National Aeronautics and Space Administration

GCD

Safe and Precise Landing - Integrated Capabilities Evolution (SPLICE)

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Technology Taxonomy Area (TX): 9.4.7 Guidance, Navigation, and Control (GN&C) for Entry Descent and Landing (EDL), 17.1.1 Guidance Algorithms, 17.2.1 Onboard Navigation Algorithms, 17.2.3 Navigation Sensors, 17.5.4 GN&C Ground Testbeds, 8.1 Remote Sensing Instruments and Sensors, 2.0 Flight Computing and Avionics, 10.0 Autonomous Systems

PL&HA Computer TRL: Start 2 / Current 5 / Target 6

GN&C S/W TRL: Start 3 / Current 5 / Target 6

HD Lidar TRL: Start 3 / Current 5 / Target 6

FY22 PROJECT OVERVIEW

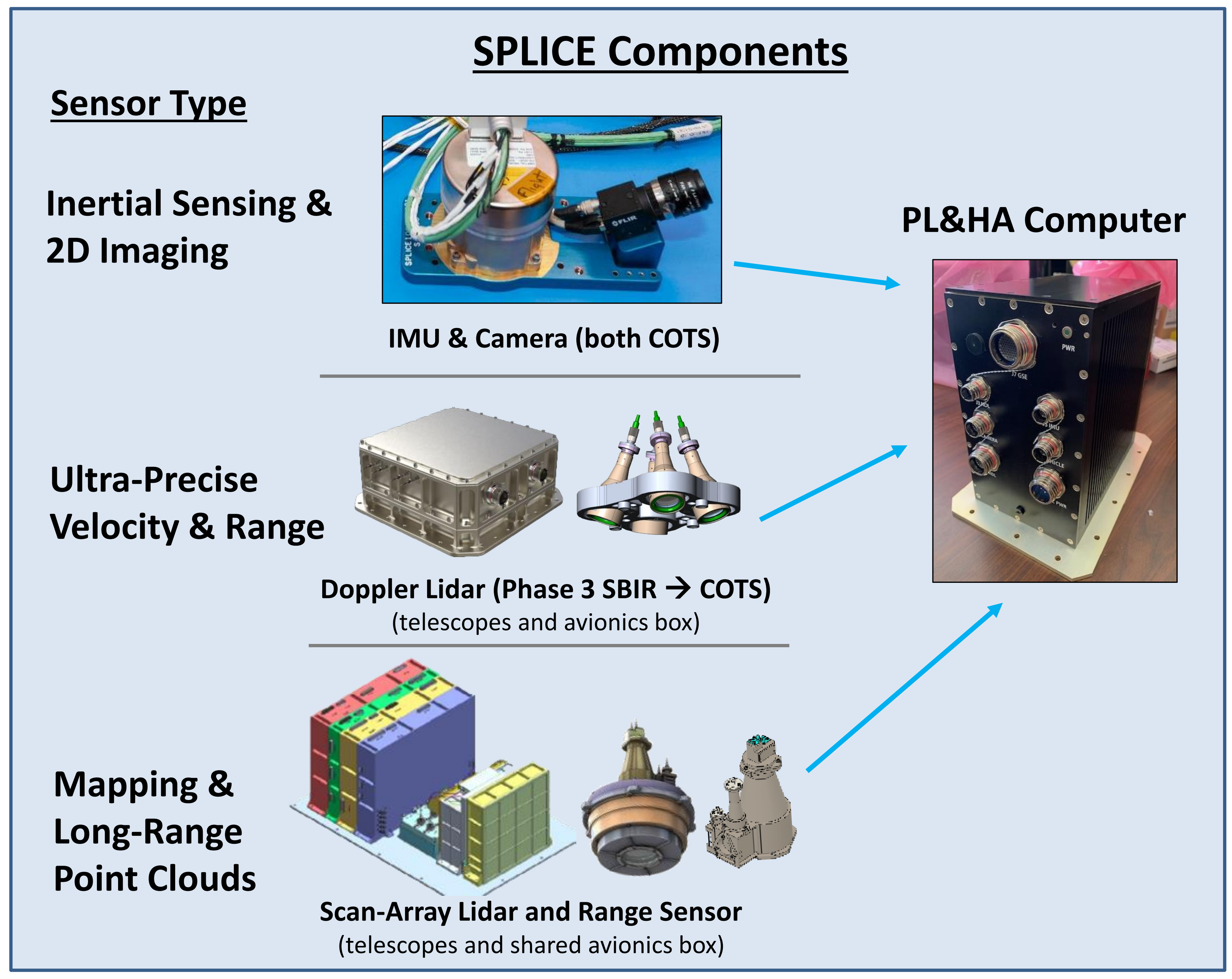
NASA's technology advancement needs for entry, descent and landing call for high-precision, high-rate sensors that can improve navigation accuracy and detect hazards. The Safe and Precise Landing—Integrated Capabilities Evolution project, or SPLICE, will develop, mature, demonstrate, and infuse precision landing and hazard avoidance (PL&HA) technologies for NASA and for potential commercial spaceflight missions. SPLICE technologies include sensors, algorithms, advanced spaceflight computing capabilities, and simulation tools used to integrate and study guidance, navigation, and control (GN&C) system performance. SPLICE efforts include hardware-in-the-loop (HWIL) simulation testing, ground testing, and flight testing.

INNOVATION

Autonomous PL&HA builds upon core GN&C capabilities to enable soft controlled landings on the Moon, Mars, and other solar system bodies. PL&HA significantly improves the probability of mission success and enhances access to sites of scientific interest located in challenging terrain. Through the addition of Terrain Relative Navigation (TRN), precision landing within tens of meters of a map-based target is possible. A 3-D terrain mapping lidar sensor improves the probability of a safe landing via autonomous, real-time Hazard Detection and Avoidance (HDA). This same lidar includes a long-range altimeter beam that can accomplish Active TRN for any lighting condition at the Moon. A multi-beam Doppler lidar is used to provide extremely precise range and velocity measurements during the descent, which limits state error growth and supports autonomous safe landing. A novel trajectory guidance methodology is used to maximize the performance advantages of the accurate sensing and navigation techniques being employed.

OUTCOME

- Develop (to TRL 6) a spaceflight-capable Descent and Landing Computer (DLC) Engineering Test Unit (ETU) as a HPSC–surrogate using SpaceVPX that performs sensor fusion, runs GN&C computing applications, and can transfer, process, and store data at high speeds
- Develop and implement a Hazard Detection Lidar (HDL) ETU to TRL 6 that rapidly collects measurements in real-time to generate a high-resolution 3-D digital elevation map/model (DEM), of the landing area at sufficient altitude in order to maneuver to avoid hazards
- Complete a full set of flight software and firmware applications running in core Flight System (cFS) on the DLC that includes navigation and guidance algorithmic technology advancements, navigation filter for sensor fusion, processes the DEM, identifies a ranked list of safe sites, chooses a new landing target (based on user configured weighting parameters), and calculates and updated trajectory to the new landing target within modeled vehicle constraints
- Facilitate development of a COTS Navigation Doppler Lidar (NDL) EDU (via SBIR) which utilizes technology advances in integrated photonics to improve SWaP-C (size, weight, and power, plus cost)



OUTCOME (CONT.)

- Perform a series of ground-based and flight tests of all SPLICE components, including performance testing, HWIL testing and an integrated TRL 6 validation

INFUSION SPACE / EARTH

SPLICE is composed of multiple technologies that can be infused separately, or as a whole system. The future project goal is to infuse the full SPLICE PL&HA system on a CLPS robotic flight demo, which is outside of current project scope. Infusion and commercialization of each of the individual component technologies is being pursued. Primary infusion targets are lunar landing missions (HLS and CLPS). Future mission infusion includes Mars robotic and human landers, Europa, and Icy Worlds missions. Similar capabilities (and advancements) are needed for Rendezvous and Capture applications.

PARTNERSHIPS / COLLABORATIONS

Contributing NASA Programs include STMD/GCD, STMD/FO, SBIR, and ECF. Contributing Centers are JSC, GSFC, LaRC, and JPL. Industry partners are (in no particular order) Draper, Psionic, Blue Origin, Astrobotic, Masten, Intuitive Machines. Academics partners are Univ. of Washington, Univ. of Texas, Texas A&M, San Diego St, Univ. of Illinois, Georgia Tech.

FUTURE WORK

FY22-23: Develop and demonstrate the component technologies to advance TRL. Complete HWIL, field, and flight test, including an integrated TRL 6 validation flight test on a suborbital rocket.