National Aeronautics and Space Administration

NASA

TECHNOLOGY SOLUTION

Information Technology and Software

Unique Datapath Architecture Yields Real-Time Computing

Architecture unencumbers microprocessors, maximizing computational speed for software

Innovators at NASA Johnson Space Center have developed and successfully flight tested a high-performance computing platform, known as the Descent and Landing Computer (DLC), to suit the demands of safe, autonomous, extraterrestrial spacecraft landings for robotic and human exploration missions. Unique to this platform is a datapath architecture that unencumbers microprocessors by isolating them from input and output interruptions, thus staving off latency and maximizing computational speed for the flight software.

To safely land, the DLC must process landing-specific sensor data in real-time and relay this information to the primary flight computer for the spacecraft to avoid environmental hazards like craters and boulders. The datapath architecture presented allows for the DLC's high-speed computational processing to provide this capability. This technology will be critical for safe access to other surface regions of the solar system in which spacecraft missions could not succeed with current landing capabilities.

This datapath architecture technology is at a technology readiness level (TRL) 6 (system/subsystem prototype demonstration in a relevant environment) and is now available for your company to license. Please note that NASA does not manufacture products itself for commercial sale.

BENEFITS

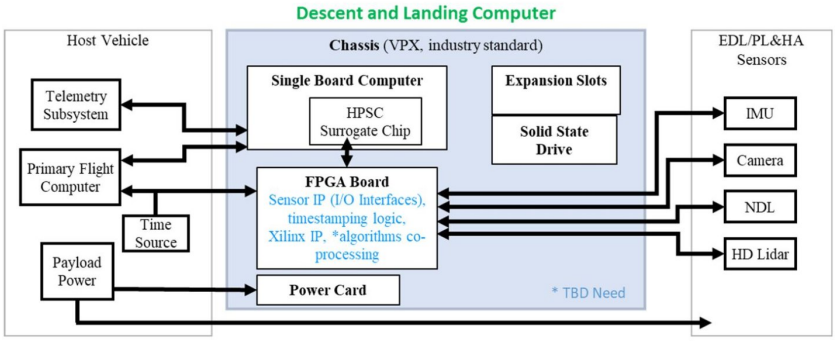
- Allows unencumbering of system microprocessors to prevent disruptions
- Enables processing large amounts of data in real-time
- Designed to OpenVPX standard
- Incorporates commercially available microprocessors
- Architecture has potential to be implemented separately for less demanding applications
- Broadly applicable as an embedded system for a variety of applications
- Successfully flight tested in DLC application presented

THE TECHNOLOGY

The DLC platform is composed of three key components: a NASA-designed field programmable gate array (FPGA) board, a NASA-designed multiprocessor on-a-chip (MPSoC) board, and a proprietary datapath that links the boards to available inputs and outputs to enable high-bandwidth data collection and processing.

The inertial measurement unit (IMU), camera, Navigation Doppler Lidar (NDL), and Hazard Detection Lidar (HDL) navigation sensors (depicted in the diagram below) are connected to the DLC's FPGA board. The datapath on this board consists of high-speed serial interfaces for each sensor, which accept the sensor data as input and converts the output to an AXI stream format. The sensor streams are multiplexed into an AXI stream which is then formatted for input to a XAUI high speed serial interface. This interface sends the data to the MPSoC Board, where it is converted back from the XAUI format to a combined AXI stream, and demultiplexed back into individual sensor AXI streams. These AXI streams are then inputted into respective DMA interfaces that provide an interface to the DDRAM on the MPSoC board. This architecture enables real-time high-bandwidth data collection and processing by preserving the MPSoC's full ability.

This sensor datapath architecture may have other potential applications in aerospace and defense, transportation (e.g., autonomous driving), medical, research, and automation/control markets where it could serve as a key component in a high-performance computing platform and/or critical embedded system for integrating, processing, and analyzing large volumes of data in real-time.



Shown: a diagram of the Descent and Landing Computer's (DLC) computing platform with datapath architecture

APPLICATIONS

The technology has several potential applications:

- Aerospace & Defense: autonomous landing of air and spacecraft
- Automotive: autonomous driving and driver-assistance systems
- Manufacturing: manufacturing process automation and optimization; predictive analytics and failure prognostics
- Medical: systems for medical sensor arrays, equipment, and instrumentation
- Research: data acquisition and computational analysis

PUBLICATIONS

Patent Pending

A System to Provide Deterministic Flight Software Operation and Maximize Multicore Processing Performance: The Safe and Precise Landing – Integrated Capabilities Evolution (SPLICE) Datapath, IEEE Space Mission Challenges for Information Technology - IEEE Space Computing Conference (IEEE SMC-IT/SCC 2023), July 18, 2023, NTRS Document ID: 20230001114 . https://ntrs.nasa.gov/citations/20230001114.

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