts and handles the electrical interface between standard differential Ethernet signals and the digital signal levels in the FPGA.

*Patent Number: 9,680,527*

##### **CUBESAT FORM FACTOR THERMAL CONTROL LOUVERS**

The thermal control louvers use passive thermal control to significantly improve the internal thermal stability of small spacecraft, creating a difference of several watts in dissipated heat between open and closed louvers. The modular design can be produced in large quantities and swapped into various sized plates to tailor the thermal control to each spacecraft's needs.

*Patent Number: 9,862,507*

##### **CUBESAT COMPATIBLE HIGH RESOLUTION THERMAL INFRARED IMAGER**

The thermal infrared imager has high quantum efficiency, broad spectral response, and ease of fabrication. It is small and compact, making it ideal for the CubeSat platform.

*Patent Number: 10,306,155*

##### **DELLINGR 6U CUBESAT**

The Dellinger CubeSat design is more reliable than previous CubeSat designs. It is cost effective and more robust in terms of volume and power than older designs.

*Patent Number: 9,938,023*

##### **MICROSCALE ELECTRO HYDRODYNAMIC (EHD) MODULAR CARTRIDGE PUMP**

This innovation incorporates a simplistic design that reduces the number of components required to make an assembly by up to 90 percent over previous iterations, ensuring a solid, reliable electrical connection to the electrodes that form the pumping sections. Its modular design allows for flexibility in incorporating the pump cartridge into various assemblies and applications.

*Patent Number: 10,461,621*

##### **OCCULTER FOR CUBESAT CORONAGRAPH**

This technology is designed to minimize noise from the coronagraph that can interfere with data collection and analysis. It has applications in solar research and photography where the goal is to image a dim object near a bright one.

*Patent Number: 9,921,099*

##### **SMALLSAT ATTITUDE CONTROL AND ENERGY STORAGE**

By replacing reaction wheel ensembles with reaction spheres, this technology reduces the overall size and net power consumption of conventional three-axis attitude control systems.

*Patent Number: 10,053,242*

##### **GRAPHENE FIELD EFFECT TRANSISTORS FOR RADIATION DETECTION (GFET-RS)**

Unlike conventional charge-sensing detectors, the GFET-RS utilizes the sensitive dependence of graphene conductance on local change of the electric field, which can be induced by interaction of radiation with the underlying absorber substrate. This technology provides low power consumption and high sensitivity radiation sensors for the commercial space industry and government agencies.

*Patent Number: 9,508,885*

##### **MAGNETIC SHAPE MEMORY ACTUATOR**

The push-pull type actuator utilizes a magnetic shape memory alloy. The actuator has nanometer precision and self-position sensing, enabling reliable actuation with applications ranging from precise optical instrument pointing to simple locking mechanisms.

*Patent Number: 10,581,345*

##### **DEPLOYABLE BOOM FOR CUBESATS**

The deployable boom for CubeSats is a rigid boom over 50 centimeters in length when deployed that houses a three-axis magnetometer. It is stowed on one side of the CubeSat with a double hinge system.

*Patent Number: 10,717,548*

##### **NOVEL ANTENNA CONCEPT FOR CUBESAT PLATFORMS**

By integrating the antenna into the structure of a CubeSat, the need for extruding antennas, packaging considerations, and a deployment mechanism are eliminated. The resulting antenna has reduced weight and volume, as well as increased dependability.

*Patent Number: 10,361,472*

##### **ULTRA COMPACT STAR SCANNER**

This innovative approach fuses the rapid advancements in miniaturized high-speed electronics with the ultra-compact freeform optical design from NASA efforts to create the next generation of stellar scanner instruments.

*Patent Pending*

#### A TWO-WAY MICROWAVE POWER DIVIDER USING MICROSTRIP TRANSMISSION LINES

The power divider has matched impedances via Klopfenstein tapered transmission lines to provide ultra-bandwidth functionality with low losses and a small physical footprint.

*Patent Number: 10,370,127*

#### SMALLSAT COMMON ELECTRONICS BOARD (SCEB) COMPLEMENT BOARD DESIGN: MEMORY CARD

The innovation is a miniaturized memory board that has up to 96 GB of NAND Flash memory along with either a radiation tolerant FPGA or a set of three commercial FPGAs. The memory board is designed to interface with the standard subsystems of Goddard's Modular SmallSat Architecture (GMSA).

*Patent Pending*

#### ACTIVE POINTING AND TRACKING DESIGN TO CORRECT YAW AND PITCH RANGE ERROR IN LASER SATELLITE-TO-SATELLITE TRACKING (SST)

By using a programmable phase mirror, a communication laser beam from the master satellite can be dynamically diffracted into multiple narrow beams, and each diffracted beam tracks a separate receiving satellite to broadcast information.

*Patent Pending*

#### MINIATURIZED ASTROMETRIC ALIGNMENT SENSOR

The technology advances satellite capabilities for astrophysical measurements, which are necessary for formation flying, relative navigation, and virtual telescope capabilities. The Miniaturized Astrometric Alignment Sensor makes it possible to measure a spacecraft's altitude and orientation with respect to known stellar objects.

*Patent Number: 10,657,371*

#### ION CONTROL SYSTEM

The electric propulsion system is suitable for small satellite attitude control, precision orbit control, constellation formation management, and extended low-thrust maneuvers.

*Patent Pending*

#### A BROADBAND, COMPACT LOW-POWER MICROWAVE RADIOMETER DOWN CONVERTER FOR SMALL SATELLITE APPLICATIONS

The system includes a fundamental local oscillator source composed of a broadband tunable frequency synthesizer as well as a crystal oscillator. The synthesizer employs a harmonic doubler to expand frequency coverage.

*Patent Number: 10,659,094*

#### SELF-REGULATING CURRENT CIRCUIT

This technology utilizes a switching regulator to provide high-efficiency power conversion. The Self-Regulating Current Circuit simplifies the deployment of a circuit as circuit resistance associated with wire and interfaces are negated due to the self-regulating circuit. The entire circuit can be miniaturized and can still provide relatively high constant current needed for nickel chrome based deployment devices.

*Patent Number: 10,742,115*

#### DEPLOYABLE SYSTEM FOR CUBESAT ELECTRIC FIELD INSTRUMENT (CEFI)

CEFI is a 3-axis electric field instrument with six rigid booms packaged into a less than 1.5U CubeSat volume.

*Patent Pending*

#### DIRECTION OF ARRIVAL ESTIMATION SIGNAL OF OPPORTUNITY RECEIVER

This transceiver technology for small satellite and CubeSat platforms enables maximization of antenna gain in a specific direction to receive desired signals and suppress signals from other directions.

*Patent Pending*

#### SILICON OXIDE COATED ALUMINIZED POLYIMIDE FILM RADIATOR COATING

This technology uses all the exposed surfaces on the six sides of a CubeSat as radiators. All the internal components are thermally coupled to the radiators. The technology lowers power demand and eliminates the need for voluminous heat regulation.

*Patent Pending*

#### SOFTWARE

##### THE CORE FLIGHT SYSTEM (CFS)

The cFS is a flight software framework with a layered architecture that builds on best practices from previous missions and works in tandem with mission-specific applications.

##### THE NASA OPERATIONAL SIMULATOR FOR SMALL SATELLITES (NOS<sup>3</sup>)

NOS<sup>3</sup> is a suite of tools that caters specifically to small satellite missions and helps shorten development timelines.

*Photo Credit: NASA/P. Black*

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