Science Hardware Engineering PlatformS (SHEPS) for Remote Sensing and Space Flight Applications

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Abstract

A broadband reconfigurable space-qualified digital signal processing board is the enabling technology for an array of remote sensing instruments ranging from Ground-based to Flagship missions. Figure 1 illustrates the Science Hardware Engineering PlatformS (SHEPS) of the ASU School of Earth and Space Exploration (SESE) Digital Signal Processing Technology Development Lab (DSPTechDev Lab). Our current research in RADAR and Submillimeter passive spectroradiometry illustrate our diverse capabilities in understanding the relationship between the science measurement and the information that results from applying digital signal processing algorithms onto flexible hardware platforms like the field programmable gate array (FPGA). Our heritage instruments from Ground-based to Flagship demonstrate our collaborative experience here at ASU SESE for instrument development. The opportunity here is in using the reconfigurable digital hardware platform for real-time, high-speed, onboard digital signal processing. The DSPTechDev Lab seeks to advance science algorithm development on FPGAs and characterize their performance on ground-based and flight opportunity missions.

The Opportunity

The reconfigurable DSP board will greatly reduce costs and development time for ground-based instrumentation, mission concept studies and balloon missions. Because there is an ever-increasing demand for higher bandwidth and more distant missions, it is necessary to increase onboard DSP on FPGAs to relax the data rate. Flight qualified FPGAs create the environment for algorithm development so that the post processing typically performed on downlinked data, can be performed in real-time. In this manner, the science information is transmitted (rather than only raw data) at a lower data rate. The space-enabled platform illustrated in Figure 1 provides the Technology Roadmap from ground-based to spaceflight instruments at ASU SESE. The flexible digital platform reduces development time through shared libraries, increases confidence in dsp algorithms through lab testing and tech demo missions, and provides a pathway to Application Specific Integrated Circuit (ASIC) development. Digital signal processing on FPGAs has broad cross-cutting applications in submillimeter digital receivers for planetary missions, ultra-broadband spectroradiometry for planetary boundary layer sensing, hyperspectral sounding of atmospheric temperature and water vapor, cryogenic detectors for radio astronomy, and RADAR applications. The proposed work effort is both an ***urgent short-term and strategic long-term*** necessity for developing suborbital flight demonstrations.

Conclusion

As illustrated from the Technology Roadmap in Figure 1, ASU School of Earth and Space Exploration has successfully developed/flown instruments from ground-based ("Volcano RADAR", Bryan, et al., 2017) to flagship ("Psyche" Elkins-Tantan, et al., 2020). Development of robust digital signal processing of science algorithms on reconfigurable digital hardware is essential for cost-effective missions. Instruments can share a common digital platform while running proprietary code, thereby enabling more efficient instrument development.

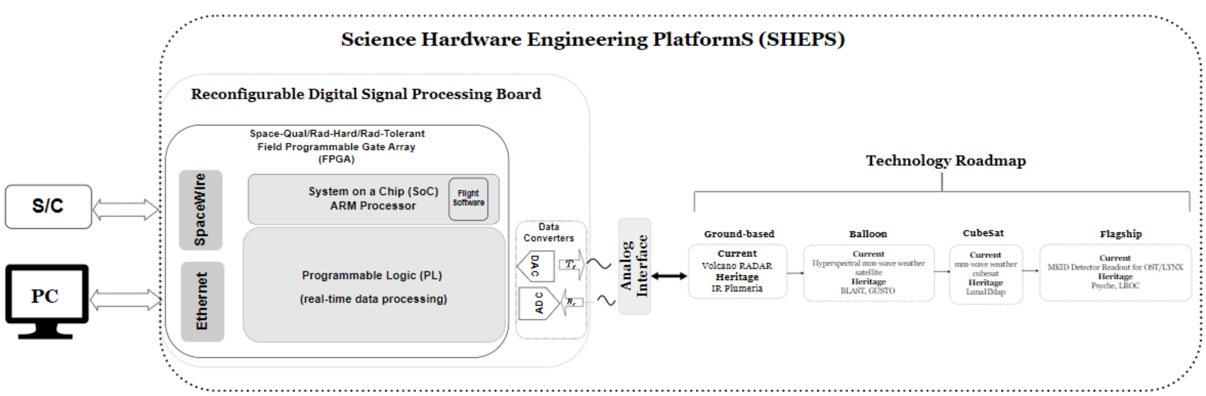

Figure 1: ASU School of Earth & Space Exploration SHEPS Technology Roadmap