National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Aerospace

Affordable Vehicle Avionics (AVA)

Common Modular Avionics System for Nano-Launchers offering affordable access to space

NASA Ames Research Center has developed a novel low-cost, self-contained Guidance, Navigation and Control (GNC) subsystem for developers and operators of small-payload Space Launch Vehicles (SLVs). Small satellites are becoming ever more capable of performing valuable missions for both government and commercial customers. However, currently these satellites can only be launched affordably as secondary payloads which makes it difficult for the small satellite mission to launch when needed into the desired orbit, and with acceptable risk. NASA's Affordable Vehicle Avionics (AVA) technology offers access to space for small-payload SLV operators with an ability to provide dedicated launch to Low Earth Orbit (LEO), when and where they need. AVA demonstrates a self-contained GNC subsystem that can be integrated and operated at a fraction of the recurring costs of existing units.

BENEFITS

- Small and light-weight
- Common suite of avionics and demonstration software made available to several launch providers
- Self-contained guidance system
- Lab tested and qualified to survive the launch environment
- Common suite of avionics and software made available to several launch providers
- Leverage commercial-off-the-shelf COTS hardware (sensors and flight processor)
- Maintain performance and reliability

APPLICATIONS

The technology has several potential applications:

- Nano/micro/small-spacecraft space launch vehicle industry
- If augmented by additional attitude-measurement sensors: Small-satellite industry including spacecraft attitude determination & control, orbit maintenance, and support of payloads for imaging, communications, and remote sensing
- Space industry

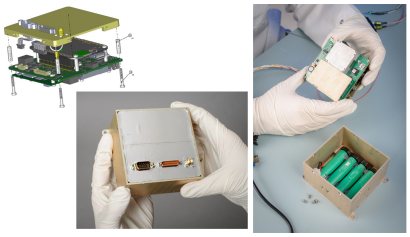
THE TECHNOLOGY

Significant contributors to the cost of launching nano- and micro-satellites to orbit are the costs of software, and Guidance, Navigation and Control (GNC) avionics systems that steer, navigate and control the launch vehicles, sequence stage separation, deploy payloads, and pass data to Telemetry. The high costs of these GNC avionics systems are due in part to the current practice of developing unique, custom, single-use hardware and software for each launch, and requiring high-precision measurements of position and attitude states. NASA Ames Research Center has developed and tested a low-cost avionics system prototype called Affordable Vehicle Avionics (AVA). AVA integrates a low-cost moderately-precise sensor suite with an advanced error-correcting software package to provide GNC for space launch vehicles in a package smaller than a multilayer sandwich (100 mm x 120 mm x 69 mm; 4in x 4.7in x 2.7in), and with a mass of less than 0.84kg (2lbs). The invention provides a common suite of avionics components and demonstration software that deliver affordable, capable GNC with flexible I/O which is applicable to a variety of nano/micro-sat launch vehicles at less than 10 percent of the cost to procure current state-of-the-art GNC avionics. Affordable Vehicle Avionics' (AVA's) approach to drastically reduce costs includes: (1) use of low-cost "tactical-grade" Commercial-off-the-Shelf MicroElectroMechanical Systems (MEMS) inertial measurement unit, wherein adequate navigation precision is achieved by fusing outputs from a Global Positioning System receiver, inertial sensors and a magnetic field vector sensor in an extended Kalman filter formulation that corrects inertial sensor biases; (2) a streamlined "cookbook" approach to define an effective process for launch vehicle developers to design, simulate, verify and support assembly, integration and testing of their SLVs, driven by high-fidelity six degrees of freedom SLV simulations and real-time hardware-in-loop tests to validate guidance, navigation and control for early test flights.

Development Status:

As of spring 2020, AVA has flown twice in its current configuration on a suborbital platform. Its navigation and control functions were successfully demonstrated for roll-rate control within a tight deadband onboard the first flight test, and it successfully issued attitude pointing commands to a failed reaction control subsystem and it issues issued a rocket-motor ignition command on a second flight test. To date, failure of SLV components other than AVA (e.g., electrical power) has precluded demonstration of navigation and control of an orbital or sub-orbital launch system, which remains to be demonstrated.

AVA development was accomplished using a single magnetometer-based magnetic field vector sensor to provide attitude observability during free-fall (inter-stage coast periods). Therefore, the current tested AVA configuration is susceptible to magnetic/electric fields produced by other components and payloads onboard the SLV, so care must be exercised to either mount AVA well away from sources of such fields and or to incorporate magnetic/electric field barriers on field emitters if separation from emitters is inadequate. Also, licensees may wish to provide new AVA inputs from a pair of external Sun Sensors to provide more accurate attitude navigation during coast phases of the SLV mission.



AVA Controller is smaller than a stack of 6 Compact Disc cases, and weighs in at under a kilogram - batteries included!

PUBLICATIONS

Patent No: 10,669,045

technology.nasa.gov

NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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More Information

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